

Effect of Aquatic Physiotherapy on Functioning, Balance Performance, Motor Performance, and Health-Related Quality of Life in Patients with Parkinson's Disease: A Review of Structure and Dosimetry of Aquatic Exercise Programs

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ABSTRACT: The aim of this review was to study the effects of aquatic physiotherapy on functional ability, balance, motor impairments and quality of life in patients with Parkinson's disease. The MEDLINE, SCIENCE DIRECT, and Physiotherapy Evidence Database (PEDro) databases were searched. This review included randomized clinical trials that were applied to individual with Parkinson's disease included protocols in which aquatic physiotherapy programs were compared either with a control group, or with respective land-based exercise programs, or were part of combination protocols of complex treatment regimens. Thirteen studies were included in this review. PEDro was used to assess the quality of all articles. Aquatic physiotherapy programs include gate training, resistance and balance exercises. Most of the results of the included studies suggested that aquatic physiotherapy had positive effects on functioning, balance, motor impairments and quality of life in people with Parkinson's disease. However, due to low quality of evidence in the included studies the bias risk was high. Aquatic physiotherapy may have a positive effect in reducing the symptoms of patients with Parkinson's disease. Multimodal aquatic exercise programs containing both resistance and water balance exercises seem to be as effective as the corresponding multimodal land-based exercises and in fact have a more positive effect on balance. Furthermore, combination programs that contain both types of exercise (aquatic physiotherapy and land-based exercises) do not seem to be more effective than the individual application of aquatic exercises. Four through 12 weeks of combined (resistance and balance) aquatic physiotherapy, with a frequency of two to five times a week, may help improve functioning, balance, quality of life and help reduce motor impairments resulting from the disease. However, more studies of greater methodological validity need to be conducted in the future in order to draw safer conclusions.

KEY WORDS: Parkinson's disease, aquatic physiotherapy, exercise, rehabilitation

I. INTRODUCTION

Parkinson's disease is a progressive degenerative disease of the central nervous system characterized by progressive loss of dopamine neurons in the substantia nigra of the

brain.^{1–3} It manifests itself gradually through motor impairments such as bradykinesia, resting tremor and instability while walking, but also from non-motor manifestations such as neurobehavioral symptoms (dementia and depression) and reduced quality of life.^{1,4,5} The causes of the disease are not known. However, both genetic and environmental factors have been implicated.^{6,7} Studies in patients have shown an increased incidence of gene mutations, a history of viral infections, a lack of dopamine which is responsible for controlling normal muscle function and normal motor function, reduced levels of noradrenaline and Lewy body presence, α -synuclein concentration.^{8–10} Important is the research of the Stanford School of Medicine which showed that the mutation of the *Leucine-Rich Repeat Kinase 2 (LRRK2)* gene is responsible for both the dopamine disorder and the appearance of the disease.¹¹

Parkinson's disease is the second most common neurodegenerative disorder after Alzheimer's disease.¹² According to recent epidemiological data, the global prevalence of the disease reaches seven million while in the United States the number of patients reaches 1 million. The disease occurs more often in the elderly.^{12,13} One in 100 patients over 60 is more likely to develop the disease while this rate quadruples for those over 80.¹² In most cases the disease appears after the age of 60. However, there is a small percentage (5–10%) of cases that show symptoms at a young age. It has also been found that there is an effect of gender on the disease with men being affected more often than women, with a ratio of about 3:2.^{12–14}

Exercise has been shown to slow the progression of the disease and is an additional strategy to reduce disability in patients with Parkinson's.^{15,16} Therapeutic exercise in the context of physiotherapy intervention helps to reduce motor impairments,^{17–19} improves functional ability,^{20–22} balance^{18,22,23} and quality of life.^{15,16,22} Various types of exercise have been suggested to treat Parkinson's symptoms. One such type is resistance exercise, which has been shown to positively affect disease-related motor impairments^{21,24} and improve sleep quality, daily functioning²⁵ and stress levels²⁶ of Parkinson's patients. Early to mid-stage patients have been proposed to follow a moderate progressive resistance exercise program with a duration of 8–10 weeks and frequency of two to three times per week that can facilitate improvements in their balance and strength and reduce motor impairments.²⁷

Another type of training that is recommended for patients with Parkinson's is endurance exercise which aims to improve their maximum rate of oxygen consumption ($\dot{V}O_2$ max) and as a consequence their cardiorespiratory capacity.²⁸ According to Lamotte et al.,²⁹ training in 40–85% $\dot{V}O_2$ max can prove beneficial for the endurance of the patient. They further report that improving gait speed in Parkinson's patients with the use of high-intensity endurance exercise leads to an enhancement of their cardiorespiratory capacity.

The endurance training programs that are usually applied in studies with Parkinson's patients have a frequency of two to three times per week and last 4–8 weeks.^{29,30} They show great heterogeneity in terms of exercise protocols that are applied and include body-weight-supported treadmill, gait and step training, aerobic exercise, Tai Chi, Nordic walking and dance.³⁰

Another type of training that is applied is proprioceptive exercise. Research has shown that proprioceptive training improves postural control in patients with Parkinson's.^{18,20} The different motor impairments associated with Parkinson's such as Parkinson's gait, bradykinesia and movement freezing make static and dynamic balance training very important in these patients.¹⁸ Proprioceptive exercises are usually incorporated into strength training programs and include the performance of functional skills such as activities while standing on one leg on an uneven surface or special functional tests.^{18,20}

Recent research indicates the positive effect of aquatic exercises performed in a pool with hot water as hydrokinesiotherapy, due to buoyancy and water temperature, allows movement in the water without causing muscle fatigue and seems to be a safe choice within the frame of physiotherapy treatment for these patients.^{15,25–28} Several systematic reviews have highlighted the positive effects of pool exercises on reducing symptoms and improving the functionality and quality of life of Parkinson's patients.^{29–32} However, although the research data that support the view on the positive effect of exercise in water in patients with Parkinson's is constantly increasing, the appropriate choice of therapeutic exercise combinations as well as the parameters of exercise are factors that require further investigation.

II. METHODS

A. Article Search Strategy

A systematic review of randomized clinical trials was conducted from November 2020 to January 2021. This review was performed in accordance with PRISMA analysis recommendations (<http://www.prisma-statement.org/>) (Fig. 1). The MEDLINE, SCIENCE DIRECT, and Physiotherapy Evidence Database (PEDro) databases were searched using the following key word combinations: “Parkinson” and “Aquatic physiotherapy” and “Exercise” and “Rehabilitation” or “resistance exercise” or “endurance exercise” or “proprioceptive exercise.”

B. Article Inclusion and Exclusion Criteria

This review included randomized clinical trials that were selected according to the following criteria: (1) clinical trials in patients with Parkinson's disease in which at least one intervention group followed an aquatic physiotherapy program in a swimming pool, (2) clinical trials whose outcome measures included functional ability, balance, motor impairments related to the quality of life in Parkinson's patients, (3) clinical studies in which aquatic physiotherapy programs were either compared with a control group, or compared with corresponding land-based exercise programs or were part of combination protocols that included other types of off-water exercise.

Criteria for rejection of articles were: (1) articles that were not available in full-text and (2) articles that were not published in English.

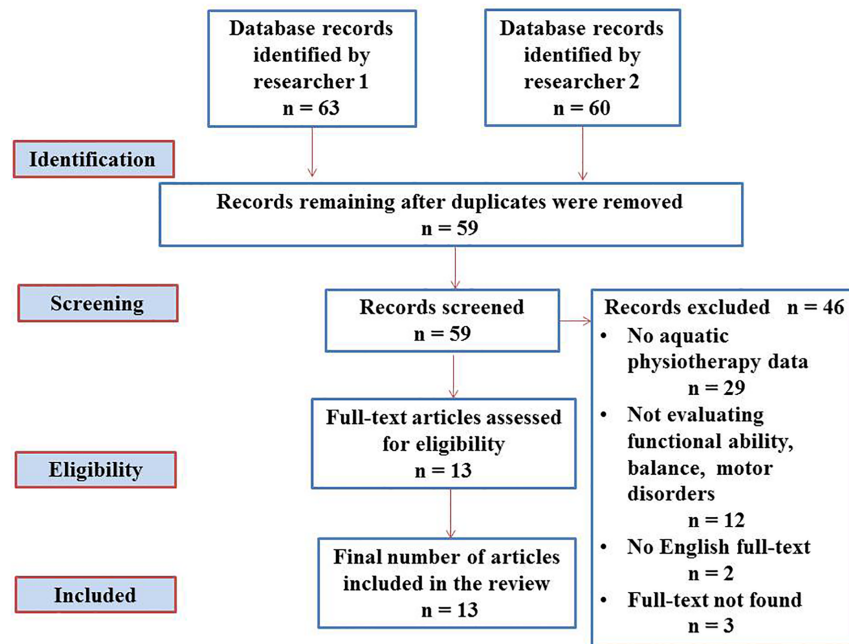


FIG. 1: Study selection flow chart

C. Quality Assessment

The PEDro scale was used for the quality assessment of the included studies³³ (Table 1), which is considered a valid measurement scale for the methodological assessment of clinical trials included in a systematic review.³⁴ This scale consists of a 10-point rating scale where each item is scored with yes or no with each positive answer corresponding to a point (<https://pedro.org.au/english/resources/pedro-scale/>). A higher score on the scale indicates higher quality of the specific research.³⁴

D. Study Selection Process

The search for articles was performed by two independent researchers who, using the same key word combinations, studied the titles and summaries from the lists of articles that resulted from the search. The articles by the two researchers were then collected and the duplicate articles were removed. After removing the duplicate manuscripts, researchers screened the articles according to the inclusion and exclusion criteria.

III. RESULTS

Thirteen clinical trials were included in this review. The article selection process is shown in the flow chart (Fig. 1). Of the 123 articles that were initially collected by both

TABLE 1: PEDro scale total scores of the included studies

Author (Year)	Eligibility criteria	Random allocation	Allocation was concealed	Baseline comparability	Blind subjects	Blind therapists	Blind assessors	Adequate follow-up	Intention-to-treat analysis	Between-group comparisons	Point estimates and variability	Total score
Terrens et al. ³¹	Yes	Yes	No	Yes	No	No	Yes	No	No	Yes	Yes	5/10
Clerici et al. ³²	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	7/10
da Silva et al. ¹⁵	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	7/10
Zhu et al. ⁴³	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8/10
Kurt et al. ⁴⁴	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	7/10
de la Cruz ⁴⁸	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7/10
Palamara et al. ⁵⁰	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	7/10
Carroll et al. ⁴⁷	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	7/10
Ayan et al. ⁴⁹	Yes	Yes	No	Yes	No	No	Yes	No	No	Yes	Yes	5/10
Volpe et al. ⁴⁶	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8/10
da Silva et al. ³⁸	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4/10
Ayan et al. ⁴²	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4/10
Vivas et al. ⁴⁵	Yes	Yes	No	No	No	No	No	Yes	No	Yes	Yes	4/10

researchers (63 from the first and 60 from the second), 64 were found to be common and were removed from the list. 59 articles were retained for screening. After screening, 13 articles satisfied the inclusion criteria, while 46 were rejected. The characteristics of the included studies are summarized in Table 2.

A. Main Characteristics of the Included Studies

Below are the main characteristics (design, outcome measures, and results) of the clinical trials included in the review.

In a study applied to 13 patients with Parkinson's followed a combined exercise therapy protocol in a heated pool.³² This protocol included warming up by walking in different directions in the pool, stretching, exercises for proprioception and resistance in the water and relaxation exercises. Participants attended 16 sessions over two months with a frequency of twice a week. The 13 participants were divided according to their stage into three groups according to the Hoehn and Yahr categorization.³⁵ The perception of quality of life was measured by the 39-item Parkinson's Disease Questionnaire (PDQ-39), before and after intervention. The results of the research showed that there was a statistically significant reduction both in the total score of the PDQ-39 and in all areas. It has been shown that at more progressed stages of Parkinson's, patients perceive a worse quality of life. Due to that and because the application of aquatic physiotherapy helped improved quality of life overall in Parkinson's patients, it was more impactful in patients at later stages. These patients still reported worse quality of life, but showed greater improvement comparatively.

In another study,¹⁵ the researchers wanted to study the effect of a dual-task aquatic exercises program on functional mobility, balance and gait in individuals with Parkinson's disease. Twenty-eight patients with Parkinson's disease were divided into two groups (intervention group and control group). The participants of the intervention group were subjected to a dual-task aquatic exercise program, twice a week for 10 weeks (each session lasted 40 min), while the individuals in the control group did not follow any treatment. Functional mobility with the Timed Up and Go (TUG) test and Five Times Sit-to-Stand (FTSTS) test, balance with the Berg Balance Scale (BBS) and gait through the Dynamic Gait Index were assessed before and after the program implementation and a follow-up measurement was conducted on three months. The results of the research showed that this dual-task aquatic exercise program was able to improve functional mobility, balance and gait of individuals with Parkinson's disease, as statistically significant differences were identified between the groups in all examined variables. These positive effects were maintained three months later.

Furthermore, an additional study³⁶ wanted to compare the effect of two different water exercise programs on functional ability, motor symptoms and quality of life in patients with Parkinson's. Twenty participants were divided into two groups; the first group followed a low-intensity program of exercises in the water with a duration of 12 weeks (frequency twice a week), while the second group followed a program of resistance exercises in the water of equal duration and frequency. The researchers assessed

TABLE 2: Characteristics of the included studies

Author (year)	Number of participants	Type of training		Number of groups	Program duration	Outcome measures	Results
		Aquatic physiotherapy	Land-based exercises				
Terrens et al. (2020) ³¹	30	Halliwick technique program Conventional aquatic exercise program (Resistance, aerobic, balance, range of motion exercises and walking)	Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) (Halliwick technique program vs. Conventional aquatic exercise program vs. Conventional land-based exercise program)	3	2 times per week for 12 weeks	UPDRS III (motor subsection) BBS Mini-BESTest Modified Falls Efficacy Scale	All examined variables were significantly improved in all three groups. However, there was only a statistically significant difference between the groups in terms of the score of the Mini-BESTest, with the Halliwick group showing greater improvement compared to the other two groups.
Clerici et al. (2019) ³²	60	Conventional aquatic physiotherapy program (Resistance, aerobic, balance, range of motion exercises and walking)	Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) (Combined aquatic and land-based exercise program vs. land-based program alone)	2	5 times per week for 4 weeks	Unified Parkinson Disease Rating Scale FOGQ TUG Test 6-Minute Walk Test	Both groups improved the same without any differences between the groups after 4 weeks.
da Silva et al. (2019) ¹⁵	28	Dual-task aquatic exercise program vs. Control	X	2	2 times per week for 10 weeks	BBS TUG Test Five Times Sit to Stand Dynamic Gait Index	Statistically significant improvement in the participants of the intervention group in all the examined variables after the completion of the program, which was maintained in the 3-month follow-up.

TABLE 2: (continued)

Author (year)	Number of participants	Type of training		Number of groups	Program duration	Outcome measures	Results
		Aquatic physiotherapy	Land-based exercises				
Zhu et al. (2018) ⁴³	46	Aquatic obstacle training (Slalom walking trials, Obstacle circling, Crossing overs) vs. Conventional aquatic exercise program (Resistance, aerobic, balance, range of motion exercises and walking)	X	2	5 times per week for 6 weeks	FOGQ BBS TUG Test	Obstacle aquatic therapy participants showed a significantly better improvement than the conventional aquatic exercise program group in the FOGQ and TUG test.
Kurt et al. (2018) ⁴⁴	40	Ai Chi exercise program	vs. Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises)	2	5 times per week for 5 weeks	Unified Parkinson Disease Rating Scale III BBS TUG Test PDQ-39	Statistically significant improvement in intervention group participants in all examined variables.
de la Cruz (2017) ⁴⁸	30	Ai Chi exercise program	vs. Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises)	2	2 times per week for 10 weeks	VAS pain Unified Parkinson Disease Rating Scale III BBS Tinetti scale Five Times Sit to Stand TUG Test	Statistically significant improvement in intervention group participants in all examined variables.

TABLE 2: (continued)

Palamara et al. (2017) ⁵⁰	34	Conventional aquatic physiotherapy program (Resistance, aerobic, balance, range of motion exercises) and walking	Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) (Combined aquatic and land-based exercise program vs. land-based program alone)	2	5 times per week for 4 weeks	UPDRS II-III BBS Timed Up Go Test	BBS scores at follow-up were significantly higher in participants of the combined program compared to participants of conventional land-based exercise. Both groups also showed an improvement in UPDRS II-III and TUG at the end of treatment compared to baseline, but the finding was lost at the 6-month follow-up.
Carroll et al. (2017) ⁴⁷	21	Aquatic exercise program (Cardiovascular and stretching warm up, water gait training and cool down) vs. Control	X	2	2 times per week for 6 weeks	Motion capture system UPDRS PDQ-39	Statistically significant improvement in intervention group participants compared to the control group in the UPDRS score.
Ayan et al. (2016) ⁴⁹	20	Conventional aquatic physiotherapy program (Resistance, aerobic, balance, range of motion exercises and walking)	Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) Treadmill gait training (Combination of aquatic and land-based with or without treadmill gait training)	2	2 times per week for 15 weeks	UPDRS PDQ Senior Fitness Test	There were no statistically significant differences between the groups with the addition of treadmill gait training to a combined protocol of aquatic and land-based exercises.

TABLE 2: (continued)

Author (year)	Number of participants	Type of training		Number of groups	Program duration	Outcome measures	Results
		Aquatic physiotherapy	Land-based exercises				
Volpe et al. (2014) ⁴⁶	34	Aquatic exercise program (Cardiovascular and stretching warm up, perturbation-based balance, water gait training and cool down)	Active control conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) (Aquatic exercise program vs. Active control land-based exercise program)	2	5 times per week for 8 weeks	Stabilometric platform (pressure sway displacement) UPDRS II-III PDQ-39 BBS TUG Test Activities-specific Balance Confidence Scale Falls Efficacy Scale and Falls diary	There was a statistically greater improvement in patients who underwent hydrotherapy than in patients treated with land-based therapy in the center of pressure sway area with closed eyes in BBS score, in Activities-specific Balance Confidence Scale, in PDQ-39 and in Falls Diary.
da Silva et al. (2013) ³⁸	13	Graded aquatic physiotherapy program (Resistance, aerobic, balance, range of motion exercises and walking) in patients belonging to the 3 different categories of Parkinson's (1, 2 and 3), according to the Hoehn and Yahr categorization.	X	3	2 times per week for 8 weeks	PDQ-39	There was a significant reduction both in the overall score of the PDQ-39 and in its individual areas. The score was most affected in the higher stages of the disease.

TABLE 2: (continued)

Ayan et al. (2012) ⁴²	20	Low-intensity aquatic exercise program vs. Resistance aquatic exercise program	X	2	2 times per week for 12 weeks	UPDRS PDQ-39	There was a statistically significant difference in the score of all outcome measures in the group members who followed the resistance program in relation to the participants of the low-intensity exercise program.
Vivas et al. (2011) ⁴⁵	11	Conventional aquatic physiotherapy program (Resistance, aerobic, balance, range of motion exercises and walking)	Conventional land-based exercise (Resistance, aerobic, balance, range of motion exercises) (Aquatic exercise program vs. land-based program)	2	2 times per week for 4 weeks	UPDRS BBS TUG Test 5-Meter Walk Test Functional Reach Test	There was a statistically significant improvement in individuals in the aquatic physiotherapy program compared to land-based individuals in the UPDRS score and BBS score.

the clinical picture of the participants with FTSTS, the Unified Parkinson's Disease Rating Scale (UPDRS) and PDQ-39. The results of the study showed that the participants of both groups improved significantly after the end of the intervention. However, the members of the group that followed the resistance program showed a statistically significant difference in the improvement of the functional ability and in the reduction of motor impairments in relation to the participants of the group that followed the low-intensity exercise program in the water. The researchers concluded that water exercises are an effective intervention in patients with Parkinson's. However, resistance exercises seem to further improve the functional ability and quality of life of these patients.

The effect of aquatic obstacle training in relation to a conventional hydrotherapy program was also studied.³⁷ Forty-six patients with Parkinson's disease were divided into two groups (obstacle training group and conventional hydrotherapy group). All participants undertook aquatic therapy for 30 minutes, five times per week for 6 weeks with a session time of 45 minutes. The aquatic obstacle training program included activities in the water such as slalom walking trials, obstacle circling and crossing over different types of steps. The conventional hydrotherapy program included mobility exercises (axial and proximal rotation), postural stability training exercise such as one-leg stance activities inside the water, trunk shifts in different directions (anterior, posterior and lateral) in the standing position, hip, knee and ankle range of motion exercises holding onto the side of the pool and going up and down the stairs inside the pool. The Freezing of Gait Questionnaire (FOGQ), Functional Reach Test, TUG, and BBS were assessed at baseline, post-treatment and the six-month follow-up. Participants of both groups showed significant improvement in all examined variables. However, from the inter-group comparison it was concluded that the obstacle aquatic therapy showed significantly better improvement for FOGQ ($p < 0.05$) and the TUG test ($p < 0.001$).

Other researchers have attempted to compare the effect of aquatic exercise with land-based exercise in patients with Parkinson's disease.^{38,39}

Other researchers contrasted the effect of an Ai Chi program in a pool in relation to a conventional land-based exercise program on balance, functioning, quality of life and motor impairments in people with Parkinson's disease.³⁸ According to the Hoehn and Yahr Scale,³⁵ 40 patients with stage 2 and 3 Parkinson's disease were divided into two groups. The first group followed an Ai Chi program in the pool, while the second group followed a land-based exercise program. Both programs lasted 5 weeks with a frequency of five times a week and a session duration of 30 minutes. The results of the research showed positive effects on all the examined variables with both programs. However, *post hoc* tests to identify differences between groups showed that improvement of dynamic balance was significantly greater in the Ai Chi group ($p < 0.001$) as well as in the BBS score ($p < 0.001$). The same stands for TUG ($p < 0.002$), the PDQ-39 ($p < 0.001$), and UPDRS-III ($p < 0.001$).

The effectiveness of aquatic exercises in comparison to land-based exercises in patients with Parkinson's was the research point of another study.³⁹ Eleven participants with Parkinson's disease were divided into two groups, the land-based exercise group (active control group) and the water-based exercise group (experimental). Each group

followed a 4-week exercise program with a frequency of two times a week and 45-minute sessions. Functional ability with the Functional Reach Test, TUG and the 5-Meter Walk Test, and motor status with UPDRS and BBS, were evaluated before and after the intervention. The results showed that both groups showed improvement in all the examined variables. However, the participants of the water-based exercise group showed a statistically significant improvement over the members of the land-based exercise group in terms of the score of UPDRS and BBS ($p < 0.05$). The researchers therefore argued that water exercises improve postural stability more effectively than land-based exercises.

The comparison of aquatic and land-based exercise programs was the interest of even more researchers.⁴⁰ Thirty-four patients with Parkinson's were divided into two groups: the aquatic exercises group (experimental) and the land-based exercises group (active control). Each program had a duration of two months five times a week and the sessions lasted 60 minutes. Both water and land-based exercise program included the same routine: A 10-minute warm up with stretching exercises, 40 minutes of balance training and finally, cooling down for another 10 minutes. It should be noted that the exercises performed by both groups (water and land-based) during their 40-minute main training were focused on perturbation. The aim of this research was to study the effect of the two programs on the parameters of balance and functional ability. The following were evaluated: displacement of the pressure sway area recorded with open and closed eyes using a stabilometric platform, motor status with UPDRS II and III, functional ability with TUG and the Activities-specific Balance Confidence Scale, balance with BBS, the risk of falling with the Falls Efficacy Scale and Falls Diary and quality of life with PDQ-39. The results in terms of differences between the groups showed that there was a better improvement in patients who underwent hydrotherapy than in patients treated with land-based therapy in the center of pressure sway area with closed eyes ($p < 0.05$), in BBS score ($p < 0.001$), in Activities-specific Balance Confidence Scale ($p < 0.001$), in PDQ-39 ($p < 0.001$) and Falls Diary ($p < 0.001$).

Moreover, other researchers studied the effect of a pool exercise program on motor impairments and functioning in patients with Parkinson's.⁴¹ Twenty-one patients were divided into two groups: the hydrotherapy group and the usual care (active control) group. The hydrotherapy program included cardiovascular and stretching warm up for 10 minutes followed by a 25-minute water gait training and a 10-minute cool down. The program lasted 6 weeks with a frequency of two times a week and session duration of 45 minutes. Motor impairments with the motion capture system and UPDRS and quality of life with PDQ-39 were evaluated before and after the intervention. The results of the research showed that there was a statistically significant difference between the groups only in the evaluation of UPDRS with the hydrotherapy group showing greater improvement compared to the control group, while the authors report that the participants of the hydrotherapy program found this program more pleasant and safe.

Ai Chi was also the focus of a study that compared the effect of an Ai Chi exercise program on water to a conventional land-based exercise program.⁴² Thirty patients with Parkinson's disease were divided into two groups: an Ai Chi experimental group

and a land-based exercise active control group. Participants in both groups followed a 10-week program with a frequency of twice a week (20 sessions in total with a session duration of 45 minutes). The participants of the aquatic exercise group followed a group program of gradually increasing difficulty based on the Ai Chi technique, while the participants of the land-based exercise group followed a program which included free weight resistance exercises and aerobic exercise both in groups as well as individually in the gym area. The following were assessed before and after the intervention and in a follow-up measurement one month later: pain with the Visual Analog Scale (VAS), balance with BBS, functional ability with the Tinetti Scale, FTSTS, TUG and UPDRS. No statistically significant changes were observed in the control group between the baseline and one-month follow-up measurements, apart from an improvement on the VAS for pain ($F = 8.3$, $p = 0.004$). The experimental group showed greater improvement on pain VAS and exhibited statistically significant changes in pain perception values ($F = 26.89$, $p < 0.001$) and the Tinetti test ($F = 21.57$, $p < 0.001$); the latter compared to the control group ($p < 0.05$). Furthermore, the experimental group showed no significant changes on FTSTS ($p = 0.006$). Lastly, concerning the UPDRS scores in the experimental group, it was notably differentiated in daily activities and motor ability, but not in behavior and mental activity.

In their research, Terrens et al.³¹ report that in most aquatic physiotherapy programs for patients with Parkinson's disease, the exercises applied mimic exercises from land-based exercise programs such as water walking and resistance exercises. For this reason, the researchers proposed the implementation of a special hydrotherapy program based on the Halliwick technique. The researchers wanted to compare a technique-based program with a traditional hydrotherapy program and a land-based exercise program. Thirty participants with Parkinson's disease were divided into three groups. The first group followed a Halliwick program, the second a traditional aquatic physiotherapy program and the third a conventional land-based exercise program. All programs lasted 12 weeks with a frequency of twice a week and a session time of 60 minutes. The following were evaluated before and after the intervention: safety, adherence and attrition of exercise programs, functional ability through UPDRS-III, balance with BBS and fall risk with the Mini Balance Evaluation Systems Test (Mini-BESTest) and modified Falls Efficacy Scale. The results of the research showed that all the examined variables were significantly improved in all three groups. However, there was only a statistically significant difference between the teams in terms of the Mini-BESTest score with the Halliwick group showing a greater improvement over the other two groups ($p = 0.011$, 95% confidence interval, -7.36 to -1.31 , $t_{(10)} = -2.98$).

Finally, other researchers studied the effect of a treadmill training program when implemented with a combined exercise protocol that includes both in-water and land-based exercises.⁴³ Twenty adult patients with Parkinson's were divided into two groups. The first group followed an exercise program that included land-based exercises and water exercises combined with walking on a treadmill twice a week for 15 weeks. The second group followed the same exercise protocol without the addition of gait training.

Some of the tools used in the research are UPDRS, PDQ-39, and Senior Fitness Test. The results showed a significant improvement in aerobic ability, functional ability and quality of life in participants in both groups, but no differences were observed between the groups. Thus, the results of this study showed that the addition of gait training to a combined program of water and land-based exercises does not further improve the clinical picture of Parkinson's patients.

In two clinical trials, researchers wanted to compare the effect of adding aquatic physiotherapy exercises to a land-based exercise program in relation to the individual application of land-based exercises.^{26,44}

A clinical study was applied to 34 patients with Parkinson's disease.⁴⁴ Participants were divided into two groups: the combination therapy group and the land-based exercise group. Both protocols lasted 4 weeks with a frequency of five times a week and a session duration of 60 minutes. The following were evaluated before and after the intervention and at the 6-month follow-up measurement: balance with BBS and functional ability with UPDRS-II and III and TUG. The results of this study showed improvement after treatment in both groups. However, there were statistically significant differences between the groups only in the 6-month follow-up with the group that followed the combination therapy protocol showing much higher BBS scores than the land-based exercise group. As for the examination of the other variables, the results showed that they improved equally after the end of the program. However, these positive effects were not maintained at the 6-month follow-up.

The effect of adding water exercises to a conventional land-based exercise program in relation to the individual application of land-based exercises on the freezing of gate of patients with Parkinson's disease was additionally studied.²⁶ Sixty patients with Parkinson's disease were divided into two groups; the first group followed a combination program while the second a conventional land-based program. Both programs had a duration of 4 weeks with a frequency of five times a week and a session time of 30 minutes. The primary outcome measure was FOGQ and secondary outcome measures were UPDRS, BBS, TUG, and 6-Minute Walk Test. The results showed that both groups improved the same without any differences between them after the completion of the two programs.

IV. DISCUSSION

The aim of this review was to study the effects of aquatic physiotherapy on functioning, balance, motor impairments and quality of life in patients with Parkinson's disease and to provide details about structure and dosimetry of aquatic exercise programs. According to the results of research included in this review, aquatic physiotherapy seems to have positive effects on functioning, balance, motor impairments and quality of life in people with Parkinson's disease.^{15,41,44} Most aquatic physiotherapy programs include gate training exercises in the water,^{23,25,26,41,44} going up and down steps,⁴³ balance exercises^{32,40,44} and resistance exercises.^{36,41,43} The effectiveness of the Ai Chi technique is studied in two studies^{38,42} while only one employs the Halliwick technique.²⁵

A. Synthesis of Results of the Included Studies

The results of this review show that aquatic physiotherapy produces positive effects when compared to a control group. Aquatic physiotherapy was evaluated in this way in two clinical trials.^{15,45} In both studies, the programs implemented improved the clinical picture of the participants, however, the studies were greatly heterogeneous both in terms of implemented protocols and in terms of outcomes measures. In one study, the effect of dual-task training in combination with the positive effects of water was studied.¹⁵ Dual-task training is a type of training that combines the simultaneous execution of the exercise with the execution of cognitive functions and there is research data that its application can positively affect the parameters of gait and functional ability in general.^{15,45,46} On the contrary, in the second study the program that was implemented had different characteristics as it consisted of a combination of resistance training, endurance training and gait training.⁴⁷ From the findings of this study, positive effects on the intervention group were identified only in terms of the score of the UPDRS which is associated with non-motor and motor impairments related to the performance of daily living activities.^{31,47} Therefore, the results of this review do not provide strong evidence that the application of aquatic physiotherapy is more effective when compared to a control group.

B. Aquatic Physiotherapy versus Land-Based Exercise

The effect of aquatic physiotherapy in relation to land-based exercise programs was investigated in a total of six studies.^{31,32,44,45,48,49} In two of them, the effectiveness of the Ai Chi technique was compared with a conventional multimodal land-based exercise program that was considered as standard treatment (the same in both studies).^{44,48} The two studies followed a similar design comparing parameters such as balance and functional ability and concluded that the Ai Chi technique significantly improves these parameters. However, it is noteworthy that there was heterogeneity in the frequency and duration of the programs as one study had more regular sessions (five times a week) and was implemented in a shorter period (5 weeks),⁴⁸ while in the second, the sessions were more sparse (two times a week) and its duration was longer (10 weeks).⁴⁴ Consequently, the results of this review show some indications that the Ai Chi technique further improves gait and balance parameters compared to land-based exercises. To provide an interpretation to this, perhaps the reason is that water resistance exercises are performed at a slow pace, emphasizing the stabilization of the trunk in combination with breathing (slow and harmonious execution of movements in the water), so perhaps the exercise programs that incorporate them are more effective in patients with Parkinson's.

The above conclusion is supported by the results of another study that supports the positive effect of the Halliwick technique on balance and functional ability compared to the same conventional land-based exercise program with a frequency of sessions twice a week for 12 weeks.³¹ This technique includes the same features as Ai Chi (slow execution of exercises, stabilizing the trunk and breathing) emphasizing the smoothness

of movement. We could therefore argue that there is evidence that performing water exercises with characteristics such as those of the Ai Chi and Halliwick techniques may be more effective in patients with Parkinson's disease than conventional land-based exercise programs.

In three more studies comparing water exercises with land-based exercises the results were contradictory.^{32,45,49} One of them⁴⁵ points out the positive effect of aquatic physiotherapy on balance and the ability to perform daily skills while in the others the results do not support the superiority of aquatic physiotherapy over land-based exercise.⁴⁹ Studies comparing the effect of the combination of both aquatic physiotherapy and land-based exercise versus aquatic physiotherapy alone failed to show that the combination of both was superior to the individual application.^{32,49} The results of this review do not provide strong evidence as to the greater effectiveness of one type of exercise over the other. Nevertheless, we can say that there is some evidence that aquatic physiotherapy has a better effect than land-based exercises in terms of balance. The results of this review are consistent with similar results of other systematic reviews such as that of Cugusi et al.,³¹ which concluded that aquatic physiotherapy improves the symptoms of Parkinson's patients and that in relation to land-based exercises, water exercises seem to help improve balance in Parkinson's patients. However, several more studies are needed to determine the appropriate combination of different types of exercise in a single treatment regimen.

V. STUDY LIMITATIONS

Various methodological weaknesses may have affected the results of this review as in several studies the samples of the participants are small, and this may affect the representativeness of the samples in relation to the general population. For this reason, it is proposed to implement more clinical trials that recruit a larger number of participants.

VI. CONCLUSIONS

The results of this review reinforce the research data on the positive effects of aquatic physiotherapy on balance, functioning, motor impairments, and quality of life in patients with Parkinson's disease. According to the results of the studies included in this review, combined water exercise programs that include both resistance and proprioception exercises have the greatest positive effect on the clinical picture of Parkinson's patients. Comparing water exercise programs with land-based exercises, we found indications that water exercises further improve balance while these improvements are not greater when water exercise programs are concurrently combined with land-based exercises. However, the findings of this review are of limited relevance and are questionable. In many of the included studies, the number of participants was small and, based on the PEDro score, most of them are rated under poor evidence and quality. For this reason, the need for future research with better quality and larger samples is emphasized.

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