



ISSN Online: 2821-1936

Transactions on Data Analysis in Social Science

Journal Homepage: <https://transoscience.ir>

## Comparison of the Effect of a Period of Aquatic and Land-Based Exercises on Pain, Disability, and Muscle Endurance in Women with Non-specific Chronic Low Back Pain

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ARTICLE INFO	ABSTRACT
<p>Article History:            Received 13 February 2019            Received in revised form 11 August 2019            Accepted 15 September 2019            Available online 21 September 2019</p>	<p><b>Background:</b> Nonspecific chronic low back pain is one of the most prevalent musculoskeletal disorders. Aquatic and land-based exercises are commonly used by physiotherapists for the management and treatment of chronic low back pain. Pain, functional disability, and reduced muscle endurance are frequent complaints among these patients. <b>Objective:</b> The present study aimed to compare the effects of a course of aquatic and land-based exercises on pain, disability, and muscle endurance in women with nonspecific chronic low back pain. <b>Methods:</b> This quasi-experimental study employed a pretest-posttest design. Thirty women aged 20 to 45 years, selected via convenience sampling, were randomly assigned into three groups: a control group, which performed routine activities; a land-based exercise group, which performed structured exercises on the ground; and an aquatic exercise group, which performed exercises in water. The intervention lasted six weeks for both the land-based and aquatic exercise groups. Pain intensity, functional disability, and muscle endurance were assessed at pretest and posttest stages. Data were analyzed using repeated measures ANOVA, ANCOVA, independent t-tests, and paired t-tests. <b>Results:</b> Both aquatic and land-based exercises were effective in reducing pain, improving functional disability, and enhancing muscle endurance. <b>Conclusion:</b> The findings suggest that implementing aquatic or land-based exercise programs can be beneficial for women suffering from nonspecific chronic low back pain.</p>
<p>Keywords:            Non-Specific Chronic Low Back Pain, Aquatic Exercises, Land-Based Exercises, Pain, Disability, Muscle Endurance</p>	

### 1. INTRODUCTION

Low back pain is a prevalent and significant clinical, social, and economic issue in both industrialized and non-industrialized countries. Epidemiological studies have shown that more than 80% of the global population experiences low back pain at least once in their lives [1]. Chronic low back pain significantly impacts the quality of life and leads to disability and reduced activity. For instance, annually, approximately 150 million workdays are lost

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<http://dx.doi.org/10.47176/TDASS.2019.143>



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due to low back pain in the United States, with over 200,000 individuals in the United Kingdom reporting back pain at their workplace at least once a year [2]. The economic cost of low back pain is substantial, estimated at 100 to 200 billion dollars annually in the United States alone [3]. The majority (85%) of low back pain cases are described as "non-specific" due to a lack of alignment between symptoms and radiological findings [4]. Non-specific chronic low back pain is strongly associated with disability, psychological changes, and work absenteeism, contributing to high associated costs [5].

Exercise therapy targeting the muscles of the spinal column and trunk at ground level is typically the foundation of clinical programs for individuals with chronic low back pain, demonstrating effectiveness in reducing pain, disability, and improving muscle function and strength [6,7]. Therapeutic approaches use graded general exercises and specific muscle exercises to enhance lumbar stability, as alterations in neural control of spinal and pelvic motion, along with generalized weakness around the hip and abdominal joints, are evident in individuals with chronic low back pain [2]. Aquatic exercises are also frequently employed in the management and treatment of low back pain due to significant advantages over land-based exercise, promoting balance, mobility, and pain control. For example, warm water can facilitate muscle elasticity, buoyancy reduces joint loads, and hydrostatic pressure provides support [2]. Studies on aquatic exercises have reported positive effects on patient outcomes, such as improved muscle function, increased spinal flexibility, and reduced work absenteeism [8,9].

Despite well-documented positive effects of exercise, the National Institute for Health and Care Excellence in the United Kingdom recommends exercise in all its forms for individuals with low back pain [2]. However, it remains unclear which type of exercise may be superior for managing or treating back pain [10]. Reports suggest that aquatic exercise has similar or greater positive effects than land-based programs [12,8] and may be suitable for individuals with low back pain, especially during the initial stages of rehabilitation and for those struggling with land-based exercises [2].

Nevertheless, practical application of research findings in this area is still limited despite evidence supporting the benefits of aquatic exercises for individuals with low back pain. One reason for this limitation is that programs and exercises used in aquatic studies are often not well-reported. Additionally, to maximize program effectiveness, it is crucial for exercises to directly target the intended muscles [2].

Given the limitations of previous research in accurately reporting muscle activity during aquatic exercises, the selection of exercises by physiotherapists is often arbitrary or evidence-based. However, there is available research addressing this limitation to some extent [2]. Therefore, research in this area requires improved methods to advance knowledge and facilitate the generalizability of findings. The researcher aimed to compare the exercise protocol of the above article in the treatment of patients with chronic low back pain. Therefore, the objective of this study is to investigate the comparative effects of a course of aquatic and land-based exercises on pain, disability, and muscle endurance in women with non-specific chronic low back pain.

## **2. METHODOLOGY**

The present research is a quasi-experimental study. The research design was a pre-test and post-test multi-group design with a control group (three groups: 1. Control group, 2. Aquatic exercise group, and 3. Land-based exercise group). The study population included all female patients aged 20 to 45 with non-specific chronic low back pain in Tehran. The research sample consisted of 30 female patients who were purposefully selected based on inclusion criteria, including a history of pain lasting more than three months, ranking 3 or lower in the visual analog scale (VAS) pain grading system, no specific pathology in the spine such as disc herniation, no history of spine fractures or surgery, ability to perform daily activities, and no significant postural abnormalities affecting the research process. No dropouts occurred until the end of the study.

Research tools included a personal information recording form, Oswestry Disability Questionnaire, visual analog scale (VAS) pain grading system, and the Sorensen test. To assess the level of back pain, the Visual Analog Scale (VAS) pain grading system was used, which is an 11-point scale for reporting pain intensity. Patients choose a number according to the line scale (0-10) that best represents their pain intensity. The number zero indicates no pain, and ten indicates the most severe or worst pain [12]. The Persian version of this scale is available in Iran for patients with low back pain, showing excellent internal consistency ( $\alpha=0.91$ ) and reliability coefficient of 0.73 [13].

The Oswestry Disability Questionnaire, with validity and reliability reported during the research by Davidson and Keating (0.84) [14], was used to measure patients' disability in daily activities. This questionnaire evaluates patients' functional disability in 10 six-option sections (ranging from a minimum of zero to a maximum of five) in areas such as pain tolerance, coping with pain intensity, personal care, lifting objects, walking, sitting, standing, sleeping, sexual life, social life, and traveling. In each section, a score of five represents maximum disability, and a score of zero represents minimum disability. The total disability is then calculated by multiplying the sum of scores in each section by two. In fact, this questionnaire rates disability in performance between 0 and 100, categorizing it as follows: 0-20 for minimal disability, 21-40 for moderate disability, 41-60 for severe disability, 61-80 for being bedridden, and 81-100 for the inability to get out of bed [15].























To assess the level of muscle endurance in the extensor muscles of the trunk, the Sorensen test was used. Patients were placed prone on the examination table, with the upper part of the iliac crest at the edge of the table. During this test, the hip, knee, and ankle joints were fixed with three bands. Participants were asked to place their hands on their chest and maintain their trunk in a horizontal isometric position, and the duration the patient could maintain this position was recorded. When the trunk bent more than 5 to 10 degrees, the test was stopped [16]. The validity and reliability of this test in measuring the muscle endurance of trunk extensors were confirmed, with reliability reported as 0.88 in individuals with low back pain [17].

After selecting the participants and conducting initial tests in the post-test, the aquatic and land-based exercise groups were selected according to the exercise protocol by Saikorakis and colleagues (2019), considering their suitability for rehabilitation. After a complete multi-stage process, including consultation with physiotherapists and stakeholders, the movements and guidelines were standardized for participants (in terms of the form of movements). The exercises with dynamic upper limb movements and dynamic lower limb movements used in this study are described in Figure 1. Aquatic and land-based exercises are outlined in Figure 1 [2].

The exercise intervention was conducted regularly over six weeks, three days a week, with each session lasting 45 to 60 minutes, including warm-up and cool-down exercises.

It is worth mentioning that all patients in the aqua and land exercise groups were familiarized with the correct execution of exercises through verbal instructions and images at the beginning of the program. The exercises were conducted at Diamond Gym in Tehran under the supervision of the researcher, who provided feedback to correct any improper movements during the exercises.

Descriptive statistics were employed to describe and organize the data obtained from pre-test and post-test (mean and standard deviation). In the inferential statistics section, the Kolmogorov-Smirnov test was utilized to assess the normality of raw data. Furthermore, Levene's test was employed to check the homogeneity of variances, and the Box's M test was used to examine the homogeneity assumption of variance-covariance matrices. Subsequently, for investigating intra-group and inter-group differences, analysis of covariance (ANCOVA), independent t-test, and dependent t-test were conducted. The significance level for all tests was set at 0.05. All analyses were performed using SPSS software version 24.

Aquatic Exercises		Land Exercises	
Description	Photo	Description	Photo
1L and 1R (performed separately): Hold a disc (23cm diameter) between the hands just below water surface with arms fully outstretched in front. Rotate the trunk steadily as far to one side as possible and back to midline (35 bpm).		1L and 1R (performed separately): Hold a Swiss ball (55cm diameter) between the hands with arms fully outstretched in front at chest height. Move the ball steadily as far to one side as possible and back to midline (35 bpm).	
2: Hold a kicking board (34x24cm) vertically with arms fully outstretched just below water surface. Move the arms backwards towards the body and forwards to the starting position (45 bpm).		2: Hold a Swiss ball (55cm diameter) with arms fully outstretched in front at chest height. Bring it close the chest and then return to starting position (45 bpm).	
3: Hold buoyant discs (12.5cm diameter) in each arm just below water surface, the left close to the body and the right fully outstretched. Perform alternate reciprocal punching actions with the arms (45 bpm).		3: Hold a blue Theraband in each hand passing round the trunk level at the middle of the thoracic spine. Alternately fully outstretch the arms, similar to a punching action (45 bpm).	
4: Have arms by the sides with forearms pronated and paddles (12.5x20cm) strapped to the hands. Bring the arms together to just below water surface while flexing the knees to a squat. Return to starting position (45bpm).		4: Hold a Swiss ball (55cm diameter) above the head with arms fully extended. Move the ball to chest height while performing a squat with the lower body. Return to starting position. (45 bpm).	
5: Have the left arm by the side and the right arm outstretched in front, just below the surface, with forearms supinated and paddles strapped to the hands. Bring the left arm to just below water surface and simultaneously the right arm to the side. Return to starting position (30 bpm).		5: Have the arms by the side of the body and hold the two ends of a blue Theraband passing behind the body under the gluteal fold. Move alternately each arm upwards to chest height and back to starting position (30 bpm).	
6: Have the trunk in an upright position, arms outstretched and hands resting on the surface holding dumbbell floats. Move dumbbells forwards slowly with the body in a neutral posture tilting on the tips of the toes. Return to starting position maintaining neutral body posture (12bpm).		6: Kneel on the ground in an upright posture with hands resting on a Swiss ball (65cm diameter). Roll the ball forwards slowly until forearms are resting on it and shoulders are above elbows. Roll back to starting position maintaining a neutral body posture (20 bpm).	
7L and 7R (performed separately): Stand on one leg with arms abducted at 45°. Abduct the opposite leg as far as possible, retaining a neutral position throughout (avoid external rotation). Return to starting position (45bpm).		7L and 7R (performed separately): Same as aquatic exercises 7L and 7R.	
8L and 8R (performed separately): Stand on one leg with arms abducted at 45°. Perform hip extension maintaining the lower limb in a neutral position (avoid external hip rotation). Return to starting position (45bpm).		8L and 8R (performed separately): Same as aquatic exercises 8L and 8R.	
9L and 9R (performed separately): Stand on one leg with arms crossed at chest, the non-weight bearing limb in a neutral position with the knee flexed to 90°. Perform single leg squat on the weight-bearing limb so that the knee moves just in front of the toes (50bpm).		9L and 9R (performed separately): Same as aquatic exercises 9L and 9R, but with arms by the side.	
10: Stand on both legs with arms by the side. Take a large step to one side keeping the knee extended, then bring the other leg next to it. Repeat to the other side (65bpm).		10: Same as aquatic exercise 10, but with a blue Theraband tied round the ankles (40bpm).	
11: Hold dumbbell floats in each hand and position the arms by the side. Raise the knees alternately until thighs are parallel to the water surface (30bpm).		11: Sit on a Swiss ball (65cm diameter) with knees positioned at 90° and arms by the side without the hands touching the ball. Raise the feet alternately from the ground to a height of approximately 20cm (30bpm).	

**Fig. 1.** Aquatic and Land-based Exercises Adapted from Saikorakis et al. (2019) [2]

### 3. RESULTS

All participants completed the study, and no adverse effects were reported throughout the intervention. The Kolmogorov-Smirnov test indicated that the distribution of the variables in all study groups was normal. The demographic characteristics of the three groups are presented in Table 1. Age, height, weight, and body mass index (BMI) were homogeneous across the control, aquatic exercise, and land-based exercise groups, with no statistically significant differences observed ( $p > 0.05$ ).

**Table 1.** Demographic characteristics of the three groups

Group	n	Variable	Mean $\pm$ SD
<b>Control</b>	10	Age (years)	36.70 $\pm$ 6.70
		Weight (kg)	65.93 $\pm$ 15.21
		Height (cm)	163.90 $\pm$ 5.10
		BMI (kg/m <sup>2</sup> )	24.31 $\pm$ 4.83
<b>Aquatic Exercise</b>	10	Age (years)	32.30 $\pm$ 7.49
		Weight (kg)	63.61 $\pm$ 12.35
		Height (cm)	164.30 $\pm$ 5.20
		BMI (kg/m <sup>2</sup> )	23.83 $\pm$ 3.54
<b>Land-Based Exercise</b>	10	Age (years)	31.70 $\pm$ 4.29
		Weight (kg)	60.58 $\pm$ 6.30
		Height (cm)	159.50 $\pm$ 3.92
		BMI (kg/m <sup>2</sup> )	23.78 $\pm$ 1.88

In the present study, pain intensity, functional disability, and the Sorensen test were considered as dependent variables. The descriptive statistics (mean  $\pm$  SD) for these variables at pretest and posttest are presented separately in Table 2.

**Table 2.** Descriptive statistics of the dependent variables at pretest and posttest (n = 30)

Group	Variable	Pretest Mean $\pm$ SD	Posttest Mean $\pm$ SD
<b>Control</b>	Pain intensity (women with chronic low back pain)	3.40 $\pm$ 0.70	3.60 $\pm$ 1.26
<b>Aquatic Exercise</b>	Pain intensity	3.70 $\pm$ 0.82	1.60 $\pm$ 0.84
<b>Land-Based Exercise</b>	Pain intensity	3.60 $\pm$ 0.84	2.40 $\pm$ 0.52
<b>Control</b>	Functional disability	21.20 $\pm$ 7.79	21.20 $\pm$ 8.44
<b>Aquatic Exercise</b>	Functional disability	23.40 $\pm$ 7.12	13.60 $\pm$ 5.15
<b>Land-Based Exercise</b>	Functional disability	21.40 $\pm$ 3.53	16.00 $\pm$ 3.13
<b>Control</b>	Extensor muscle endurance (Sorensen test, sec)	69.40 $\pm$ 31.93	72.90 $\pm$ 33.73
<b>Aquatic Exercise</b>	Extensor muscle endurance	77.50 $\pm$ 18.72	104.20 $\pm$ 19.33
<b>Land-Based Exercise</b>	Extensor muscle endurance	71.40 $\pm$ 25.35	90.20 $\pm$ 29.08

One of the assumptions for multivariate analysis of variance (MANOVA) is the normality of the dependent variables. If this assumption is violated, various data transformation methods may be applied. The Kolmogorov-Smirnov test was used to assess normality. As shown in Table 3, the significance level for all variables exceeded 0.05, indicating that the variables were normally distributed. Therefore, parametric tests could be applied to test the study hypotheses.

**Table 3.** Kolmogorov-Smirnov test for normality

Variable	z	p-value
Pain intensity (women with chronic low back pain)	0.754	0.751
Functional disability (women with chronic low back pain)	1.685	0.326
Extensor muscle endurance (women with chronic low back pain)	1.024	0.852

To test the hypotheses regarding pain intensity, functional disability, and muscle endurance, a multivariate analysis of covariance (MANCOVA) was employed. The results of this analysis are presented in Table 4. Prior to performing the parametric MANCOVA, Box’s test and Levene’s test were conducted to ensure that the assumptions of the analysis were met.

**Table 4.** Box’s M test for study variables

Variable	Box’s M	F	Sig.
Pain intensity	9.83	4.75	0.48
Functional disability	7.43	4.95	0.52
Muscle endurance	9.33	5.63	0.74

As none of the variables were significant in Box’s test, the assumption of homogeneity of variance-covariance matrices was satisfied. Therefore, multivariate analysis of covariance (MANCOVA) could be applied. The comparison of aquatic and land-based exercises on pain intensity, functional disability, and muscle endurance in women with chronic low back pain is presented in the following tables.

**Table 5.** Comparison of the effects of aquatic and land-based exercises on pain intensity in women with chronic low back pain

between groups	Repeated Measures Analysis of Variance within the group		Paired t-test	Covariance analysis		mean standard deviation	group	Variables
	Group †	Group ‡		probability value	Percentage of changes			
F = 4.21	F = 5.14	F = 3.51	-	P=0.692	-	3.4000 .69921	control	pre-test
P = 0.000	P = 0.000 Significant cause: pain reduction	P = 0.002 Significant cause: pain reduction	P = 0.841	P=0.021	percent increase °	3.7000 .95412	Water exercises	
						3.6000 .84327	Ground exercises	
						3.6000 1.26491	control	
						1.6000 .98412	Water exercises	
			P = 0.000		61% decrease			After the test
			P = 0.002		33% reduction	2.4000 .51640	Ground exercises	

The results of the ANCOVA, as shown in Table 5, indicated that at both pretest and posttest stages, the scores of the experimental groups (aquatic and land-based exercises) differed significantly from the control group. Specifically, there was a significant reduction in pain intensity in the exercise groups compared to the control group (F = 4.21, P < 0.05). The aquatic exercise group showed the largest decrease in pain intensity (61% reduction),

followed by the land-based exercise group (33% reduction), while no significant change was observed in the control group.

**Table 6.** Comparison of the Effects of Aquatic and Land-Based Exercises on Functional Disability in Women with Chronic Low Back Pain

between groups	Repeated measures analysis of variance within the group		T couple	Covariance analysis		average standard deviation	group	Variables
	Group2	Group1		probability value	Percentage of changes			
F = 5.14	F = 6.25	F = 4.62	-	P=0.625	-	21.2000 7.78603	control	pre-test
P = 0.000	P = 0.000 :Significant cause reduction of functional disability	P = 0.002 :Significant cause reduction of functional disability	P = 0.805	P = 0.003	no change	23.4000 7.12117	Water exercises	
						21.4000 3.53396	Ground exercises	
						21.2000 8.44327	control	
			P = 0.000		43% decrease	13.6000 5.14674	Water exercises	After the test
			P = 0.000		24% reduction	16.0000 3.12694	Ground exercises	

The results of the covariance analysis test, as presented in Table 6, indicate that in both the pre-test and post-test stages, the scores of the exercise group differ significantly from those of the control group. Therefore, there is a significant difference between the control and exercise groups in terms of functional disability (F=5.14, and P<0.05).

**Table 7.** Comparison of the Effects of Aquatic and Land-Based Exercises on Muscle Endurance in Women with Chronic Low Back Pain

between groups	Repeated measures analysis of variance within the group		T couple	Covariance analysis		average standard deviation	group	Variables
	Group2	Group1		probability value	Percentage of changes			
F = 4.47	F = 0.90	F = 5.25	-	P=0.851	-	69.4000 31.93118	control	pre-test
P = 0.000	P = 0.002 :Significant cause increase in functional endurance	P = 0.005 :Significant cause increase in functional endurance	P=0.625	P = 0.000	5% increase	77.5000 18.71571	Water exercises	
						71.4000 25.35175	Ground exercises	
						72.9000 33.72586	control	
			P = 0.006		35% increase	104.2000 19.33218	Water exercises	After the test
			P = 0.004		27 % increase	90.2000 29.07767	Ground exercises	

The results of the covariance analysis, as presented in Table 7, indicate significant differences in the scores of the exercise group compared to the control group in both the pre-test and post-test stages. Therefore, there is a significant difference between the control and exercise groups in terms of functional endurance (F=4.47 and P<0.05).

#### 4. CONCLUSION AND DISCUSSION

The aquatic exercises in this study consisted of specialized training sessions conducted at the Diamond Club pool in Tehran, with water temperature maintained between 33 and 36°C under the supervision of the researcher [18]. The duration of the aquatic intervention was standardized to match the land-based exercise sessions. Participants were instructed to make up any missed sessions. Several previous studies have implemented land-based exercises for managing non-specific chronic low back pain [19,20], providing strong evidence that exercise therapy is at least as effective as other conservative interventions for this condition. However, there is limited evidence regarding aquatic interventions.

Aryoshi et al. (1999) studied 35 patients (25 women and 10 men) with non-specific chronic low back pain undergoing aquatic exercise interventions. During this intervention, some patients participated in short-term programs with fewer sessions, while others received long-term programs with more frequent sessions. Those who participated in long-term programs with higher session frequency showed significantly greater improvements in physical scores compared to those who exercised only once per week [21].

The present study revealed significant improvements in both aquatic and land-based exercise groups compared to the control group in pre- and post-test measurements. Furthermore, the results suggested a slight superiority of aquatic exercises over land-based exercises.

Regarding pain intensity, functional disability, and lumbar extensor muscle endurance, no significant differences were found between the aquatic and land-based groups. This lack of difference between the groups does not imply that the interventions were ineffective; rather, both interventions produced significant improvements compared to the control group. Our findings on pain intensity and functional disability are consistent with several previous studies [18,22,23]. The results for muscle endurance were partly inconsistent with some studies [18] and aligned with others [22]; this inconsistency may be due to differences in the type of performance tests, sample characteristics, and exercise protocols.

One limitation of the present study was the absence of male participants. Future research is recommended to include a larger sample size with male patients. Given the significant effects of aquatic and land-based exercises on pain reduction, functional improvement, and lumbar extensor muscle endurance, the use of these interventions is recommended for individuals with non-specific chronic low back pain.

## **Acknowledgments**

The authors would like to express their sincere gratitude to all colleagues and participants, especially Mr. Emad Ghasemi Ghal'eh, for their cooperation and support in conducting this study.

## **Declaration**

We acknowledge that we used ChatGPT to enhance the academic writing of our manuscript while ensuring the originality and integrity of our work.

## **Transparency Statement**

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

## **Acknowledgments**

We would like to express our gratitude to all individuals who contributed to this project.

## **Declaration of Interest**

The authors declare that they have no competing interests.

## **Funding**

This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

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