



AQUATIC AND LAND AEROBIC TRAINING FOR PATIENTS WITH CHRONIC LOW BACK PAIN: A RANDOMIZED STUDY

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ABSTRACT

Purpose. The study aimed to verify the influence of aerobic training environment on pain, disability, and oxygen uptake in patients with chronic low back pain.

Methods. The randomized study involved 14 patients of both sexes, with chronic low back pain. One group performed deep-water walking/running and the other practised land walking/running, both with moderate intensity. Pain, disability, peak oxygen uptake (VO_{2peak}), and second ventilatory threshold oxygen uptake (VO_{2VT2}) were assessed before and after the intervention.

Results. Decreases in pain and disability were observed in both groups, without differences between them. VO_{2peak} and VO_{2VT2} did not change in either group after the training.

Conclusions. Aerobic exercise training of moderate intensity seems to be effective in improving pain symptoms and reducing disability among people with chronic low back pain, independently of the environment in which it is performed.

Key words: exercise, aerobic training, deep water running, low back pain

Introduction

Currently, musculoskeletal pains are extremely frequent in the world population, mainly in middle-aged and working-aged adults [1]. Low back pain affects about 12% of the world population [2]. Chronic low back pain refers to pain in the vertebral region or lumbar paravertebral region; it is considered chronic when it lasts more than 12 weeks [3]. It is not considered a disease, but rather a secondary symptom of pathologies of diverse origins and severities. A considerable number of patients who develop chronic symptoms do not respond to conventional therapies [4] such as physiotherapy and medication. Thus, it is believed that regular mechanical activity, such as that produced by physi-

cal exercise, seems to be the most reasonable treatment for patients with chronic low back pain [3, 5–7].

Systematic reviews have shown that aerobic exercises are effective in reducing pain and improving function in patients with chronic low back pain [8–10]. Among aerobic exercises, the practice of walking has been indicated for this population [11, 12]. However, few studies have evaluated its effectiveness in the treatment of chronic low back pain. Nevertheless, the studies that have been conducted demonstrate improvements in pain and gains in function [13–16]. Despite the positive results, it is known that walking has a high impact on the lower limb joints and spine, which may aggravate a pre-existing problem. In this context, exercises performed in an aquatic environment stand

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out owing to the reduced impact associated with facilitating their execution and allowing the exercise to reach higher physiological intensities [17–19].

Deep-water running, specifically, does not produce any impact on the lower limbs, and is also notable for causing spinal decompression compared with walking/running on a treadmill or in a shallow pool [20]. In addition, this modality allows one to achieve high aerobic intensities, which offer benefits related to function, strength, and resistance [20, 21], negatively correlated with the degree of disability and pain. Despite the benefits reported, there are still few studies evaluating the effectiveness of training that involves aerobic deep-water running for the treatment of patients with chronic low back pain. To the best of our knowledge, no studies have compared aerobic walking/running training performed on land with the same type of training carried out in an aquatic environment. Thus, the present study aimed to compare pain, disability, and oxygen uptake in patients with chronic low back pain who underwent aerobic walking/running training on land with the parameters in patients who practised aerobic walking/running training in deep water. According to the hypothesis of this study, it was believed that both training types would enhance the outcomes, but training in aquatic environment would result in more significant improvements.

Material and methods

Experimental design and problem approach

The study is characterized as a randomized clinical trial with two groups in parallel. Two interventions were performed to verify the effects of aerobic training in different environments (aquatic and land) on pain, disability, and oxygen uptake in patients with chronic low back pain. One group participated in deep-water walking/running training, and the other performed land walking/running, both at moderate intensity. A control group was not tested, since the effectiveness of aerobic exercise interventions in the issues of interest is already well documented in the literature [1, 3, 5, 7, 13–16, 22, 23], with a gap regarding the superiority of either environment.

All measurements were taken before the intervention period and 72 hours after the last training session, with all assessments completed within a maximum period of one week after the end of the training. Each evaluation was carried out by the same specifically trained researcher, and with the same equipment. In addition, the evaluators were blinded to the interven-

tion groups. The study followed the recommendations of the Consolidated Standards of Reporting Trials (CONSORT) [24].

Participants

Overall, 14 physically active patients of both sexes (7 men, 7 women) with chronic low back pain participated in the study. The eligibility criteria included a medical diagnosis of chronic low back pain, with or without radiation to the lower limbs, persisting for more than 12 weeks, as well as age between 30 and 50 years, and the level of pain classified as equal or greater than 3 (moderate) on the Visual Analogue Scale (VAS). The project was publicized in social networks and local newspapers. The participants were informed of the study objectives, the possibilities of discomfort, and the risks of the procedures and interventions.

After all pre-intervention evaluations, the participants were randomized into two intervention groups: deep-water walking/running training (DWT; $n = 7$) and land walking/running training (LWT; $n = 7$). The simple randomization process was carried out by a researcher not involved in the evaluations, and the interventions of the study were determined by the removal of a paper from an opaque envelope in which the numbers corresponding to each group were included.

Assessments

The evaluations were conducted in the Biodynamics Laboratory of Movement of the School of Physical Education, Physiotherapy, and Dance of the Federal University of Rio Grande do Sul. All evaluations were performed individually during only one session of approximately 45 minutes.

Initially, the participants remained at rest, sitting in a chair with their arms relaxed at the sides of their body. They remained in this resting position for 15 minutes. After this period, blood pressure (BP) was determined as a safety measure in preparation for the maximum treadmill test that was performed later (MAPA, Meditech, model ABPM-04). Systolic BP below 140 mm Hg and diastolic BP below 90 mm Hg was considered adequate [25].

Afterwards, the participants were instructed to respond to the VAS and the Oswestry indexes that assess pain and disability, respectively. Then, they were positioned on the treadmill to begin the maximal test. The test objective was to evaluate the peak oxygen uptake (VO_{2peak}) and the oxygen uptake in second ventilatory

threshold (VO_{2VT2}). The participants were instructed to avoid both the consumption of caffeine and exercise within 24 hours before the test and to avoid eating within 3 hours before the test. We used an Inbramed treadmill (Porto Alegre, Brazil) and a VO2000 portable gas analyser (MedGraphics, Ann Arbor, USA). The protocol involved the application of an incremental load, with an initial velocity of 6 km/h and an inclination change of 1% for 2 minutes. Afterwards, the inclination was maintained at a fixed level and we increased the velocity to $1 \text{ km} \cdot \text{h}^{-1}$ every 2 minutes until the participant reported exhaustion. The assessment was considered valid when some of the following criteria were met at the end of the test: the estimated maximal heart rate (HR) was reached (220 minus the participant's age, in beats per minute [bpm]), a respiratory exchange ratio greater than 1.15 was reached, and an effort perception of 19 (Borg Rating of Perceived Exertion [RPE] Scale, range of 6–20) was appraised [26].

Training

The study participants were trained on non-consecutive days, twice a week for a period of 12 weeks. In case of failure to participate on one of the training days, an extra session for recovery was scheduled. The adherence of participants to interventions was 83% in DWT and 80% in LWT. Both groups performed the training sessions at 7:15 pm. The classes had a duration of 45 minutes and consisted of warming up, the main exercise period, and stretching. The warm-up period included a walk at a self-selected intensity. The main exercise period included walking and/or running at the intensities prescribed for each phase of the training and lasted 35 minutes. Finally, the priority of the stretching portion was to stretch the main muscles used during the main exercise period.

Deep-water running is carried out with the help of a float vest, which keeps the individual upright without using the foot support at the bottom of the pool. The elbows should be flexed at 90° , the hands closed, and the movement of the upper limbs alternating relative to the movement of the lower limbs.

The periodization was the same for both groups and the intensity prescription was in accordance with the HR of the second ventilatory threshold (HR_{VT2}). During the classes, each participant used an HR monitor to control the training (HR), and was allowed a variation of 5 bpm above or below the targeted HR. Table 1 shows the periodization of the 12 weeks.

To determine the HR_{VT2} used in the prescription for the aquatic environment training, a maximal deep-water running test was performed in accordance with the methodology described in detail by Kanitz et al. [27]. To establish the HR_{VT2} in the prescription on land, the same progressive test already described for the analyses of VO_{2peak} and VO_{2VT2} was used.

Statistical analysis

Descriptive statistics (mean \pm 95% confidence interval) were used to report the results. The sample characteristics (at baseline) of both groups (DWT and LWT) were compared with the independent *t*-test. Generalized estimating equations (GEE) and the Bonferroni *post hoc* test were applied to compare the means of all dependent variables. Furthermore, the effect size (*ES*; Cohen's *d*) was calculated from the difference in post-training values between the DWT and LWT groups, and classified as small (between 0.2 and 0.5), moderate (between 0.5 and 0.8), or large (≥ 0.8) [28]. The significance level was set at $\alpha = 0.05$ for all tests. The SPSS statistical software (version 22.0) was used for all analyses. In addition, the sample size was analysed by the G*Power version 3.1 program, which adopted $\alpha = 0.05$, the power of 90%, the *ES* of the study that evaluated the results of deep pool training, and a control in people with chronic low back pain [23]. For the disability variables, primary outcomes of the study, the calculation indicated a minimum of 6 people in each group.

Ethical approval

The research related to human use has been complied with all the relevant national regulations and institutional policies, has followed the tenets of the

Table 1. The 12-week periodization of the walking/running training in an aquatic environment and on land

Week	Volume \times intensity	Total time
1, 2, 3, and 4	$7 \times (3 \text{ min } 85\% HR_{VT2} + 2 \text{ min } < 85\% HR_{VT2})$	35 min
5, 6, 7, and 8	$7 \times (4 \text{ min } 90\% HR_{VT2} + 1 \text{ min } < 85\% HR_{VT2})$	35 min
9, 10, 11, and 12	$7 \times (4 \text{ min } 95\% HR_{VT2} + 1 \text{ min } < 85\% HR_{VT2})$	35 min

HR_{VT2} – heart rate of the second ventilatory threshold

Declaration of Helsinki, and has been approved by the Research Ethics Committee of the Federal University of Rio Grande do Sul (registration No.: 39789014.6.0000.5347).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

The total of 20 participants entered the study; 6 withdrew during the intervention period (3 from DWT and 3 from LWT), which represents about 30% of dropout. Thus, 14 participants finished the study interventions and completed all assessments (Figure 1).

The baseline characteristics of the patients are presented in Table 2. These were similar between the groups ($p > 0.05$).

Decreases in pain and disability were observed in both groups. VO_{2peak} and VO_{2VT2} did not change after the training intervention (Table 3).

The analysis of the ES, comparing the LWT and DWT groups, showed a moderate magnitude of effect for pain (0.52 [from -0.26 to 1.30]) and small effect was observed for the disability index (0.17 [from -0.60 to 0.93]), VO_{2peak} (0.46 [from -0.29 to 1.22]), and VO_{2VT2} (0.33 [from -0.44 to 1.09]).

Discussion

The aim of the present study was to verify the impact of the environment in which aerobic exercise was performed on pain, disability, and oxygen uptake in patients with chronic low back pain. The results showed that the environment did not influence these responses: both modalities significantly improved pain and disability and maintained oxygen uptake. In this way, the results agree in part with our hypothesis, since we believed that both groups would show improvements in the outcomes evaluated. However, we also expected that the aquatic environment would stand out in the improvements found. Contrary to our belief, this was not observed.

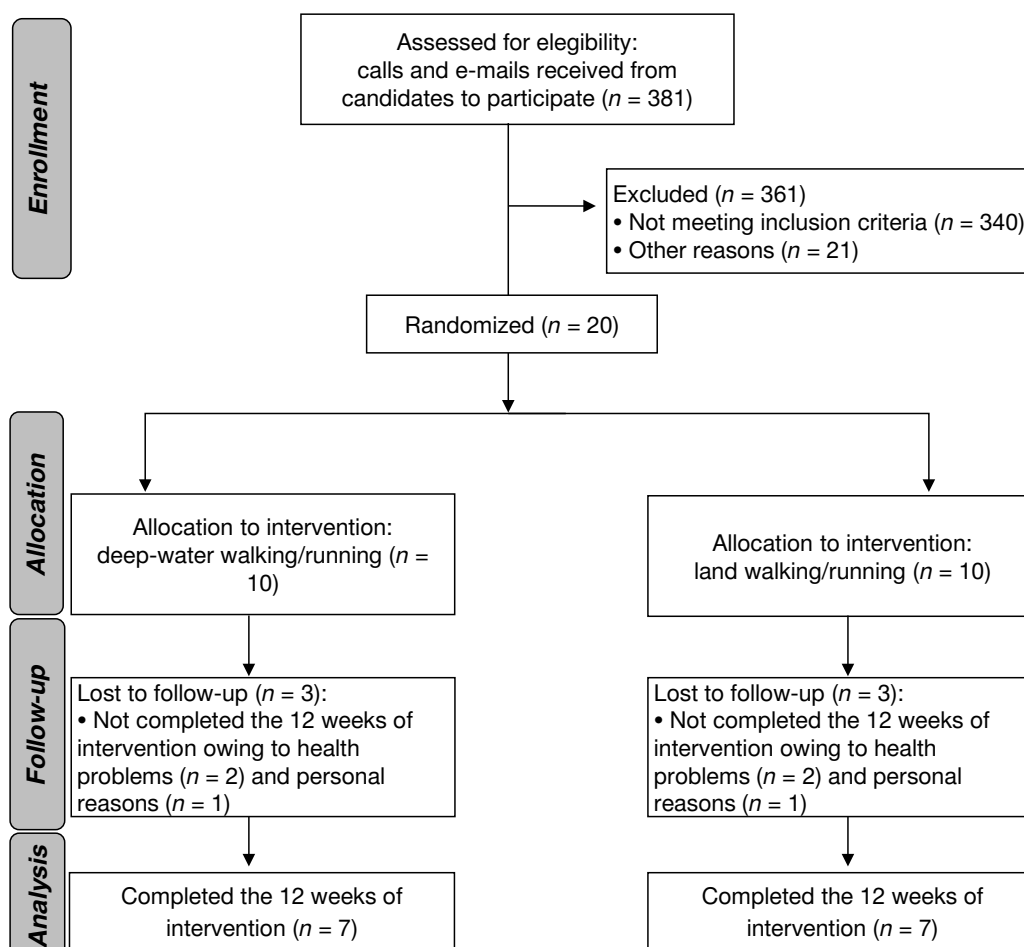


Figure 1. Flow diagram of the participants' enrolment process, allocation, follow-up, and analysis

Table 2. Patients' characteristics

Variable	LWT		DWT		<i>p</i>
	Mean	95% CI	Mean	95% CI	
Age (years)	40	36–50	39	31–47	0.718
Body mass (kg)	80	60–85	83	56–106	0.314
Body height (m)	1.68	1.61–1.72	1.69	1.58–1.79	0.300
BMI (kg · m ⁻²)	28	23–29	28	22–34	0.380
Duration of symptoms (months)	99	19–180	54	13–120	0.799
Men	3		4		
Women	4		3		

LWT – land walking/running training, DWT – deep-water walking/running training, BMI – body mass index
Comparisons were performed by the independent *t*-test; $\alpha = 0.05$.

Table 3. Pain, Oswestry disability index, VO_{2peak}, and VO_{2VT2} for LWT and DWT before and after 12 weeks of training

	LWT			DWT		
	Baseline	12 weeks	D	Baseline	12 weeks	D
Pain (per 100 mm VAS)	5.7 (4.4–6.9)	1.9* (1.1–2.6)	-3.8	5.5 (3.7–7.3)	2.9* (1.5–4.4)	-2.6
Oswestry disability index	10.1 (7.4–12.9)	6.0* (3.3–8.7)	-4.1	10.0 (6.6–13.4)	5.2* (3.9–6.5)	-4.8
VO _{2peak} (ml · kg ⁻¹ · min ⁻¹)	44.5 (39.1–49.9)	44.4 (38.5–50.3)	-0.01	43.7 (36.7–50.7)	50.0 (44.3–55.8)	6.3
VO _{2VT2} (ml · kg ⁻¹ · min ⁻¹)	34.2 (29.1–39.4)	31.9 (31.9–42.8)	-2.3	37.0 (29.7–44.4)	41.4 (34.6–48.2)	4.4

VO_{2peak} – peak oxygen uptake, VO_{2VT2} – second ventilatory threshold oxygen uptake, LWT – land walking/running training, DWT – deep-water walking/running training, VAS – Visual Analogue Scale

Data are expressed as means and 95% CI; $\alpha = 0.05$.

* *p* < 0.05 for time effect (baseline vs. 12 weeks)

Generalized estimating equation; Bonferroni correction.

Regarding the pain and disability results, these corroborate the literature that shows that aerobic exercises are effective for improvements in these parameters [1, 3, 5, 7, 13–16, 22, 23]. It is believed that physical exercise causes stress-induced analgesia, releasing cortisol and adrenaline into the bloodstream, and consequently increasing the practitioner's pain threshold [1]. In this sense, the literature has shown that intensities above 50% of VO_{2max} are already sufficient to provide an analgesic effect of exercise in patients with chronic low back pain [29]. In the present study, both groups started training at the intensity of 85% of HR_{VT2} and progressed up to 95% of HR_{VT2}, and thus these intensities were enough to observe a significant improvement in pain and disability. Moreover, reductions in pain scores of greater than 20% are considered clinically relevant [30]; in the present study, there was a mean reduction in pain scores of 60% in both intervention groups.

The improvements observed in pain and disability demonstrate that running/walking aerobic exercise on land at moderate intensity does not exert adverse effects on patients, such as an increase in pain. It should be noted that the volunteers in the study group started the first month of training (intensity \leq 85% HR_{VT2}) with only walking; however, in the following two months, they had to practise jogging in order to reach the training intensities (90–95% HR_{VT2}). In this way, the importance of a progression of intensity is highlighted in order to acquire the benefits of aerobic training in pain and disability. Still, care should be taken at higher intensities, as these were not tested in the present study.

Although no significant differences were observed between the two environments, it is worth mentioning that in the aquatic environment, vertically oriented physical exercise modalities, such as water aerobics and deep-water walking/running, have important charac-

teristics that include articular impact reduction [17, 18] and spinal decompression [20]. These aspects make this environment safer, especially for patients with musculoskeletal problems involving pain. Thus, aquatic exercises can provide the practitioner, in addition to a safer training, with the additional ability to reach higher intensities in order to maximize the effects of aerobic training. However, studies on this issue have yet to be conducted.

According to the data published in the literature, the improvement of pain and disability seems to be related to improvements in physical fitness [5–7]. In this context, the present study evaluated VO_{2peak} and VO_{2VT2} . However, the two interventions tested were not effective in improving this parameter; they only allowed to maintain it, which demonstrates that improvements in pain and disability can occur even if there is no improvement in physical fitness. In the literature, studies that used frequencies of three or more sessions per week for aerobic training showed significant improvements in VO_{2peak} or VO_{2max} in patients with chronic low back pain [31, 32]. Thus, the frequency of the present study – twice per week – was perhaps not enough to provide significant improvements in cardiorespiratory parameters.

In addition, the participants of the present study started the study with mean values of VO_{2peak} of $44 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$, which classify cardiorespiratory fitness as ‘good’ for men and ‘excellent’ for women [33]. Thus, the high initial VO_{2peak} values in the present study reflect smaller amplitude for improvements. Once again, it is believed that a higher weekly frequency may have been more effective in providing improvements in cardiorespiratory parameters. Nevertheless, this result shows that chronic low back pain can occur even in people with good physical fitness, failing to demonstrate a relationship between pain/disability and cardiorespiratory capacity.

The main limitations of the study were the small number of patients and the low weekly frequency of training for participants already considered as active with a good-to-excellent physical fitness rating. Thus, for future studies, a larger sample size and training at higher weekly frequency are suggested.

Conclusions

From the results of the present study, we can conclude that aerobic training at moderate intensity seems to be effective for improving pain symptoms and reducing disability in patients with chronic low back pain. These improvements seem to be independent of

the environment in which the training is performed, including training on land performed with progression from walking to running, which did not present damages in the evaluated parameters. Still, these improvements are not necessarily related to an increase in physical capacity, since the VO_{2peak} values were maintained throughout the intervention in both groups.

Thus, aerobic exercise of walking/running at moderate intensity in both the aquatic environment and on land may be indicated for patients affected by chronic back pain, without prejudice to aspects of pain and disability. However, as for improvement in cardiorespiratory fitness, we suggest a higher weekly frequency of training. Nonetheless, it is emphasized that the interventions were effective in maintaining cardiorespiratory fitness.

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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