Aquatic Dual-Task Training and Its Relation to Motor Functions, Activities of Daily Living, and Quality of Life of Individuals With Parkinson's Disease: A Randomized Clinical Trial

Health Services Insights
Volume 16: 1–9

DOI: 10.1177/11786329231180768
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ABSTRACT

OBJECTIVES: Parkinson's disease (PD) is a neurodegenerative disorder that impacts the dopaminergic neurons of the substantia nigra, leading to motor and non-motor symptoms, as well as changes in activities of daily living (ADL) and quality of life (QoL). Aquatic physical exercises and dual-task physical exercises have been used to manage PD symptoms. The aim of this study was to investigate the effects of a dual-task aquatic exercise program on the ADL, motor symptoms, and QoL of individuals with PD.

METHODS: A randomized controlled trial with a parallel group design was employed, and participants were randomized into 2 groups: a control group and an experimental group. The intervention was a 10-week program consisting of twice-weekly 40-minute aquatic dual-task exercises. Pre-intervention evaluations of ADL, motor function, and QoL were conducted at baseline (AS1), immediately after the intervention (AS2), and 3 months post-intervention (follow-up—AS3). The Unified Parkinson's Disease Rating Scale (UPDRS) II and III sections and the Parkinson's Disease Questionnaire 39 (PDQ-39) were utilized for outcome measures.

RESULTS: A total of 25 individuals completed the study. The experimental group showed significant improvements in both the UPDRS II (ADL) and III (motor function) sections (P's < .05), but there was no significant difference in PDQ-39 scores. Additionally, significant differences were observed in the experimental group between the AS2 and AS3 time periods ($P < .05$) for both UPDRS II and III scores ($P < .05$).

CONCLUSIONS: Aquatic dual-task training may be effective in improving both ADL and motor functions in individuals with PD. Furthermore, the combination of aquatic environment and dual-task exercises may represent a promising approach to maintaining and improving the functionality of individuals with PD.

KEYWORDS: Exercise, hydrotherapy, Parkinson's disease, quality of life

RECEIVED: January 31, 2023. **ACCEPTED:** May 22, 2023.

TYPE: Health promotion, disease prevention and lifelong care strategies - Original Research Article

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES), finance code 001.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: All authors declare that they have contributed to this paper, have no conflict of interest and have approved the final manuscript.

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Highlights

- People with Parkinson's disease presents deficits in their activities of daily living, motor functions, and quality of life
- Aquatic dual-task exercise improves activities of daily living and motor functions in people with Parkinson's disease
- Aquatic physiotherapy arises as a promising complementary therapy for people with Parkinson's disease

Introduction

Functional changes occur in the human body throughout aging. Due to this process, there is an increase in chronic non-communicable diseases,[1] for example Parkinson's disease (PD). PD affects 1% to 2% of the population over 65 years old and PD is the second most common neurodegenerative disorder.[2]

As the disease and its symptoms progress, the physical condition of individuals with PD is gradually impaired, what consequently decreases their independence to perform activities of daily living (ADL) and compromises their motor functions (gait, balance, and functional mobility).[1]

Such decrease in motor and non-motor functions may decrease quality of life (QoL),[2] which includes health, personal, social and religious relationships, work, accessibility, transportation, wellbeing, and life satisfaction.[3]

Among the available pharmacological treatments, levodopa therapy is widely used to treat individuals with PD, since it has shown great efficacy and low mortality rate.[4] However, the progression of the disease and continued use of levodopa may cause dyskinesia and motor fluctuation,[5] as well as *"wearing off"* episodes (decrease in medication effect time), *"random on-off"* (sudden worsening of PD symptoms), and *"delayed on"* (delay in medication action).[6]

Thus, several non-pharmacological therapies have been used to control disease symptoms, which consequently help maintain independence level and QoL of individuals with PD.[1,7,8] Among the therapies for Parkinson's disease (PD), physical exercise has been described as a stimulus for the synthesis of endogenous neurotrophic factors such as glutamate receptors and neurotrophic factors including insulin-like growth factor 1 (IGF-1), vascular endothelial growth factor (VEGF), cerebral dopaminergic neurotrophic factor (CDNF), brain-derived neurotrophic factor (BDNF), and glia cell line-derived neurotrophic factor (GDNF).[9] Aquatic training has been increasingly used for physical rehabilitation in professional practice. Although some studies have analyzed the effects of aquatic training on the treatment of PD and other neurodegenerative diseases,[1,10,11] little detailed research has been done on the advantages, disadvantages, and precautions related to the practice of this physical activity. Thus, defining frequency, volume, and exercise intensity for this population in the aquatic environment is necessary. In addition to improving motor functions, the benefits of aquatic training can also be observed in broader aspects, for instance improved self-esteem, socialization, communication, and QoL. This happens because the modality allows both individual and collective care, which promote improvements in psychological and emotional aspects of individuals with PD.[12,13]

The aquatic environment also offers some advantages for dual-task training. Dual-task training consists of initiating a second activity, which can be motor or cognitive, at the same time as performing a primary activity.[14] Some examples are walking and speaking the name of cities; stand on one leg and throw a ball, etc. Individuals who already present a decrease in balance and gait quality have always been discouraged from facing dual-task situations, due to the high risk of falling in situations of conflict in information processing. However, activities that require balance and involve dual-task exercises in the aquatic environment present less postural oscillation and lower risks of falling and eventual injuries.[14] These characteristics make dual-task aquatic exercises a training possibility for groups with coordination and balance deficits, such as PD individuals.

Although current research has shown beneficial results on motor functions with training involving dual-task aquatic exercises, the benefits for broader aspects in individuals with PD, essentially ADLs and QoL, are not vastly explored. Therefore, this study aimed to verify the effect of aquatic dual-task training not only in motor functions, but mainly in ADLs and QoL of individuals with PD.

Methods

Randomized controlled trial parallel group design. The study is registered in the Brazilian Clinical Trials Registry under the RBR-8cxzf2 registry and was approved by the Research Ethics Committee of the *Trabalhador Hospital* under the number 05271512.7.00005225 and proof number 0629919/2015, following the Declaration of Helsinki. In this experimental research, participants were selected through convenience sampling. Individuals were recruited from the Parkinson Parana Association, and they participated voluntarily.

Participants

Sample calculation was performed by GPower 3.1 software,[12] which stipulated a minimum sample of 30 individuals, assuming an effect size of .25 on a probability distribution F, whose value consists of a mean distance between sample mean and population mean; Type I error equivalent to .05 and analysis power equal to .84.[1]

Individuals considered eligible were patients of both sex with clinical diagnosis of idiopathic PD; patients who were in stages 1 to 4 on the Hoehn and Yahr scale; and patients with a clinical certificate allowing aquatic physical activity in a heated pool. The following exclusion criteria were adopted: wheelchair mobility, related or not to PD; presence of another disease that could interfere with physical evaluations (such as alterations in balance of vestibular origin); contraindications to use heated swimming pools: fever, incontinence, severe changes in blood pressure, and open wounds; change in levodopa dosage during the study period; impairments that affected visual or auditory abilities, unable to follow verbal and visual instructions (determined by Mini-Mental State Examination); or those who did not agree to the informed consent term were also excluded.

A group of 6 researchers were involved in the study. Three of them were responsible for the evaluations in the 3 moments. Two researchers were responsible for the application of the aquatic dual-task intervention program and had no contact with the 3 evaluators. Finally, one researcher was in charge of randomizing groups, tabulating and analyzing the data. Therefore, the evaluators and the person performing the analysis were blinded. No participants or caregivers were blinded.

After the initial assessments, the participants were randomly assigned to either the Experimental Group (EG) or Control Group (CG) using sealed envelopes.

Procedures

Eligible individuals were recruited in January 2016. They all signed an informed consent term, agreeing to participate in the research. Assessments were performed by blinded assessors, physical therapists, who did not participate in the intervention program, had experience in assessing people with PD and were trained to apply the scales used in the study. Assessors took part in a pilot study of which the intraclass correlation coefficient was verified and calculated at .959 in UPDRS scale and .903 and PDQ-39 which is considered an excellent inter-examiner reliability.

The assessments were conducted at 3 different time points. The first assessment (AS1) was carried out before the participants were randomly allocated into either the Experimental Group (EG) or Control Group (CG) using sealed envelopes. Individuals assigned to the CG did not undergo any intervention and continued with their regular activities. Both groups underwent 2 additional assessments, one at the end of the intervention program (AS2) and another 3 months after AS2 (AS3), after the EG detraining period. All interventions and assessments were conducted during the "on" phase of each individual's medication.

Measures

Valid and replicable evaluation methods for PD patients were chosen. To assess the primary outcome, ADL, and motor examination the *Unified Parkinson's Disease Rating Scale* (UPDRS) was used.[15] This scale is widely used to analyze progression of PD and impairment degree of patients, as well as to evaluate its signs and symptoms, self-reported activities, and clinical assessment items. The scale is divided in 4 sections: I—mental activity, behavior, and mood; II—ADLs; III—motor examination; and IV—motor complications. It evaluates 42 items, with scores varying from 0 to 4, in which higher the score, greater the impairment of the individual. In the study, only sections II and III were used, which correspond to ADLs and motor examination, respectively. Section II encompasses elements such as speech, feeding, dressing, personal hygiene, tremor, and independence to perform functional activities, among others. Section III includes items such as locomotion, posture, change of positions, finger taps, hand and foot movements, among others.

To evaluate secondary outcome QoL, the *Parkinson's Disease Questionnaire* (PDQ-39) was used,[16] which is composed of 39 questions distributed in 8 domains: mobility (10 items); ADLs (6 items); emotional well-being (6 items); stigma (4 items); social support (3 items); cognitions (4 items); communication (3 items); and bodily discomfort (3 items). Each item has 5 predetermined answers that correspond to scores ranging from 0 to 4 points: never (0); occasionally (1); sometimes (2); often (3); and always (4). Total score ranges from 0 to 100 points, lower scores mean higher QoL. The total score for each individual is calculated according to the formula: $100 \times$ (sum of patient's scores in the 39 questions/4×39). The score of each dimension is obtained in the same way as the total score. The dimension "social support" includes the item "support received from the partner," which can change the equation and is important to highlight: if the person has a partner or spouse, the dimension is multiplied by 3, but if he/she does not, this item is excluded, and the dimension is multiplied by 2.

Both UPDRS and PDQ-39 are valid and reliable scales for application in the Brazilian population and these scales are currently recommended by the European Physiotherapy Guideline for Parkinson's Disease.[17]

Interventions

The intervention program with EG occurred throughout 20 sessions. They lasted 1-hour and were held twice per week. In each session, we used 20 minutes for an initial and final vital sign check, and 40 minutes for immersion and exercise.

Aquatic dual-task physical exercises were proposed. The intervention was previously planned to follow an increasing complexity sequence, aimed at a gradual progression of difficulty. When the individual was able to perform the proposed activity, a more complex activity was then suggested.

The complexity of dual-task exercises progressed according to 2 items. First, according to the primary motor task, initially ranging from basic movements, such as vertical and horizontal rotations, and progressing to specialized therapeutic exercises, such as balance and gait training in different postures. Second, according to the secondary task, or dual-task, which ranged from simpler motor activity, such as manipulating or carrying objects, to more complex cognitive activities, such as memory recall and calculations.

As an intervention strategy, learning tips were used. Initially, it was to verbally describe the exercise, demonstrating and commenting on critical and attention points. General corrections to improve movements were made and never directed toward a specific participant. Directing attention to the task and giving learning tips favor motor acquisition in neurological patients. The exercise program appears in an article previously published by the authors.[1]

The CG did not participate in any activities and was instructed to keep their daily activities. After all data collection and follow-up assessment, the control group was invited to participate of the aquatic exercise.

Statistical analysis

Shapiro-Wilk test was used to evaluate data considering the residual distribution pattern. Initial characteristics of the participants were compared using Student's *t*-test. For comparison between groups (CG and EG) and between assessments (AS1-AS3), one-way Anova repeated measures was used. Bonferroni post-hoc test was used for multiple comparisons. Level of statistical significance adopted was $P \leqslant .05$. Finally, Statistica 7 software was also used.

Results

The process of sampling selection and exclusions are described in the CONSORT flow diagram below (Figure 1).

A total of 36 individuals with PD were recruited. Of these, 28 initially met the inclusion criteria, while 8 were excluded for

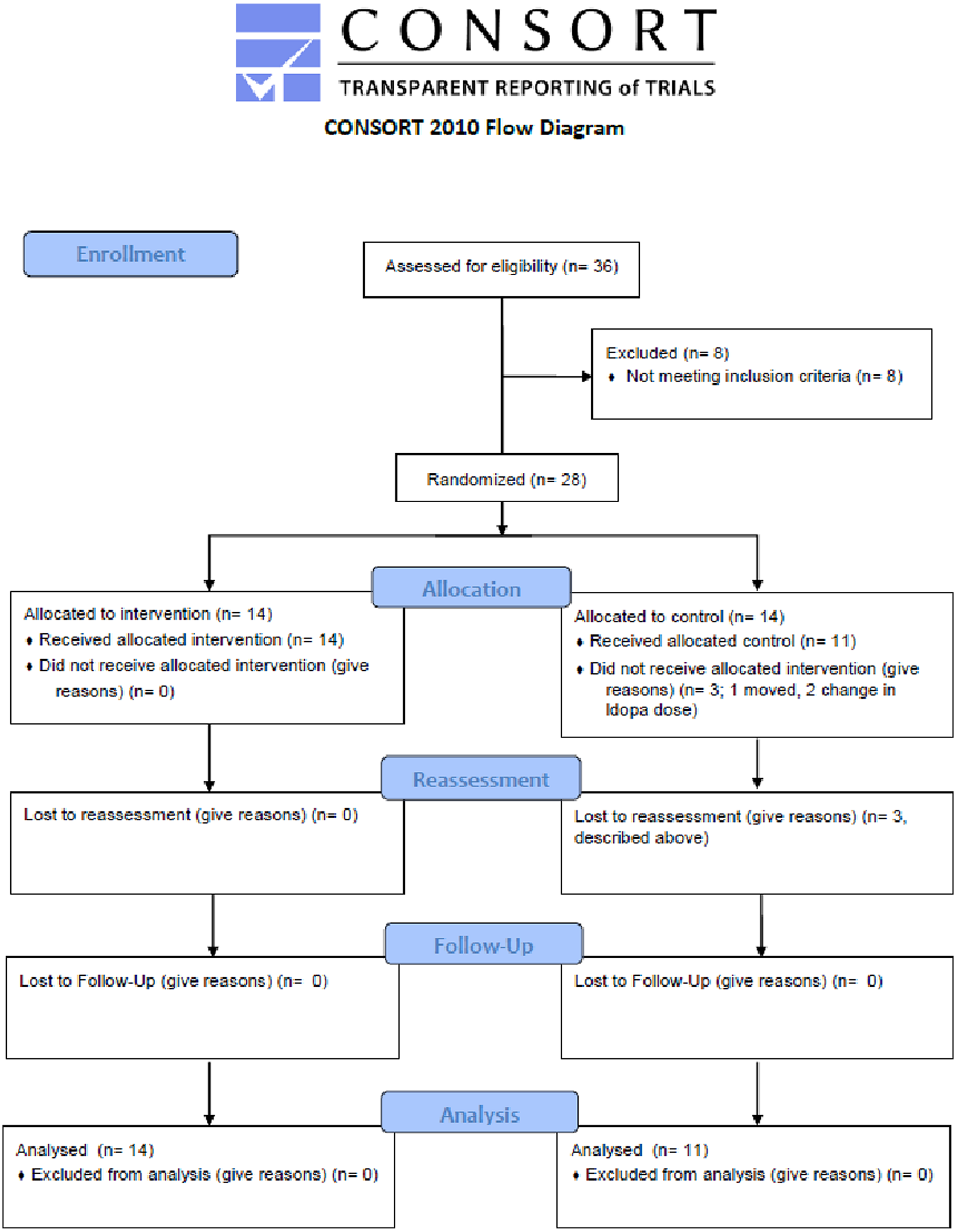

Figure 1. CONSORT flow diagram.

having one or more exclusion criteria. No patient was excluded due to visual, auditory or cognitive impairment. After randomization, both EG and CG were composed of 14 individuals each. However, 3 individuals from the CG did not complete the research: 1 due to city change and 2 due to changes in levodopa dosage. Thus, the sample of the present study consisted of

Table 1. Initial characteristics of the sample.

CATEGORIES	EG MEAN ± SD	CG MEAN ± SD	P^{a}
Age (y)	63 ± 13	64 ± 13	.793
Time of diagnosis (mo)	77 ± 45	69 ± 42	.103
Hoehn & Yahr	3 ± 1	3 ± 1	.872
Sex	5 male	6 male	.093
	8 female	5 female	
UPDRS II—ADL	13.76 ± 4.49	16 ± 2.16	.701
UPDRS III—motor examination	15.53 ± 6.59	10.45 ± 6.23	.038*
PDQ-39	21.49 ± 4.61	22.19 ± 15.38	.367

Abbreviations: ADL, activities of daily living; CG, control group; EG, experimental group; PDQ-39, Parkinson's Disease Questionnaire; SD, standard deviation; UPDRS, Unified Parkinson's Disease Rating Scale.
[a]Student's *t*-test (*$p \leq 0.05$)

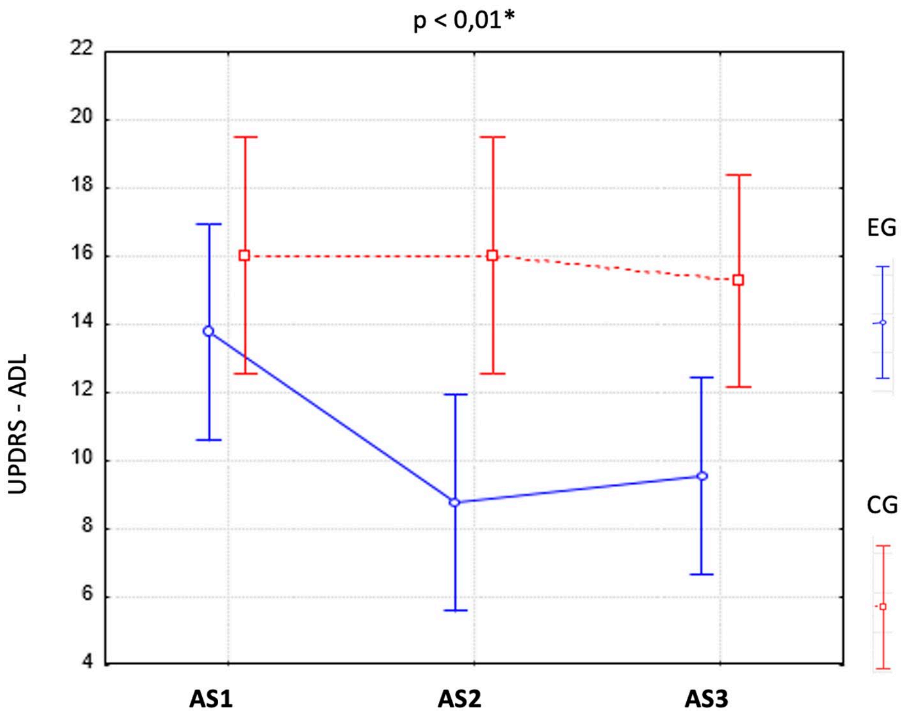

Figure 2. Mean and confidence interval (95%) of ADL between AS1, AS2, and AS3 of CG and EG. In each assessment (AS) the bars on the left represent the experimental group, while the bars immediately on the right represent the control group.
Abbreviations: ADL, activity daily life; AS1, assessment at baseline; AS2, assessment at post-intervention; AS3, assessment at follow-up; CG, control group; EG, experimental group; UPDRS, Unified Parkinson's Disease Rating Scale.
(F 2, 44 = 6.1; *P* = .004).

25 individuals: 14 from the EG and 11 from the CG. Values referring to mean age and mean time of diagnosis, as well as classification by the Hoehn & Yahr scale, UPDRS II and III and PDQ-39 are described in Table 1.

During the application of the aquatic exercise program there were no falls, drownings or accidents inside the pool, or during access to the aquatic environment. Regarding ADLs, in the EG, there was a significant difference (*P* = .019) between AS1 and AS2, and between AS1 and AS3 (*P* = .014), which shows an improvement in the performance of ADLs by the participants. In CG, there was no significant difference between any of the evaluations. It is also worth noting that there was a time × group effect (*P* = .02) (Figure 2).

Concerning the Motor Functions, in EG, there was a significant difference (*P* = .001) between AS1 and AS2, and between AS1 and AS3 (*P* = .036), which evidences an improvement in the participants' physical performance. In CG, there was no significant difference between AS1 and AS2, nor

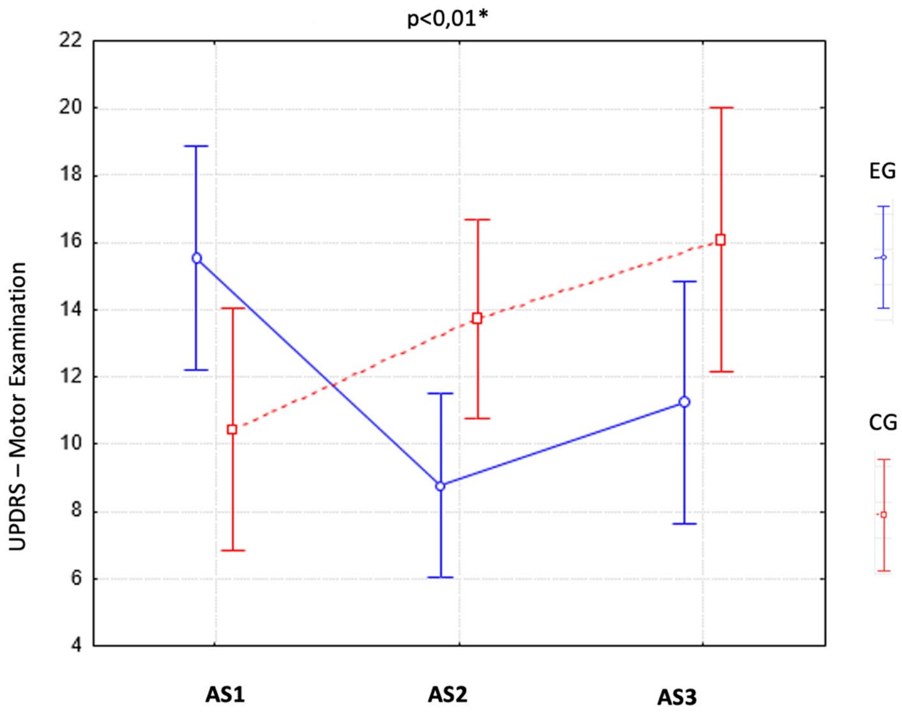

Figure 3. Mean and confidence interval (95%) of motor functions between AS1, AS2, and AS3 of CG and EG. In each assessment (AS) the bars on the left represent the experimental group, while the bars immediately on the right represent the control group.
Abbreviations: AS1, assessment at baseline; AS2, assessment at post-intervention; AS3, assessment at follow-up; CG, Control Group; EG, Experimental group; UPDRS, Unified Parkinson's Disease Rating Scale.
(F 2, 44 = 18.2; $P = .000$).

between AS2 and AS3. However, there was a significant difference between AS1 and AS3 ($P = .039$), which shows a decrease in the participants' physical performance. It is also worth noting that there was a time × group effect ($P < .01$) (Figure 3).

Regarding the scores for PDQ-39, there was no significant statistical difference for the interaction between groups and for the evaluation periods ($P = .164$). Moreover, after comparing each of the evaluation periods, there were also no significant statistical differences between groups ($P > .05$) (Figure 4).

Discussion

This research aimed to verify the effect of aquatic dual-task training in ADLs, motor functions, and QoL of individuals with PD. The results indicated that dual-task training in the aquatic environment was feasible and improved ADLs and motor aspects.

The section II of the UPDRS scale concerns items related to ADLs of individuals with PD. It is worth mentioning that the higher the score, the worse the performance of the individual in their ADLs. By the end of the proposed intervention program, there was a significant decrease in the average of the EG, while the CG did not present changes.

Although there are many studies related to dual-tasking in people with PD, little is known about the effects of dual-tasking in the aquatic environment. There is a lack of studies that report on the prescription parameters for this type of study.

Thus, it is possible to observe a direct influence of the intervention program on such decrease for the EG, which results in a better performance of ADLs by the participants of this group.

PD is topographically characterized as subcortical, affecting the substantia nigra in the midbrain and PD is manifested especially in the motor system in a progressive way, which changes the lives of individuals with PD and people close to them. Therefore, for proper performance in ADLs, a balance between intrinsic factors, such as the integrality of individuals' mental and physical functions, and extrinsic factors, such as environmental restrictions (adequate accessibility),[18] is necessary.

In a study that used a 2-month 5 times a week aquatic exercise program, there was also a significant decrease in the averages of section II of the UPDRS.[19] Another study, which combined high-intensity land-based training with aquatic exercises, found that there was a significant improvement at the end of the intervention program.[20] Authors who proposed a 3-month 3 times a week aquatic physical therapy program achieved a significant improvement in the average of section II of the UPDRS.[19] When movements performed in ADLs are compromised, they can be stimulated in water, because they provide specific characteristics including physical and thermal properties. These characteristics facilitate the performance of movements and activities, allowing physical-functional gains in water and a possible transfer of aquatic motor skills to land motor skills.[21]

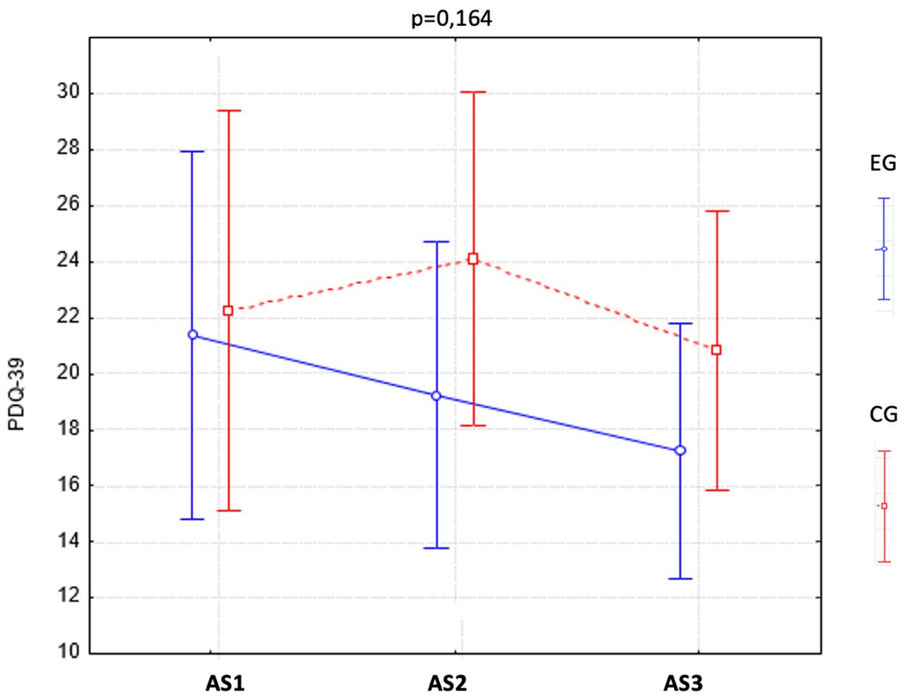

Figure 4. Mean and confidence interval (95%) of PDQ-39 between AS1, AS2, and AS3 of CG and EG. In each assessment (AS) the bars on the left represent the experimental group, while the bars immediately on the right represent the control group.
Abbreviations: AS1, assessment at baseline; AS2, assessment at post-intervention; AS3, assessment at follow-up; CG, control group; EG, experimental group; PDQ, Parkinson's Disease Questionnaire 39.
(F 2,44 = 1.88; P = .164).

Motor examination of PD is described in section III of the UPDRS scale and, as in section II, the higher the score the worse the performance of the individual regarding motor functions. In this study, the averages of section III of the UPDRS for the EG decreased significantly; thus, indicating a better performance in motor functions, while the CG did not present changes. Similar results were observed in a study comparing 2 groups over a 4-week period: one of the groups performed high-intensity land-based training plus aquatic exercises, and the other performed high intensity land-based training alone.[22] In the study, both groups showed a significant decrease in the average of section III of the UPDRS. However, in another study with EG submitted to aquatic training over a 6-week twice-a-week program, the EG presented significant differences [in relation to itself], as well as a time × group effect in relation to the CG.[19] Likewise, another study compared a 2-month 5 times a week aquatic intervention program, and a land-based training program with the same load of exercises and found significant differences in both groups.[23]

Following the assumption that physical exercises promote improvements in motor functions of individuals with PD, a study compared 2 types of aquatic exercises, one of low intensity and one of muscular endurance, and observed that only the second type promoted a significant decrease on the average (functional addition) of section III of the UPDRS after the end of the intervention program.[20] These results may indicate that more challenging aquatic exercises promote neuromusculoskeletal adaptations that affect motor functions of individuals with PD, whether these are muscular, balance, or gait challenges.

Regarding the influence of cognitive training on motor functions of individuals with PD, a study compared a dual-task training group with a single task training group and verified that the group submitted to dual-task decreased the average result of section III of the UPDRS, but that the difference found was not significant.[24] Another research, which used gait training associated with dual cognitive tasks, did not obtain significant differences as well.[25] The association of physical activity with a cognitive demand for individuals with balance and gait deficits and functional dependence is constantly being highlighted in the literature.[24] The present research shows a beneficial effect of aquatic exercises associated with cognitive demand on motor functions of individuals with PD, highlighted by the increase in exercise complexity. This enhances integration between balance and coordination systems, which may favor the individuals' neuroplasticity.[9]

Regarding the PDQ-39 scale, which is used to evaluate QoL of individuals with PD, the results obtained did not show significant values after the training program. However, a greater decrease on the averages of the EG when compared to the CG was observed; thus, indicating a higher QoL reported by the individuals assessed.

A similar study used the PDQ-39 scale to assess the effects of aquatic exercises over 6 weeks, twice a week, and found no significant difference.[12] Another study evaluated the effect of a

2-month, 5 times a week aquatic intervention, when compared to the same load of land-based training. In the initial assessment, the aquatic group presented a beneficial time × treatment effect in relation to the land group; thus, indicating the aquatic training improved the participants' QoL.[19]

Since physical exercises may influence the QoL of individuals with PD, a study compared 2 types of aquatic exercises, one of low intensity and one of muscular endurance, and found that both groups significantly increased QoL after the end of the intervention program. These results show aquatic training improved QoL of these individuals, regardless of exercise intensity or load.[20]

Aquatic activities, especially when performed in groups, favor socialization, integration, and sharing of situations, expectations, and difficulties. These characteristics may help in the understanding, acceptance, and overcoming of the diagnosis of a neurodegenerative disease.[1] The second group of the aforementioned research corroborates with our findings and shows the improvement of other variables, for example, motor functions and ADLs, may be associated with the maintenance or increase of QoL of individuals with PD.

Even though the effects of single task aquatic exercises on the QoL of individuals with PD are known, there is still little information on the effects of dual-task exercises in this environment. A study that analyzed gait training associated with a cognitive task, utilizing the SF-36 scale in the *Physical Health* and *Mental Health* versions, presented benefits in other variables, but QoL did not present significant improvements after training.[26] Accordingly, QoL is still a controversial item in the context of PD, because it requires the individual's subjective understanding of situations of the world around them as well as their body and health perceptions.

It is essential to highlight that in PD there is a tendency for symptoms to progress. Since the study indicates a stabilization of symptoms and even an improvement over them, the relevance of a continuous program of dual-task physical exercises is highlighted, especially in the aquatic environment for this population.

This study contains methodological limitations. The absence of exercise groups, whether aquatic-based or land-based, limits the perception of the real benefits of the proposed intervention program. Another limitation was that it did not achieve the sample size. This reduces the power of the statistical analysis and also the scope of the results obtained. Future studies should include larger samples of people with PD in new RCTs. New research needs to be conducted in similar situations so that the effects are better verified and widespread.

Conclusion

Although the study did not indicate improvements in the QoL of the individuals assessed, the proposed intervention program was able to promote improvements in their performance in ADL and motor functions. These results show that aquatic dual-task training may be a promising approach in the complementary treatment of people with PD.

This manuscript presents limited results. Future research should include additional intervention groups. Currently, little is known about the differences between single and dual tasks in land based versus water-based exercises.

Acknowledgements

The authors would like to thank the Pontificia Universidad Catolica for yielding the heated swimming pool and the Academic Publishing Advisory Center (Centro de Assessoria de Publicação Acadêmica, CAPA—www.capa.ufpr.br) of the Federal University of Paraná for assistance with English language editing.

Author Contributions

Adriano Zanardi Da Silva: project conception, data collection, data analysis, article writing and discussion.
Dielise Debona Iucksh: data analysis, article writing and discussion.
Vera Lúcia Israel: project conception, data analysis, article writing and discussion.

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