# Aquatic physical therapy effects on cardiorespiratory variables in Parkinson's disease

*Efeitos da fisioterapia aquática sobre variáveis cardiorrespiratórias na doença de Parkinson*

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**Abstract**

**Introduction:** Parkinson's (PD) is a neurodegenerative disease characterized by the loss of dopaminergic neurons in the substantia nigra. It has motor and non-motor symptoms which is directly related to these people's decreased autonomy and quality of life. Aquatic physical therapy (APT) is a non-drug treatment option that is a resource to complement functional rehabilitation and/or prevention. **Objective:** To analyze the effects of an APT program on cardiovascular and fatigue conditions in individuals with PD. **Methods:** The cardiorespiratory conditions were assessed with vital signs – heart rate (HR) and blood pressure (BP), measured before and after each intervention. The double product (DP) and the Fatigue Severity Scale (FSS), measured pre- and post-intervention, were also used as variables. The intervention had eight 40- minute biweekly sessions over 4 weeks, with immersion in a heated swimming pool at 33 °C on average. The statistical analysis was made with the paired t-test (to analyze the FSS) and the repeated measures ANOVA test (for DP, BP and HR); significance was set at $p < 0.05$. **Results:** Fatigue perception with FSS improved significantly ($p = 0.037$), from 4.7 ± 1.6 (pre-intervention) to 4.3 ± 1.6 (post-intervention). There were no statistically significant differences in DP, BP and HR ($p = 1$). **Conclusion:** HR and BP remained at appropriate values for older people, and DP remained within a safe submaximal training range. Furthermore, the proposed APT program statistically decreased fatigue in this specific group of people with PD.

**Keywords:** Cardiovascular system. Exercise. Fatigue. Hydrotherapy. Parkinson's disease.

***Resumo***

***Introdução:*** *A Doença de Parkinson (DP) é uma doença neurodegenerativa caracterizada pela perda de neurônios dopaminérgicos na substância negra. Apresenta sintomas motores e não motores ligados à diminuição da autonomia e qualidade de vida. Entre os tratamentos prescritos está a fisioterapia aquática (FA), sendo um recurso na reabilitação e/ou prevenção de alterações funcionais.* ***Objetivo:*** *Analisar os efeitos de um programa de FA nas condições cardiovasculares e fadiga em indivíduos com DP.* ***Métodos:*** *Foram utilizados os sinais vitais frequência cardíaca (FC) e pressão arterial (PA), mensurados antes e depois de cada intervenção, e o duplo-produto (DPr) e Escala de Severidade da Fadiga (ESF) pré e pós-intervenção. A intervenção consistiu em oito encontros, durante quatro semanas, duas vezes por semana, com 40 minutos de imersão em piscina aquecida com média de 33 °C. A análise estatística deu-se pelo test T pareado para a ESF e teste Anova para medidas repetidas do DPr, PA e FC, adotando p < 0,05.* ***Resultados:*** *Houve melhora significativa na percepção de fadiga pela ESF (p = 0,037) de 4,7 ± 1,6 (pré-intervenção) para 4,3 ± 1,6 (pós-intervenção). DPr, PA e FC não apresentaram diferença significativa (p = 1).* ***Conclusão:*** *Os sinais vitais de FC e PA se mantiveram em valores apropriados para idosos, bem como o DPr se manteve dentro de uma faixa segura de treinamento submáximo. Assim, o programa de FA proposto foi capaz de diminuir de forma significativa a fadiga nesta amostra de pessoas com DP.*

***Palavras-chaves:*** *Sistema cardiovascular. Exercício. Fadiga. Hidroterapia. Doença de Parkinson.*

## Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disease in the older population, characterized by the loss of dopaminergic neurons in the substantia nigra of the midbrain, showing a chronic and progressive form. The initial manifestations can be observed in activities of daily living (ADLs), resulting from a motor decline, which can affect the mental state and the relationship with the environment and can lead to difficulty in social participation.[1,2] During its manifestations, some signs can be observed, such as bradykinesia (slowness of movement), resting tremor, body rigidity and postural instability. In addition to these, non-motor characteristics can be observed, some of which appear even before motor symptoms, such as olfactory, cognitive, behavioral, sleep and psychiatric disorders, autonomic dysfunctions, constipation and fatigue.[3,4]

During the evolution of PD in non-motor alterations, cardiorespiratory compromise is present, which leads to a decrease in autonomy and is involved in a risk of falls by these individuals, as in cases due to neurogenic orthostatic hypotension. Among the parameters that can be evaluated in PD are heart rate (HR), which is the number of times the heart beats per minute, blood pressure (BP), determined by the interaction of peripheral vascular resistance and the stiffness of the central arteries, the double product (DP), the product of systolic blood pressure (SBP) and HR, and fatigue, which can be defined as a state of extreme tiredness, weakness or lack of energy, whether physical or mental. In PD, a lower HR, BP abnormalities and a higher fatigue index are expected, and cardiorespiratory conditions are limiting factors for the regular practice of physical exercises and one of the main causes of death in this population.[5-9]

Accordingly, regular physical exercise has been shown to be of great help to people with PD, and may present benefits in the physical fields and, consequently, in the functional aspects.[10,11] Among the recommended physical exercises is aquatic physical therapy (APT), which presents benefits in a differentiated environment and therapeutic, physical and physiological effects provided by water properties.[12] A recent systematic review[12] found the effectiveness of APT in the rehabilitation of elderly people with PD and observed that the most used technique was Ai Chi aquatic therapy, a method created from the combination of the concepts of Tai-Chi and Qigong, using a combination of deep breathing with light and wide movements of the upper and lower limbs and trunk. The same authors also found that most studies carried out APT interventions twice a week, and that the main results included improvement in gait, balance and mobility and decrease in pain perception, in addition to helping to modulate levels of brain-derived neurotrophic factor (BDNF) and inflammatory markers (MCP-1, interleukin (IL)-1ra and IL-1β), contributing to neuroplasticity and neuroprotection. However, there is a scarcity of studies with aquatic exercises with cardiorespiratory outcomes and fatigue in PD.[12]

Thus, the objective of this study was to analyze the effects of an AF program on HR, BP, DP and fatigue in people with PD. [10-12]

## Methods

The study included 10 participants with a clinical diagnosis of PD, who were recruited from a public health service and submitted to an intervention through an APT program. Subsequently, the participants had their pre- and post-intervention assessments compared. The assessments were performed during the on period of medication.[13] The volunteers were assessed after signing an informed consent form. The project was approved by the Research Ethics Committee of the Hospital do Trabalhador/State Health Department of Paraná (CAAE: 05271512.7.0000.5225).

Volunteers of both sexes with a clinical diagnosis of PD, had an impairment level of 1 to 4 on the Hoehn & Yahr (H&Y) scale and a clinical certificate for aquatic physical activity in a heated pool were included in the research. Exclusion from the study were for the following reasons: did not have independent gait, whether or not related to PD; had sensory, visual or auditory cognitive impairment that prevented them from following verbal and visual instructions; had another pathology that interfered with physical assessments or that prevented participation in the research; had contraindications to use a heated pool, such as fever, urinary or fecal incontinence; changes in BP and open wounds; did not give signed consent to participate; and has a change in the prescription of medication during the intervention period.[14,15]

The Fatigue Severity Scale (FSS) was used to assess fatigue, which was validated for people with PD. FSS consists of nine items that assess the influence of fatigue in ADLs. Each question is scored from 1 to 7, and to obtain the final score it is necessary to add all the items and divide by the number of items. If the result is greater than or equal to 4, the assessed individual is considered to be fatigued.[16] For the assessment of cardiorespiratory conditions, vital signs of HR and BP were determined in the pre- and post-immersion periods. HR was obtained by palpating the radial artery and counting the beats for 1 minute (bpm). For BP measurement (mmHg), a properly calibrated stethoscope and sphygmomanometer were used.[17] DP was obtained by SBP x HR multiplication. DP is considered the best non-invasive method to evaluate the work of the myocardium due to the correlation with oxygen consumption, where it is able to establish a safety range to avoid cardiac overload.[18]

The intervention was carried out in eight meetings, for four weeks, twice a week. Each APT session last an average of 1 hour, with 40 minutes of immersion in a heated pool at 33 °C, and the remaining time was for measuring vital signs (BP and HR) before and after immersion, as well as for personal care such as showering, changing and moving. The intervention was previously designed to follow an increasing sequence of complexity, aiming at a gradual increase in difficulty. The exercises progressed according to the acquired motor skills, following the progression of Israel and Pardo,[19] which is in five phases (Table 1). The exercises were instructed by a physical therapist who did not carry out the assessments on the floor and in the water.

Statistical analysis was performed using the paired t-test for FSS analysis and the repeated measures ANOVA for DP, BP and HR, using $p < 0.05$.

**Table 1** - Intervention based on the progression of Israel and Pardo,[19] performed twice a week for four weeks

| Intervention phase | Description |
|---|---|
| I. Ambiance | Respiratory control and adaptation of body to water |
| II. Liquid environment domain | Balance and body control in water |
| III. Relaxation | Body relaxation through sliding and curved and smooth movements |
| IV. Specialized therapeutic exercises | Specific aquatic exercises based on therapeutic objectives |
| V. Global organic conditioning | Cardiorespiratory exercises |

## Results

The sample consisted of 10 volunteer participants with a mean age of 63.70 ± 11.04 years, including five males and five females (Table 2).

According to Table 3, HR, BP and DP did not show a statistically significant difference (p = 1). Mean HR was 79 bpm [76 - 82]; mean BP remained at 120/79 mmHg [118 – 122/77 - 81]. DP was 9483.7 ± 595.1 in the pre-intervention and 9659.3 ± 455.4 in the post-intervention with APT. In the perception of fatigue, based on the

FSS, the participants showed a significant improvement (p = 0.037), with scores going from 4.7 ± 1.6 in the pre-intervention period to 4.3 ± 1.6 in the post-intervention period.

**Table 2** - Characteristics of participants (n = 10)

| Characteristics | |
|---|---|
| Age (years)* | 63.70 ± 11.04 |
| Men | 5 |
| Women | 5 |
| Hoehn & Yahr Scale | 1- 4 |

Note: *Mean ± standard deviation.

**Table 3** - Results of cardiorespiratory variables and perception of fatigue before and after aquatic physical therapy

| Variables | Before | After | Mean |
|---|---|---|---|
| HR (bpm) | 76 | 82 | 79 |
| BP (mmHg) | 118 x 77 | 122 x 81 | 120 x 79 |
| DP (SBP x HR) | 9486.3 ± 595.1 | 9659.3 ± 455.4 | - |
| FSS | 4.7 ± 1.6 | 4.3 ± 1.6 | - |

Note: HR = heart rate; bpm = beats per minute; BP = blood pressure; DP = double product; SBP = systolic blood pressure x heart rate; FSS = Fatigue Severity Scale (p < 0.05).

## Discussion

The aim of this study was to analyze the effects of an APT program on HR, BP, DP and fatigue in people with PD. Within these variables, a statistically significant result (p = 0.037) was obtained in the perception of fatigue through the FSS. Fatigue in PD has a high prevalence and is often not recognized clinically because of its subjectivity and lack of exploration, which can directly affect ADLs and quality of life (QoL). Few studies correlate fatigue with cardiorespiratory conditions in PD, and topics with motor correlations are more addressed, as in the case of gait and balance, and non-motor ones, such as depression, and neither do they address this theme in interventions with aquatic exercises, limited only to floor exercise programs.[8,20-23]

Although still controversial in the literature, some studies[7,20] demonstrate the association of fatigue with motor aspects through its correlation with Part III of the Unified Parkinson's Disease Rating Scale (UPDRS), referring to the motor examination, which includes items such as bradykinesia, postural stability, gait and rigidity, where these symptoms are studied in interventions with APT, which demonstrates good results.[24] Responses regarding resting tremor are not yet well understood, especially in interventions in an aquatic environment. Resting tremor is linked to combined actions of the basal ganglia with the cortical, cerebellar and thalamic pathways, but evidence indicates that the expression of this symptom may or may not be related to neurotransmitters, such as dopamine.[25,26] Thus, interventions that generate positive effects in the nigrostriatal system, as well as in the improvement of neurotrophic factors such as APT, could generate some results for this symptom. However, there is still a lack of evidence to confirm the hypothesis. Studies also demonstrate the relationship between fatigue and non-motor aspects, such as depression, apathy, sleep disorders and autonomic dysfunctions.[7,20] Evidence also points to a relationship with cognitive impairment.[20] These relationships can be explained by the fact that fatigue is associated with the pathophysiology of PD, which may be a primary manifestation of the disease and not secondary to other symptoms. Neuroinflammatory markers, such as IL-6, may be associated with higher levels of fatigue, as seen in depression and in the cognitive impairments of the disease. Other factors related to high levels of fatigue are the changes in the basal ganglia with their cortical connections, in addition to impairment involving neurotransmitters such as dopamine and serotonin. Furthermore, higher levels of fatigue may also reflect a greater presence of α-synuclein, a protein that plays a central role in the progression of motor impairment in PD. Thus, fatigue can be a limiting factor for people with PD, directly affecting QoL.[7,20,24-26]

Among the studies with PD there is no consensus or systematization of the prescription of therapeutic exercises, particularly in the aquatic environment, because of the great heterogeneity of the manifestations of the disease.[24,27] Thus, corroborating this study, Yamagushi et al.[28] carried out an intervention with aquatic exercises, also following the progression of Israel and Pardo,[19] in which they found a significant difference in the perception of fatigue through the FSS at the end of the intervention. The authors had a sample and staging of the disease similar to those of the present study, but proposed an intervention for three months, totaling 25 sessions.[28] In the present study, eight sessions were performed over four weeks, enough to obtain statistically significant gains in the perception of fatigue. Thus, the importance of the proposed intervention with APT is highlighted, given the various relationships described with fatigue, which is also correlated with the staging of the disease and its progression.[7,29] About the staging of the disease, classified by H&Y, a meta-analysis showed that in 13 of 21 studies, fatigue levels were higher in individuals with higher stages of the scale. It was also observed that patients with fatigue had an H&Y average of 0.33 points higher than those without fatigue.[7] Another study followed up 45 patients for eight years, checking the fatigue indices and the H&Y level, concluding that fatigue can predict the progression and motor severity of the disease.[30] Thus, interventions with APT can be a non-pharmacological alternative for delaying disease progression, as well as for improving ADLs and QoL in this population.[7,12,22,29,30]

Regarding markers of the cardiovascular system during immersion in water, it is expected that HR decreases due to hydrostatic pressure, leading to an increase in venous return and, consequently, in systolic volume (SV); however, due to physical activity, the HR tends to increase due to the greater metabolic demand. The acute effects of physical exercise tend to increase BP and DP. As DP is SBP x HR, it can show the oxygen consumption and the repercussion of the effort on the myocardium. During physical exercise, a high DP is related to increases in BP and cardiac output, due to the increase in SV and HR, becoming an important safety parameter for the prescription of physical exercise.[31,32] In the long term, these cardiovascular markers of HR and BP tend to decrease because of changes in cardiac sympathetic input and vagal and vascular tone through physical exercise. In this study, the results obtained are within an adequate range, making the proposed intervention safe for this population.[33-35]

Another article investigated changes in BP, HR and DP in people with PD, submitted to a program of aquatic exercises and observed a significant increase in mean HR, DP and diastolic blood pressure.[36] Although the data of the present study did not show statistically significant responses, the results are in line with the article in question, tending toward very similar increases. This can be explained by the longer intervention time performed by the authors (20 sessions, with approximately 40 minutes of training), since the sample number and disease staging are similar to those of the present study.[36] Furthermore, such findings can be explained by the already described mechanism of the physical properties of water. During immersion, hydrostatic pressure contributes to facilitating venous return, increasing the volume of blood that is ejected from the heart (it is not necessary to increase HR greatly to reach the required CO level), besides playing an important role in the respiratory muscles, favoring their activation and regulation between the pressures of the thoracic and abdominal cavity, further contributing to this process with better oxygenation.[37]

With regard to DP, within cardiorespiratory parameters, a low DP is associated with greater cardiovascular safety. Some authors sought to standardize DP values in a sample of 1623 participants and managed to establish a resting DP of 7524 ± 1753 and DP of 21218 ± 8928 in submaximal exercise, with a maximum of 32798 ± 4465.[38] In line with these findings, the DP range obtained in the present study was above a resting DP, but far from values of submaximal exercise, making the intervention of our study a safe way to work with such study population.[38]

Thus, since the proposed intervention with APT for this population proved to be safe from a cardiovascular point of view, it can be an alternative to conventional treatment to improve the perception of fatigue, since it allows movements that would not be possible on the floor, stimulating pathway nerves involved in neurodegenerative diseases such as PD.[39,40]

As limitations of the present study, we make mention of the small sample size, as well as the absence of comparative groups, whether passive or with other types of exercises. We highlight the need for more studies that seek to investigate the effects of aquatic exercises on cardiorespiratory conditions in PD and with larger population samples, comparative studies between individuals with PD and matched healthy individuals, in addition to comparing the levels of disease staging.

## Conclusion

The hemodynamic variables of HR and BP remained at appropriate values, as well as DP being within a safe training range, corresponding to values far lower than those in submaximal exercise and making the intervention of this study safe for this population. In addition, the proposed APT program was able to improve the perception of fatigue in this specific group of individuals with PD, being a statistically significant result with clinical importance due to the association of fatigue with motor and non-motor aspects of PD and consequent relationship with biopsychosocial factors and QoL. We emphasize the need for further studies on this topic.

## Authors' contributions

AEFD and TKM were responsible for the conception and design of the study and analysis and interpretation of data. All authors participated in writing and revising the manuscript and approved the final version..

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