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ORIGINAL PAPER

The effectiveness of balneotherapy and thermal aquatic exercise in postoperative persistent lumbar pain syndrome

Elif Yolgösteren[1] · **Sevinç Külekçioğlu**[1]

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Abstract

In our study, we aimed to investigate the effectiveness of balneotherapy and aquatic exercises in patients with postoperative chronic low back pain. Forty-three patients over the age of 18 who had been operated on for herniated disc and who had at least 6 months of back and/or leg pain were included in the study. The patients have been distributed randomly into 2 groups prior to the treatment. The program comprising aquatic exercises distributed into 5 days a week for 2 weeks and 20 min (min) a day, in a 33 °C spa pool was applied to the first group. After the first group's treatment was completed, a program consisting of walking out of the pool and strengthening and stretching exercises for the hip, abdominal, back, and waist muscles was distributed into 5 days a week for 2 weeks for a total duration of 20 min per day was applied to both groups. The patients subjected to the study were evaluated before treatment, after treatment (2nd week), and at 1st and 6th months after treatment. The Visual Analogue Scale, Modified Schober Test, Finger-to-Floor Distance, Sorensen Test, Progressive Iso-inertial Lifting Evaluation, Rolland Morris Disability Index, Leeds Disability Scale, Beck Depression Inventory, Nottingham Health Profile, and Short Form 36 Health Survey parameters were evaluated. We detected a significant improvement in all parameters except for the Sorensen test, in both groups. We observed that the changes in VAS, Sorensen, NHP, and SF 36 tests in the aquatic exercise group were significantly better than those in the non-aquatic exercise group.

Keywords Back pain · Hydrotherapy · Physical therapy · Postlaminectomy syndrome · Post lumbar surgery syndrome · Failed back surgery syndrome

Introduction

Technological progresses have provided both patients and surgeons with significant benefits for the surgical treatment of lumbar vertebral column impairment. However, a considerable part being 10–40% of the patients who have undergone surgical fixation continue to suffer from permanent functional limitations, including chronic low back pain, leg pain, loss of capacity in daily living activities, and accompanying reduced quality of life (Van Buyten and Linderoth 2010; Chan and Peng 2011). This condition is also named as postoperative persistent syndrome (POPS), postlaminectomy syndrome, post lumbar surgery syndrome, or failed back surgery syndrome (FBSS) (Weinstein et al. 2008; Rigoard et al. 2015). Despite the name, FBSS does not necessarily describe a failed surgical procedure; rather, it is a technically successful operation that fails to produce good clinical results in the long term. If patients show chronic back pain or leg pain in the postoperative period and the pain has no specific cause, a diagnosis can be made (Rigoard et al. 2015). Increase in pain, lack of muscle strength and endurance, decrease in general body performance, increase in somatic complaints, changes in anxiety, and difficulties in movement are common in POPS patients. There is strong evidence regarding the effectiveness of exercise in the treatment of chronic low back pain and it is one of the methods that are suggested most frequently (Sertpoyraz et al. 2009; Liddle et al. 2004). There are studies showing the effectiveness of different exercise methods in patients who have undergone back surgery, even though few in number, and most of these studies are made to avoid POPS development by assigning postoperative routine exercise programs, rather than POPS treatment (Karahan et al. 2016; Filiz et al. 2005; Mathews et al. 2014; Ostelo et al. 2003).

✉ Sevinç Külekçioğlu
sevinckulek@gmail.com

[1] Bursa Yüksek Ýhtisas Eðitim Ve Araþtýrma Hastanesi, Bursa Yuksek Ihtisas Egitim ve Arastirma Hastanesi, Çamlýca Mah, Bursa, Turkey

Balneotherapy (BT) is frequently used in the treatment of musculoskeletal system diseases in daily practice in many countries including Turkey (Gutenbrunner et al. 2010; Kesiktas et al. 2012; Karagülle et al. 2017). Contrary to the hydrotherapy that generally uses regular tap water, balneotherapy is defined as the usage of baths that contain thermal mineral water from natural sources of min. 20 °C temperature having min. 1 g/l mineral content (Pittler et al. 2006; Angioni et al. 2019). It is believed that the therapeutically beneficial effects of spa treatments are mainly related to the physical, chemical, and thermal features of the water (Bernetti et al. 2020; Fioravanti et al. 2017; Masiero et al. 2020a, b). Published studies show that balneotherapy is beneficial in relieving pain in patients suffering from low back pain (Pittler et al. 2006; Bai et al. 2019; Dilekçi et al. 2020). The patients who have limitations during the performance of land exercises may benefit from aquatic exercise. Aquatic exercise creates a supportive rehabilitation environment, mitigates the risks of a non-aquatic rehabilitation area, provides a new therapeutic activity, mitigates the risk of injury, and facilitates returning to previous activities. Besides, water reduces the effects of compressive and shearing forces on vertebra, expands the safety limits of postural dysfunction, and regulates postural stability (Yücesoy et al. 2021a; Yozbatıran et al. 2004). Many studies have been conducted on exercise-based rehabilitation of patients suffering from chronic low back pain, whereas the number of studies on patients suffering from persistent or recurrent postoperative low back pain remains limited. There are a limited number of studies conducted by assigning aquatic exercise in chronic low back pain cases (Yozbatıran et al. 2004; Musumeci et al. 2018; Masiero et al. 2018). To the best of our knowledge, there is no study on the use of hydrotherapy and aquatic exercise in POPS published in an indexed journal.

In our study, we aimed to investigate whether aquatic exercises performed along with the spa are effective on the patients suffering from postoperative chronic low back pain who are operated due to lumbar disc herniation and whether such exercises have an edge over non-aquatic exercises.

Patients and methods

This prospective, randomized controlled, and single-blind study was conducted in Uludag University Faculty of Medicine (UUMS) Department of Physical Therapy and Rehabilitation. Approval of UUMS Ethical Committee is obtained. The procedures followed were in accordance with the Declaration of Helsinki. The patients were informed about the treatment program to be implemented and the "Informed Voluntary Form" was signed by those who have accepted the program. Patients who were operated for lumbar disc herniation (single-level discectomy) and diagnosed as POPS due to low back and/or leg pain lasting at least 6 months after surgery were included in the study. The patients suffering from severe lumbar spondylosis, having compression fracture on vertebrae, having decompensated organ failure and malignancy, having inflammatory and infection diseases, having peripheral vascular disease, neurological and mental disorder, who are obese (BMI > 25), having low weight (BMI > 18.5), who have received balneotherapy or physiotherapy within the last one year, and who have used analgesics and antidepressants within the last 1 month were excluded from the study. The study was initiated with patients who met the inclusion criteria. An inspection form containing demographic characteristics, location and duration of pain, and operation dates has been filled in for the patients subjected to the study. The patients have been distributed randomly into 2 groups prior to the treatment. The program comprising aquatic exercises distributed into 5 days a week for 2 weeks and 20 min (min) a day, in a 33 °C thermal pool (warm-up exercises in the form of walking in water for 5 min, aerobic exercise in the form of hip flexion-abduction, trunk lateral flexion, arm circling for 5 min, cool down exercise in the form of slow walking in water for 5 min, and stretching exercise for 5 min), was applied to the first group. After the first group's treatment was completed, a program consisting of walking out of the pool and strengthening and stretching exercises for the hip, abdominal, back, and waist muscles was distributed into 5 days a week for 2 weeks for a total duration of 20 min per day was applied to both groups. The patients were ensured to continue the non-aquatic exercise program in the form of a home program distributed into 3 days a week and for a duration of 20 min per day, for 6 months. Aquatic and non-aquatic exercises in the first 2 weeks were carried out in groups and under the supervision of a physiotherapist. Aquatic exercises were carried out in a pool having a width of 4.15 m (m), a length of 8.20 m, and a maximum depth of 1.25 m that was filled with hot thermal water. Properties of the thermal spring were the following: hyperthermal (74.5 C), hypotenic (23.1 mmol), ph 6.8, electrical conductivity 1366 microohm/cm at 25 C, total hardness (CaCO3) 260.2 mg/l, calcium 87.18 mg/l, Mg 11.44 mg/l, sulfate 272 mg/l, Na 193.3 mg/l, K 22.54 mg/l, Fe 0.08 mg/l, manganese 0 mg/l, ammonium 0.0238 mg/l, nitrite nitrogen 0.043 mg/l, orthophosphate 0.227 mg/l, hydrogen sulfide 0.36 mg/l, free CO2 90 mg/l, dissolved solids 959 mg/l.

The patients subjected to the study were evaluated before treatment, after treatment (2nd week), and at 1st and 6th months after treatment. Parameters used to assess clinical and functional status were recorded at all visits. SF 36, used to assess quality of life, was evaluated at baseline and 6 months after treatment.

Parameters to be used in the study

1. Pain Severity Assessment
   - Visual Analogue Scale (VAS): It is a common, simple method that is well-constructed and validated and reliable. The physician explained the meanings of each number on a 10 cm (cm) scale to the patients and asked them to mark the pain severity level (0 = no pain; 5 = moderate pain; 10 = severe pain) accordingly during movement, resting, and night respectively (Hawker et al. 2011).
2. Lumbar Flexibility Measurement
   - Modified Schober Test (MST): It is a reliable technique used to evaluate spinal flexion. 5th lumbar spinous process and 10 cm (cm) above were marked while the patient was standing upright on foot. The patient was asked to try to touch the ground with her knees extended. The distance between the markings was measured in this position and the difference was noted in cm by the physician.
   - Finger-to-Floor Distance (FFD): The patient standing upright on foot was asked to bend forward and touch the floor with fingertips while the knees were in extension. In this position, the distance between the fingertips and the ground was measured and the difference was recorded in cm by the physician.
3. Low back, Back Muscle Strength and Endurance Assessment
   - Sorensen Test: It tests the strength and endurance of back extensors. The person asked to lie face downwards on a table and to keep the trunk parallel to the ground against the gravity once the lower extremities and pelvis are fixed. The time of holding this position was recorded in seconds (McKeon et al. 2006).
4. Measurement of Functional Work Performance and Weight-lifting Capacity
   - Progressive Iso-inertial Lifting Evaluation (PILE): Lifting capacity is an easy test that provides information about the general body performance (Lygren and Dragesund 2005) and it was conducted by the physician. The persons with high risk for back injuries are revealed by means of the evaluation of this capacity. This assessment can assist clinicians in determining whether the patient is ready to return to any task that requires repetitive lifting. The starting weight is 3.6 kg (kg) for women and 5.85 kg for men. The patient lifted the weights from the floor to the waist level for 4 times. Each completed lifting cycle, the pressure was increased by 2.25 kg for women and by 4.5 kg for men. Men can lift 50% of their body weight and women can lift 35% of their body weight from the ground to waist level. The test was complete when the patient is unable to lift the box four times in 20 s and decides to stop due to fatigue or pain heart rate exceeds 85% of maximum heart rate.
5. Evaluation of Daily Living Activities
   - Rolland Morris Disability Index (RMDI): It comprises of 24 articles. Activity level, daily living activities, eating, and sleeping are questioned by means of this index. It does not measure psychosocial function. The total score is calculated by scoring in the manner that yes is 1 and no is 0 (Küçükdeveci et al. 2001).
   - Leeds Disability Scale (LDS): It comprises of 16 articles in total, being 4 for evaluating mobility, 4 for evaluating bending forward, 4 for evaluating neck motions, and 4 for evaluating posture (Ranieri et al. 2009).
6. Psychological Assessment
   - Beck Depression Inventory (BDI): The BDI contains 21 questions where each answer is scored on a scale of 0 to 3. BDI evaluates the parameters such as depression, sleep disturbances, weight loss, irritability, and sexual dysfunction. Total score varies between 0 and 63 (Kapci et al. 2008). Higher total scores indicate more severe depressive symptoms.
7. Evaluation of the Quality of Life
   - Nottingham Health Profile (NHP): In this questionnaire, patients are asked to answer the questions as yes and no. The questionnaire contains a total of 38 questions and comprises of 6 sections. Pain and physical activity are questioned in 8 questions, sleep in 5 questions, fatigue in 3 questions, social isolation in 5 questions, and emotional reaction in 9 questions. The weighted score of the respective question is noted for each yes answer given by the patients while 0 point is noted for each no answer. Scores in each section are calculated separately. Each category takes a value between 0 and100. Thus, the health profile score is obtained. It has been tested for the conditions in Turkey (Küçükdeveci et al. 2000).
   - Short Form 36 Health Survey (SF-36): Consists of 9 subscales including 36 questions involving the physical and social function. These subscales are the physical function, social function, role limitations related to physical problems, role limitations related

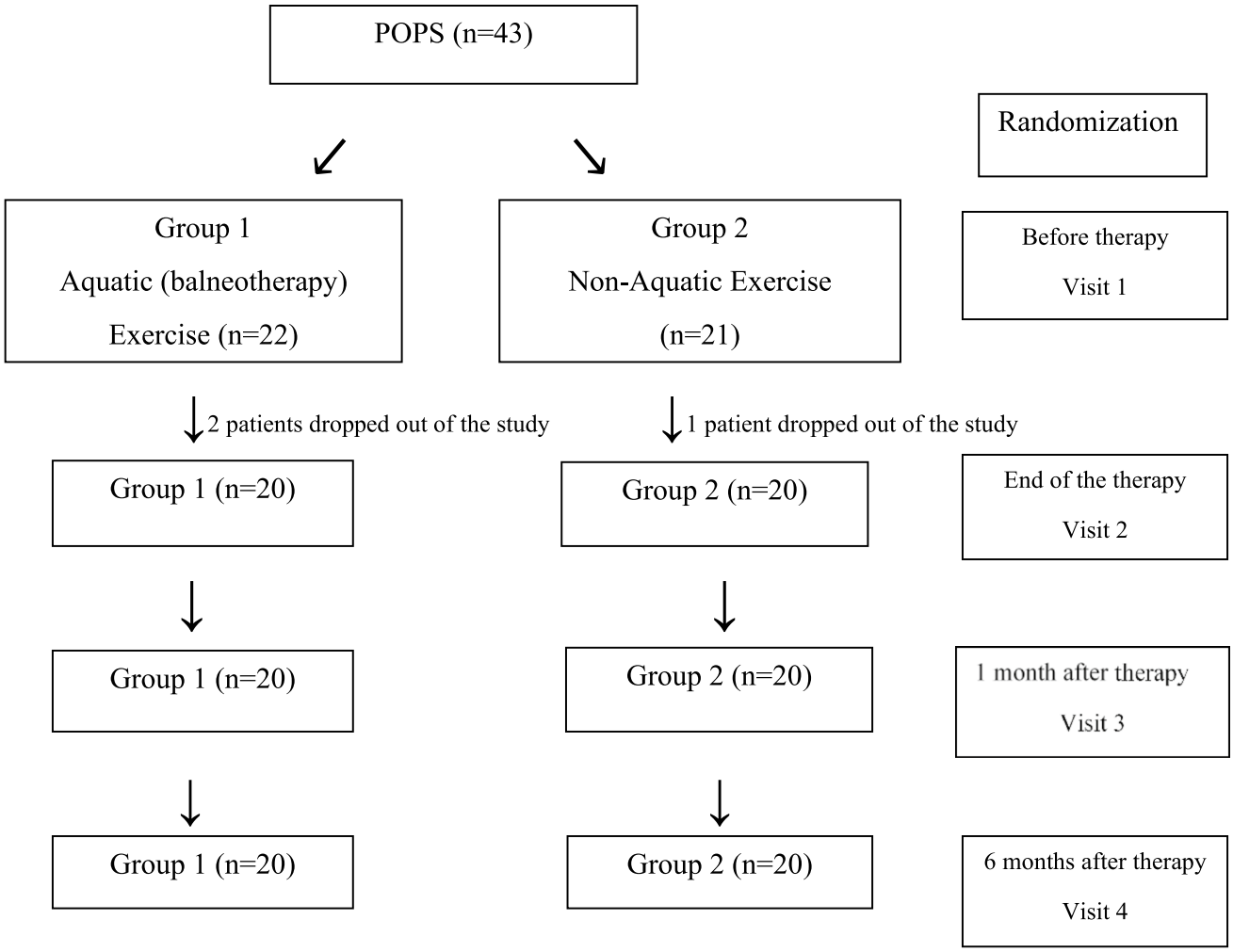

Fig. 1 Flow chart of groups

to emotional problems, mental health, energy/vitality, pain, general perception of health, and the health status compared to the previous year. With this scale, health status is investigated in detail. Patients were asked to choose the most appropriate option for each question. Each subtitle was scored between "0 and 100." The best score was determined to be 100. Its validity and reliability were demonstrated in Turkish (Demiral et al. 2006).

Table 1 Demographic and clinical data

	Group 1 ($n=20$)	Group 2 ($n=20$)	p
Age (years)	55.0 ± 11.0	54.6 ± 9.3	$p > 0.05$
Female	16	15	$p > 0.05$
Male	4	5	$p > 0.05$
Duration of complaint (month)	31.5 ± 26.9	37.5 ± 25.6	$p > 0.05$

Statistical analysis

Table 2 Distribution of movement, resting, and night VAS values of the facts according to the groups. *VAS*, Visual Analogue Scale

		Start	2 weeks	1 month	6 months
Movement VAS	Group 1 ($n=20$)	6.5 ± 1.3 4.0–8.5	4.3 ± 1.3* 2.0–8.0	3.0 ± 1.5* 0–5.0	2.8 ± 1.9* 0–8.0
	Group 2 ($n=20$)	6.1 ± 1.4 4.8–10.0	5.5 ± 1.8 3.0–9.0	4.6 ± 1.5* 2.0–8.0	4.6 ± 1.7* 0–8.0
Resting VAS	Group 1 ($n=20$)	2.0 ± 2.1 0–5.8	1.2 ± 1.6* 2.0–4.0	0.7 ± 1.1* 0–3.5	0.4 ± 0.9* 0–3.0
	Group 2 ($n=20$)	2.1 ± 1.7 0–5.0	1.5 ± 1.7* 0–5.0	0.9 ± 1.4* 0–4.0	0.9 ± 1.4* 0–4.0
Night VAS	Group 1 ($n=20$)	3.5 ± 2.8 0–7.0	1.9 ± 2.0* 0–5.0	1.1 ± 1.4* 0–4.0	1.0 ± 1.8* 0–7.0
	Group 2 ($n=20$)	2.8 ± 2.6 0–8.0	2.5 ± 2.5 0–8.0	1.9 ± 1.9* 0–6.0	1.8 ± 1.9* 0–6.0

*$p < 0.05$

Table 3 Distribution of 2nd week and 1st and 6th month MST and FFD distance values of the facts. *MST*, Modified Schober Test; *FFD*, Finger-to-Floor Distance

		Start	2 weeks	1 month	6 months
MST (cm)	Group 1 ($n=20$)	4.3 ± 0.7 2–5	4.7 ± 0.4* 4–5	4.7 ± 0.4* 4–5	4.7 ± 0.5* 3–5
	Group 2 ($n=20$)	4.5 ± 0.8 2–5.5	4.8 ± 0.4* 4–5.0	4.8 ± 0.5* 3–5.5	4.8 ± 0.5* 3–5.5
FFD (cm)	Group 1 ($n=20$)	7.1 ± 9.0 0–40	4.0 ± 5.4* 0–20	5.3 ± 6.0 0–20	5.1 ± 6.6 0–25
	Group 2 ($n=20$)	8.3 ± 6.7 0–25	4.7 ± 4.2* 0–14	6.1 ± 5.4* 0–20	5.5 ± 5.1* 0–20

*$p < 0.05$

Statistical evaluation of the study is realized on a computer by using SPSS for Windows, 13.0 static module under the guidance of Uludag University, Faculty of Medicine, Biostatistics Department. Continuous variables are presented as average (± standard deviation), while the categorical variables are presented as frequency (n). Normality ranking was made for the variables that take continuous values. The Kolmogorov–Smirnov test was used for single samples. The Wilcoxon test was used for intragroup comparison of the treatment-induced changes, and the Kruskal–Wallis test was used for intergroup comparison. The significant ones were evaluated with the Mann–Whitney U test and the group causing the difference was investigated. $p < 0.05$ level was considered to be statistically significant in all evaluations.

Results

Forty of 43 participant patients completed the study. Two of 3 patients who failed to continue were excluded from the study due to increasing pain while 1 of them did not want to attend follow-ups (Fig. 1). The study was conducted with 20 patients in the first group scheduled with aquatic exercise program and with 20 patients in the second group scheduled with non-aquatic exercise program. There was no statistical difference between the groups for the demographical and clinical assessments at the beginning of trial ($p > 0.05$) (Table 1). Tables 2, 3, 4,5, 6, and 7 show the distribution of movement, resting, and night VAS values of the subjects; the distribution of MST and FFD distance values; the distribution of Sorensen, PILE, RMDI, LDS, and BDI values according to the groups; and the distribution of NHP and SF-36.

Discussion

In our study, we investigated whether aquatic exercises performed along with balneotherapy are effective on patients with POPS who are operated due to lumbar disc herniation and whether such exercises have an edge over non-aquatic exercises. After the treatment, we detected a significant improvement in all parameters except for the Sorensen test, in both groups. We could not find any significant change in Sorensen parameters in the non-aquatic exercise group. We attributed this result to the fact that the exercises intended to strengthen the back extensors cannot be done effectively except water. In compliance with the literature, we observed that the changes in VAS, Sorensen, NHP, and SF 36 tests in the aquatic exercise group were significantly better than the non-aquatic exercise group. We did not observe any difference between the 2 groups in terms of other parameters. To the best of our knowledge, our study is the first study investigating the effectiveness of balneotherapy and aquatic exercise on POPS. In a study with a different design that was conducted by Moreira et al. on a small number of patients, the effectiveness of only hydrotherapy (normal tap water) on POPS was evaluated, whereas a decrease in pain level and an increase in lumbar flexibility were detected (Musumeci et al. 2018). Especially in recent years, non-drug methods have been used frequently and balneotherapy selected for the treatment of chronic musculoskeletal diseases, and exercises appear as safe methods. Exercise has been used for a long time for the purpose of chronic low back pain rehabilitation and has recently been added to treatment programs as a home program. It is possible to reduce pain, strengthen

Table 4 Start, 2nd week, and 1st and 6th month Sorensen and PILE average distribution. *PILE*, Progressive Iso-inertial Lifting Evaluation

		Start	2 weeks	1 month	6 months
Sorensen (cm)	Group 1 ($n=20$)	20.0 ± 14.3 5–70	27.5 ± 14.7* 12–80	33.2 ± 18.1* 10–90	34.6 ± 20.4* 5–90
	Group 2 ($n=20$)	27.7 ± 14.8 7–50	28 ± 13.9 10–65	29.8 ± 15.4 10–70	27.6 ± 17.4 10–70
PILE (kg)	Group1 ($n=20$)	4.6 ± 2.0 2.5–10	5.3 ± 1.8* 3–10	5.3 ± 1.9* 3–10	5.4 ± 2.0* 3–10
	Group2 ($n=20$)	5.0 ± 1.9 3–10	5.4 ± 2.2* 3–10	5.4 ± 2.0* 3–10	5.4 ± 2.0* 3–10

*$p < 0.05$

Table 5 Distribution of RMDI, LDS, and BDI values of the facts according to the groups. *RMDI*, Rolland Morris Disability Index; *LDS*, Leeds Disability Scale; BDI, Beck Depression Inventory

		Start	2 weeks	1 month	6 months
RMDI	Group 1 ($n=20$)	13.1 ± 4.3 6–24	10.0 ± 3.5* 5.0–20.0	9.2 ± 3.7* 3.0–18.0	9.1 ± 4.0* 3.0–18.0
	Group 2 ($n=20$)	11.5 ± 3.9 5–16	10.0 ± 4.6 1.0–18.0	9.9 ± 4.2* 1.0–16.0	9.7 ± 4.3* 1.0–17.0
LDS	Group 1 ($n=20$)	8.7 ± 4.8 0–19	7.7 ± 6.4 0–28.0	6.9 ± 6.5* 0–30.0	5.5 ± 3.9* 0–13.0
	Group 2 ($n=20$)	8.2 ± 4.5 2–17	6.8 ± 4.6* 0–17.0	7.0 ± 4.2* 0–15.0	6.6 ± 4.5* 0–15.0
BDI	Group 1 ($n=20$)	9.4 ± 5.7 3–21	8.2 ± 5.9 0–21.0	8.5 ± 5.9 0–21.0	7.8 ± 5.7* 0–19.0
	Group 2 ($n=20$)	10.4 ± 5.6 0–19	9.1 ± 5.5* 0–17.0	8.6 ± 5.7* 0–18.0	8.8 ± 5.8* 0–17.0

*$p < 0.05$

weak muscles, reduce mechanical load, stabilize hypermobile vertebral segments, improve posture, and cure deteriorated low back functions (Sertpoyraz et al. 2009; Searle et al. 2015). In the postoperative acute period, the patients carry out only protective activities and reduce physical activity since they believe that movement will increase their pain. However, restriction of physical activity in the chronic period causes decreased muscle strength and flexibility. Social isolation increases stress and supports the emerging anxiety and depression pain behavior (Chan and Peng 2011). All of the aforementioned result in poor quality of life of the patient. Among the conservative treatment methods applied to the patients with POPS, the importance of exercise has been emphasized in the literature (Karahan et al. 2016; Filiz et al. 2005; Mathews et al. 2014; Ostelo et al. 2003). In parallel with the literature, a significant improvement was observed in pain intensity, functional status, and quality of life in both exercise groups in our study. There have been studies conducted with regard to the rehabilitation of patients with chronic low back pain (LBP) based on aquatic exercise (Olkoski et al. 2020; Carvalho et al. 2020), whereas, to the best of our knowledge, there is no study conducted with regard to aquatic exercise on POPS. There is evidence that aquatic exercises are effective in the conservative treatment of chronic low back pain, whereas these are in compliance with the results of our study (Carvallo et al. 2020; Olkoski et al. 2020; Shi et al. 2018). Aquatic exercises have significant benefits compared to non-aquatic exercises. It can help to control balance, mobility, and pain (Baena-Beato et al. 2014). Exercising in warm water may facilitate muscle relaxation, and the water buoyancy reduces joint loads (Baena-Beato et al. 2014). Water is an environment that is suitable for activating joints. It has been brought forward that the physical properties (buoyancy, viscosity, hydrostatic pressure) together with the high temperature of the water allow joint movements within a wider range of motion and provide long-term flexibility (Lineker et al. 2000).

BT is a very old and traditional treatment method used in the treatment of locomotor system diseases. In addition, it has been reported that patients with low back pain have an effect on pain, physical function limitations, and activities of daily living (Kesiktas et al. 2012; Karagülle et al. 2017; Bai et al. 2019; Dilekçi et al. 2020). The possible effect of CT is the result of a combination of factors with mechanical, thermal, and chemical effects (Yücesoy et al. 2019, 2021a). One of the most important positive effects of BT is the fact that it can be applied to the entire body at the same time. The waist area is the center of gravity of the body and is affected by almost all body movements due to the gravity. As a result of the hydrostatic and physical effects of water, blood flow is centralized, peripheral vascular resistance decreases, and cardiac blood flow, muscle perfusion, and oxygen availability increase (Carter et al. 2014). This results in an improvement in general health, reduction of muscle spasms that cause low back pain, and an increase in endorphin production that binds to opiate receptors in the pain perception system in the brain and spinal cord (Galvez et al. 2018). Endorphin is a peptide having morphine-like analgesic effects and is a natural alternative that is capable of reducing the pain associated with musculoskeletal problems (Hartwig 1991; Maccarone et al. 2021; Masiero et al. 2020b). In addition, decreased levels of some proinflammatory cytokines such as prostaglandin E2, leukotriene B4, IL-1, IL-6, and TNF-a;

Table 6 Distribution of initial, 2nd week, and 1st and 6th month NHP values. *NHP*, Nottingham Health Profile

NHP	Start		2 weeks		1 month		6 months	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Pain	59.3	53.7	45.6*	46.8*	36.8*	40.0*	38.7*	40.0*
Physical activity	42.5	41.2	33.1*	38.7	31.2*	38.1*	31.8*	36.8*
Fatigue	66.6	74.9	49.9*	73.3	43.3*	63.3*	39.9*	64.9*
Sleep	31.0	32	26	30	22.0	30.0	22.0*	29.0
Social isolation	17.0	20	17	18	14.0	18.0	16.0	20.0
Emotional reaction	26.0	32.1	17.7*	26.6*	17.2*	25.5*	17.7*	26.6*
Total	242.6	254.1	189.4*	233.5*	164.6*	214.9*	165.8*	217.4*

*$p < 0.05$

Table 7 Distribution of initial, 2nd week, and 1st and 6th month SF-36 values

SF-36	Start		2 weeks		1 month		6 months	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Physical function	51.5	44	63.5*	47	66.0*	49.5*	66.2*	48.7*
Physical role potency	37.5	41.2	52.5*	48.7	62.5*	47.5	61.2*	50.0
Pain	39.5	41	55.5	45	61.0	47.5	65.0	47.0
General health	50.1	42.8	60.4*	44.8	60.6*	46.6	63.1*	46.6
Vitality	45.2	47.0	54.0*	47.8	57.5*	46.3	57.2*	46.8
Social function	55.5	73.7	68.7	74.3	69.6	74.7	70.2	74.1
Emotional role potency	54.9	53.3	69.9*	56.6	73.3*	59.9	73.2*	59.9
Mental health	56.1	61.5	63.5*	63.1	64.0*	63.1	64.5*	63.8

*$p < 0.05$

positive effects on antioxidant markers; and cartilage degradation are associated with the reduction in perceived pain and analgesic effects of BT (Galvez et al. 2018; Fioravanti et al. 2011). The temperature of the water stimulates the thermoreceptors in the skin and indirectly reduces muscle tone, while the resulting antispasmodic and analgesic effect allows improvement of active and passive ranges of motion (Yücesoy et al. 2021b). The mechanical and thermal effects of BT may be similar to hydrotherapy; however, it has been reported that BT is superior to hydrotherapy in the long term in terms of reducing pain and improving function (Kulisch et al. 2009; Tefner et al. 2012). In our study, in support of the literature, the long-term (6th month) BT results were found to be significant, whereas this result may be one of the most important reasons for using BT. The higher the mineral concentration of the water, the greater the hydrostatic pressure and its effect on the patient's body (Huber et al. 2019; Gati et al. 2018) indicates that calcium-magnesium-sodium-bicarbonate may have a positive effect on the clinical parameters of balneotherapy in patients suffering from chronic low back pain. Besides, there is a strong placebo effect attributed to spa treatments, and the psychological effect it causes is considered an important factor (Antonelli and Donelli 2018).

As a result, additional positive changes in patients with POPS can be attributed to the fact that BT, through mechanical, thermal, and chemical ways, reduces nociception and muscle spasm in the entire body in general, increases flexibility of tissues, and stimulates the mechanisms associated with the heat applications in the entire body. In our study, we established that the additional positive effects of BT could be an effective treatment alternative for the POPS patient group. Exercising with less effort and less weight feeling in water and reducing the load on the joints can be more motivating and pleasing for patients. This study is important in terms of considering that the balneotherapy and the exercise programs combined with balneotherapy in the guidebooks are prepared for the purpose of multimodal POPS treatment management and suggesting that further studies regarding this subject are needed.

The most important limitations of our study are that balneotherapy was not compared with hydrotherapy, the social outcomes of group treatment were not evaluated, and the number of patients was few. Besides, it is not known to what extent the temperature and mineral content of the available spring water make a difference in balneotherapy.

Conclusion

Balneotherapy plus thermal aquatic exercise therapy was found to be more effective than exercise therapy alone in POPS patients. Although exercise therapy was effective in improving lumbar flexibility, lifting capacity, general body performance, activities of daily living, and psychological state, thermal water exercise program combined with balneotherapy was found to be more effective in improving pain severity and low back pain, back muscle strength-endurance, and quality of life. However, it should be underlined that there is a need for future studies with a larger number of patients and longer follow-up periods.

Declarations

Conflict of interest The authors declare no competing interests.

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