Original Article

CLINICAL REHABILITATION

Water-based vs. non-water-based physiotherapy for rehabilitation of postural deformities in Parkinson's disease: A randomized controlled pilot study

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Abstract

Objective: To compare the efficacy of two physiotherapy protocols (water-based vs. non-water-based) on postural deformities of patients with Parkinson's disease.
Design: A single blind, randomized controlled pilot study.
Setting: Inpatient (Rehabilitative Department).
Participants: A total of 30 patients with idiopathic Parkinson's disease.
Interventions: Participants were randomly assigned to one of two eight-week treatment groups: Water-based ($n = 15$) or non-water-based physiotherapy exercises ($n = 15$).
Outcome measures: Changes in the degree of cervical and dorsal flexion and in the angle of lateral inclination of the trunk (evaluated by means of a posturographic system) were used as primary outcomes. Unified Parkinson Disease Rating Scale section III, Time Up and Go Test, Berg Balance Scale, Activities-specific Balance Confidence, Falls Efficacy Scale and the Parkinson's disease quality of life questionnaire (39 items) were the secondary outcomes. All outcomes were assessed at baseline, at the end of training and eight weeks after treatment. Patients were always tested at the time of their optimal antiparkinsonian medication ('on' phase).
Results: After the treatment, only Parkinson's disease subjects randomized to water-based treatment showed a significant improvement of trunk posture with a significant reduction of cervical flexion (water-based group: –65.2°; non-water-based group: +1.7°) and dorsal flexion (water-based group: –22.5°; non-water-based group: –6.5°) and lateral inclination of the trunk (water-based group: –2.3°; non-water-based group: +0.3°). Both groups presented significant improvements in the secondary clinical outcomes without between-group differences.

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Conclusion: Our results show that water-based physiotherapy was effective for improving postural deformities in patients with Parkinson's disease.

Keywords
Parkinson's disease, postural deformities, rehabilitation, water-based physiotherapy

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Introduction

Patients with Parkinson's disease frequently show mild to severe axial deformities.[1] The classic Parkinsonian posture is characterized by a flexed posture of the trunk and extremities (stooped posture). Moreover, an important subset of patients shows more severe abnormalities of posture or spinal alignment, leading to significant disability[1] with a negative impact on quality of life.[2] These severe postural deformities may be present in the sagittal plane (camptocormia, antecollis, retrocollis) and in the coronal plane (Pisa syndrome, scoliosis).

Camptocormia occurs frequently in patients with Parkinson's disease, with a prevalence rate between 3% to 17% of subjects.[3] It is defined as a severe forward flexion originating in the thoracolumbar spine, which typically increases during walking or standing and completely disappears in a supine position.[4] Pisa syndrome is clinically characterized by a lateral inclination of the trunk[1] with a corresponding tendency to lean to one side, which is more evident in the standing posture, while it resolves in the recumbent position. First described as a motor complication of neuroleptic drugs,[5] this manifestation has also been reported frequently in subjects with idiopathic Parkinson's disease (or atypical Parkinsonism).[6,7]

The possible mechanisms underlying postural deformities in these patients are still unclear and it has been suggested that central and peripheral mechanisms might both contribute to the pathogenesis.[1,5] Both camptocormia and Pisa syndrome are generally regarded as clinical phenomena non-responsive to dopaminergic or other drug treatment[8] as well to Deep Brain Stimulation.

Owing to poor benefits of pharmacological or surgical therapies, Parkinson's disease subjects with postural deformities are often referred to physiotherapy. However, the role of rehabilitation in improving postural deformities was rarely investigated and no consensus is available concerning the efficacy of physiotherapy for Parkinson's disease-related postural abnormalities.[9,10] Some recent studies[11,12] suggested that postural rehabilitation could represent an effective treatment for postural abnormalities.

Water-based physiotherapy is often used in treating motor impairments owing to orthopaedic[13] and neurological diseases,[14] but its effectiveness in treating postural deformities in Parkinson's disease was not definitively proven. We might postulate that the water environment, because of its microgravity-like properties, can exert a therapeutic influence on postural deformities.

The aim of this study was to verify if intensive physiotherapy in the water environment is feasible and leads to an improvement of posture in Parkinson's disease patients presenting postural deformities. To this purpose, we designed a randomized controlled trial to compare the efficacy of water-based vs. non-water-based physiotherapy in subjects with camptocormia and/or Pisa syndrome.

Methods

This randomized controlled trial was registered in the EudraCT register with the number 2013-000802-43, approved by the hospital ethical committee with the number 2012-11 and was conducted in accordance with the declaration of Helsinki.

This study had a parallel group design and consisted of a bi-centred, single blind, randomized controlled trial, with a two-month follow-up period. After the initial screening procedures and

baseline testing, participants were randomly allocated to two arms: (a) eight weeks of water-based physiotherapy; or (b) eight weeks of non-water-based physiotherapy. The randomization sequence was created using computer-generated random number tables with 1:1 allocation of participants by an independent researcher. Opaque envelopes were used to conceal allocation. Trained assessors who were blinded to group allocation conducted all the assessments. Physiotherapists providing the rehabilitative interventions could not be blinded to group allocation, but were unaware about the goal of the research and not involved in other aspects of patients' care. Written informed consent was obtained prior to the experiments for all participants.

Participants

Subjects were eligible for study if they met the following inclusion criteria: Diagnosis of idiopathic Parkinson's disease (according to the United Kingdom Parkinson's Disease Society Brain Bank criteria)[15] Hoehn and Yahr (H&Y)[16] stage $\leqslant 3$, Mini Mental State Examination (MMSE)[17] score >24, flexion (in the sagittal plane) of the thoracolumbar spine with an almost complete resolution in the supine position, and/or lateral flexion (in the coronal plane) that could be almost completely alleviated by passive mobilization or supine positioning, ability to attend physiotherapy. Subjects were excluded if they had fixed postural deformities (ankylosing spondylitis, vertebral fractures, idiopathic or degenerative scoliosis), in the presence of major depression (diagnosed by means of Diagnostic and Statistical Manual of Mental Disorders (DSM IV) criteria), if they were implanted for Deep Brain Stimulation, in case of severe co-morbidities (cardiac, pulmonary or orthopaedic diseases) or urinary incontinence.

Procedures and outcome measures

In both arms, participants received an intensive training programme for posture consisting of 60-minute sessions (five sessions per week) over a period of eight weeks. The water-based programme was conducted in a therapeutic swimming pool by physiotherapists and included exercises aimed to correct postural deformities (for details, see supplementary material available online).

Non-water-based training was also held by physiotherapists and consisted of exercises designed for postural deformities as much as possible similar to those used in the hydrotherapy programme. Each session consisted of 60 minutes: 10 minutes of warm up with relaxing exercises, 40 minutes of exercises for postural realignment, 10 minutes of cooling down and relaxation exercises.

Both interventions were conducted in two rehabilitative departments, which were similar in terms of healthcare facilities, and the reproducibility of interventions was carefully checked. Subjects in both arms of the study otherwise continued their usual medical treatment, which remained stable for the entire duration of the study.

Postural deformities were evaluated by means of a posturographic system (Milletrix Model 2.0, Rome, Italy) and the Body Analysis Kapture (BAK) System[18] was used to elaborate the goniometric analysis of postural data. During the postural evaluation, participants were positioned on a platform standing barefoot, keeping their arms alongside and maintaining their usual posture. All measures were recorded both in sagittal and frontal planes. Markers were placed on different anatomical landmarks (apophysis of 7th cervical; 3rd, 5th, 7th, 9th and 11th dorsal; 1st, 3rd and 5th lumbar; 1st sacral vertebrae, Acromion processes for shoulder symmetry, Anterior Superior Iliac Spines in order to evaluate pelvic symmetry). Before each evaluation, patient's height and weight were recorded in order to calibrate the system (Figure 1, available online).

The primary outcome measures were changes in postural parameters, represented by changes in the degree of cervical and/or dorsal flexion and in the angle of lateral inclination of the trunk. Secondary outcomes were: Unified Parkinson's Disease Rating Scale (UPDRS) section III,[19] to quantify motor symptoms of Parkinson's disease; Time Up and Go Test (TUG),[20] Berg Balance Scale (BBS),[21] Activities-specific Balance Confidence (ABC),[22]

Table 1. Demographic and clinical characteristics of patients with Parkinson disease.

	Water-based group ($n = 15$) Mean ± SD (range)	Non-water-based group ($n = 15$) Mean ± SD (range)	Statistical analysis
Age (y)	70.6 ± 7.8 (59–84)	70 ± 7.8 (51–82)	$p = 0.79$
Gender	9 male/6 female	10 male/5 female	$p = 0.66$
Height (cm)	163.9 ± 9 (148–179)	163.2 ± 13.3 (140–180)	$p = 0.81$
Weight (kg)	73.3 ± 10.6 (54–90)	75.3 ± 20.9 (52–118)	$p = 0.49$
Disease duration (y)	9.4 ± 7.5 (2–32)	9 ± 7.0 (3–25)	$p = 0.57$
Hoehn-Yahr stage	2.6 ± 0.5 (2–3)	2.7 ± 0.5 (2–3)	$p = 0.68$
UPDRS total (score)	58.7 ± 10.1 (42–76)	63.3 ± 13.5 (38–90)	$p = 0.39$
UPDRS III (score)	41.1 ± 6.7 (36–53)	45.2 ± 12.2 (24–64)	$p = 0.48$
MMSE (score)	26.5 ± 1.5 (24–29)	26.6 ± 1.6 (25–30)	$p = 0.71$
LEDD (mg/day)	437.2 ± 179.9 (250–900)	353.1 ± 280.9 (100–1000)	$p = 0.25$

UPDRS: Unified Parkinson's Disease Rating Scale; UPDRS III: motor section; MMSE: Mini-Mental State Examination; LEDD: levodopa equivalent daily dose.

Falls Efficacy Scale (FES)[23] to evaluate gait, dynamic balance, and fall risk respectively; the Parkinson's disease quality of life questionnaire (PDQ-39)[24] to quantify health-related quality of life.

Evaluation was performed at: (1) baseline (within one week before the rehabilitative intervention), (2) after treatment (at the end of the eight weeks treatment), (3) follow-up (eight weeks after the end of treatment without any further rehabilitative intervention). During the follow-up period, subjects were allowed to continue their customary motor activities; however, they were asked not to practice any specific physical therapy. Patients were always tested at the time of their optimal antiparkinsonian medication ('on' phase) and no change in medication was allowed during the study period.

Statistical analysis

Gender differences between the groups were assessed by the Chi-square test. Baseline differences between groups (water-based and non-water-based), for demographic and clinical characteristics, were assessed by independent *t*-tests, for data normally distributed (UPDRS – Part III Motor) and by the non-parametric Mann–Whitney *U*-test for data (age and disease duration) without a normal distribution (according to the Kolmogorov Smirnov statistical test).

All variables were examined for normality, and mean and standard deviation (SD) were calculated. Each parameter was analysed by means of a repeated measure (RM) analysis of variance (ANOVA) with time (baseline, eight weeks, 16 weeks) as within subject factor, and intervention (water-based and non-water-based) as between subject factors. When ANOVA gave a significant result ($p < 0.05$), post-hoc analysis was performed to investigate differences between time and type of training (water-based and non-water-based), by means of independent *t*-test applying the Bonferroni correction for multiple comparisons where necessary. For data without normal distribution (Likert pain scale), groups were compared by means of Kruskal–Wallis at each study visit (baseline, eight weeks, 16 weeks), and in case of significant effect of the group factor, post-hoc analysis was performed by means of the Mann–Whitney *U*-test. All statistical analyses were performed with SPSS 18.0.

Results

Demographic and clinical data are reported in Table 1. Eleven potential participants were excluded for various reasons (seven did not meet inclusion criteria; four for personal reasons) and 30 patients were enrolled (Figure 2).

No significant differences were detected at baseline in the demographic and clinical data

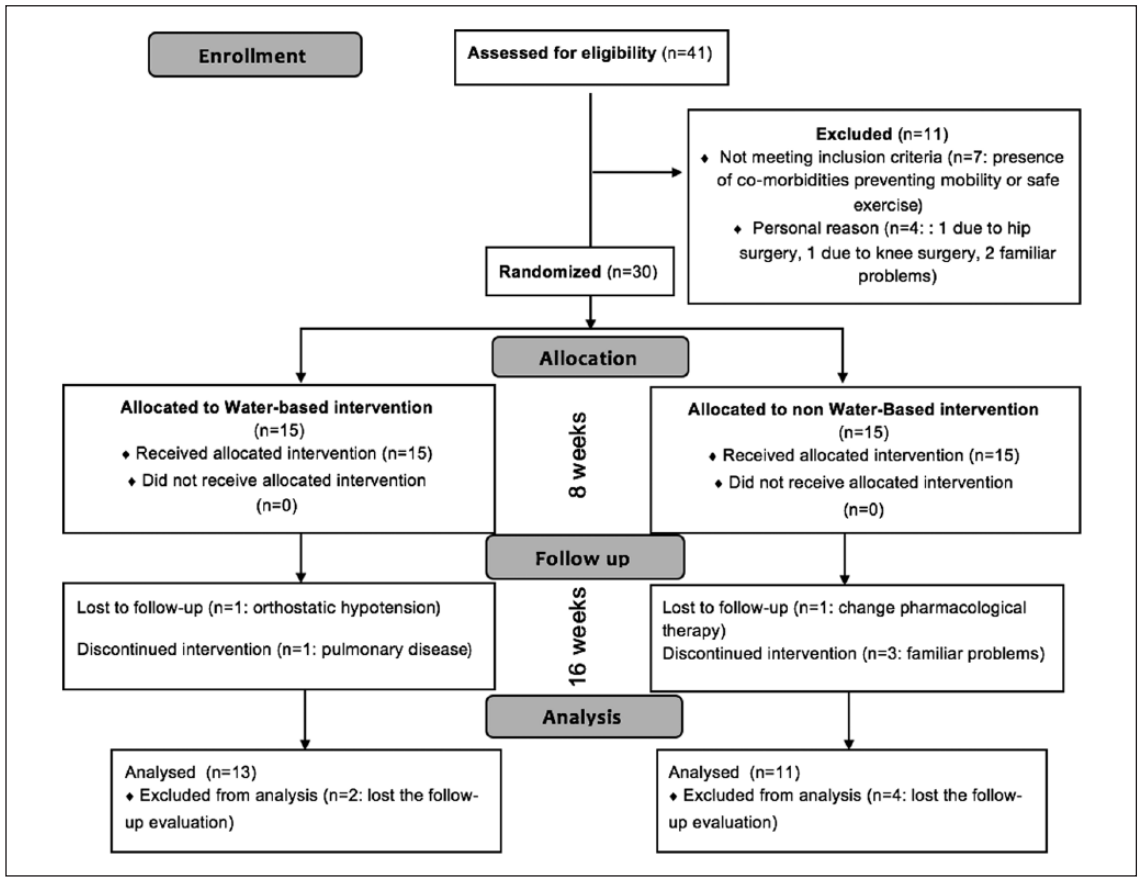

Figure 2. Consort diagram.

between the two groups of patients (P always > 0.05) (Table 1).

Postural parameters

At baseline no significant intergroup differences were found for all the postural parameters measured (p always >0.05).

Only subjects randomized to water-based treatment showed a significant improvement of the trunk posture in the sagittal and coronal plane. RM-ANOVA showed a main effect of time ($p<0.001$) for BAK-cervical data (Δ eight weeks: water-based group: –65.2°; non-water-based group: +1.7°; Δ 16 weeks: water-based group: –35.5°; non-water-based group: +7°), with a significant interaction time × intervention ($p=0.024$). Post-hoc analysis revealed that cervical flexion was significantly reduced only in patients who received water-based intervention (eight weeks: $p=0.004$; 16 weeks: $p=0.001$), whereas no differences were found in participants receiving non-water-based intervention (eight weeks: $p=0.94$; 16 weeks: $p=0.52$). For BAK-dorsal data (Δ eight weeks: water-based group: –22.5°; non-water-based group: –6.5°; Δ 16 weeks: water-based group: –12.4°; non-water-based group: +5°), statistical analysis showed a main effect of time ($p=0.008$), with a significant interaction time × intervention ($p=0.046$). Post-hoc analysis showed significant decrease of dorsal flexion immediately after water-based treatment ($p=0.002$) and no changes at the end of non-water-based treatment ($p=0.26$). Similarly, a main effect of time ($p=0.038$) was

identified for shoulder symmetry data (Δ eight weeks: water-based group: –2.3°; non-water-based group: +0.3°; Δ 16 weeks: water-based group: +0.2°; non-water-based group: +0.3°), with a significant interaction time × intervention ($p = 0.047$). Post-hoc analysis revealed a significant improvement of symmetry only in the water-based group ($p = 0.002$), whereas no significant changes were found in the non-water-based group ($p = 0.95$) at the end treatment. However, for dorsal flexion and shoulder symmetry data, post-hoc analyses did not reveal significant changes at follow-up evaluation (16 weeks) in both groups (p always >0.05).

Finally, for all posturogragific parameters, post-hoc analysis did not reveal significant differences between groups (water-based and non-water-based) at each testing time (eight weeks, 16 weeks; p always > 0.05).

Clinical parameters

Statistical analysis of secondary outcomes, showed a positive effect of both physiotherapy interventions for most of the considered variables, suggesting that the improvement was similar across groups with no differences depending on the type of intervention. RM-ANOVA showed a significant effect of time (p always <0.05) without a significant time × intervention interaction.

In both groups the mean UPDRS-III score was significantly reduced (eight weeks: $p = 0.001$; 16 weeks: $p = 0.037$)) and the BBS score was significantly increased (eight weeks: $p < 0.001$; 16 weeks: $p = 0.019$). The ABC score improved in both groups exclusively at the end of treatment (eight weeks: $p = 0.02$; 16 weeks: $p = 0.34$) as well as the TUG performance (eight weeks: $p = 0.036$; 16 weeks: $p = 0.13$).

Similarly, changes in the FES score (indicated a significant reduction of the perceived fear of falling only after the end of treatment (eight weeks: $p = 0.027$; 16 weeks: $p = 0.87$).

Statistical analysis showed a main effect of time ($p = 0.002$) with a significant interaction time × intervention ($p = 0.001$) for the PDQ-39. The mean score of PDQ-39 significantly improved at eight weeks in both groups (water-based: $p < 0.001$; non-water-based: $p = 0.045$), but this result was confirmed at 16 weeks only in the water-based group ($p = 0.008$). No significant change was found in both groups for the Likert scale ($p > 0.05$). All data are reported in Table 2.

Discussion

This preliminary study showed that water-based physiotherapy induced significant improvements of postural deformities present in patients with Parkinson's disease both in the sagittal and coronal plane. Similar improvement could not be achieved in the group of patients randomized in the non-water-based training exercises. On the other hand, at the end of training, participants randomized to either water-based or non-water-based physiotherapy, showed significant changes in the secondary clinical outcomes (UPDRS-III, BBS, ABC, TUG, FES) as well as in quality of life measures (PDQ-39) without between-group differences.

The efficacy of water-based intervention in patients with neurological diseases has been already documented by studies showing significant therapeutic results, such as: a decrease in muscle tone,[25,26] an improvement of postural stability,[27] an increment of functional mobility[28] and a reduction of spasm severity in spasticity.[29] Furthermore, it has been shown that hydrodynamic resistance contributes to strengthen the muscles of the trunk in static condition and during walking.[30,31]

The evidence regarding the efficacy of water-based physiotherapy in Parkinson's disease is limited. It has been suggested that this type of training can contribute to improve the UPDRS scores (ADL and motor sections) and gait with a positive consequence on quality of life.[32] Moreover, recent studies[33,34] demonstrated that water-based physiotherapy has beneficial effects on postural instability with significant reduction in the number of falls in Parkinson's disease subjects, presenting a moderate stage of disease, with a greater effect of water therapy vs. land-based therapy.

These results might suggest that the specific properties of a water environment (density, specific gravity, hydrostatic pressure, buoyancy, viscosity and thermodynamics) can play an important role in

Table 2. Statistical analysis of primary and secondary outcomes.

	Water-based group (mean ± SD)			Non-water-based group (mean ± SD)		
	Baseline	8 weeks	16 weeks	Baseline	8 weeks	16 weeks
Postural parameters						
BAK-cervical (mm)	231.5 ± 93.9	166.3 ± 56[a]	196 ± 83.1[b]	177.1 ± 71.7	178.8 ± 54.8	184.1 ± 52.7
BAK-dorsal (mm)	46.6 ± 28.3	24.1 ± 22.2[a]	34.2 ± 30	38.7 ± 22.6	32.2 ± 26.3	33.7 ± 25.8
Shoulder symmetry (°)	6.8 ± 2.5	4.5 ± 1.7[a]	7 ± 3	5.8 ± 3.6	5.5 ± 3.1	6.1 ± 4
Pelvic symmetry (°)	3.6 ± 2.5	3.3 ± 3.1[a]	3 ± 2.4	4.2 ± 3.9	3.5 ± 3.1	3.3 ± 4.6
Motor performance tests						
UPDRS-III (score)	40.9 ± 6.7	34.8 ± 5.6	37.2 ± 6.1	40.2 ± 11.1	33 ± 12.8	35.2 ± 11.3
BBS (score)	46.7 ± 6.6	50.2 ± 4.6	48.8 ± 5.1	42.3 ± 8.5	49.2 ± 5.1	44.6 ± 6.9
ABC (%)	62 ± 18.4	70.1 ± 19.7	68 ± 19.3	71.1 ± 18.7	73.5 ± 20.4	69.3 ± 25.4
TUG (sec)	12.9 ± 2.1	11.5 ± 2	12 ± 2.4	14.8 ± 8.4	11.6 ± 2.3	12 ± 2.4
FES (score)	8.3 ± 5.5	6 ± 4.6	7.6 ± 6.5	11 ± 7.5	9.7 ± 7.6	11.4 ± 8.1
Quality of life and pain						
PDQ-39 (score)	49.1 ± 20.3	39.5 ± 18.9[a]	38.1 ± 20.7[b]	50.8 ± 20.8	46.6 ± 20.7[a]	61 ± 19.6[b]
Likert (score)	5.7 ± 2.5	3.8 ± 2.2	5.3 ± 2.9	5.7 ± 3	3 ± 2.7	4.5 ± 2.7

BAK: Body Analysis Kapture; UPDRS-III: Unified Parkinson's Disease Rating Scale – motor section; BBS: Berg Balance Scale; ABC: Activities-specific Balance Confidence; TUG: Time Up and Go Test; FES: Fall Efficacy Scale; PDQ-39: Parkinson's disease quality of life questionnaire-39 items.

Mean data (± standard deviation) at different testing times are reported.

[a]Significant difference in post-hoc analysis (baseline vs. eight weeks).

[b]Significant difference in post-hoc analysis (baseline vs. 16 weeks), when RM-ANOVA gave a significant interaction (time × intervention).

improving postural control and dynamic balance. Recent hypothesis suggested that postural deformities in Parkinson's disease could be also related to a deficit in somatosensory integration.[35] We may speculate that external stimulation by water resistance can favour a specific modulation of proprioceptive afferents, possibly underlying the selective postural improvement observed only in the water-based group. Indeed, it has been demonstrated that the water environment can increase proprioceptive inputs to the immersed body leading to a better body alignment.[36] Thus, we may suggest that intensive proprioceptive training involving the whole body (as in the water environment) might favour more persistent improvements of postural abnormalities as shown by the results observed at the 16-week follow-up.

As expected, all the secondary outcomes (UPDRS-III, BBS, ABC, TUG, FES) were significantly improved after treatment, irrespectively of water-based or non-water-based physiotherapy. Nevertheless, a more efficient correction of postural deformities can theoretically reduce the risk of future falls.

We acknowledge that our study has several important limitations. The sample size is relatively small and the follow-up period relatively short, hence the results need to be interpreted carefully with regard to the magnitude of treatment effects. The drug state of the participants is also an important element to take into account for the future. We have designed this study to evaluate participants while *on* drugs, while to better understand the results evaluations in *on* and *off* periods would be needed.

In conclusion, this pilot randomized controlled trial shows that a water-based physiotherapy programme appears specifically effective on postural deformities, suggesting that it could be considered a useful approach for patients with Parkinson's

disease. Our investigation provides encouraging data but future, larger scale, randomized controlled trial studies are certainly warranted and will expand our knowledge on the mechanisms of postural deformities, on the expected time needed to achieve a meaningful improvement and on its long-term duration.

Clinical messages

- Water-based physiotherapy was effective in improving postural deformities (in the sagittal or coronal planes) in patients with Parkinson's disease. Similar improvement could not be achieved in patients submitted to non-water-based training exercises.
- The improvement of postural abnormalities after water-based exercises might be related to a compensation of defective proprioceptive mechanism in Parkinson's disease.
- Water-based intervention might represent a useful approach to postural deformities in Parkinson's disease, but its effectiveness needs to be supported with large randomized controlled trial studies.

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Declaration of conflicting interest

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