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ACADEMIC LITERATURE REVIEW

Effectiveness of water-based exercise in people living with Parkinson's disease: a systematic review

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Abstract This systematic review summarizes the relatively scant literature concerning the effectiveness of water-based exercise (WBE) interventions in people with Parkinson's disease (PD). Databases MEDLINE, EMBASE, PEDro, Scopus, and SportDiscus were searched from the earliest available date to December 2011. Studies had to meet the following selection criteria: (1) the target population was patients with PD; (2) the effects of a WBE intervention (as the primary intervention) were tested; (3) the abstract of the research was available in English. Selected studies were subject to unmasked quality assessment by applying a methodological scoring with a possible maximum score of 15 points. Twelve studies met the inclusion criteria, although only three of them achieved a methodological quality score above 10 points. Collectively, the data showed that WBE has some beneficial short-term effects on the impact that PD has on the patients (mainly on their motor symptoms and on their functional mobility), as well as on their quality of life. This review provides evidence that WBE is safe for patients with PD, but there is a lack of hard evidence regarding its beneficial effects. Further randomized and controlled trials with larger sample sizes are required.

Keywords Parkinson · Rehabilitation · Review · Water-based exercise

Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by a loss of dopaminergic neurons in the basal ganglia, specifically the substantia nigra pars compacta. The cardinal features of PD are rigidity, bradykinesia, tremor, and postural instability [16]. Levodopa remains the most effective anti-Parkinson medication, but chronic levodopa therapy is associated with motor fluctuations and dyskinesias [33], leading patients and clinicians to consider neurosurgical options. Deep brain stimulation of subthalamic nucleus is currently the most common therapeutic surgical treatment for PD patients who have failed medical management [39]. However, not all the patients are eligible for this treatment, and quality of life fails to improve in a relevant proportion of those who opt for this technique [8]. Therefore, since it seems that pharmacological and surgical treatments are not able to completely reduce the neurological deficits of bradykinesia, rigidity, and freezing [22], there is a need for alternative therapies capable of improving functional autonomy and minimizing PD secondary complications. In this regard, the existing literature strongly suggests that physical exercise is useful in forestalling the onset of PD and slowing its progression, and this is the reason why many clinicians recommend its practice to those patients who are able to do it [40].

To date, several systematic reviews and meta-analyses about the effects on PD of different therapies based on the performance of physical activity and physical therapy (physiotherapy) have been published [7, 9, 14, 22, 35, 36]. Some of them have focused on the effects of a specific type of physical exercise program, such as resistance [13], balance [10], or treadmill training [24], whereas others have focused on alternative movement therapies

Carlos Ayán role • Designed research
• Performed research
• Wrote the paper

JM Cancela role • Designed research
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[11, 23]. However, there is lack of scientific evidence regarding the effects of water-based exercise programs, which is one of the most commonly used exercise therapy approaches in a wide variety of medical conditions. The potential benefits for PD patients have been previously observed [26]. For instance, rigidity, postural instability, and bradykinesia are well-known basic PD symptoms that could be ameliorated by means of water exercise programs. Indeed, it has been proposed that the use of aquatic environments can decrease muscular tone, reduce spasm severity, as well as increase functional mobility [38]. Besides, it can also improve balance and coordination in older individuals who face an increased risk of falling [3]. Given these specifications, aquatic exercise may be a highly suitable intervention for individuals with PD. However, despite the fact that a number of reviews and meta-analyses have confirmed that aquatic exercise programs are a useful nonpharmacological tool in the rehabilitation process of patients suffering from different neurologic or musculoskeletal conditions [3, 15, 19, 37], to the author's knowledge, no systematic review or meta-analysis has been published about its effects on PD. The lack of studies in this regard hinders the obtainment of methodological guidelines which may contribute to not only enhance intervention procedures, but also establish a frame of reference within which proper scientific discussion regarding the effects of water exercise programs on PD must be based. Therefore, it seems necessary to carry out a critical review of the literature in order to evaluate the strength of evidence to inform clinical practice. Under these circumstances, this research aims to summarize and critically assess the available evidence concerning the potential benefits of aquatic exercise interventions for people with PD.

Methods

Search strategy

The following electronic databases were searched up to February 2013: MEDLINE, EMBASE, PEDro, Scopus, and SportDiscus. The reference lists of research works identified by the literature search were also screened for additional and relevant information. The following search terms were used: "Parkinson's disease" and "aquatic therapy", "aquatic exercise" or "water exercise". Studies had to meet the following selection criteria: (1) the target population was patients with PD; (2) the effects of a water-based exercise (WBE) intervention (as the primary intervention) were tested; and (3) the abstract of the research was available in English.

Study selection

Two independent searchers screened the titles and abstracts of identified studies for eligibility. After independently reviewing the selected studies for inclusion, these were compared by both searchers to reach an agreement. Once the agreement had been reached, a full-text copy of every potentially relevant study was obtained.

Data extraction

Two independent searchers extracted data, including study characteristics, study results, and point estimates, as well as measures of variability for selected outcome variables. They used a data extraction form, together with coding instructions for data collection, both designed for this review. When further or missing data was required, authors of studies were contacted. All discrepancies were reviewed, and agreement was reached by discussion. The main content and methodological details from the relevant literature were extracted and tabulated into a matrix (Table 1) which organized all the relevant information related to the design, intervention, and limitations of the studies.

Quality assessment

Selected studies were subject to unmasked quality assessment by two independent reviewers. This assessment was carried out by applying a methodological scoring list following previous recommendations in this regard [5]. The list contained 10 items with a possible maximum score of 15 points, and was adapted from a methodological screening list previously used in a similar research [9]. The following items were evaluated: (1) *randomization* (0, not; 1, yes); (2) *follow up* (0, not; 1, yes); (3) *matching procedure* (1, two or fewer variables as inclusion criteria; 2, more than two variables as inclusion criteria); (4) *blinding* (1, single; 2, double); (5) *dropouts analysis* (0, not described; 1, described in half the groups; 2, described in all the groups); (6) *measuring instruments* (0, there is no reference to the validity of the instruments used; 1, there is reference to the validity of the instruments used); (7) *cointerventions* (0, there is no control of parallel interventions in the experimental group; 1, there is control of one parallel intervention in the experimental group; 2, there is control of two or more parallel interventions in the experimental group); (8) *patient characteristics* (0, no group homogeneity; 1, statistical group homogeneity); (9) *dose of therapy* (0, intervention time is not described; 1, intervention time is described); (10) *statistics* (0, results are not statistically described; 1, the statistical inference of the results is described (p); 2, the statistic inference of the results is described including the final n of the groups).

Results

Twenty-three publications were identified and screened against the inclusion and exclusion criteria. No previous reviews or meta-analyses on this topic were identified. Seven

Table 1 Summary description of the 12 studies included in the review

Reference	Aim	Measurement tools (variable)	Evaluation on/off	Participants (*n*)	Mean age (years)	Disease severity (H&Y)	Duration of PD (years)	Type of intervention	Dropouts during intervention (*n*)	Adherence	Findings
Reuter et al. [29]	To investigate the influence of an intensive exercise training on motor disability, mood and subjective well-being	BMT (strength, flexibility and coordination), UPDRS (PD Disability Scale), CURS (PD specific motor disability), MMSE (dementia), AMQZ (quality of life), SIP (well-being)	On	$E=16$	65.4±5.9	2.84±0.4	6.7±3.7	E=WBE (water program)+LBE (gymnasium program)	$E=0$	92.8 %	Significant improvements in UPDRS ($p<0.0001$), CURS ($p<0.0001$), and BMT ($p<0.0001$)
Pellecchia et al. [25]	To evaluate the effects of a rehabilitation program on disability in patients with PD	UPDRS-II (activities of daily living), UPDRS-III (motor symptoms), Ten-Meter Walk (mobility), SaPDDS (PD Disability Scale), Self-rating depression Scale (depression)	On	$E=20$	59±11.8	1.5–3	4.8±3.4	E=LBE+WBE (rehabilitation program)	$E=0$	NR	Significant improvements in UPDRS-II ($p<0.002$), UPDRS-III ($p<0.0001$), Ten-Meter Walk $p<0.012$), SaPDDS ($p<0.001$) and Self-Rating Depression Scale ($p<0.0001$)
Pospíšil et al. [27]	To study elucidation of the reaction of basic haemodynamic parameters to water immersion of the lower part of the body	SBP and DBP (blood pressure), HR and RPP (HR × SBP).	On	$E=9$	71±7	2.2±0.7	7±3	E=WBE (balneotherapy)	$E=0$	NR	Significant reduction of HR ($p\leq0.05$) and DBP values ($p\leq0.05$)
Crizzle and Newhouse [6]	To study the effect of WBE on PD symptoms	ABCS (balance), VPS (health-related quality of life), Ten physical tests (fitness)	On	$E=6$	71–89	2	NR	E=WBE (water exercise)	$E=2$	89.5±10.2 %	Improvements were found in all analyzed variables, except in flexibility tests, ABCS and VPS
Therrien et al. [34]	To study the effect of WBE on postural control and quality of life	BCS (balance and posture), PDQ-8 (quality of life), UPDRS-III (motor symptoms)	NR	NR	NR	NR	NR	E=WBE (aquatic exercise)	NR	NR	Significant improvements in the psychological factor ($p=0.015$), UPDRS-III ($p=0.025$) and postural stability (BCS) ($p<0.024$)
Sage et al. [31]	To evaluate the effectiveness of four exercise interventions on motor symptoms of PD	UPDRS-III (motor symptoms)	On	$E_1=12$(M)	$E_1=63.1\pm9.2$	NR	$E_1=7.7\pm6.4$	E_1=WBE (aquatic exercise)	$E_1=0$	90 %	E_1=UPDRS-III did not improve significantly ($p>0.05$)
				$E_2=17$	$E_2=65.8\pm9.9$		$E_2=3.8\pm3.9$	E_2=LBE (aerobic intervention)	$E_2=0$		E_2=UPDRS-III did not improve significantly ($p>0.05$)
				$E_3=18$	$E_3=68.7\pm8.3$		$E_3=5.7\pm4.0$	E_3=LBE (strength training)	$E_3=0$		E_3=UPDRS-III improved significantly ($p<0.004$)
				$E_4=24$	$E_4=68.0\pm11.0$		$E_4=5.1\pm4.5$	E_4=LBE (sensory attention-focused exercise)	$E_4=0$		E_4=UPDRS-III improved significantly ($p<0.001$)
				$C=18$	$C=68.6\pm8.1$		$C=3.2\pm2.8$	C=nonexercise	$C=0$		
Ayán and Cancela [2]	To evaluate the feasibility and efficacy of WBE on PD	SFT (fitness), PDQ-39 (quality of life), UPDRS-III (motor symptoms), UPDRS-I	On	$E=13$	65.3±9.6	1–3	5.8±3.9	E=WBE (aquatic exercise)	$E=3$	≥80 %	Significant improvements in PDQ-39 (parts I and II) ($p\leq0.05$), UPDRS-II

Table 1 (continued)

Reference	Aim	Measurement tools (variable)	Evaluation on/off	Participants (n)	Mean age (years)	Disease severity (H&Y)	Duration of PD (years)	Type of intervention	Dropouts during intervention (n)	Adherence	Findings
		(mental status), UPDRS-II (activities of daily living), and BI (autonomy)									(p≤0.05), BI (p≤0.01), SFT flexibility (p≤0.05), and SFT aerobic (p≤0.01).
Ayán and Cancela [1]	To compare the effects of 2 different WBE on PD symptoms	FTSTS (functional mobility), UPDRS-III (motor symptoms) and PDQ-39 (quality of life)	On	E_1=11 E_2=10	E_1=68.9±9.6 E_2=71.9±5.1	E_1=2.4±0.7 E_2=2.0±0.7	E_1=6.1±3.1 E_2=7.5±5.5	E_1=WBE (low-intensity water exercise) E_2=WBE (muscular resistance water exercise)	E_1=1 E_2=0	80–85 %	Significant improvements in UPDRS-III (p=0.006), PDQ-39 (p=0.001) and FTSTS (p=0.001)
Kargarfard et al. [20]	To survey the effects of WBE on balance	BBS (balance)	On	E=10(W) C=10(W)	E=87.6±1.4 Ca=60.8±5.5	NR	NR	E=WBE (aquatic exercise) C=Maintain their current lifestyle	E=0 C=0	NR	Significant improvements in BBS (p≤0.05)
Kawasaki [21]	To explain the effects of WBE on balance improvement and to discuss the differences with home-based land exercise	BBS (balance), BBT (balance), STS (balance) and ABCS (balance)	NR	E=15 Ca=15	NR	NR	NR	E=WBE (therapeutic exercise) Ca=LBE (similar exercises at home)	E=0 Ca=0	NR	Significant improvements in STS (p<0.05) and BBT (p<0.05)
Vivas et al. [38]	To compare 2 different protocols of physiotherapy (WBE, LBE) on postural stability and self-movement	FRT (flexibility), BBS (balance), gait (balance) TUG (postural stability) and UPDRS (PD Disability Scale)	Off	E=6 Ca=6	E=65.6±3.6 Ca=68.3±6.9	E=2.67±0.5 Ca=2.40±0.5	E=4.17±1.6 Ca=7.83±3.9	E=WBE (water-based therapy) Ca=LBE (land-based therapy)	E=1 Ca=0	NR	Significant improvements in BBS (p=0.010) and UPDRS (p=0.036)
Jung et al. [18]	To investigate the effects of WBE on various balance outcomes	ABCS (balance), BBS (balance), postural sway (balance) and STS (balance)	NR	E=12 Ca=12	NR	NR	NR	E=WBE (therapeutic exercise program) Ca=LBE (similar exercises at home)	E=3 Ca=6	NR	Significant improvements in STS (p<0.039)

ABCS Activities Specific Balance Confidence Scale, *ADL* activities of daily living, *AMQZ* Adjective Mood Questionnaire of Zeersen, *BI* Barthel index, *BBS* Berg Balance Score, *BBT* Biodex Balance Test, *BCS* Balance Control System, *BMT* Basic Motor Test, *C* control group, *Ca* active control group, *CURS* Columbia University Rating Scale, *DBP* diastolic blood pressure, *E* experimental group, *FRT* Functional Reach Test, *FTSTS* Five Times Sit-to-Stand, *HBE* home-based exercise, *HR* heart rate, *H&Y* Hoehn and Yahr scale, *LBE* land-based exercise, *M* men, *MMSE* Mini-Mental State Examination, *NR* not reported, *On* presence of the effect of medication, *Off* no presence of the effect of medication, *PD* Parkinson's disease, *RPP* rate × pressure product, *SaPDDS* Self-Assessment Parkinson's Disease Disability Scale, *SBP* systolic blood pressure, *SIP* Sickness Impact Profile, *SFT* Senior Fitness Test, *STS* Sit to Stand, *TUG* Timed Up and Go, *UPDRS* Unified Parkinson's Disease Rating Scale, *UPDRS-I* mental status of Unified Parkinson's Disease Rating Scale, *UPDRS-II* activities of daily living of Unified Parkinson's Disease Rating Scale, *UPDRS-III* motor symptoms of Unified Parkinson's Disease Rating Scale, *VPS* Vitality Plus Scale, *W* women, *WBE* Water-Based Exercise training, *PDQ-39* 39-item Parkinson's Disease Questionnaire, *PDQ-8* eight-item Parkinson's Disease Questionnaire out of the 23 identified publications were rejected at the title stage since they were not related to the topic under study. The other three publications were rejected at the abstract stage because they were opinion articles [17, 32] and books concerning the potential effects of aquatic exercise on PD [30]. One of the remaining 13 papers which were retrieved for more detailed evaluation was excluded because it did not include a proper WBE intervention [4]. Therefore, 12 studies proceeded to the paper-screening stage and were accepted for review (Fig. 1).

Methodological quality

The results of the methodological quality assessment of the remaining 12 studies are shown in Table 2. Nine studies [1, 2, 6, 11, 25, 27, 29, 31, 34] were classified as quasi-experimental, and three [18, 21, 38] were classified as true experimental. The methodological quality total score of the 12 finally included studies ranged from 2 to 13 points. Randomization was carried out in three studies [18, 21, 38]. None of them included information about the process followed. Patients were monitored after the intervention in five out of the 12 analyzed studies [20, 25, 29, 31, 38]; only one was true experimental [38].

As regards the matching procedure, we must point out that three studies did not describe it [18, 21, 34], and the other three [6, 25, 29] took into account only one selection criterion—Hoehn and Yahr scale (H&Y). The remaining six [1, 2, 11, 27, 28, 31] applied more than two selection criteria in order to select the population (age, H&Y, mobility, cognitive level…). All the studies were single blind. Dropout information was included in eight of them [1, 2, 6, 18, 25, 29, 31, 38].

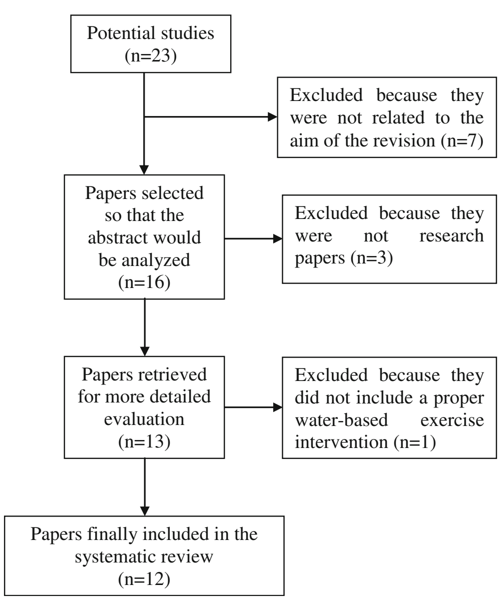

Fig. 1 Flow of studies through the review

The reliability of the measuring instruments was carried out or mentioned in only four studies [1, 2, 20, 29].

Seven studies included control of the co-interventions [1, 2, 20, 25, 29, 31, 38], being a double co-intervention (medication and program) in two of them [2, 38]. Sample homogeneity was checked in four [2, 20, 31, 38] of the six studies in which it could be applied; there is no reference in the remaining two [18, 21]. Reference to dose therapy was not appropriately detailed in one study [34]. Inferential analysis was carried out in all the studies but one [6], being much more exhaustive in nine of them [1, 2, 18, 20, 25, 27, 29, 31, 38].

Study characteristics

A specific intervention mainly based on the performance of a WBE training program was carried out in 10 out of the 12 analyzed papers [1, 2, 6, 18, 20, 21, 27, 31, 34, 38]. Two of them included this modality as part of a more comprehensive and multidisciplinary exercise rehabilitation program, since they were aimed at evaluating the effects of such interventions on PD patients [25, 29]. Three out of the five pilot studies were aimed at confirming the beneficial effects of water exercise on PD [1, 6, 34]. Pospíšil et al. [27] analyzed the reaction of basic haemodynamic parameters to water immersion among this population. One study was specifically aimed at comparing the effects of WBE versus usual pharmacological treatment [20]. Four studies included a second intervention group; three of them compared the effects of WBE versus land-based training [18, 21, 38]; the other one analyzed the effects of two different water-based exercise programs [2]. Finally, one study included four exercise groups which allowed for the comparison between a WBE program and three different land-based training modalities (aerobic, strength, and sensory attention-focused exercise), as well as with a non-intervention (control) group [31] (Table 1).

Intervention

All the analyzed studies reported the aims of the WBE intervention; in one of the studies, this intervention was highly detailed [1] (Table 3). The interventions were mainly focused on the development of the aerobic capacity, balance and postural control, mobility, and strength. The overall duration of the aquatic exercise treatment ranged from 4 to 20 weeks, with an average of 22.33±8.51 group exercise sessions. The interventions took place from one to three times a week for a minimum of 30 and a maximum of 60 min (mean, 53.63±10.02 min). Total treatment time ranged from 6 to 60 h (mean, 26.33±15.31; median, 24). Five studies [1, 2, 20, 27, 34] properly reported the way in which the workload intensity of the program and the progression criteria were set. Three of them provided information about the qualifications of the personnel in charge of monitoring the sessions [1, 2, 38]. Eight studies [1,

Table 2 Methodological quality of the 12 studies reviewed

Reference	Study design	Randomization	Follow-up	Matching procedure	Simple/double blind	Dropouts analysis	Measuring instruments	Co-interventions	Patient characteristics	Dose of therapy	Statistics	Total score	Limitations
Reuter et al. [29]	Quasi-experimental	0	1	1	1	2	1	1	NA	1	2	10	No control group, study not randomized.
Pellecchia et al. [25]	Quasi-experimental	0	1	1	1	2	0	1	NA	1	2	9	No control group, study not randomized, adherence to the program is not mentioned.
Pospíšil et al. [27]	Quasi-experimental	0	0	2	1	NR	0	NR	NA	1	2	6	Very small sample size, no control group, study not randomized, adherence to the program is not mentioned
Crizzle and Newhouse [6]	Quasi-experimental	0	0	1	1	2	0	NR	NA	1	0	5	Very small sample size, no control group, study not randomized, no reference to how long the patients have been suffering from PD.
Therrien et al. [34]	Quasi-experimental	0	0	NR	1	NR	0	NR	NA	NR	1	2	Sample size is not indicated, no control group, study not randomized, adherence to the program is not mentioned, the state of the patients and pathology length are not identified, no mention to the mean age of the patients, nor to the frequency or timing of the intervention
Sage, Johnston and Almeida [31]	Quasi-experimental	0	1	2	1	2	0	1	1	1	2	11	Study not randomized, no women were included in Aquatic exercise, no adherence to the program, state of the patients not identified
Ayán and Cancela [2]	Quasi-experimental	0	0	2	1	2	1	1	NA	1	2	10	No control group, study not randomized.
Ayán and Cancela [1]	Quasi-experimental	0	0	2	1	2	1	2	1	1	2	12	Small sample, study not randomized.
Kargarfard et al. [20]	Quasi-experimental	0	1	2	1	NR	1	1	1	1	2	10	Small sample size, study not randomized, no man was included in the study, adherence to the program is not mentioned, state of the

Table 2 (continued)

Reference	Study design	Randomization	Follow-up	Matching procedure	Simple/double blind	Dropouts analysis	Measuring instruments	Co-interventions	Patient characteristics	Dose of therapy	Statistics	Total score	Limitations
													patients is not identified, no mention to how long patients have been suffering from PD
Kawasaki [21]	Experimental	1	0	NR	1	NR	0	0	NR	1	1	4	No adherence to the program, pathology length, state and mean age of the patients are not identified
Vivas et al. [38]	Experimental	1	1	2	1	2	0	2	1	1	2	13	Very small sample size, adherence to the program is not mentioned, study not randomized
Jung et al. [18]	Experimental	1	0	NR	1	2	0	0	NR	1	2	7	Study not randomized, adherence to the program is not mentioned, age and state of the patients are not identified, no reference to how long the patients have been suffering from PD, intervention program is not described

NA not applicable, *NR* not reported, *PD* Parkinson's disease

Table 3 Characteristics of the water-based exercise intervention carried out in the 12 studies reviewed

Study	Intervention focus	Main water session content	Duration	Intensity	Progression	Type of pool	Water temperature	Supervisor
Reuter et al. [29]	Motor disability, mood and well-being	Exercises for muscle strength, motor control, balance, swimming	One 60-min session per week for 14 weeks	NR	NR	NR	NR	NR
Pellecchia et al. [25]	Motor dexterity	Exercises for the coordination of all limbs and trunk control	One 60-min session per week for 20 weeks	NR	NR	NR	28–32 °C	NR
Pospíšil et al. [27]	Aerobic capacity	Balance exercises. Gross and fine motor tasks	One 60-min session per week for 12 weeks	Borg's rate of perceived exertion (11–14)	NR	Chest deep	32.5 °C	NR
Crizzle and Newhouse [6]	Balance and strength	Walking, balance and upper body exercises (Water Art Fitness International Manual)	Three 30/45-min sessions per week for 6 weeks	NR	More challenging and complicated movements. Aqua steps	Shallow	31–33 °C	NR
Therrien et al. [34]	Balance and postural control	Free standing, standing with support, moving, and suspended exercises	8 weeks	Borg's Rate of Perceived Exertion (<6)	NR	Chest-deep	30–31 °C	NR
Sage et al. [31]	Mobility, strength and aerobic capacity	Stretching, balance, strengthening and aerobic exercises	Three 60-min sessions per week for 10/ 12 weeks.	NR	NR	Chest-deep	NR	NR
Ayán and Cancela [2]	Balance, strength and coordination	Callisthenic movements, dynamic progressive exercises and games	Two 60-min sessions per week for 12 weeks	Sets, repetitions and resting time between exercises	NR	Shallow	28 °C	A specialist in physical exercise and a physiotherapist
Ayán and Cancela [1]	Aerobic capacity	Balance, coordination and dynamic exercises. Group games	Two 60-min sessions per week for 12 weeks	Sets, repetitions and resting time between exercises	More challenging and complicated movements.	Shallow	28 °C	A single specialist in physical exercise and rehabilitation
	Muscular resistance	Strength exercises with aquatic cuffs, and noodles, pull-buoy and swim-boards.			Increasing the number of sets and velocity of the movements			
Kargarfard et al. [20]	Aerobic capacity	Walking, range of motion, different floating positions	Three 60-min sessions per week for 8 weeks	50–85 % maximal heart rate reserve	NR	NR	NR	NR
Kawasaki [21]	Balance	Balance exercises, variations of Tai Chi movements, treadmill walking	Three 50-min sessions per week for 10 weeks	NR	NR	Therapeutic	34 °C	NR
Vivas et al. [38]	Postural stability and body control	Trunk mobility, postural stability, changing body positions and transferring oneself exercises (Halliwick method)	Two 45-min sessions per week for 4 weeks	NR	More challenging and complicated movements	NR	NR	A single physiotherapist
Jung et al. [18]	Balance	NR	Three 50-min sessions per week for 9 weeks	NR	NR	Therapeutic	34 °C	NR

NR not reported, °*C* degree centigrades

2, 6, 18, 21, 25, 27, 34] reported the water temperature, which ranged between 28–34 °C. Similarly, eight studies [1, 2, 6, 18, 21, 27, 31, 34] included information about the depth of the water, which was between waist and chest height.

Outcome measurement

Nine studies [1, 2, 6, 18, 20, 21, 31, 34, 38] reported the specific effects of a WBE intervention on PD symptoms and related outcomes. The following variables were assessed by means of different measuring tools.

PD progression This parameter was assessed by means of the total score of the Unified Parkinson's Disease Rating Scale (UPDRS), which was only used in one study [38]. A significant effect of the WBE program on this variable was observed.

Motor function Four studies [1, 2, 31, 34] evaluated the impact of the WBE on the patients' motor function by means of part III of the UPDRS scale; they reported positive results. Thus, Therier et al. [34] and Ayán and Cancela [2] found a statistical significant effect (for the muscular resistance intervention only). Similarly, Sage et al. [31] and Ayán and Cancela [1] observed the existence of a slight improvement in this parameter.

Activities of daily living and disability After taking part in the WBE program, a significant improvement was found in this parameter by Ayán and Cancela [1]. This was observed after comparing the pre- and post-intervention scores obtained in the UPDRS-II, part II of the 39-item Parkinson's Disease Questionnaire (PDQ-39), and the Barthel Index.

Health-related quality of life This parameter was assessed in three studies. Ayán and Cancela [2] observed a significant influence of the two WBE programs performed by means of the PDQ-39. Therrien et al. [34] obtained similar results after using the Parkinson's Disease Quality of Life Questionnaire (PDQ-8). Crizzle and Newhouse [6] found no significant effect after analyzing the PD patients scores obtained in the Vitality Plus Scale.

Cognitive impairment In the first study by Ayán and Cancela [1], this parameter was assessed by means of a cognitive index, on the basis of the scores obtained in the UPDRS-II and PDQ39-VI subscales. No significant effect of the WBE intervention was observed.

Walking parameters Vivas et al. [38] found some improvements in the velocity, step amplitude, turn time, and cadence of the patients after the WBE program, although they did not reach statistical significance. Similar results regarding step amplitude and walking velocity were observed by Crizzle and Newhouse [6]. In the first case, patients walked along a 5-m walkway and turn round a pivot to come back to the starting position three times. In the second case, patients completed a 32-ft course.

Balance Four pilot studies were specifically aimed at analyzing the effect of a WBE program on this variable, with mixed results. For instance, according to the scores obtained in the Biodex Balance and in the Sit to Stand Test, Kawasaki [21] found a significant improvement. This was not the case for the Berg Balance Scale (BBS) and for the Activities-specific Balance Confidence Scale (ABCS). Similar results were obtained in the study by Jung et al. [18], except for the postural sway variable, which did not show a significant improvement. Kargarfard et al. [20] reported a significant effect of the WBE intervention after analyzing the BBS pre- and post-test scores. Finally, Therrien et al. [34] evaluated the patients' balance and postural control by means of the Balance Control System by NeuroCom, and observed improvements in the sensory organization and motor adaptation areas. Two studies [6, 38] assessed the effects of the proposed WBE intervention on different variables, including the patients' balance level and confidence. Thus, Vivas et al. [38] reported significant improvements according to the BBS pre- and post-test scores, and Crizzle and Newhouse [6] noted some improvements according to the results obtained in the static and dynamic balance test of the American Council on Exercise used in their research. This was not the case for the ABCS.

Functional mobility This parameter was assessed in four studies by means of the Get up and Go [6], Timed up and Go [38], 8-Foot up and Go [1], and Five Times Sit-to-Stand tests [2]. A positive influence of the WBE program on this variable was observed in all the interventions, although it was only statistically significant in one case [2].

Flexibility Three studies reported information about the effects of WBE on this variable, with controversial findings. For instance, Crizzle and Newhose [6] and Ayán and Cancela [1] used the flexibility tests of the Senior Fitness battery, but statistically significant improvements were only seen in the second study. This was also the case for the study by Vivas et al. [38] who used the Functional Reach Test.

Cardiorespiratory endurance and muscular strength Two studies used the Senior Fitness Test in order to measure the effects of the WBE program on these fitness parameters [6, 31]. Both parameters considerably improved after the intervention.

Aquatic versus land-based exercise

Six studies included a land-based exercise program in their design [18, 21, 25, 29, 31, 38]; four of them [18, 21, 31, 38] compared its effectiveness to that of water exercise performance. Sage et al. [31] observed that the WBE program was less effective than other three land-based exercise programs according to the score obtained by the patients in the UPDRS-III. Vivas et al. [38] observed that aquatic exercise was more effective than land-based exercise when trying to improve balance and the impact of the disease according to the scores obtained in the BBS and UPDRS. Finally, in the studies by Kawasaki [21] and Jung et al. [18], the practice of aquatic exercise showed better results in only some of the different tests which assessed the level of balance of the patients.

Withdrawals and adverse events

No subjective inconveniences or clinical manifestations of possible pathological changes specifically related to the WBE interventions were observed in seven studies [2, 20, 25, 27, 29, 31, 38]. In this regard, only two serious adverse effects were informed. Thus, Crizzle and Newhouse [6] reported that one patient left the study due to anxiety in the water, while Ayán and Cancela [1] informed that one patient developed an allergy to chloride. Jung et al. [18] reported three dropouts, but they did not state the reasons. Finally, Therrien et al. [34] and Kawasaki [21] did not provide information about this kind of events.

Discussion

The aim of this systematic review was to analyze the effectiveness of WBE exercise interventions in people with PD. The studies analyzed in this paper are comparable in that they targeted the same population (people with PD) using WBE as an intervention, and that they reported outcomes that displayed some similarities. After the analysis of the retrieved data, several findings are worth mentioning.

Firstly, regarding the methodological quality of the studies, it is worth to mention that very few studies included a true experimental design, and only three of them were classified as randomized [18, 21, 38]. This is the reason why the PEdro Checklist scale was not used to assess the methodological quality of the reviewed studies. Although it is widely used in physiotherapy-related systematic reviews, it only rates randomized clinical control trials, and consequently, most of the studies would not have been analyzed. Secondly, and in line with what has been previously mentioned, it must be pointed out that it was impossible to carry out a formal meta-analysis, since most of the studies reviewed were burdened with serious methodological flaws. For instance, three of the 12 analyzed studies [18, 21, 34] were published only as abstracts, hence, they were not formally peer reviewed and also lacked essential details.

Along this line, two studies [25, 29] also included a co-intervention of land therapy that made it difficult to interpret the results and establish which part of the treatment was causing the effect seen. Finally, only three trials [2, 31, 38] reached a quality score above 10 points and could be considered as good-quality research works. Thus, taking into account these facts, considering the small sample size and short duration of many of the included studies, and given the lack of randomized controlled trials, no meaningful meta-analysis could be performed [12, 28]. This lack of methodological quality studies when reviewing the effects of physical exercise in PD has already been previously observed [14, 35] and suggests the need for further improvement in this regard. One of the most interesting aspects about a systematic review of the effects of physical exercise modality on a specific population is the possibility to offer basic intervention guidelines so that its implementation can be guaranteed in a clinical environment.

A large number of the reviewed studies clearly stated the objective and characteristics of the proposed water exercises, mainly aimed at improving aerobic capacity, strength, balance, and postural control.

In general, sessions were carried out in warm, shallow swimming pools, although this information was not reported in all the studies. Most of the studies did not report how the exercise intensity was controlled, and only three of them [30, 34, 37] included an explanation about how the progression of the program contents was established. This was mainly based on the execution of more challenging and complicated movements. In fact, only one study provided complete and detailed information about how to effectively apply an aquatic exercise program to PD populations [2]. This lack of methodological rigor when describing the design and development of the WBE intervention makes it difficult for health and exercise professionals to safely and successfully replicate many of the interventions described in this review. It is also remarkable that most failed to name the skills and academic qualifications of the personnel who implemented and administered the intervention.

As regards the potential benefits of WBE for PD patients, some of the analyzed studies noted that this type of interventions may produce some improvements in motor function [1, 2, 31, 34], functional mobility [1, 2, 6, 38], fitness level (mainly balance) [18, 20, 21, 34], flexibility [1, 6, 38], and cardiorespiratory endurance [6, 31].

However, due to the low number of studies which included information about other variables [1, 38], such as PD progression, cognitive impairment, or activities of daily living, it cannot be stated with certainty that this positive effect is applicable to them.

In this line, the existing evidence about the influence that the WBE programs may have on the health-related quality of life seems to be contradictory; two studies [2, 34] observed positive results on this variable, whereas another one found no significant effects [6]. In any case, it must be taken into account that these results may be somehow influenced by the characteristics of the measuring tool (specific for PD in the first two previously mentioned studies; nonspecific in the third study).

Finally, judging from the findings of all the reviewed studies, the safety and the feasibility of WBE interventions in PD can be confirmed, since information on adverse events was collected on a relatively small number of subjects undertaking aquatic physical exercise.

This review study has not been able to establish the relevance of the water-based exercise to the different methods of therapeutic rehabilitation in PD or to determine which exercise program could be most appropriate. In fact, the results of the studies designed to compare the effects of the land- and water-based exercise programs did not allow determining the supremacy of one type of intervention over the other in a precise way [18, 21, 31, 37]. Along the same lines, only one study compared the effects of two different WBE programs [2], so scientific evidence in that regard is scant.

From the authors' point of view, it seems that the most important finding of this study is that very few rigorous trials about the effect of WBE on PD have been carried out up to date. This is surprising, since aquatic exercise is an officially recommended method for treating several neurological disorders [3], as well as for improving the PD patient's quality of life [26].

Under these circumstances, future studies about the effects of WBE on PD should take into account the following indications. First, randomized clinical trials with greater sample size are needed. Secondly, interventions should be described in detail so that the prescription of the aquatic exercise can be replicated in a medical environment with safety and effectiveness. Thirdly, given that PD is a multidimensional disease, studies should provide data on the effects of WBE interventions on a number of variables such as the number of falls, depression and anxiety, or freezing of gait, which have been almost omitted in the studies here reviewed. Finally, it seems important to compare the effectiveness of the WBE as opposed to other modalities of physical exercise which may be carried out by PD populations.

In closing, the results of this research synthesis support the hypothesis that WBE is a safe intervention for PD patients and provide scientific evidence about its potential benefits. However, there are a number of issues that strongly limit the strength of these findings. For instance, many of the investigations included in this review were general studies of aquatic exercise effectiveness that lacked appropriate power, and showed important methodological flaws related to aspects such as randomization, allocation concealment, and blinding to outcome measurement. Moreover, a considerable number of them were pilot studies which presented a single group. Therefore, the effect size could not be contrasted and the confidence interval could not be compared. In this line, the use of different measuring tools to assess the effect of the WBE intervention on the same parameter greatly hindered the comparative research of the results of the studies here analyzed.

Conclusion

There is a lack of good-quality studies about the effects of water-based exercise interventions in PD. Although aquatic exercise appears to be safe and to have some beneficial effects for PD patients, the controlled and randomized studies in this area are still too few so that the scientific evidence can be considered as definite. Higher-quality more comprehensive studies are therefore required.

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The data and results showed in this paper have not been published anywhere.

No animal or human studies were carried out by the authors for this article.

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