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ORIGINAL RESEARCH

Aquatic Exercise Therapy for People With Parkinson Disease: A Randomized Controlled Trial

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Abstract

Objective: To evaluate the effects of aquatic exercise therapy on gait variability and disability compared with usual care for people with Parkinson disease (PD).

Design: Single-blind randomized controlled trial.

Setting: Community-based hydrotherapy pool.

Participants: Individuals with PD (Hoehn-Yahr stages I–III) (N=21).

Interventions: Participants were randomly assigned to either an aquatic exercise therapy group (45min, twice a week for 6wk) or a group that received usual care.

Main Outcome Measures: The primary outcome measure was gait variability as measured using a motion capture system. Secondary outcomes were quality of life measured on the Parkinson's Disease Questionnaire-39 and freezing of gait and motor disability quantified by the Unified Parkinson's Disease Rating Scale. Feasibility was evaluated by measuring safety, adverse events, and participant satisfaction.

Results: People in the aquatic therapy group and usual care group showed similar small improvements in gait variability. The aquatic therapy group showed greater improvements in disability than the usual care group ($P<.01$). No differences between groups or over time were identified for freezing of gait or quality of life. Aquatic therapy sessions were safe and enjoyable with no adverse events.

Conclusions: Aquatic therapy appears feasible and safe for some people in the early stages of PD.

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Aquatic exercise therapy for people with Parkinson disease (PD) has become a recent focus of attention, given emerging evidence that physical activity has the potential to be both enjoyable and have neuroprotective effects.[1,2] PD is associated with impairments of movement, especially a reduction in step length and gait speed.[3,4] Freezing of gait also occurs in up to half of individuals with PD.[5,6] These gait disorders are associated with increased falls risk, with >60% of people with PD experiencing a fall every year.[7,8] Falls are associated with negative physical and psychological consequences, including physical injuries, loss of independence, fear of falling, and sometimes the need for residential care.[9,10]

Exercise, physical activity, and physiotherapy are core elements of a comprehensive rehabilitation program, alongside medical management of PD.[7,11] People with PD are encouraged to maintain adequate levels of physical activity throughout the course of the disease and try different forms of exercise over time, to maintain long-term exercise participation.[12,13] Aquatic therapy is one form of exercise for people with early PD, alongside strategy training,[14] progressive resistance strength training,[7,8] cycling,[15] tai chi,[16] therapeutic dancing,[17,18] and walking programs.[19,20] Aquatic therapy enables some people with PD to move more easily while reducing the fear of falling.[21,22] Aquatic therapy can also improve balance and functional mobility in some

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individuals with PD.[22-24] The current evidence to support the use of aquatic therapy to improve gait in adults with neurologic conditions including PD is mainly derived from small pilot trials.[25,26] The mixed outcomes of previous studies appear related to the variability in intensity and dose of the aquatic therapy, sample characteristics, and the outcome measures used to assess change.

The assessment of gait variability is recommended because research has shown a strong link between increased variability of gait and falls risk in people with PD.[27] Gait variability is a loss of consistency in the production of a steady, rhythmic gait.[27,28] Measuring variability using 3-dimensional gait analysis enables sensitive and reliable quantification of changes in gait performance over time.[29,30]

The primary aim of this study was to evaluate the effects of a 6-week aquatic therapy program compared with usual care on gait variability, motor disability, freezing, and health-related quality of life in people with mild to moderately severe PD. We hypothesized that, compared with a group that received usual care, the aquatic exercise therapy group would show reduced variability in step length, improved motor disability, less freezing, and improved quality of life. We also predicted that aquatic therapy would be viable and safe for people with PD.

Methods

Participants

A sample of convenience of 21 participants (14 men, 7 women; mean age, 71.42±4.9y) with idiopathic PD, who were deemed eligible to partake in the study by their chartered physiotherapist or specialist PD nurse, were recruited. Volunteers received an information leaflet about the study and were asked to provide written informed consent prior to participating in the study. Recruitment took place from March to May 2015. All volunteers lived in the Munster region of Ireland. Ethics approval was received from the Irish Health Service Executive, Hospital Scientific Research Ethics Committee (ethics no. 014/15).

Inclusion criteria were a diagnosis of idiopathic PD according to the UK Brain Bank Criteria[31] and confirmed by a neurologist, Hoehn and Yahr stages I through III, and stable medication status over the last 3 months.[32] Participants were required to be able to walk 10m 3 times, without assistance.[14] Participants were excluded if they had contraindications to aquatic therapy, including cardiovascular or pulmonary conditions,[22] previous history of deep brain stimulation,[7] or any musculoskeletal condition that affected their ability to participate in the exercise group.[26]

Twenty-one participants were randomized and allocated into 2 groups: the physiotherapy treatment group (n=11), who had aquatic therapy and usual care, and the usual care group (n=10), who continued with their usual care involving medication alone (table 1). Randomization was carried out using sequentially numbered sealed envelopes, and this procedure was conducted by a third party. Opaque envelopes were used to conceal allocation. All participants were blinded to group allocation.

List of abbreviations:

PD	**Parkinson disease**
RPE	**Rating of Perceived Exertion**
UPDRS	**Unified Parkinson's Disease Rating Scale**

Assessments

Assessments took place 1 week before the 6-week aquatic or usual care intervention (T1) and 1 week after intervention completion (T2). All assessments were carried out by a trained physiotherapist (L.M.C.). To minimize performance variability because of the effects of medication, participants were assessed at the same time of day, between 1 and 2.5 hours after their last medication dose ("on" medication phase).[33] Participants in both groups were instructed to continue with their usual care and advised not to change their typical exercise routine. Each participant was asked to inform the physiotherapist running the group of any changes to their medication or exercise habits throughout the 6 weeks of the trial.

Outcome measures

A dual Coda CX1 motion capture system[a] was used to analyze 3-dimensional gait and measure the primary outcome measure. This 3-dimensional system uses optical sensors fixed onto parallel rigid frames to detect infrared light signals, which were consecutively pulsed at a sampling rate of 200Hz from the markers positioned at anatomic landmarks on the lower body.[34] In accordance with previous research,[35] 20 active light-emitting diode markers were positioned on the pelvis and lower body segments bilaterally. The spatiotemporal gait variables measured were step length (distance between 2 consecutive footprints), step time (timing of the gait cycle for each step), and step width (distance between the mediolateral ankle joint centers).[36,37] Terminal swing end, initial contact, and toe off were selected manually within the Odin software (version 1.0)[b] using standardized definitions for the gait events.[38,39] Data were exported to SPSS version 22[c] for further analysis.

Procedure

Following a gait familiarization trial, participants were instructed to walk at their comfortable walking pace for a minimum of 10 trials on a 10-m walkway.[36] They were instructed to take rest breaks as required between each trial. Steps recorded during each test were combined across trials with a minimum of 60 steps (30 steps on the left, and 30 steps on the right).[36] Fifty or more steps is suggested as optimal when calculating gait variability,[36,40] with ≥10 gait trials recommended.[35] The SDs for left and right steps were calculated separately and then combined to determine gait variability.[36] The combined SD was determined by calculating the square root of the mean variance of the left and right steps.[36]

For the secondary outcome measures, health-related quality of life was quantified by the Parkinson's Disease Questionnaire-39.[41] Severity of PD was categorized using the Unified Parkinson's Disease Rating Scale (UPDRS) part III (motor).[42] Freezing was assessed using a 6-point freezing of gait questionnaire.[43] These tools have been found to be both valid and reliable measures[44-46] and were used in previous studies investigating the effects of aquatic therapy on people with PD.[32] Demographic details (eg, age, disease duration, weight, height) were also recorded for each participant.

The feasibility of implementing the aquatic therapy intervention was also assessed by recording adverse events (eg, falls, extreme fatigue, changes in PD symptoms) throughout the 6-week intervention phase. We also quantified levels of recruitment, attendance, and attrition rates. An exit questionnaire[47] captured the experiences and viewpoints of participants. The questionnaire incorporated a 5-point Likert scale to examine changes in health and well-being in the participants after the aquatic therapy intervention.[48]

Table 1 Demographic characteristics of participants at baseline and between-group differences

	Aquatic Group	Usual Care Group	Intervention vs Usual Care Differences, *P*
	Baseline T1	Baseline T1	
Sex, male:female	7:3	5:3	>.99
Age, y	69.5 (67.75–71.75)	74 (67–77)	.32
Hoehn and Yahr score	2.0 (1.5–2.25)	2.0 (1.625–2.88)	.63
Disease duration, y	7 (3.25–12.25)	10.5 (4.25–13.5)	.57
Step length, m	0.02 (0.02–0.03)	0.03 (0.02–0.03)	.90
Step time, s	0.02 (0.01–0.02)	0.02 (0.02–0.03)	.57
Step width, m	0.03 (0.03–0.04)	0.03 (0.03–0.04)	.83
UPDRS part III*	17.5 (8.75–21.25)	16.5 (10.25–21.25)	>.99
FOGQ†	5.5 (3.75–8.25)	5.0 (2.25–13)	.86
PDQ-39‡	19.87 (7.69–31.48)	21.47 (17.54–28.21)	.83

NOTE. Values are median (interquartile range) or as otherwise indicated.
Abbreviations: FOGQ, freezing of gait questionnaire; PDQ-39, Parkinson's Disease Questionnaire-39.
* UPDRS III includes a maximum score of 108 based on 27 items. Higher scores indicate greater effect of PD symptoms.
† FOGQ is a self-reporting questionnaire consisting of 6 items with a maximum score of 24. High FOGQ values were related to disease severity.
‡ PDQ-39 is a self-reporting questionnaire comprising 39 items. Items are scored as a percentage score ranging between 0 and 100. High score values are related to more problems because of PD.

Intervention

Participants in the intervention group attended aquatic therapy (two 45-minute sessions each week for 6wk) in a local hydrotherapy pool, which was 12m long and 6m wide with a graded depth, varying from 0.6 to 1.30m. The water temperature was set at 32°C, and air temperature was set at 31°C. A trained lifeguard was present on the pool deck at all times. Aquatic therapy was delivered by a physiotherapist with 8 years postgraduate experience in aquatic therapy. Aquatic therapy intervention occurred during the period from May to October 2015.

Defining the optimal intensity for aquatic gait training was determined from first principles because there was no standard measure for evaluating intensity of gait training in water for people with PD.[15] Each session comprised a cardiovascular and stretching warm-up for 10 minutes, followed by 25 minutes of specific gait training exercises based on recommendations recently published in the European Physiotherapy Guideline for Parkinson's Disease,[11] and a 10-minute cooldown (appendix 1). Many of the water-based exercises followed a water-specific therapy approach as outlined in Lambeck and Gamper.[49] Exercises were progressed according to individual ability by increasing the numbers of repetitions, the period of aerobic training, the amount of resistance, and the level of difficulty of a task (eg, walking with or without fins). A written recording of each class was completed by the physiotherapist to document each participant's self-reported performance, and the Borg Rating of Perceived Exertion (RPE) Scale was scored during each session.[50] Participants were monitored using a 1 to 10 Borg RPE Scale, which was used as a means of increasing both the intensity and challenge of the therapeutic protocol. When ratings were reported as <4 (moderate difficulty), a progression was introduced following the format outlined in appendix 1.

Statistical analysis

Sample size calculations were based on motor disability effect sizes from previous studies of people with PD.[23,32] An a priori sample size calculation, based on UPDRS part III scores with a 10% dropout rate, 80% power, and α set at .05, showed that we needed at least 10 participants in each group.

Preliminary descriptive analyses were generated for all variables to present the demographic and clinical characteristics of the groups. We checked to ensure that no differences between groups existed for baseline characteristics using independent *t* tests and chi-square analyses. Most variables were not normally distributed; hence, Mann-Whitney *U* tests were used to determine differences in variables for between-subject factors (aquatic therapy vs usual care), and Wilcoxon signed-rank tests were used for within-subject factors (T1 vs T2). Descriptive statistics included the median and interquartile range, with a *P* value <.05 considered to be statistically significant. SPSS version 22 was used for all statistical analyses.

Results

Of the 21 participants, 11 were randomized into the intervention group, with all completing the aquatic therapy program. Data from 1 participant were excluded from the final analysis because they received medical intervention for a flare up of fibromyalgia symptoms not related to PD just before testing. Ten participants were randomized into the usual care group, with the data from 2 participants being excluded prior to follow-up because of an episode of acute back pain and transportation difficulties (fig 1). Intention to treat analysis using last observation carried forward was carried out, including for the UPDRS part III.

There were no statistically significant differences between groups at baseline, including age, disease duration, and levodopa equivalent dose (see table 1). The pre-post test results are provided in table 2. There were no significant differences observed between groups for changes in gait variability over the course of therapy (see table 2). Nevertheless, after aquatic therapy, variability was reduced for step length (T1 median: .03; T2 median: .02) and step time (T1 median: .02; T2 median: .01). There were no changes in gait variability in the usual care group over the course of the study.

A key finding was a statistically significant improvement in motor disability in the aquatic therapy group, as shown by improvements in the UPDRS part III ($P=.01$). The effect size was 4.5 between the median values (13–17.5). Given the report by Shulman et al,[51] this difference in median scores would denote a moderate clinically important difference for the UPDRS motor score. There

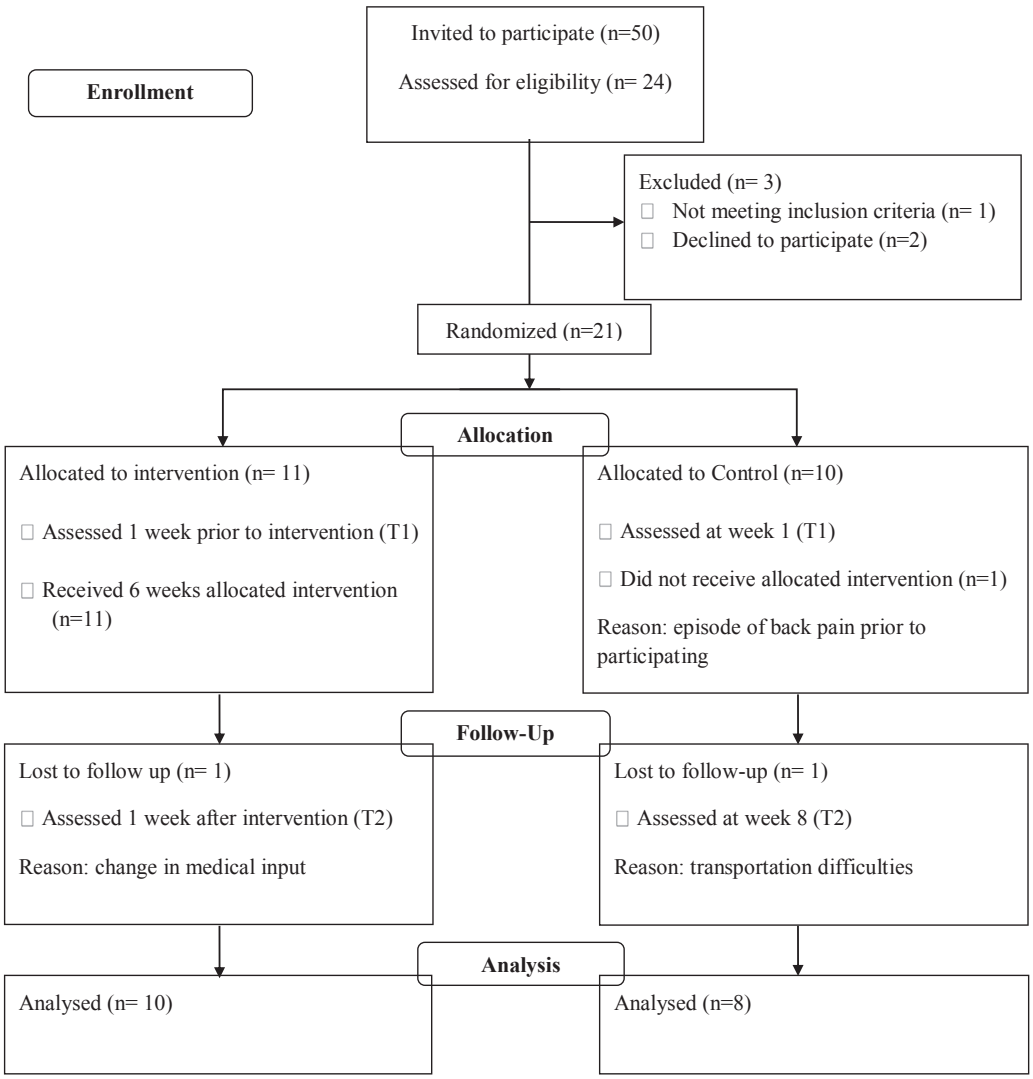

Fig 1 Flow diagram of study procedures.

was no difference between groups for the quality of life or freezing of gait questionnaires, with small improvements in scores observed for both questionnaires in the intervention group only.

Feasibility

The aquatic therapy was found to be feasible and safe, with no adverse events, extreme fatigue, or exacerbation of PD symptoms reported. There was no attrition in the intervention group; however, 2 participants attended 11 of the 12 sessions because of medical appointments. There was a 100% attendance recorded for the other participants.

The results from the exit questionnaire showed the aquatic exercise program to be very enjoyable, with 90% expressing a strong interest in continuing the classes (fig 2). Overall, 70% of participants reported improvements in their walking and confirmed that the program was challenging. Participants enjoyed being "challenged" and felt that "progression was evident in the skills taught." Most participants reported that walking with the "flippers (fins) was probably the most difficult but still beneficial." Most described the stepping-up exercises as the most beneficial exercise because it "brought about a sense of achievement and confidence in my walking." When asked which exercises included in the program were least beneficial, most reported that "all exercises had a purpose" and were "beneficial."

Discussion

This randomized trial showed that aquatic therapy was associated with improvements in motor function as measured by the UPDRS part III. Aquatic therapy was also feasible and safe in this sample of people with mild to moderately severe PD, with no adverse events reported. These findings are in agreement with the preliminary international trials by Vivas,[23] Ayán,[32] and colleagues.

Contrary to predictions, no significant group differences were found for the gait variability in relation to step length, step width, or step time. The negligible changes in gait variability might have been related to the relatively short intervention period. A 6-week intervention period was chosen based on local usual clinical practice, a previous research study in Spain,[23] and clinical guideline recommendations.[11] Although Vivas[23] found improvements in postural stability after 4 weeks of aquatic therapy (45 minutes

Table 2 Outcome variables at T1 and T2 and between-group differences

Variable	Aquatic Therapy Group (n = 10)		Usual Care Group (n = 8)		Intervention vs Usual Care Group
	T1	T2	T1	T2	Changes T1 to T2, *P*
Gait variability (SD)					
Step length (m)	0.03 (0.02–0.03)	0.02 (0.02–0.03)	0.03 (0.03–0.03)	0.03 (0.02–0.03)	.83
Step time (s)	0.02 (0.01–0.02)	0.01 (0.01–0.02)	0.02 (0.02–0.03)	0.02 (0.02–0.02)	.83
Step width (m)	0.03 (0.03–0.04)	0.03 (0.03–0.04)	0.03 (0.03–0.04)	0.03 (0.03–0.05)	.32
Secondary outcomes					
UPDRS III	17.5 (8.75–21.25)	13 (5.25–16.25)	16.5 (10.25–21.25)	16.5 (11.25–21.75)	.01*
FOGQ	5.0 (3.75–8.25)	3.5 (1–9)	5.0 (2.25–13)	6.5 (3.5–12.75)	.17
PDQ-39	19.87 (7.69–31.48)	14.10 (7.21–24.15)	21.47 (17.54–28.21)	23.08 (13.48–28.85)	.20

NOTE. Values are median (interquartile range) or as otherwise indicated.
Abbreviations: FOGQ, freezing of gait questionnaire; PDQ-39, Parkinson's Disease Questionnaire-39.
* Statistically significant.

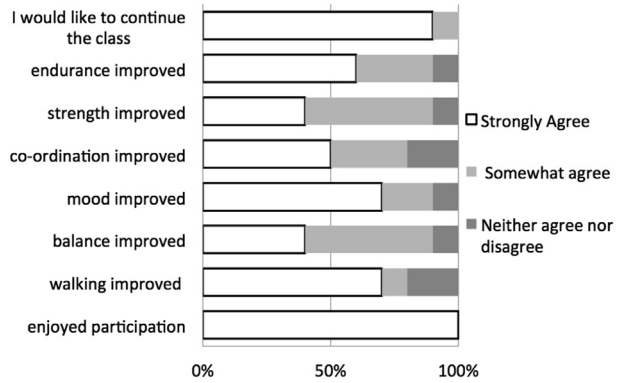

Fig 2 Aquatic group participant feedback. Questions were scored using a 5-point Likert scale (where 1 is strongly agree, 2 is somewhat agree, 3 is neither agree nor disagree, 4 is somewhat disagree, and 5 is strongly agree).

twice weekly), other studies reporting changes after aquatic therapy had interventions between 2 and 5 months.[22,25,26,32]

Aquatic therapy was challenging and enjoyable for the participants with PD in this study. Biomechanically, walking in water may be easier for people with PD because of an increased resistance to movement from the drag forces of water along with a reduction in actual body weight as a result of buoyancy forces.[24] Because the protocol used in this program may be adapted for larger controlled trials, further studies examining intensity, dose effects, and long-term benefits for aquatic therapy in PD are warranted. Efforts were made to monitor intensity throughout each class; however, the endurance and fitness levels of the participants were varied at baseline as indicated by the Borg RPE Scale, which resulted in participants progressing at different rates.

Recruitment of participants was challenging. Over half of the eligible participants declined, with an acceptance rate of 48%. Reasons given for not participating included an inability to swim, with few reporting a fear of water. This varies from other PD aquatic studies[22,32] and may reflect sample characteristics. To increase sample sizes, future studies should consider providing the aquatic therapy intervention across several centers and offering water confidence sessions, possible adopting a Halliwick approach,[49] prior to commencing the trial.

Study limitations

There were some limitations of this trial. First, the small sample size may have affected on the ability to detect significant changes in gait variability. The sample size calculation was based on an estimate of the changes reported for the UPDRS because at the time there were no other published studies which directly assessed the effects of aquatic therapy on gait variability. This study has a small sample size and generates new data that can be used for accurate sample size calculation for future studies, including for gait variability. Second, although testing occurred at the same time of the day, we could not rule out the bias introduced by fluctuations in levodopa plasma concentrations. Nevertheless, there were no changes to anti-Parkinson medication reported between T1 and T2 in each group. Although all patients were tested and treated during the on medication phase, the effect of aquatic therapy during the off state needs to be established. This trial tested people with early to middle stage PD, and the effects of aquatic therapy on people who are in the more advanced stages remains unknown.

Conclusions

In this small feasibility trial, group aquatic therapy delivered over a 6-week period did not improve gait variability to a greater extent than usual care. Aquatic exercise therapy was associated with improvements in motor disability and was safe, enjoyable, and feasible in the early stages of PD. Prospective large-scale randomized long-term studies are needed to establish whether group aquatic therapy can have a positive influence on gait and well-being in people with progressive neurologic conditions.

Suppliers

a. Coda CX1 motion capture system; Codamotion, Charnwood Dynamic Ltd.
b. Odin (version 1.0).
c. SPSS version 22; SPSS.

Keywords

Exercise; Gait; Hydrotherapy; Parkinson disease; Rehabilitation

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Appendix 1 Warm-Up (10min)

Cardiovascular exercises (moving around independently in multiple directions)

- Marching with arm swings
- Walking backward with knees straight
- Walking with leg curls
- Jogging
- Skipping
- Walking in slow motion (stepping with a 1-s pause before heel strike)
- Walking with longer strides
- Walking on heels
- Walking on toes

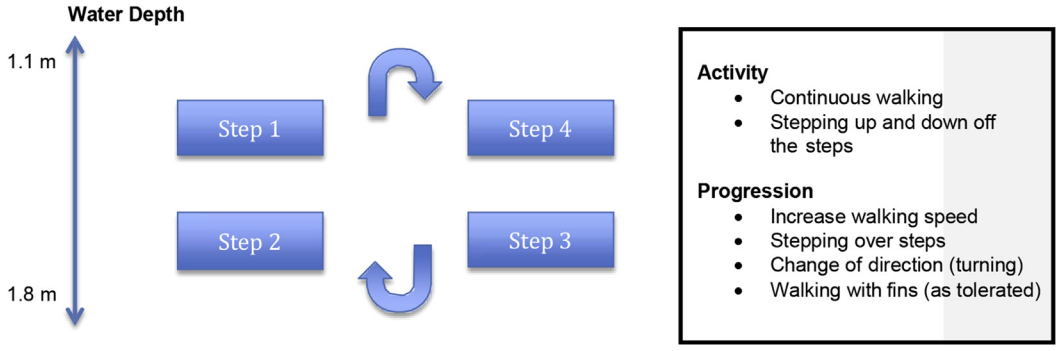
Upper body stretches

- Cervical rotation and side flexion (2 repetitions x 10-s hold bilaterally)
- Shoulder raises (2 repetitions x 5-s hold)
- Shoulder rolls (10 repetitions bilaterally)

Trunk stretches (with aqua noodle)

- Trunk rotation with arms abducted and externally rotated holding the aqua noodle (5 repetitions bilaterally)
- Arm raises reaching both arms overhead holding the noodle (5 repetitions bilaterally)
- Side bends pressing the aqua noodle into the water (5 repetitions x 5-s hold bilaterally)

Gait re-education (20min)



Strength exercises (10min)

(2min per exercise; 3 exercises selected per class, with as many repetitions carried out as possible within the time)

Circuits

- Sit to stand (using pool chair)
- Step-ups (progression: raising arms up and down holding the aqua noodle)
- Side step-ups
- Trunk rotation (performed standing back to back with a partner, passing ball x 10 repetitions bilaterally)
- Squats with aqua noodle
- Lunges

Group

- Single-leg stand (light finger hold at baseline progressed to 10s, with no hand support by session 12)
- Calf raises (10 repetitions at baseline progressed to 2 sets x 15 repetitions by session 12)
- Single-leg calf raises (5 repetitions at baseline progressed to 15 repetitions by session 12)
- Push downs with aqua noodle (15 repetitions at baseline progressed to 30 repetitions by session 12)

Cool-down (5min)

(Performed standing by pool wall at water depth level of T8 vertebrae, 30-s hold x 3 repetitions)

- Quadriceps, hamstring, and calf stretches performed using aqua noodle

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