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# REHABILITATION SECTION

## *Original Research Article*

# Effects of Different Frequencies (2–3 Days/Week) of Aquatic Therapy Program in Adults with Chronic Low Back Pain. A Non-Randomized Comparison Trial

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### Abstract

**Objective. To study the effects of an aquatic therapy program with different frequencies (2 vs 3 days per week) in chronic low back pain.**

**Desing. Non-randomized comparison trial.**

**Setting. Sport and spa community health club.**

**Subjects. Fifty-four adults with chronic low back pain (48.9 ± 10.0 years).**

**Intervention. Eight-week aquatic therapy program.**

**Outcome Measures. Pain (visual analog scale [VAS]), disability (Oswestry Disability Index), and quality of life (Short-Form Health Survey 36), body composition (weight, body mass index, body fat mass, body fat percentage, and skeletal muscle mass), and health-related fitness (sit and reach, handgrip strength, curl-up, Rockport 1-mile test).**

**Results. Both experimental groups presented significant improvements in low back pain and disability (*P* < 0.001) compared with control group. The 3 days/week group showed significantly greater benefits at VAS flexion and disability (*P* < 0.001) than the 2 days/week group. Regarding quality of life, both intervention groups presented significant differences for Physical Role (*P* < 0.05), Bodily Pain (*P* < 0.001), General Health (*P* = 0.012), and Standardized Physical Component (*P* < 0.001) compared with control group. Both experimental groups significantly improved all health-related fitness parameters (*P* < 0.01). The 3 days/week group showed significantly greater benefits at curl-up and heart rate (*P* < 0.001) than the 2 days/week group. No significant changes between treatment groups and control were found in body composition.**

**Conclusions. Eight weeks of aquatic therapy program decrease levels of back pain and disability, increase quality of life, and improve health-related fitness in adults with chronic low back pain without effects in body composition. A dose–response effect was observed in some parameters, with greater benefits when exercising 3 days per week compared with 2 days.**

**Key Words. Aquatic Exercise; Chronic Low Back Pain; Disability; Quality of Life; Body Composition; Physical Fitness**

### Introduction

Exercise therapy is recommended as first-line treatment for patients with chronic low back pain (CLBP) [1]. Given the high prevalence and significant economic costs of low back pain, cost-effective management of low back pain requires community-based approaches that use existing infrastructure to help individuals prolong function, minimize pain, and maintain quality of life (QoL) [2].

Research has consistently demonstrated that impairments in strength [3,4], flexibility [5,6], endurance [7], and obesity [8] are present in many patients with CLBP. Recent systematic reviews of exercise have each concluded that exercise is an effective therapy for CLBP [9,10]. These exercise programs, according to several clinical trials, are effective in decreasing the incidence and duration of CLBP episodes by improving strength and endurance of muscles, by increasing flexibility of soft tissues and aerobic capacity, thus reducing pain and disability, and improving QoL [1,11,12].

Exercising in water has become increasingly popular, and it has been reported that therapeutic aquatic exercise appears to be a safe and effective treatment modality for patients with low back pain [13–17]. Water immersion decreases axial loading of the spine and, through the effects of buoyancy, allows the performance of movement that are normally difficult or impossible on land [18]. By utilizing the unique properties of water (buoyancy, resistance, flow, and turbulence), a graded exercise program from assisted to resisted movements can be created to suit the patients' needs and function. Aquatic exercise may improve pain and disability, and maintain QoL in patients with CLBP [19], especially in individuals with low levels of physical fitness [20,21]. These findings suggest the potential benefits of aquatic exercise for people with CLBP.

In previous studies on therapeutic aquatic exercise and CLBP, authors found that most trials demonstrated major flaws in their methodology and were in most cases not well reported; often the details of the intervention were completely absent [22,23]. The frequency of the aquatic exercise sessions per week and outcomes measured varied considerably in the different studies, and some of them did not have a control group, which makes comparison difficult. To the best of the authors' knowledge, only one study has investigated the effects of different amounts of sessions per week of aquatic therapy, with 7 patients exercising once per week, 19 patients twice per week, and 9 patients three or more times per week [24]. However, the program consisted of exercise performed outside or inside the swimming pool, not only aquatic therapy. Thus, more controlled trials are needed to clarify the frequency of the aquatic exercise sessions per week in the management of CLBP.

The purpose of the non-randomized comparison trial was to study the effects of an 8-week aquatic therapy program with a frequency of 2 and 3 days per week on pain, disability, and QoL (primary outcomes), and body composition and health-related fitness (secondary outcomes) in men and women with self-reported CLBP.

## Methods

### *Participants*

A total of 78 sedentary adults with CLBP volunteered to participate in this study. They were all recruited in Massam Sport Center (Granada, Spain); this contact followed their referral for aquatic exercise by their medical practitioner, and received written and oral instructions about the intervention, test protocol, and the possible risks and benefits of the study. The inclusion criteria for this study were: age between 18 and 65 years, and presence of self-reported low back pain for more than 12 weeks [25]. Exclusion criteria were: symptoms or signs that might suggest serious medical illness; pregnancy or recent childbirth; major rheumatologic, neurologic, neoplastic, or other conditions that may prevent full participation in the intervention; previous spinal surgery; inflammatory, infectious, or malignant diseases of the vertebra; presence of severe cardiovascular disease; presence of any psychiatric disorder which might affect the compliance and the assessment of symptoms; and engagement in physical activity ≥60 minutes per week during the last 12 months [26].

A total of four patients were eventually not included in the study (three not meeting inclusion criteria and one refused to participate). Therefore, a final sample of 74 completed all requirements of this study. The study flow of participants is presented in Figure 1. The sociodemographic characteristics of participants in the intervention and usual care groups are shown in Table 1.

### *Study Design*

The present study was a non-randomized comparison trial with allocation of participants into the two experimental groups, experimental group 2 days per week (EG2d, N = 24) and experimental group 3 days per week (EG3d, N = 24), or waiting list (Control Group, N = 26). We had an ethical obligation with the Massam Sport Center (Granada, Spain) to provide treatment to all patients willing to participate in the study, for this reason, randomization was not possible. However, due to the limitations of the available resources concerning aquatic exercise, a waiting list was created and patients in this list agreed to be part of the usual care group (CG) being then offered the same intervention program, in the same center after the follow-up period. The control group received different recommendations about adequate posture, healthy lifestyle, and information about exercises contraindications for CLBP patients. For those subjects in the waiting list, data collected only during the control period were included in the current analysis. The sport center only accepts eight subjects per group in a total of six groups of aquatic physical therapy (three for EG2d and three for EG2d). Each participant was allocated to a treatment group according to their time availability. Throughout the study, all participants (including those in the CG) were encouraged to maintain their normal dietary habits and physical activity level.

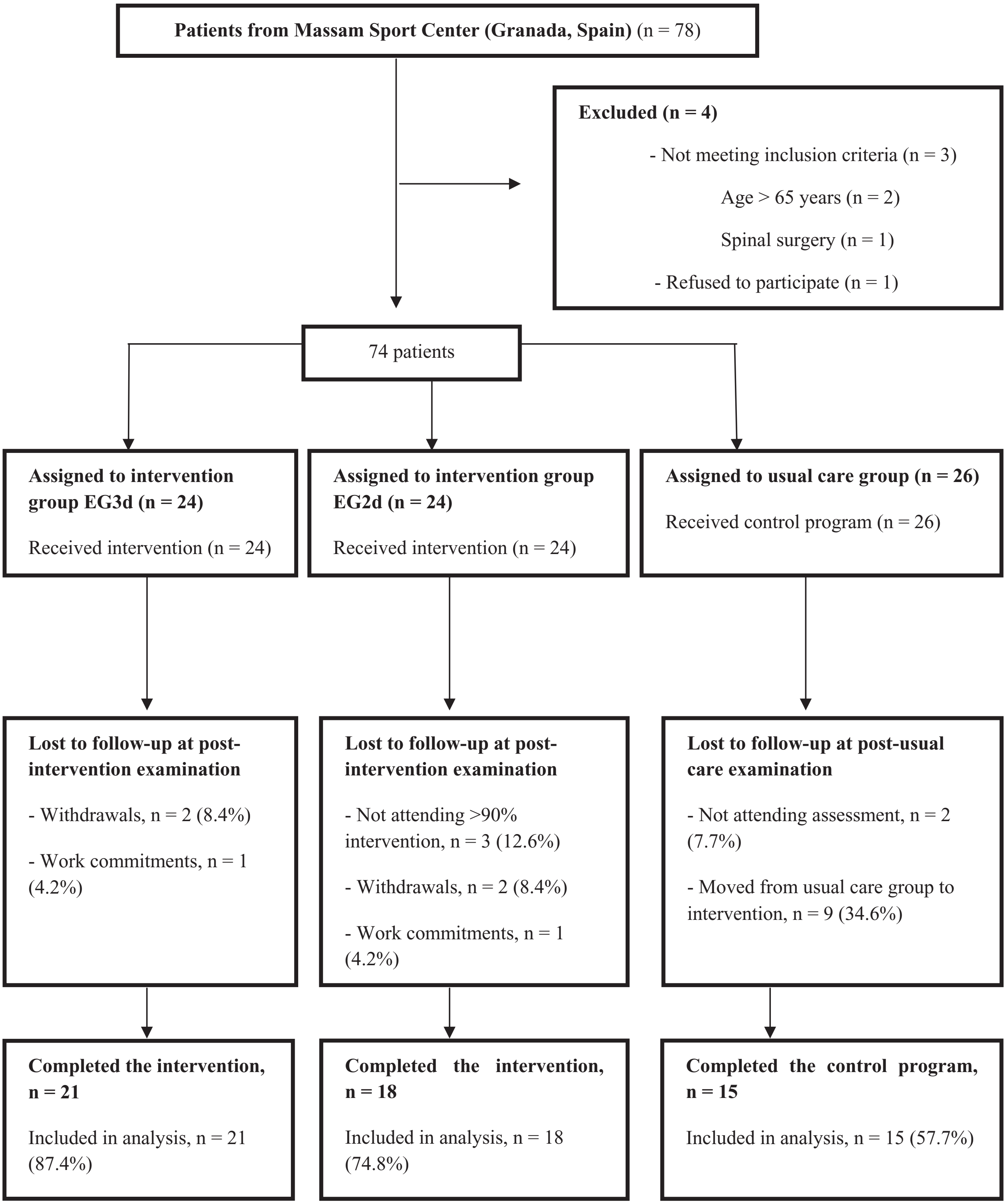


**Figure 1** Flow of patients throughout the trial. EG2d = experimental group 2 days per week; EG3d = experimental group 3 days per week.

**Table 1** Sociodemographic characteristics of participants by group

| Variable | CG (N = 15) | EG2d (N = 18) | EG3d (N = 21) | *P* Value* |
|---|---|---|---|---|
| Gender, N (%) | | | | 0.905 |
| Men | 7 (46.7) | 9 (50.0) | 9 (42.9) | |
| Women | 8 (53.8) | 9 (50.0) | 12 (57.1) | |
| Age, years ± SD | 44.93 ± 9.70 | 50.17 ± 9.72 | 50.67 ± 10.22 | 0.197 |
| Civil status, N (%) | | | | 0.025 |
| Married | 9 (60.0) | 17 (94.4) | 13 (61.9) | |
| Unmarried | 5 (33.3) | 0 (0.0) | 3 (14.3) | |
| Separated/divorced/widowed | 1 (6.7) | 1 (5.6) | 5 (23.8) | |
| Educational status, N (%) | | | | 0.003 |
| Unfinished studies | 0 (0.0) | 3 (16.7) | 0 (0.0) | |
| Primary school | 3 (20.0) | 5 (27.8) | 9 (42.9) | |
| Secondary school | 10 (66.7) | 2 (11.1) | 4 (19.0) | |
| University degree | 2 (13.3) | 8 (44.4) | 8 (38.1) | |
| Occupational status, N (%) | | | | 0.811 |
| Housewife | 2 (13.3) | 3 (16.7) | 4 (19.0) | |
| Student | 0 (0.0) | 0 (0.0) | 0 (0.0) | |
| Working | 10 (66.7) | 8 (44.4) | 9 (42.9) | |
| Unemployed | 2 (13.3) | 3 (16.7) | 3 (14.3) | |
| Retired | 1 (6.7) | 4 (22.2) | 5 (23.8) | |

* Independent *t*-test or $\chi^2$–Pearson test.
CG = control group; EG2d = experimental group 2 days per week; EG3d = experimental group 3 days per week; SD = standard deviation.

Written informed consent was obtained before participation. The study was approved by the Ethical Committee of the University of Granada and was performed in accordance with the Helsinki Declaration, last modified in 2000.

*Intervention Program*

The 8-week aquatic therapy program consisted of 16 and 24 sessions in EG2d and EG3d, respectively (Table 2), and no exercise sessions in CG. The aquatic therapy program was carried out in an indoor pool sized 25 × 6 m, with 140-cm water depth, 29 ± 1°C of water temperature, and 32°C of room temperature. Before aquatic therapy program, participants took part in one session of exercises with no external resistance to familiarize with the movements in the aquatic environment and the flotation material. During this session, the participants also familiarized themselves with the use of the rating of perceived exertion (RPE) scale from 6 to 20 [27], exercising at different intensities. The aim was to use this scale during the 8 weeks to control the intensity of the aerobic exercises. Participants were asked not to change their medication during the 2-month intervention period.

*Aquatic Therapy Program*

Each aquatic therapy session was conducted in reduced groups of eight participants and lasted 55–60 minutes. They were closely supervised by trained exercise specialists and a physiotherapist with 5 years of previous experience with similar programs. Each session included 10 minutes of warm-up, 15–20 minutes of resistance exercise, 20–25 minutes of aerobic exercise, and 10 minutes of cooldown (stretching exercises).

Resistance Exercises

The resistance exercises progressed throughout the program by changing the number of repetitions per set (volume), by including specific resistance material that increase the resistance offered by the water, and by increasing the velocity of the movements [28]. Noodles and cuff devices were used for upper body and lower body exercises, respectively. Each training session included the following resistance exercises: hip flexion–extension, hip abduction–adduction, arms abduction–adduction at chest level, curl-ups, scissors leg, backstroke kick with water noodle under the waist.

Aerobic Exercises

The planning of the aerobic exercises was done considering the intensity (Borg scale 6 to 20) and the volume (minutes). The Borg scale has showed adequate reliability to quantify training loads during aquatic exercise [29]. The aerobic exercises incorporated large muscle mass and consisted of lateral displacements; long-lever pendulum-like movements of the extremities; forward and backward jogging with arms pushing, pulling, and pressing; leaps;

**Table 2** Aquatic therapy program in each experimental group

Experimental Group 3 Days per Week (EG3d)

| Type of Exercise | | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Number of Sessions | Adherence to the Program |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Resistance | Volume (sets × repts) | 3 × 12 | 3 × 12 | 3 × 15 | 3 × 15 | 3 × 12 | 3 × 12 | 3 × 15 | 3 × 15 | 24 | 93% |
| | Intensity | No resistance material<br>Low velocity | | | | With resistance material<br>High velocity | | | | Total volume of aerobic exercise = 525 minutes | |
| Aerobic | Volume (minutes) | 60 | 60 | 75 | 75 | 75 | 60 | 60 | 60 | | |
| | Intensity (RPE scale) | | | 10–12 | | | | 12–15 | | Total volume of flexibility exercises = 240 minutes | |
| Flexibility | | 10 minutes, 3 × 20 seconds per exercise | | | | | | | | | |

Experimental Group 2 Days per Week (EG2d)

| Type of Exercise | | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Number of Sessions | Adherence to the Program |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Resistance | Volume (sets × repts) | 3 × 12 | 3 × 12 | 3 × 15 | 3 × 15 | 3 × 12 | 3 × 12 | 3 × 15 | 3 × 15 | 16 | 97% |
| | Intensity | No resistance material<br>Low velocity | | | | With resistance material<br>High velocity | | | | Total volume of aerobic exercise = 350 minutes | |
| Aerobic | Volume (minutes) | 40 | 40 | 50 | 50 | 50 | 40 | 40 | 40 | | |
| | Intensity (RPE scale) | | | 10–12 | | | | 12–15 | | Total volume of flexibility exercises = 160 minutes | |
| Flexibility | | 10 minutes, 3 × 20 seconds per exercise | | | | | | | | | |

repts = repetitions; RPE = rating of perceived exertion.

kicks; leg crossovers; hopping movements focusing on traveling in multiple directions; and bounding off the bottom of the pool. Heart rate (HR) was assessed using the POLAR 610 heart-rate monitor (Polar Electro OY, Kempele, Finland) at different moments of the program when patients were out of pool. Participants were monitored in different sessions to assess if the intensity recommendations were followed.

#### Flexibility Exercises

Lower body stretching exercises were performed at the end of each session, as part of the cooldown. The muscle groups to stretch were gluteus, lumbar back, and hamstrings. A static stretching technique was used, where the posture was achieved in 5 seconds, maintained during 20 seconds in its maximum amplitude without pain, and 5 seconds to go back to the initial posture, repeated three times per exercise [30].

### *Testing Procedure*

After agreeing to participate and completing the informed consent form, all participants attended two initial measurement sessions, where back pain, disability, QoL, body composition, and health-related fitness were measured. Assessment sessions were carried out prior to the start and immediately after the exercise therapy intervention. All testing sessions were conducted by the same researcher.

Testing took place in laboratory conditions at 24°C temperature in two sessions. In the first day, participants were evaluated for (in this order) body composition, sit and reach test, handgrip strength, and curl-up test. In the second day, the questionnaires Quality Short-Form Health Survey 36 (SF-36), Oswestry low back pain disability questionnaire (Oswestry Disability Index, ODI), and visual analog scale (VAS), as well as the Rockport 1-mile test were administered. Resting HR was also measured.

#### Pain, Disability, and QoL (Primary Outcomes)

Three different questionnaires were used to evaluate self-estimated participants' level of pain, disability, and QoL.

1. Back pain was assessed at rest and during movement (flexion and extension) with a VAS, ranging from 0 to 10 cm (0 means no pain, 10 means highest level of pain). The reliability and validity of VAS have previously been found to be acceptable [31], and the minimal clinical important change has been estimated to be 15 mm in patients with low back pain [32].
2. The Spanish version of the Oswestry low back pain disability questionnaire [33] was used to measure back-related disability of activities of daily living. The sum of the response scores was calculated and presented as a percentage, where 0% represents no pain or disability and 100% represent the worst possible pain and disability. The reliability and validity of ODI have previously been found to be acceptable [33], and the minimal clinical important change has been estimated to be 10% [32].
3. The SF-36 is a generic instrument assessing health-related QoL. In this study, we used the Spanish version of SF-36 [34]. It contains 36 items in eight domains (parameters): physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health. These eight parameters can be used to derive two composite scoring summaries: physical composite summary (physical functioning, role physical, bodily pain, and general health perceptions) and mental composite summary (vitality, social functioning, mental health, and role emotional). The SF-36 is a sensitive measure of treatment success in patients with low back pain [35]. Each domain is scored on a scale from 0 (worst possible health) to 100 (best possible health).

#### Body Composition (Secondary Outcome)

Body composition was measured using Octapolar bio-impedance analyses (Biospace Inbody 720; Biospace Company, Ltd, Seoul, Korea). Biospace Inbody analyzer has been found in the literature to be reliable in the calculation of body composition [36]. We measured weight (kg), body fat mass (kg), body fat percentage (%), and skeletal muscle mass (kg). Height was measured in the Frankfurt plane with a telescopic height-measuring instrument (Type SECA 225, Frankfort, KY, USA; range, 60 to 200 cm; precision, 1 mm). Body mass index (BMI) was calculated ($kg/m^2$).

#### Health-Related Fitness (Secondary Outcome)

1. Trunk flexion and hamstring tone were determined via the sit and reach test, as described by the American College of Sports Medicine's (ACSM) protocol [30]. The test was performed twice, and the best result in centimeters was recorded. If the ruler was somewhere between two centimeters, the lower one was scored.
2. Upper body isometric strength was assessed by using handgrip strength test. A hand dynamometer with adjustable grip was used (TKK 5101 Grip D; Takey, Tokyo, Japan). The patients squeezed gradually and continuously for at least 2 seconds, performing the test with the right and left hands in turn, with the elbow in full extension. The test was performed twice and the maximum score for each hand was recorded in kilograms. Optimal grip was noted for each participant in the pretest, and repeated in the posttest. The sum of the scores achieved by left and right hands was used in the analysis [37].
3. Abdominal muscular endurance was measured using the curl-up test [30]. The subjects were allowed to practice a few repetitions before testing. The cadence for the test was 40 beats/min, paced by a metronome. The test was terminated when the subject was unable to maintain the required cadence or unable to maintain the proper curl-up technique for two consecutive repetitions despite feedback from the researcher. A maximum of three corrections were allowed by the

appraiser before termination of the test. The highest number of repetitions completed while maintaining proper form was recorded.

4. Cardiorespiratory fitness was determined by using the Rockport 1-mile test. This test is recommended by the ACSM [30] to choose the level of practice in cardiovascular exercises for people with low fitness (sedentary). The time (minutes and seconds) employed by each participant to cover the distance, together with his/her HR at the end of the test, was registered. Maximal oxygen uptake ($VO_{2max}$) was estimated as described by Berger [38], considering gender, age, weight, time, and HR. The validity of Rockport 1-mile test has previously been found to be acceptable [39].
5. Resting HR
   Patients were instructed in the procedure of measuring their pulse, and then were asked to register resting HR manually at home, from the carotid artery using a stopwatch. They registered resting HR in four nonconsecutive days during pretest and posttest weeks: in the morning before getting up or after staying in prone position for at least 30 minutes. The average HR among the four measurements was used as resting HR before and after the intervention.

### *Statistical Analyses*

One-way analysis of the covariance (ANCOVA) was used to compare participants' characteristics by groups, both at baseline (pretest) and follow-up (posttest). In these models, the outcome variables (pain, disability, QoL, body composition, and fitness) were entered as dependent variables, group was used as fixed factor, while sex and age were used as covariates [40]. To analyze the effects of the training program we used ANCOVA with post-pre differences as dependent variables, group as fixed factor, and sex, age, and the baseline level of the variable as covariates. Bonferroni's adjustments were used for pair wise comparisons (*post hoc*). The analyses were not adjusted for the number of sessions actually performed, as the adherence to the intervention was very high: all participants performed at least 97% (15 from a total of 16) and 93% (22 from 24) of the sessions in EG2d and EG3d, respectively. Intergroup effect sizes were calculated (d, *Cohen*) to provide information about the change magnitude. Due to the small number of missing data, we included in the analyses those subjects who completed both the pretest and posttest evaluations and, thus, it was not necessary to employ imputation methods. Data analyses were performed using PASW statistical package version 18.0 (SPSS Inc., Chicago, IL, USA). Significance level was set at $P < 0.05$.

## Results

Six participants from the intervention groups discontinued the program due to withdrawals or work commitments (three in each intervention group), and the other three participants were excluded for attending less than 97% of the program in the EG2d group (attendance: 76.6%). During the study period, nine patients (34.6%) changed from the CG (waiting list) to the intervention group—their data were not included in this report, and two more patients from CG (7.7%) did not attend final assessment. Finally, a total of 21 (87.4%) patients from the EG3d, 18 (74.8%) from the EG2d, and 15 (57.7%) from the CG completed both pre and post intervention assessments and were included in the analysis (Figure 1).

Back pain (VAS at rest, in flexion, and in extension) and disability (ODI) results are shown in Table 3. The ANCOVA with post-pre differences showed significant differences in both experimental groups in VAS and ODI ($P < 0.001$) compared with CG. Significant differences were also noted between EG2d and EG3d: EG3d experimented significantly greater improvements at VAS flexion and disability compared with EG2d ($P < 0.001$).

QoL results are given in Table 4. We observed significant differences between groups in Physical Role ($P < 0.05$), Bodily Pain ($P < 0.001$), General Health ($P < 0.05$), and Standardized Physical Component ($P < 0.001$). All these parameters improved in EG2d and EG3d compared with CG.

Intervention effects on body composition are displayed in Table 5. The ANCOVA with post-pre differences showed no significant differences between groups in body composition. The results in health-related fitness are given in Table 6. Significant differences ($P < 0.001$) were observed between groups in sit and reach, handgrip, curl-up, $VO_{2max}$, and resting HR. Both experimental groups (EG2d and EG3d) improved all these fitness parameters compared with the CG. EG3d presented significantly greater improvements compared with EG2d in curl-up, resting HR, and HR in the Rockport 1-mile test ($P < 0.05$).

## Discussion

The principal finding of this study was the dosage effect of aquatic exercise in CLBP. An aquatic therapy program performed 3 days per week had a greater effect in VAS at flexion, ODI, curl-up, and HR at rest and post effort than 2 days per week.

This study sought to determine the effectiveness of an aquatic therapy program, with a frequency of two and three sessions per week, as a rehabilitation strategy for patients with CLBP. In general, the present data provide further support that aquatic therapy program is effective at inducing meaningful changes in back pain, disability, and QoL; musculoskeletal strength; aerobic fitness; and flexibility using either 2 or 3 days per week. We observed significant improvements in back pain levels from baseline, where VAS at rest decreased 49% and 61%, VAS in flexion decreased 39% and 68%, and VAS in extension decreased 46% and 74% in EG2d and EG3d, respectively. We observed significant improvements in disability levels from baseline, where ODI decreased 27% and 57% in EG2d and EG3d, respectively. Our results in these parameters (back pain and disability) exceeded the estimated minimal clinical important changes in patients with low back pain [32] in both experimental groups.

**Table 3** Effects of an 8-week aquatic therapy program on pain (visual analog scale [VAS] at rest, flexion, and extension) and back-related disability (Oswestry Disability Index)

| | Pretest* | Posttest* | Differences (Post-Pre)† | Effect Size |
|---|---|---|---|---|
| VAS at rest (cm, 0–10) | | | | |
| CG | 6.6 ± 0.6 | 7.0 ± 0.5 | 0.5 ± 0.4 | EG2d vs CG = 2.25 |
| EG2d | 5.9 ± 0.5 | 3.2 ± 0.5 | –2.9 ± 0.3‡ | EG3d vs CG = 2.96 |
| EG3d | 6.4 ± 0.5 | 2.5 ± 0.5 | –3.9 ± 0.3‡ | EG3d vs EG2d = 0.71 |
| *P* value | 0.643 | <0.001 | <0.001 | |
| VAS at flexion (cm, 0–10) | | | | |
| CG | 6.6 ± 0.6 | 7.2 ± 0.5 | 0.7 ± 0.4 | EG2d vs CG = 2.25 |
| EG2d | 6.1 ± 0.6 | 3.8 ± 0.4 | –2.4 ± 0.3‡ | EG3d vs CG = 3.56 |
| EG3d | 6.2 ± 0.5 | 2.1 ± 0.4 | –4.2 ± 0.3‡§ | EG3d vs EG2d = 1.32 |
| *P* value | 0.829 | <0.001 | <0.001 | |
| VAS at extension (cm, 0–10) | | | | |
| CG | 6.0 ± 0.8 | 6.1 ± 0.6 | 0.5 ± 0.4 | EG2d vs CG = 2.03 |
| EG2d | 5.4 ± 0.7 | 2.8 ± 0.5 | –2.5 ± 0.3‡ | EG3d vs CG = 2.61 |
| EG3d | 4.6 ± 0.6 | 1.5 ± 0.5 | –3.4 ± 0.3‡ | EG3d vs EG2d = 0.61 |
| *P* value | 0.383 | <0.001 | <0.001 | |
| Oswestry Disability Index (scores, 0–100) | | | | |
| CG | 32.2 ± 3.5 | 33.7 ± 3.0 | 2.1 ± 1.5 | EG2d vs CG = 1.60 |
| EG2d | 26.2 ± 3.1 | 19.9 ± 2.7 | –7.1 ± 1.3‡ | EG3d vs CG = 3.42 |
| EG3d | 30.8 ± 2.9 | 13.1 ± 2.5 | –17.5 ± 1.2‡§ | EG3d vs EG2d = 1.82 |
| *P* value | 0.395 | <0.001 | <0.001 | |

Data are estimated means ± standard errors.
* Analysis of the covariance (ANCOVA) with sex and age as covariates.
† ANCOVA with sex, age, and baseline level as covariates, and Bonferroni's adjustments for *post hoc* comparisons.
‡ Significantly different from CG ($P < 0.05$).
§ Significantly different from EG2d ($P < 0.05$).
CG = control group (N = 15); EG2d = experimental group 2 days per week (N = 18); EG3d = experimental group 3 days per week (N = 21).

We also observed an increase in several domains of health-related QoL in both experimental groups. These changes were accompanied by improvements in fitness, suggesting a possible mechanism by which aquatic exercise could be effective for the management of CLBP. Body composition parameters (weight, BMI, body fat mass and percentage, and skeletal muscle mass) showed a very slight improvement, but the differences before and after the intervention were not statistically significant. These findings were similar to those reported in previous studies [14,41], suggesting that these aquatic exercise programs were not enough stimulus to affect body composition.

Regarding the number of sessions per week, both experimental groups presented significant improvements in back pain (VAS) after the intervention, but EG3d had a greater improvement in VAS at flexion than EG2d. These findings are similar to those reported in previous studies where patients exercised three sessions per week. Yozbatiran et al. [14] studied 30 patients with CLBP, allocated to either aquafitness group (N = 15) or land-based fitness group (N = 15), where aquafitness group achieved a total of 12 sessions, three per week for 4 weeks. The aquafitness program consisted of warm-up and stretching exercises followed by a circuit of 15 progressive exercises, and cooldown with stretching and light aerobic exercise, according to the program described by Frost et al. [42]. At the end of this study, patients improved significantly in back pain ($P < 0.05$), with a reduction of 65% in VAS. Similarly, Saggini et al. [13] observed a reduction of back pain of 70% in VAS after an aquatic program of 3 days per week for 7 weeks ($P < 0.01$). However, none of these studies had a control group in their study, making comparison difficult. In our study, we had a control group, and our study registered more variables in VAS (at rest and at movement: flexion and extension) than previous studies [13,14].

Our study and previous studies [13,14] registered better results in percentage of back pain improvement compared with those reported by Sjogren et al. [43], whose participants attended two sessions of 50 minutes per week during 6 weeks in resistance, aerobic and flexibility exercises. At the end of the study, results indicated that the aquatic exercise group had a 25% improvement in VAS, compared with improvements of 65–74% in our

**Table 4** Effects of an 8-week aquatic therapy program on quality of life (Short-Form 36 Health Survey)

| | Pretest* | Posttest* | Differences (Post-Pre)† | Effect Size |
|---|---|---|---|---|
| Physical functioning (scores, 0–100) | | | | |
| CG | 73.5 ± 6.0 | 75.5 ± 4.2 | 3.7 ± 3.9 | EG2d vs CG = 0.41 |
| EG2d | 71.3 ± 5.4 | 81.1 ± 3.7 | 9.9 ± 3.4 | EG3d vs CG = 0.40 |
| EG3d | 69.2 ± 5.0 | 80.3 ± 3.5 | 9.8 ± 3.2 | EG3d vs EG2d = 0.01 |
| *P* value | 0.862 | 0.585 | 0.424 | |
| Physical role (scores, 0–100) | | | | |
| CG | 64.7 ± 11.7 | 58.0 ± 10.8 | 0.3 ± 8.6 | EG2d vs CG = 0.84 |
| EG2d | 44.2 ± 10.4 | 73.6 ± 9.6 | 28.0 ± 7.5 | EG3d vs CG = 0.80 |
| EG3d | 38.6 ± 9.7 | 69.3 ± 9.0 | 27.0 ± 7.0 | EG3d vs EG2d = 0.03 |
| *P* value | 0.233 | 0.551 | 0.038 | |
| Bodily pain (scores, 0–100) | | | | |
| CG | 41.7 ± 4.9 | 33.4 ± 4.5 | –5.2 ± 4.3 | EG2d vs CG = 1.45 |
| EG2d | 35.0 ± 4.4 | 55.3 ± 4.0 | 19.1 ± 3.8‡ | EG3d vs CG = 1.94 |
| EG3d | 35.1 ± 4.1 | 63.4 ± 3.8 | 27.1 ± 3.5‡ | EG3d vs EG2d = 0.49 |
| *P* value | 0.531 | <0.001 | <0.001 | |
| General health (scores, 0–100) | | | | |
| CG | 55.3 ± 4.8 | 52.7 ± 4.6 | –2.4 ± 3.4 | EG2d vs CG = 1.05 |
| EG2d | 51.1 ± 4.2 | 63.7 ± 4.1 | 11.4 ± 3.0‡ | EG3d vs CG = 0.80 |
| EG3d | 57.1 ± 4.0 | 64.4 ± 3.8 | 8.1 ± 2.8 | EG3d vs EG2d = 0.25 |
| *P* value | 0.578 | 0.126 | 0.012 | |
| Vitality (scores, 0–100) | | | | |
| CG | 56.9 ± 4.4 | 49.9 ± 4.3 | –4.4 ± 3.7 | EG2d vs CG = 0.69 |
| EG2d | 51.7 ± 3.9 | 57.3 ± 3.8 | 5.6 ± 3.3 | EG3d vs CG = 0.66 |
| EG3d | 47.9 ± 3.7 | 55.0 ± 3.5 | 5.3 ± 3.1 | EG3d vs EG2d = 0.02 |
| *P* value | 0.318 | 0.434 | 0.098 | |
| Social functioning (scores, 0–100) | | | | |
| CG | 82.4 ± 6.0 | 82.0 ± 4.6 | 2.0 ± 3.8 | EG2d vs CG = 0.28 |
| EG2d | 77.0 ± 5.4 | 83.9 ± 4.0 | 6.2 ± 3.4 | EG3d vs CG = 0.50 |
| EG3d | 76.3 ± 5.0 | 86.7 ± 3.8 | 9.3 ± 3.1 | EG3d vs EG2d = 0.22 |
| *P* value | 0.723 | 0.725 | 0.352 | |
| Emotional role (scores, 0–100) | | | | |
| CG | 88.9 ± 10.8 | 94.0 ± 8.8 | 13.0 ± 7.8 | EG2d vs CG = 0.12 |
| EG2d | 72.5 ± 9.6 | 83.6 ± 7.9 | 9.4 ± 6.8 | EG3d vs CG = 0.17 |
| EG3d | 68.1 ± 8.9 | 80.3 ± 7.4 | 8.0 ± 6.4 | EG3d vs EG2d = 0.05 |
| *P* value | 0.333 | 0.498 | 0.892 | |
| Mental health (scores, 0–100) | | | | |
| CG | 70.0 ± 3.8 | 70.0 ± 3.4 | 0.3 ± 2.5 | EG2d vs CG = 0.33 |
| EG2d | 72.8 ± 3.4 | 75.0 ± 3.1 | 3.5 ± 2.2 | EG3d vs CG = 0.19 |
| EG3d | 65.5 ± 3.2 | 68.9 ± 2.9 | 2.1 ± 2.1 | EG3d vs EG2d = 0.14 |
| *P* value | 0.283 | 0.322 | 0.632 | |
| Standardized physical component (scores, 0–100) | | | | |
| CG | 40.1 ± 2.5 | 37.9 ± 2.4 | –1.6 ± 1.7 | EG2d vs CG = 1.32 |
| EG2d | 37.1 ± 2.2 | 44.9 ± 2.1 | 7.4 ± 1.5‡ | EG3d vs CG = 1.44 |
| EG3d | 38.2 ± 2.1 | 46.4 ± 2.0 | 8.2 ± 1.4‡ | EG3d vs EG2d = 0.12 |
| *P* value | 0.673 | 0.030 | <0.001 | |
| Standardized mental component (scores, 0–100) | | | | |
| CG | 51.2 ± 2.8 | 51.9 ± 2.5 | 1.6 ± 1.9 | EG2d vs CG = 0.14 |
| EG2d | 49.6 ± 2.5 | 49.9 ± 2.2 | 0.5 ± 1.7 | EG3d vs CG = 0.20 |
| EG3d | 46.7 ± 2.3 | 47.7 ± 2.1 | 0.1 ± 1.6 | EG3d vs EG2d = 0.06 |
| *P* value | 0.449 | 0.445 | 0.841 | |

Data are estimated means ± standard errors.
* Analysis of the covariance (ANCOVA) with sex and age as covariates.
† ANCOVA with sex, age, and baseline level as covariates, and Bonferroni's adjustments for *post hoc* comparisons.
‡ Significantly different from CG ($P < 0.05$).
CG = control group (N = 15); EG2d = experimental group 2 days per week (N = 18); EG3d = experimental group 3 days per week (N = 21).

**Table 5** Effects of an 8-week aquatic therapy program on body composition

| | Pretest* | Posttest* | Differences (Post-Pre)† | Effect Size |
|---|---|---|---|---|
| Weight (kg) | | | | |
| CG | 77.3 ± 3.2 | 77.4 ± 3.2 | 0.2 ± 0.4 | EG2d vs CG = 0.47 |
| EG2d | 68.3 ± 2.9 | 67.8 ± 2.9 | −0.5 ± 0.4 | EG3d vs CG = 0.48 |
| EG3d | 73.8 ± 2.7 | 73.2 ± 2.7 | −0.5 ± 0.3 | EG3d vs EG2d = 0.01 |
| *P* value | 0.118 | 0.092 | 0.312 | |
| Body mass index (kg/m$^2$) | | | | |
| CG | 27.0 ± 1.2 | 27.0 ± 1.1 | 0.0 ± 0.1 | EG2d vs CG = 0.29 |
| EG2d | 24.6 ± 1.0 | 24.5 ± 1.0 | −0.1 ± 0.1 | EG3d vs CG = 0.54 |
| EG3d | 26.7 ± 1.0 | 26.5 ± 1.0 | −0.2 ± 0.1 | EG3d vs EG2d = 0.25 |
| *P* value | 0.225 | 0.223 | 0.280 | |
| Body fat (kg) | | | | |
| CG | 23.5 ± 2.1 | 24.1 ± 2.2 | 0.5 ± 0.6 | EG2d vs CG = 0.57 |
| EG2d | 20.1 ± 1.9 | 19.2 ± 2.0 | −0.8 ± 0.5 | EG3d vs CG = 0.49 |
| EG3d | 22.6 ± 1.8 | 22.0 ± 1.9 | −0.6 ± 0.5 | EG3d vs EG2d = 0.09 |
| *P* value | 0.433 | 0.273 | 0.227 | |
| Body fat (%) | | | | |
| CG | 30.2 ± 1.8 | 30.8 ± 2.1 | 0.6 ± 0.7 | EG2d vs CG = 0.60 |
| EG2d | 29.1 ± 1.6 | 28.1 ± 1.8 | −1.0 ± 0.6 | EG3d vs CG = 0.47 |
| EG3d | 29.9 ± 1.5 | 29.2 ± 1.7 | −0.6 ± 0.5 | EG3d vs EG2d = 0.13 |
| *P* value | 0.909 | 0.643 | 0.210 | |
| Skeletal muscle mass (kg) | | | | |
| CG | 29.9 ± 1.0 | 29.8 ± 1.1 | −0.2 ± 0.3 | EG2d vs CG = 0.64 |
| EG2d | 26.4 ± 0.9 | 26.8 ± 1.0 | 0.5 ± 0.2 | EG3d vs CG = 0.29 |
| EG3d | 28.4 ± 0.8 | 28.5 ± 0.9 | 0.1 ± 0.2 | EG3d vs EG2d = 0.36 |
| *P* value | 0.042 | 0.126 | 0.201 | |

Data are estimated means ± standard errors.
* Analysis of the covariance (ANCOVA) with sex and age as covariates.
† ANCOVA with sex, age, and baseline level as covariates, and Bonferroni's adjustments for *post hoc* comparisons.
CG = control group (N = 15); EG2d = experimental group 2 days per week (N = 18); EG3d = experimental group 3 days per week (N = 21).

study and others using 3 days per week [13,14]. A possible mechanism to explain these improvements in back pain could be that aquatic exercise provides the optimal environment for patients to exercise aerobically, and at higher intensities than would be possible on land. More intensive aquatic exercise programs, with a frequency of three sessions per week, seem to have a greater effect than two sessions per week on the treatment of back pain in CLBP.

Our results also indicate that both experimental groups had significant improvements in disability levels (ODI), with EG3d showing a greater improvement than EG2d (57% vs 27%). These findings were similar to those reported by Yozbatiran et al. [14], who observed an improvement of 48% in disability. Sjogren et al. [43] showed, in contrast, an improvement in disability of only 9% in the aquatic exercise group (2 days per week of 50 minutes), which can be insufficient and more intensive aquatic exercise programs, with a higher frequency and duration of sessions, may have a greater effect on the treatment of disability in CLBP.

Abdominal muscular endurance presented an improvement of 39% and 75% in EG2d and EG3d, respectively. Abdominal muscular endurance is suggested to be reduced in patients with CLBP [44], because weakened abdominal muscles cannot maintain normal inclination of the pelvis, which increases lordosis of the lumbar spine [21]. We observed a significant improvement in abdominal muscular endurance in both experimental groups, with EG3d showing a greater improvement than EG2d. These findings were similar to Kell and Asmundson [45], who studied 27 patients with CLBP in a land rehabilitation program, allocated to either resistance training group (N = 9), aerobic training group (N = 9), or control group (N = 9), three sessions per week for 16 weeks. From baseline to week 8, they had an improvement in abdominal muscular endurance of 11% and 39% in aerobic and resistance training groups, respectively. It is likely that the early changes (~8 weeks) in these musculoskeletal performance outcomes (i.e., strength) associated with our aquatic therapy program were attributable largely to neural adaptations [46]. After week 8, muscular hypertrophy seems to be

**Table 6** Effects of an 8-week aquatic therapy program on physical fitness

| | Pretest* | Posttest* | Differences (Post-Pre)† | Effect Size |
|---|---|---|---|---|
| Sit and reach (cm) | | | | |
| CG | 11.4 ± 2.2 | 10.3 ± 2.1 | –0.9 ± 0.8 | EG2d vs CG = 1.44 |
| EG2d | 9.4 ± 2.0 | 13.0 ± 1.9 | 3.5 ± 0.7‡ | EG3d vs CG = 1.79 |
| EG3d | 8.4 ± 1.9 | 13.2 ± 1.8 | 4.6 ± 0.7‡ | EG3d vs EG2d = 0.36 |
| *P* value | 0.616 | 0.552 | <0.001 | |
| Handgrip strength (kg) | | | | |
| CG | 69.0 ± 3.0 | 67.4 ± 3.0 | –1.5 ± 1.1 | EG2d vs CG = 0.97 |
| EG2d | 61.1 ± 2.7 | 64.2 ± 2.7 | 2.9 ± 1.0‡ | EG3d vs CG = 1.52 |
| EG3d | 70.0 ± 2.5 | 75.0 ± 2.5 | 5.2 ± 0.9‡ | EG3d vs EG2d = 0.53 |
| *P* value | 0.041 | 0.016 | <0.001 | |
| Curl-up (number of repetitions) | | | | |
| CG | 13.3 ± 1.4 | 13.0 ± 1.6 | –0.3 ± 0.5 | EG2d vs CG = 2.98 |
| EG2d | 15.0 ± 1.2 | 20.9 ± 1.4 | 5.8 ± 0.5‡ | EG3d vs CG = 4.44 |
| EG3d | 11.7 ± 1.2 | 20.5 ± 1.3 | 8.8 ± 0.4‡§ | EG3d vs EG2d = 1.46 |
| *P* value | 0.181 | 0.001 | <0.001 | |
| $VO_{2max}$ (mL/kg/min) | | | | |
| CG | 32.8 ± 2.3 | 30.1 ± 2.3 | –2.5 ± 1.5 | EG2d vs CG = 1.01 |
| EG2d | 31.2 ± 2.0 | 34.8 ± 2.1 | 3.4 ± 1.3‡ | EG3d vs CG = 1.57 |
| EG3d | 32.1 ± 1.9 | 38.7 ± 1.9 | 6.7 ± 1.2‡ | EG3d vs EG2d = 0.56 |
| *P* value | 0.876 | 0.025 | <0.001 | |
| Time Rockport 1-mile test (minutes) | | | | |
| CG | 16.7 ± 0.7 | 17.2 ± 0.7 | 0.5 ± 0.5 | EG2d vs CG = 0.77 |
| EG2d | 16.7 ± 0.6 | 15.9 ± 0.6 | –0.8 ± 0.4 | EG3d vs CG = 1.11 |
| EG3d | 16.3 ± 0.6 | 14.9 ± 0.6 | –1.4 ± 0.4‡ | EG3d vs EG2d = 0.35 |
| *P* value | 0.823 | 0.055 | 0.007 | |
| Heart rate Rockport 1-mile test (bpm) | | | | |
| CG | 104.5 ± 4.7 | 111.1 ± 4.2 | 2.7 ± 2.8 | EG2d vs CG = 0.50 |
| EG2d | 124.1 ± 4.1 | 119.7 ± 3.7 | –2.6 ± 2.4 | EG3d vs CG = 1.36 |
| EG3d | 122.3 ± 3.9 | 109.5 ± 3.5 | –11.6 ± 2.2‡§ | EG3d vs EG2d = 0.89 |
| *P* value | 0.006 | 0.116 | 0.001 | |
| Resting heart rate (bpm) | | | | |
| CG | 68.1 ± 2.2 | 69.7 ± 2.0 | 1.7 ± 0.8 | EG2d vs CG = 1.02 |
| EG2d | 66.8 ± 1.9 | 65.3 ± 1.8 | –1.6 ± 0.7‡ | EG3d vs CG = 2.04 |
| EG3d | 68.6 ± 1.8 | 63.5 ± 1.6 | –4.9 ± 0.7‡§ | EG3d vs EG2d = 1.03 |
| *P* value | 0.789 | 0.069 | <0.001 | |

Data are estimated means ± standard errors.
* Analysis of the covariance (ANCOVA) with sex and age as covariates.
† ANCOVA with sex, age and baseline level as covariates, and Bonferroni's adjustments for *post hoc* comparisons.
‡ Significantly different from CG ($P < 0.05$).
§ Significantly different from EG2d ($P < 0.05$).
CG = control group (N = 15); EG2d = experimental group 2 days per week (N = 18); EG3d = experimental group 3 days per week (N = 21).

increasingly important, contributing to musculoskeletal performance [47].

Our results indicated an improvement in cardiorespiratory fitness, with a significant reduction in resting HR of 2% and 7%, HR post effort of 2% and 9%, and an increase in $VO_{2max}$. of 11% and 21% in EG2d and EG3d, respectively. Improvements in EG3d were higher than in EG2d only for HR at rest and HR post effort. These findings were similar to Kell and Asmundson [45], from baseline to week 8, as they reported improvements of 14% and 7% in $VO_{2max}$ and 2% and 1% in HR at rest in aerobic and resistance training groups, respectively. Yozbatiran et al. [14] observed in their study a significant improvement in the 12 minutes walking test. Sjogren et al. [43] also reported improvements in time score in the 100 m walking test. Individuals with CLBP usually exhibit a reduced aerobic capacity compared with healthy controls [7], which means that improving endurance is a reasonable exercise goal for patients with CLBP. Water-based exercise is a potentially viable way to improve cardiorespiratory fitness, given that water has 700 times the density of air and this promotes increase of energy expenditure for work done [48].

### *Limitations of the Study*

The fact that we were not able to randomize participants into the intervention or usual care group is a limitation of our study; therefore, selection bias could have adversely influenced our study findings. Despite this, there were no baseline differences between groups in almost any parameter. There are pitfalls to estimating maximum aerobic power (indirect measure of $VO_{2max}$) as opposed to precise measurement with cardiopulmonary gas exchange; however, those inconveniences pertain to both baseline exercise capacity as well as the change after the exercise training programs. Another limitation of our study was the use of RPE as a subjective method to control the intensity of aerobic exercise, although it has been used in previous studies in patients with CLBP [45]. We had no data on medication use or dietary habits during the intervention, so future studies should include such information whenever possible. Long-term outcomes were not performed in these subjects, so it cannot be determined if the effect of the treatment can be maintained over time. Also, the notable physical performance improvements observed in our study may be related with the low baseline level of our participants (sedentary); thus, future research should examine if the improvement in exercise group was not an educational effect of the short-term exercise.

## Conclusion

Our results showed that 8 weeks of aquatic therapy program decreased levels of back pain and disability, increased QoL, and improved health-related fitness but did not produce any effect in body composition, in sedentary adults with CLBP. A dose–response effect was observed in some parameters, with greater benefits when exercising 3 days per week compared with 2 days in VAS at flexion, ODI, curl-up, and HR at rest and post effort.

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## References

1 Rainville J, Hartigan C, Martinez E, et al. Exercise as a treatment for chronic low back pain. Spine J 2004;4(1):106–15.

2 Becker A, Held H, Redaelli M, et al. Low back pain in primary care: Costs of care and prediction of future health care utilization. Spine 2010;35(18):1714–20.

3 Rissanen A, Kalimo H, Alaranta H. Effect of intensive training on the isokinetic strength and structure of lumbar muscles in patients with chronic low back pain. Spine 1995;20(3):333–40.

4 Holmes B, Leggett S, Mooney V, et al. Comparison of female geriatric lumbar-extension strength: Asymptomatic versus chronic low back pain patients and their response to active rehabilitation. J Spinal Disord 1996;9(1):17–22.

5 Rainville J, Ahern DK, Phalen L, Childs LA, Sutherland R. The association of pain with physical activities in chronic low back pain. Spine 1992;17(9):1060–4.

6 Mayer TG, Gatchel RJ, Mayer H, et al. A prospective two-year study of functional restoration in industrial low back injury. An objective assessment procedure. JAMA 1987;258(13):1763–7.

7 van der Velde G, Mierau D. The effect of exercise on percentile rank aerobic capacity, pain, and self-rated disability in patients with chronic low-back pain: A retrospective chart review. Arch Phys Med Rehabil 2000;81(11):1457–63.

8 Tsuritani I, Honda R, Noborisaka Y, Ishida M, Yamada Y. Impact of obesity on musculoskeletal pain and difficulty of daily movements in Japanese middle-aged women. Maturitas 2002;42(1):23–30.

9 van Tulder M, Malmivaara A, Esmail R, Koes B. Exercise therapy for low back pain: A systematic review within the framework of the Cochrane collaboration back review group. Spine 2000;25(21): 2784–96.

10 Maher CG. Effective physical treatment for chronic low back pain. Orthop Clin North Am 2004;35(1): 57–64.

11 Mather C, Latimer J, Refshauge K. Prescription of activity for low back pain: What works? Aust J Physiother 1999;45(2):121–32.

12 Koes BW, van Tulder MW, Thomas S. Diagnosis and treatment of low back pain. BMJ 2006;332(7555):1430–4.

13 Saggini R, Cancelli F, Di Bonaventura V, et al. Efficacy of two micro-gravitational protocols to treat chronic low back pain associated with discal lesions: A randomized controlled trial. Eur Med Phys 2004;40(4): 311–6.

14 Yozbatiran N, Yildirim Y, Parlak B. Effects of fitness and aquafitness exercises on physical fitness in

patients with chronic low back pain. Pain Clin 2004;16(1):35–42.

15 Cuesta-Vargas AI, Garcia-Romero JC, Arroyo-Morales M, Diego Acosta AM, Daly DJ. Exercise, manual therapy and education with or without high-intensity deep water running for nonspecific chronic low back pain: A pragmatic randomized controlled trial. Am J Phys Med Rehabil 2011;90: 526–34.

16 Cuesta-Vargas AI, Adams N, Salazar JA, et al. Deep water running and general practice in primary care for non-specific low back pain versus general practice alone: Randomized controlled trial. Clin Rheumatol 2012;31:1073–8.

17 Verhagen AP, Cardoso JR, Bierma-Zeinstra SM. Aquatic exercise and balneotherapy in musculoskeletal conditions. Best Pract Res Clin Rheumatol 2012;26:335–43.

18 Becker BE, Cole MD. Comprehensive Aquatic Therapy, 2nd edition. Hillsboro, OR: Butterworth-Heinemann; 2004.

19 Dundar U, Solak O, Yigit I, Evcik D, Kavuncu V. Clinical effectiveness of aquatic exercise to treat chronic low back pain. Spine 2009;34(14):1436–40.

20 Tsourlou T, Benik A, Dipla K, Zafeiridis A, Kellis S. The effects of a twenty-four week aquatic training program on muscular strength performance in healthy elderly women. J Strength Cond Res 2006;20(4): 811–8.

21 Takeshima N, Rogers ME, Watanabe E, et al. Water-based exercise improves health-related aspects of fitness in older women. Med Sci Sports Exerc 2002;34(3):544–51.

22 Kamioka H, Tsutani K, Okuizumi H, et al. Effectiveness of aquatic exercise and balneotherapy: A summary of systematic reviews based on randomized controlled trials of water immersion therapies. J Epidemiol 2010;20(1):2–12.

23 Waller B, Lambeck J, Daly D. Therapeutic aquatic exercise in the treatment of low back pain: A systematic review. Clin Rehabil 2009;23(1):3–14.

24 Ariyoshi M, Sonoda K, Nagata K, et al. Efficacy of aquatic exercises for patient with low-back pain. Kurume Med J 1999;46(2):91–6.

25 Andersson GB. Epidemiological features of chronic low-back pain. Lancet 1999;354(9178):581–5.

26 Haskell WL, Lee I-M, Pate RP, et al. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 2007;116(9):1081–93.

27 Borg G, Noble B. Perceived exertion. Exerc Sport Sci Rev 1974;2:131–53.

28 Poyhonen TS, Sipila S, Keskinen KL, et al. Effects of aquatic resistance training on neuromuscular performance in healthy women. Med Sci Sports Exerc 2002;34(12):2103–9.

29 Wallace LK, Slttery KM, Coutts AJ. The ecological validity and application of the session-RPE method for quantifying training loads in swimming. J Strength Cond Res 2009;23:33–8.

30 American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription, 8th edition. Philadelphia, PA: Lippincott Williams & Wilkins; 2010.

31 Boonstra AM, Schiphorst Preuper HR, Reneman MF, Posthumus JB, Stewart RE. Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. Int J Rehabil Res 2008;31(2):165–9.

32 Ostelo RW, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain: Towards international consensus regarding minimal important change. Spine 2008;33(1):90–4.

33 Flórez García MT, García Pérez MA, García Pérez F, et al. Transcultural adaptation of Oswestry low back pain disability questionnaire to Spanish population. Rehabilitación 1995;29:138–45.

34 Alonso J, Prieto L, Anto JM. The Spanish version of the SF-36 Health Survey (the SF-36 Health Questionnaire): An instrument for measuring clinical results. Med Clin 1995;104:771–6.

35 Ruta DA, Garratt AM, Wardlaw D, Russell IT. Developing a valid and reliable measure of health outcomes for patients with low back pain. Spine 1994;19(17): 1887–96.

36 Jensky-Squires NE, Dieli-Conwright CM, Rossuello A, et al. Validity and reliability of body composition analysers in children and adults. Br J Nutr 2008;100(4): 859–65.

37 Gale CR, Martyn CN, Cooper C, Sayer AA. Grip strength, body composition, and mortality. Int J Epidemiol 2007;36(1):228–35.

38 Berger C. Assessing personal fitness. In: Bushman B, ed. ACSM's Complete Guide to Fitness & Health. Champaign, IL: Human Kinetics; 2011:17–42.

39 Pober DM, Freedson PS, Kline GM, McInnis KJ, Rippe JM. Development and validation of a one-mile

treadmill walk test to predict peak oxygen uptake in healthy adults ages 40 to 79 years. Can J Appl Physiol 2002;27(6):575–89.

40 DePalma MJ, Ketchum JM, Saullo TR. Multivariable analyses of the relationships between age, gender, and body mass index and the source of chronic low back pain. Pain Med 2012;13(4):498–506.

41 Mc Ilveen B, Robertson VJ. A randomised controlled study of the outcome of hydrotherapy for subjects with low back or back and leg pain. Physiotherapy 1998;84(1):17–26.

42 Frost H, Lamb S, Klaber Moffett JA, Fairbank JC, Moser JS. A fitness programme for patients with chronic low back pain. Two year follow-up of a randomised controlled trial. Pain 1998;75(2–3):273–9.

43 Sjogren T, Long N, Storay I, Smith J. Group hydrotherapy versus group land-based treatment for chronic low back pain. Physiother Res Int 1997;2(4): 212–22.

44 Payne N, Gledhill N, Katzmarzyk PT, Jamnik V. Health-related fitness, physical activity and history of back pain. Can J Appl Physiol 2000;24(4):236–49.

45 Kell RT, Asmundson GJ. A comparison of two forms of periodized exercise rehabilitation programs in the management of chronic non-specific low-back pain. J Strength Cond Res 2009;23(2):513–23.

46 Hakkinen A, Hakkinen K, Hannonen P, Alen M. Strength training induced adaptations in neuromuscular function of premenopausal women with fibromyalgia: Comparison with healthy women. Ann Rheum Dis 2001;60(1):21–6.

47 Hakkinen K, Kallinen M, Izquierdo M, et al. Changes in agonist-antagonist EMG, muscle CSA, and force during strength training in middle-aged and older people. J Appl Physiol 1998;84(4):1341–9.

48 Moening D, Scheidt A, Shepardson L, Davies GJ. Biomechanical comparison of water running and treadmill running. Isokinet Exerc Sci 1993;3:207–15.