

# Aquatic Physiotherapy and Parkinson's Disease: Effects on Functional Motor Skills

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## Abstract

Parkinson's Disease (PD) is a progressive disease with motor impairment, and as such requires a multidisciplinary team that includes physiotherapy. Physiotherapy can stimulate learning ability, motor recovery, neuroplasticity and neuroprotection. The aquatic physiotherapy (AP) for PD enables movements to be progressively and safely executed, reducing the risk of falls. Hence, the objective of this study is to analyze the effects of an AP program on the functional motor skills of people with PD. This is a controlled quasi-experimental clinical trial, with blind assessor. The participants were male and female, diagnosed with PD, Hoehn and Yahr stages 1 to 4 and medical certificate for AP. The exclusion criteria were: not presenting independent walking; sensorial deficit; contraindications for attending a heated pool; alterations in levodopa ingestion. The functional assessments conducted on land were: walking speed test; Five Times Sit to Stand Test; Mini BESTest, Unified Parkinson's Disease Rating Scale (UPDRS) for activities of daily living (ADL); and motor skill parts, evaluated before, after and 4 months after AP. The aquatic assessment was conducted through the Aquatic Functional Assessment Scale (AFAS). The participants were allocated in two groups: Control Group (CG), which did not take part in the pool activities, and Experimental Group (EG), which was submitted to AP, throughout 32 twice-a-week, 50-minute-long appointments. Functional exercises were proposed to respect the principles of specificity and progression regarding complexity in the aquatic activities through aquatic motor skills learning phases. Groups and times were compared statistically. At the end of the study, the EG was composed of 11 participants and the CG 7. There were no differences between the groups at the beginning of the study. A difference was observed between groups for gait speed in evaluation 2; difference between assessment 1 and 2 for GE in the ADL and motor, as well as between assessment 2 and 3 for GE in the motor assessment. CG presented a decline from assessment 1 and 3. In the aquatic assessment, the EG had a statistical difference after the intervention. It was

observed that the AP program can modify the aquatic motor skills and the land motor skills of walking speed, the UPDRS ADL and the UPDRS motor.

## Keywords

Physiotherapy, Parkinson's Disease, Rehabilitation, Exercise, Hydrotherapy

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## 1. Introduction

PD is part of a group of neurological, degenerative, chronic and progressive diseases of the central nervous system [1]. Among the observed symptoms, motor impairment is quite evident. The cardinal signs are bradykinesia, muscle stiffness, tremor at rest and postural instability [2]. These difficulties and limitations lead to a functional decline, with loss in the quality of motor skills [3].

To approach PD, a multidisciplinary and complementary team is essential for the integral health treatment of the patient [4]. Physiotherapy is a central part of this team in the therapeutic process. The continuity of physiotherapy can stimulate the learning ability and aid motor recovery [5], brain function, neuroplasticity and neuroprotection, slowing neural degeneration [3]. The professionals who work with human movement seek innovative PD physiotherapy strategies to recover and stimulate motor skills [1] [3]. With this purpose, aquatic physiotherapy (AP) with PD enables movement to be progressively and safely made, reducing the risk of falls [2] [6]. This freedom of movement develops and trains aquatic motor skills, in various postures, as no other environment does [7]. Moreover, the experiences in the hydrodynamic context aid motor skills learning, because internal and external stimuli provide more possibilities for functional movements [7]. However, studies of motor learning in PD are only based on activities on land.

Hence, the objective of this study is to analyze the effects of an AP program on the functional motor skills of people with PD.

## 2. Methods

This is a quasi-experimental, controlled, assessor-blind clinical trial, in which groups were composed by random selection immediately after assessment 1.

All the participants invited to participate were members of a Parkinson Association in the city of Curitiba, Paraná, Brazil. Those who were interested agreed to the Informed Consent Form. This study was approved by the Human Research Ethics Committee of the Hospital do Trabalhador, under the Certificate of Presentation for Ethical Consideration number 05271512.7.00005225, and it complies with Resolution 466/12 of the National Health Council of Brazil.

The inclusion criteria were: people of both genders, clinically diagnosed with idiopathic PD, in Hoehn and Yahr stages 1 to 4 [8], with medical certificate for AP.

The exclusion criteria were: not presenting independent walking, related or not to PD; presenting another illness that could interfere with physical assessment; visual or auditory sensorial deficit that hindered them from following verbal or visual instructions; contraindications for using a heated pool; alterations in the parameters of levodopa-based medication ingestion during the time of the study; disagreeing to the Informed Consent Form.

An initial assessment was performed in order to verify personal data, disease history and its comorbidities. The functional assessments conducted on land were the Hoehn and Yahr Degree of Disability Scale was evaluated to classify patients within its five stages according to signs and symptoms [8], the 10 meters walking speed test [9], was evaluated on a flat corridor, with the floor previously marked using colored adhesive tape. The participant was instructed to walk the marked 14 meters. We timed the 10 central meters, disregarding the 2 meters from the beginning and 2 meters from the end of the track, considered of acceleration and deceleration. The test was performed three times and the simple average of the three attempts was used. The Five Times Sit to Stand Test (FTSST) [10] evaluation was carried out asking the participants to sit, with arms crossed in front of their bodies, on their chests, and to stand and sit again five times. The duration elapsed in this activity is timed. A shorter period of time indicates better functionality, strength and muscle resistance of the lower limbs. The body balance assessment was performed using the Mini Balance Evaluation Systems Test (Mini BESTest) [11], tracking static and dynamic postural control deficits through 14 tests, scored from 0 to 2, totaling a maximum of 28 points. Higher scores reflect better balance. The Unified Parkinson's Disease Rating Scale (UPDRS) [12], dimensions II and III, ADL (13 items) and motor sections (27 items) respectively. Each item is scored from 0 to 4, with higher values related to greater involvement. The Aquatic Functional Assessment Scale (AFAS) [6] evaluates the learning of aquatic motor skills, assessed in the pool, with 31 skills, scored from 1 to 5. The scale has a minimum score of 31 and a maximum score of 155, with higher values indicating better aquatic ability. It measures the adaptation and independence of each patient when performing the motor behaviors, according to the quality of movement.

The participants were allocated in two groups: The Control Group (CG), which did not take part in the pool activities, went on with their routine activities; and the Experimental Group (EG), which was submitted to AP. Both groups were evaluated on land. Assessment 1 took place before intervention; Assessment 2 after intervention; and, Assessment 3 after four months without intervention. Only the EG performed the aquatic assessment, before and after the intervention, Aquatic Assessment 1 and Aquatic Assessment 2 respectively

The intervention occurred throughout 32 twice-a-week, 50-minute-long appointments. Functional exercises were proposed and instructed by a physiotherapist. The activities were made in groups of six to seven participants. The exercises were designed to respect the principles of specificity and progression [13]

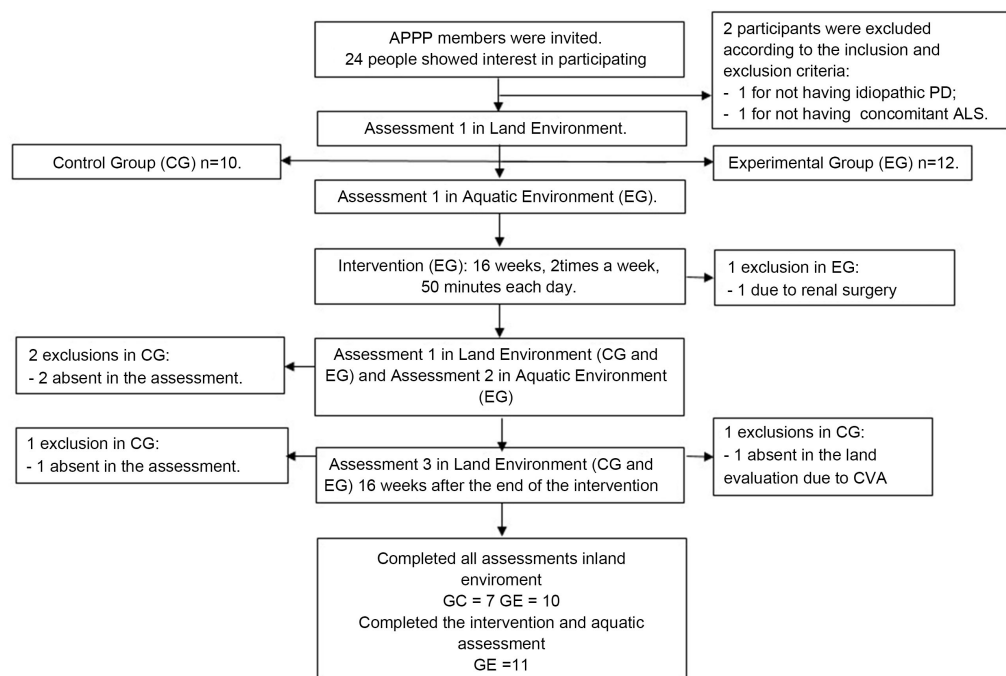
regarding complexity in aquatic activities. The aquatic motor skills learning phases [14] were used in the intervention with the purpose of developing motor skills learning (Table 1).

Initially, all the variables were verified by the Shapiro-Wilk test regarding their distribution. As for the comparison of initial characteristics, Student's *t*-test was used for independent samples, as well as Mann-Whitney test, when the variables were nonparametric. For the comparison between the groups and between the assessments for the land variables, the two-way analysis of variance (ANOVA) was used. Greenhouse-Geisser correction was used when the sphericity of the variables was not assumed. Bonferroni post hoc was applied in significant cases. In the aquatic assessment, Student's *t*-test was used for paired samples. The statistical significance was below 5%.

### 3. Results

A total of 24 people volunteered to participate in this study, of which two were excluded due to the presence of amyotrophic lateral sclerosis and another type of parkinsonism. Thus, 22 participants were selected and 17 participants completed the land assessment. Sample loss is illustrated in Figure 1.

Considering the sample loss, the EG was composed of five female participants (50% of the EG) and five male participants (50% of the EG). The CG counted with three female participants (42.9% of the CG) and four male participants (57.1% of the CG). Categorical characteristics of the participants are shown in Table 2. In turn, the initial characteristics of the dependent variables of the study participants are presented in Table 3.



**Figure 1.** Sample loss at each stage of the study. Caption = PD: Parkinson's Disease; ALS: amyotrophic lateral sclerosis; EG: experimental group; CG: control group.

**Table 1.** Aquatic motor skills learning phases, proposed by Israel & Pardo [14].

Adaptation: The objective of this phase is to adapt and start activities: getting in and out of the pool, receiving instructions, recognizing the aquatic environment, establishing communication with the patient, controlling breathing, experiencing physical properties.

Having control in the liquid environment: This phase counts with the body's adaptation and position in water, specific skills practical activities, such as balance, rotation and straightening reactions.

Relaxation: This phase is essential for hypertonia or tension. Resistance to water is avoided by making use of linear and non turbulent flow.

Specialized therapeutic exercises: This phase includes static and dynamic exercises, taking advantage of flow, resistance and other water physical properties. It develops and trains maximum functional potential.

Global organic conditioning: This phase aims to improve or maintain the cardiorespiratory condition. It includes the performance of independent and active activities.

**Table 2.** Categorical characteristics of the participants.

	EG Median 25% - 75% quartile	CG Median 25% - 75% quartile	<i>P</i> <sup>a</sup>
Age (years)	63 55 - 80	66.5 61 - 70.5	0.934
Hoehn and Yahr	2 1 - 3	2 1 - 1.75	0.695
time since diagnosed (months)	96 36 - 120	96 75 - 120	0.559
Sex (male/female)	5/6	5/3	0.475

<sup>a</sup>Mann-Whitney U Test.

**Table 3.** Initial characteristics of the study (land assessment).

	EG Median 25% - 75% quartile	CG Median 25% - 75% quartile	<i>P</i> -value <sup>a</sup>
Gait speed (m/s)	1.2 1.05 - 1.4	1.27 1.17 - 1.55	0.32
FTSST (s)	17 16.5 - 19	15.5 14 - 19	0.338
Mini-BESTest	21 19 - 25	24 14.5 - 26	0.836
UPDRS-ADL	96 48 - 120	96 78 - 120	0.559
UPDRS-Motor	12 8 - 15	13.5 11 - 15	0.59

<sup>a</sup>Mann-Whitney U Test.

There were no statistically significant differences between the groups at the beginning of the study. **Table 4** shows the means, standard deviation, minimum

**Table 4.** Descriptive statistics and significance index related to time and group.

Variable	Experimental Group Mean ± standard deviation Minimum - maximum values 95% confidence interval			Control Group Mean ± standard deviation Minimum - maximum values 95% confidence interval			Time Effect <sup>a</sup> (effect size <sup>b</sup> )	Time vs Group <sup>a</sup> (effect size <sup>b</sup> )
	Assessment 1	Assessment 2	Assessment 3	Assessment 1	Assessment 2	Assessment 3		
Gait speed (m/s)	1.17 ± 0.4 (0.3 - 1.8) [0.88; 1.46]	1.37 ± 0.39 (0.58 - 2) [1.09; 1.66]	1.3 ± 0.37 (0.7 - 1.88) [1.04; 1.57]	1.35 ± 0.43 (0.56 - 2) [0.94; 1.75]	1.14 ± 0.29 (0.58 - 1.42) [0.86; 1.41]	1.2 ± 0.42 (0.6 - 1.88) [0.81; 1.59]	<i>p</i> = 0.95 (0.03)	<i>p</i> = <b>0.01</b> (0.24)
FTSST (s)	19.4 ± 6.85 (14 - 38) [14.5; 24.3]	14.5 ± 1.17* (13 - 16) [13.66; 15.34]	15.5 ± 4.76 (9 - 26) [12.09; 18.91]	24 ± 23.45 (13 - 77) [2.3; 45.7]	23.14 ± 23* (13 - 75) [1.87; 44.42]	23.57 ± 25.44 (10 - 81) [0.04; 47.11]	<i>p</i> = 0.08 (0.15)	<i>p</i> = 0.26 (0.08)
Mini-BESTest <sup>c</sup>	20.1 ± 5.82 (6 - 27) [15.94; 24.26]	23.6 ± 4.37 (6 - 27) [20.47; 26.73]	21.4 ± 6.05 (7 - 27) [17.07; 25.73]	19.29 ± 8.22 (5 - 27) [11.68; 26.89]	19.71 ± 8.4 (5 - 27) [11.94; 27.48]	19 ± 6.58 (8 - 27) [12.91; 25.09]	<i>p</i> = 0.09 (0.16)	<i>p</i> = 0.21 (0.99)
UPDRS - AVD <sup>c</sup>	12 ± 4.83 <sup>s</sup> (4 - 19) [8.54; 15.46]	9.4 ± 5.52 <sup>s</sup> (1 - 18) [5.45; 13.35]	13 ± 4.66 (6 - 22) [9.66; 16.34]	14.86 ± 7.6 <sup>#</sup> (9 - 31) [7.83; 21.89]	14.29 ± 9.03 (6 - 33) [5.93; 22.64]	19.57 ± 8.4 <sup>#</sup> (11 - 31) [11.8; 27.34]	<i>p</i> < <b>0.001</b> (0.37)	<i>p</i> = 0.24 (0.09)
UPDRS - MOTOR	12 ± 6.46 <sup>s</sup> (4 - 27) [7.38; 16.62]	7.2 ± 4.89 <sup>s@</sup> (2 - 20) [3.7; 10.7]	11.7 ± 7.19 <sup>@</sup> (4 - 26) [6.55; 16.85]	14.29 ± 8.61 (4 - 32) [6.82; 24.33]	13 ± 8.92 (2 - 30) [4.75; 21.25]	15.57 ± 9.46 (4 - 32) [6.82; 24.33]	<i>p</i> < <b>0.001</b> (0.33)	<i>p</i> = 0.22 (0.09)

<sup>a</sup>Two-way ANOVA; <sup>b</sup>Calculated using Partial Eta Squared; <sup>c</sup>Greenhouse-Geisser correction. \*Statistical difference between EG and CG, in assessment 2; <sup>#</sup>Statistical difference between assessment 1 and 3 for the CG; <sup>s</sup>Statistical difference between assessment 1 and 2 for EG; <sup>@</sup>Statistical difference between assessment 2 and 3 for EG.

values, maximum values, confidence interval of 95% of the data from the land assessment in the groups and the p-value. No significant differences were identified in the FTSST and Mini BESTest variables.

In the gait speed variable, the interaction of the time with group was significant, with observed power of 0.747. The difference had statistical power of 0.890 for UPDRS ADL, and of 0.919 for the UPDRS motor test. In turn, the AFAS consisted of the aquatic assessments 1 and 2, with 11 participants in the EG, showing a significant difference, as presented in **Table 5**.

## 4. Discussion

In this study, the gait speed, ADL and motor assessment motor skills were modifiable by PA. Gait speed showed a significant difference in EG between assessments 1 and 2, indicating intervention as a condition for improvement in the gait performance. Other intervention methods are also capable of increasing gait speed. In a systematic review, published by Cochrane on gait training for patients with PD, the meta-analysis showed gait speed favorable to motor interventions. This meta-analysis included 261 participants in the experimental group and 249 in the control group [15]; however, none of them underwent intervention with AF. In the present intervention, neuromotor strategies that stimulate new synapses for an adequate motor response were used, resulting in an improvement in

**Table 5.** Mean values and differences between aquatic assessments 1 and 2.

	<b>Assessment 1</b>	<b>Assessment 2</b>	Mean difference
	Mean $\pm$ Standard deviation	Mean $\pm$ Standard deviation	<b>P-value*</b>
	Min - max values	Min - max values	95% confidence interval
<b>AFAS</b>	108 $\pm$ 21.90	118.36 $\pm$ 21.83	-10.36
<b>(N =11)</b>	76 - 134	89 - 149	<b>0.004*</b>
			CI [-16.65; -4.07]

\*Student's *t*-test for paired samples. \*Statistically significant difference ( $p < 0.05$ ).

physical capacities that directly reflect on physical activities, such as walking. We agree with the statement by Volpe *et al.* [5] that the aquatic physical properties such as density, hydrostatic pressure, thrust and viscosity call for exercise strategies different from automatic movements, because the latter are not efficient in PD. Different environments can promote strategies for voluntary movements of cortical action, which may contribute to a better execution of activities for people with PD.

In relation to ADLs, a relevant finding is that the CG showed a statistical difference for the UPDRS ADL from assessment 1 to 3. This difference suggests that, after 8 months, the CG showed a significant worsening for this variable. This decline can be expected in the natural course of the disease, as it is degenerative and progressive. The same difference was not observed from time 1 to 3 in the SG. There was better performance in assessment 2, statistically higher than assessment 1. Although the decrease in motor abilities expected for PD may lead to dependence when performing ADL, it seems that PA stimuli may be associated with motor tasks, which require constant adjustments in motor control, rhythm and fluidity.

We believe that PA components favor motor learning, as well as motivational aspects, such as achieving the objective and the intrinsic recreational stimulus of the aquatic environment [16]. Another aquatic strategy successful in the ADLs assessed by the UPDRS was the intervention with Ai-Chi. In the study by Villegas and Israel [17], 8 people in the intervention group participated in an activity proposed to happen 35 minutes in each appointment, twice a week, for 12 weeks, while 7 people in the control group did not take part [17].

The results of the motor assessment demonstrated a significant improvement of the EG from assessment 1 to 2, but returned after 4 months without intervention with PA to a level close to that observed in assessment 1. The motor benefits had significant decrease in the following 4 months without activity. This result corroborates with the literature, *i.e.* the need for PD patients to be physically active throughout their lives [18]. The motor UPDRS did not show any significant difference in the aforementioned study by Villegas and Israel [17]. In contrast, in the study by Ayán and Cancela [19], the PA group compared resistance activities with high intensity one and obtained positive results in the motor UPDRS variable compared to low intensity PA. Therefore, the progressive intervention proposed in the present study may have reached sufficient levels to stimulate motor



functions.

AFAS detected an improvement in motor skills in the aquatic environment after the intervention. The importance of assessment in an aquatic environment is highlighted in some studies on PA [6] [20], despite not being found in scientific research. In this study, we observed the need to first know the participants' aquatic skills. We recommend the use of aquatic assessment in clinical practice and research, proposing objectives and behaviors close to the patients' needs and potentials in the swimming pool. Verifying the participant's mastery of performing certain postures in the water, airway control and fear or anxiety are examples of determining factors for setting safe goals for participants in water activities.

We observed that PA has some advantages compared to exercise on land, such as reducing the risk of falls due to the deceleration of the falling body and support given by water resistance, buoyancy and viscosity; all already reported in the literature [21] [22]. Furthermore, since heated water is a good heat conductor, it provides the desired benefits to the care of patients with PD because it reduces muscular tension and pain, besides increasing range of motion with adequate muscle tone [22]. Thus, it provides more liberty in training which is a result of the temporary relief of muscle rigidity by the peripheral thermal stimulation [21].

The FTSSST test presented a reduction of the mean value for the EG, compared to assessments 1 and 2, but the difference was not statistically significant. In this study, the stimuli did not develop new strategies and motor skills to improve the task of standing up significantly [6] [14]. We argue that exercises within the aquatic environment are facilitated by the action of thrust, considering movements from the bottom to the water surface [22]. Thus, we consider that every movement similar to standing up is facilitated in the water, not producing an overload of body weight against gravity. When the activity is performed on the ground, it is necessary to overcome the force of gravity and the body weight. When observing a study on land, exercises are positively influenced the task of sitting and standing up in people with PD [23], supporting the theory that environmental overload can train strength, endurance and power, thus enabling improvements in this activity of standing and sitting up.

Even though there was no statistical difference in the FTSSST activity, Duncan *et al.* [24] established a cut-off line for risk of falls of patients with PD for this test; where a period of time longer than 16 seconds indicates risk of falls, and periods shorter than or equal to this do not. Thus, we can observe that the EG was at risk of falling in assessment 1. Even though there was no significant change between assessments 1 and 2, all participants in the EG reduced the test execution time to less than 16 seconds in assessment 2. We could not verify the same in the GC, which was at risk of falling in assessments 1, 2 and 3, according to the means of each assessment.

The body balance variable was also not modified in this study. The cut-off line



for risk of falling for PD using this assessment is 20 points [11]. Verifying the confidence interval of the present study, we observed values above this cut-off line only for EG in assessment 2. The minimum clinically important difference (MCID) for body balance variable assessment for this construct is 4 points [25] and it was not reached after the intervention in this variable. Individually, 6 EG participants (55%) reached MCID.

In PD, the body balance is more usually evaluated using the Berg balance scale (BBS). In a study by Pompeu *et al.* [26] evaluated balance using BBS, dynamic gait index and *time up and go* (TUG) test, with PA intervention in 17 participants, without control group, for 36 appointments of 40 minutes over 3 months, obtaining differences in BBS and TUG variables. Andrade, Silva and Dal Corso [27] also evaluated balance by BBS and TUG. In this study, PA was used in 7 individuals for one month, with three interventions per week. In this short period, a statistical difference in the evaluated equilibrium parameters was noticed. In the assessments of the study by Volpe *et al.* [5], a group of 34 participants was divided between PA and land physiotherapy activities. The results of PA were superior to those of land physiotherapy for balance measured using EBB and TUG.

Although we have not succeeded in increasing body balance, it is still advisable to use the aquatic environment for training through balance disorders. Changes in direction of movement and water movement are considered safer strategies, in terms of risk of falls, compared to land balance training [13]. In addition, the stimulation of trunk mobility and transfer of center of mass away from the base, in various planes and postures, can be used in the aquatic environment, with potential for increasing body balance [21].

### Limitations of the Study

We identified some limitations that influenced the methodological quality of this study, such as the fact that the participation of CG in aquatic assessments was not possible due to unavailability of the pool. In addition, the study had a low statistical power because of the reduced sample. Other studies also indicated difficulties in recruiting and engaging people with PD in studies [28].

### 5. Conclusion

We observed that the AP program could improve aquatic skills and motor skills of gait speed, the UPDRS ADL and the UPDRS motor. There was no maintenance of the progress achieved after the intervention in EG after 4 months without the AP.

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## Conflicts of Interest

We declare that there is no conflict of interest in respect to the research, authorship, and/or publication of this article.

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