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The effects of balneotherapy on acute, process-related, and cumulative peripheral cardiac responses and pulmonary functions in patients with musculoskeletal disorders

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Background/aim: This study aimed to evaluate the effects of balneotherapy on acute, process-related, and cumulative peripheral cardiac responses and pulmonary functions in patients with musculoskeletal disorders.

Materials and methods: Ninety-eight patients with musculoskeletal disorders referred to physiotherapy with balneotherapy were recruited. The patients received balneotherapy for 20 min 5 times per week for 2 weeks. Blood pressure and pulse were measured at the 0th, 5th, 10th, 20th, and 30th minutes during the 1st and 10th sessions. All patients were subjected to pulmonary function testing before balneotherapy and after the 10th session.

Results: It was found that systolic blood pressure decreased between the 10th and 20th minutes of the 1st session and between the 10th and 20th minutes and the 20th and 30th minutes of the 10th session ($P < 0.05$). Diastolic blood pressure (DBP) decreased and pulse increased during balneotherapy ($P < 0.05$). DBP increase and pulse decrease were observed during recovery time ($P < 0.05$). The blood pressure decreased and the pulse increased after the 1st session and after the 10th session ($P < 0.05$). Pulmonary function improved after balneotherapy ($P < 0.05$).

Conclusions: Balneotherapy may be effective for improving peripheral cardiopulmonary responses in patients with musculoskeletal disorders.

Key words: Balneotherapy, pulse, blood pressure, pulmonary function

1. Introduction

Chronic musculoskeletal complaints are very common in the general population. The percentage of treatment-seeking patients is about 39% among males and 45% among females (1). These patients complain of moderate to severe muscle tension, joint stiffness, pain, and functional, psychosocial, and life quality impairments. Moreover, some studies have revealed common cardiac and pulmonary dysfunctions in chronic musculoskeletal disorders (2–4).

Different physical and chemical modalities have been used for the treatment of musculoskeletal disorders. Balneotherapy, as an alternative or additional method, has been used for a long time against these impairments. Balneotherapy was described as a treatment procedure using physical and chemical effects of water including thermomineral, acratothermal, and acratopegal (5). The application of these waters as a therapy at a specific dose, in a certain period of time with repeated, regular intervals, and with a specific method, such as bathing, drinking, or inhalation, has a common use in various diseases, including chronic musculoskeletal (inflammatory and noninflammatory), dermatologic, metabolic, and psychological conditions (6,7). However, to our knowledge, limited evidence-based results about its effects have been presented in the literature. It was shown to be effective in muscle relaxation and in reducing symptoms such as pain and joint stiffness (8), increasing functionality, improving life quality, and reducing the need for analgesic medications in several diseases (9,10). Furthermore, it has been shown to provide significant and longer-lasting improvement compared to control groups in the symptoms of pain, joint stiffness, fatigue, and sleep disturbance (11,12).

In addition to these benefits, cardiopulmonary responses to the balneotherapy have been highlighted during and after its application since it may cause adverse as well as positive responses (13–15). Blood pressure decrease during balneotherapy was declared as a very well-

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known response due to peripheral vasodilatation (16,17). It was declared that bathing at 41 °C in a semirecumbent position decreased cardiac afterload and therefore increased venous return. It was associated with external hydrostatic pressure and resulted in increased preload during water immersion (18). Acute responses of the cardiovascular system decreased systolic blood pressure (SBP) caused by increased venous return and increased heart rate (17). However, contradictory and insufficient results about acute, process-related, and cumulative effects of balneotherapy on blood pressure and pulse have been reported in the literature (14,17,19).

Furthermore, balneotherapy has been shown to provide significant improvements in pulmonary symptoms (11,20). $PaCO_2$ decrease, forced expiratory volume at the 1st second (FEV1), the ratio of FEV1 to forced vital capacity increase, and improvement in blood gas exchange in the pulmonary capillaries during balneotherapy have been observed (21,22). However, while some studies showed positive results of balneotherapy in the improvement of respiratory functions, some others declared no improvements in pulmonary functions (14,23). It is necessary to determine the cardiopulmonary effects of balneotherapy in treatment-seeking musculoskeletal patients.

Therefore, the aim of the present study was to evaluate the acute, process-related, and cumulative effects of balneotherapy on peripheral cardiac responses and pulmonary function in patients with musculoskeletal disorders. The following hypotheses were investigated: 1) Balneotherapy would change acute, process-related, and cumulative peripheral arterial blood pressure and pulse in patients with musculoskeletal disorders. 2) Balneotherapy would improve pulmonary functions in patients with musculoskeletal disorders.

2. Materials and methods

2.1. Patients

In this study, 98 patients out of 312 (aged between 30 and 65 years) with musculoskeletal disorders who were admitted to the Kırşehir Ahi Evran University Training and Research Hospital for physiotherapy and rehabilitation were included.

The inclusion criteria were to be a volunteer patient with a chronic musculoskeletal disease, including knee osteoarthritis, fibromyalgia syndrome, rotator cuff tear, adhesive capsulitis, and intervertebral disc disorders of cervical and lumbar regions. Exclusion criteria were the presence of chronic medical disorders requiring medical treatments, fractures, infectious diseases, malignant tumors, unstable hypertension, severe cardiovascular problems, major hepatic and renal insufficiency, hemorrhagic diseases, serious anemia, pregnancy, psychiatric disorders, and any problem like heat intolerance, water phobia, skin diseases, allergy to chlorine, or skin insensitivity that may not allow participation in pool sessions and application of balneotherapy. Patients who received insufficient treatments were also excluded (balneotherapy <20 min, and/or fewer or more than 10 sessions).

All the patients were diagnosed by the same physician (SŞ) at the Physical Medicine and Rehabilitation Clinic. Laboratory tests used for patient evaluations included complete blood count, erythrocyte sedimentation rate, C-reactive protein level, fasting blood glucose level, hepatic and renal function tests, and thyroid function tests. The patients who met the necessary criteria were admitted to the hospital inpatient clinic.

The patients were fully informed about the nature and purpose of the study. Written informed consent was obtained. The study was approved by the ethics committee (Approval Number: 2015/10-30).

2.2. Outcome measures

Demographic and clinical features and measurements were recorded before participation. Patient data, including age, sex, height, weight, smoking history, and disease diagnosis, were recorded. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

Blood pressure (SBP and diastolic blood pressure (DBP)) and pulse were measured after the 1st balneotherapy session for acute effect and after the 10th balneotherapy session for cumulative effect. Moreover, process-related changes in blood pressure and pulse were assessed during balneotherapy in the pool at the 0th, 5th, 10th, 20th, and 30th (during recovery) minutes. The measurements of these changes were performed during the 1st and 10th balneotherapy sessions.

Patients were seated comfortably during blood pressure and pulse measurements before (0th minute) and after balneotherapy (30th minute) out of the pool. The blood pressure and pulse at the 5th, 10th, and 20th minutes during balneotherapy were measured in semirecumbent position in the pool. Blood pressure was evaluated with a noninvasive sphygmomanometer on the same arm (right) (Oncomed Plus+, AS-B). The pulse was assessed with the researcher's three fingers on the radial artery.

Pulmonary function tests were carried out via volumetric spirometry (Minispir, MIR, Italy) on the day before the 1st session and on the last day following the 10th session. FEV1, forced vital capacity (FVC), the ratio of FEV1 to FVC (FEV1/FVC), and peak expiratory flow (PEF) were evaluated. During the pulmonary test, patients were seated comfortably. The technique was demonstrated and the patients were instructed to take a full breath in, then to close their lips and blow out as hard and fast as possible. Inhalation should be full, and exhalation should be continued without pause. A minimum exhalation of 6 s is necessary to obtain the maximal FVC. The result was expressed in liters (body temperature, barometric pressure, and saturated). At least three pulmonary function measurements were obtained. The best FVC and FEV1 values were computed. All the measurements were taken by experienced physiotherapists (ŞTÇ, DÖK).

2.3. Intervention

All patients received 10 sessions of balneotherapy application combined with conventional physical therapy (including electrothermal applications). The patients did not perform any exercise during the treatment.

Balneotherapy was performed in pools in containing thermomineral water rich in bicarbonate, sulfate, magnesium, and calcium minerals with a temperature range of 36 °C to 40 °C. The patients received balneotherapy at the same time period every weekday (1100 to 1120 hours) for 20 min, 5 times per week for 10 days.

2.4. Statistical analyses

The G*Power package software program (G*Power, Version 3.0.10, Franz Faul, University of Kiel, Germany) was used to determine the sample size. We calculated that a sample consisting of at least 90 patients was needed to obtain 80% power with $d = 0.3$ effect size, $\alpha = 0.05$ type I error, and $\beta = 0.20$ type II error.

Data analysis was conducted using IBM SPSS Statistics 21.0 (IBM Corp., released 2012; Armonk, NY, USA). The variables were investigated using visual (histograms, probability plots) and analytical (Kolmogorov–Smirnov test) methods to determine whether or not they were normally distributed. Descriptive analyses were presented using mean and standard deviation (SD) for the normally distributed variables, and tables of frequencies, median, and interquartile range (IQR) for the nonnormally distributed and ordinal variables. Since blood pressure, pulse, FEV1, FVC, FEV1/FVC, and PEF parameters were not normally distributed, a nonparametric test was used to compare these parameters. The Wilcoxon test was used to compare the change in blood pressure, pulse, FEV1, FVC, FEV1/FVC, and PEF parameters before and after balneotherapy.

The Friedman test was conducted to test whether there was a significant change in the blood pressure and pulse variables (0th, 5th, 10th, 20th, and 30th minutes) due to violations of parametric test assumptions. The Wilcoxon test was performed to test the significance of pairwise differences using the Bonferroni correction to adjust for multiple comparisons. An overall P-value of less than 0.05 was considered to show a statistically significant result.

3. Results

The baseline demographic characteristics of the patients are displayed in Table 1. Fifty-nine (60.2%) patients had low back pain, 19 (19.4%) had neck pain, 16 (16.3%) had knee pain, and 4 (4.1%) had shoulder pain.

Table 1. Demographic characteristics of the patients.

Physical characteristics	n = 98
Age (years, X ± SD)	54.22 ± 8.85
Weight (kg, X ± SD)	82.27 ± 13.12
Height (m, X ± SD)	1.62 ± 0.09
BMI (kg/m^2, X ± SD)	31.06 ± 4.82
Sex (n, %)	
Female	71, 72.4
Male	27, 27.6
Smoking (n, %)	
No	94, 95.9
Yes	4, 4.1
Alcohol (n, %)	
No	97, 99.0
Yes	1, 1.0

X: Mean; SD: Standard deviation; BMI: Body mass index.

Significant differences in blood pressure and pulse values were detected in different time intervals (0th, 5th, 10th, 20th, and 30th minutes) of the 1st and 10th sessions ($P < 0.05$). It was found that SBP decreased between the 10th and 20th minutes of the 1st session, and between the 10th and 20th minutes and also the 20th and 30th minutes of the 10th session ($P < 0.05$). No difference was found between other time intervals in terms of SBP ($P > 0.05$). It was seen that DBP decreased and pulse increased continuously during balneotherapy sessions (between the 0th and 5th minutes, the 5th and 10th minutes, and the 10th and 20th minutes) ($P < 0.05$). DBP increase and pulse decrease were observed during the recovery time (between the 20th and 30th minutes) ($P < 0.05$). The DBP increase and pulse variation were similar in the 1st and 10th sessions (Figure).

It was seen that SBP and DBP decreased and pulse increased after the 1st (acute response) and 10th (cumulative response) sessions ($P < 0.05$) (Table 2). Moreover, it was found that FEV1, FVC, FEV1/FVC, and PEF values improved after balneotherapy ($P < 0.05$) (Table 3).

4. Discussion

This study presents peripheral cardiac responses to and pulmonary function changes caused by a 2-week balneotherapy program in patients with musculoskeletal disorders. The results indicate that SBP decreased only between the 10th and 20th minutes of the 1st session, and between the 10th and 20th minutes and also the 20th

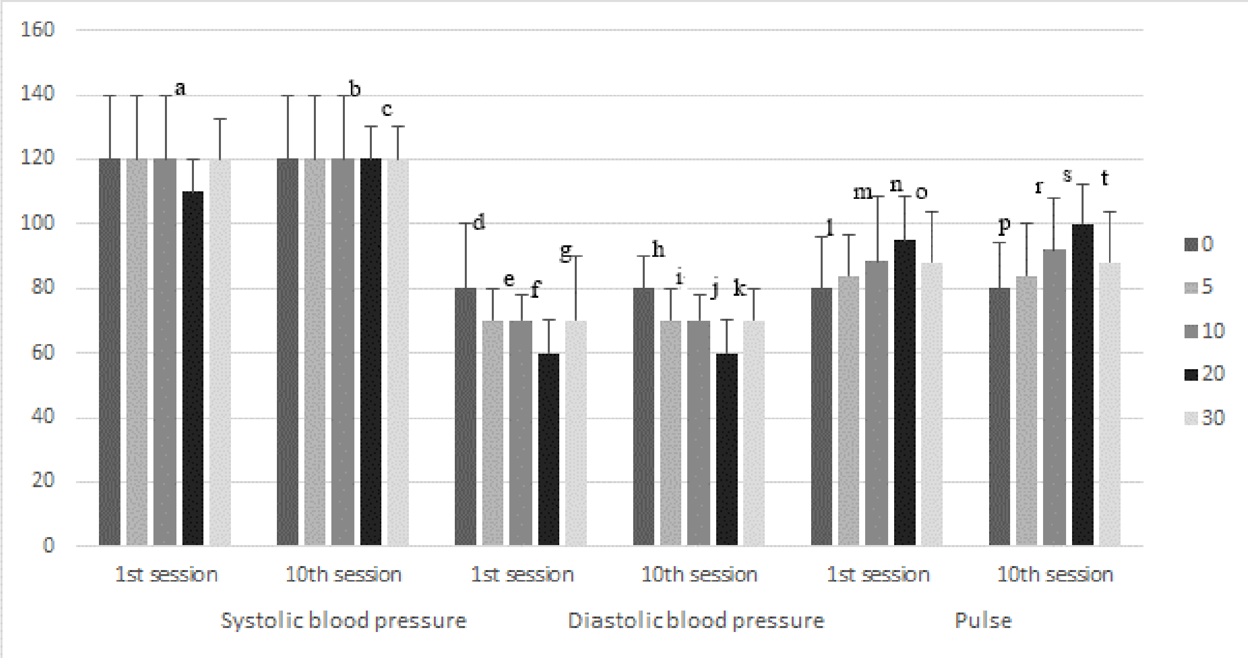

Figure. Differences between blood pressure and pulse values in different time intervals (0th, 5th, 10th, 20th, and 30th minutes) of the 1st and 10th sessions of balneotherapy.

a, b: Systolic blood pressure decreased between 10th and 20th minutes of the 1st session and the 10th session, $P < 0.05$.
c: Systolic blood pressure decreased between 20th and 30th minutes of the 10th session, $P < 0.05$.
d, h: Diastolic blood pressure decreased between 0th and 5th minutes of the 1st session and the 10th session, $P < 0.05$.
e, i: Diastolic blood pressure decreased between 5th and 10th minutes of the 1st session and the 10th session, $P < 0.05$.
f, j: Diastolic blood pressure decreased between 10th and 20th minutes of the 1st session and the 10th session, $P < 0.05$.
g, k: Diastolic blood pressure increased between 20th and 30th minutes of the 1st session and the 10th session, $P < 0.05$.
l, p: Pulse increased between 0th and 5th minutes of the 1st session and the 10th session, $P < 0.05$.
m, r: Pulse increased between 5th and 10th minutes of the 1st session and the 10th session, $P < 0.05$.
n, s: Pulse increased between 10th and 20th minutes of the 1st session and the 10th session, $P < 0.05$.
o, t: Pulse decreased between 20th and 30th minutes of the 1st session and the 10th session, $P < 0.05$.

and 30th minutes of the 10th session. DBP decreased and pulse increased at the 0th, 5th, 10th, and 20th minutes during balneotherapy. DBP increase and pulse decrease were shown during the recovery time. The DBP and pulse variations were similar in the 1st and 10th sessions. There were significant declines in SBP and DBP and an increase in pulse after the 1st (acute) and 10th (cumulative) sessions. Furthermore, it was seen that pulmonary function (FEV1, FVC, FEV1/FVC, and PEF values) was improved significantly after balneotherapy.

The acute responses of the cardiovascular system to balneotherapy were very well presented as decreased SBP caused by increased venous return and increased heart rate (17). Three variables were determined for cardiovascular responses. The first variable proposed was carbon dioxide baths, which had an immediate blood pressure-lowering effect (24). The second variable proposed was explained by physiological adaptation (25). The third variable probably depended on recovery from chronic stress. It was shown that balneotherapy could result in a reduction of blood pressure due to declined subjective stress level and increased well-being (7). Umay et al. (19) and Paran et al. (15) reported a significant decline in SBP and DBP in patients with hypertensive and normotensive status after balneotherapy. Cımbız et al. (14) also investigated acute cardiopulmonary responses to balneotherapy in patients with musculoskeletal disorders referred to physical therapy and rehabilitation clinics. They noted an increase in pulse and reduction in DBP after the 1st session, but no significant change occurred in SBP. Furthermore, Nagasawa et al. (26) reported a decrease in blood pressure in young participants during bathing, but blood pressure in the elderly reached the maximum value just at the start of immersion with a slight decline at 4 min after the start of immersion. They also reported that pulse in the young increased, but in the elderly there was an abrupt increase in pulse at the start of immersion, followed by a decrease. Both acute and cumulative results in the present study

Table 2. Differences between blood pressure and pulse values of patients before balneotherapy and after 1st session and 10th session of balneotherapy.

	Before balneotherapy (n = 98) Median (IQR)	After 1st session of balneotherapy (n = 98) Median (IQR)	Z values	P	After 10th session of balneotherapy (n = 98) Median (IQR)	Z values	P
SBP (mmHg)	120.0 (20.0)	120.0 (12.5)	−4.04	<0.001*	120.0 (10.0)	−2.71	0.007*
DBP (mmHg)	80.0 (20.0)	70.0 (20.0)	−5.03	< 0.001*	80 (10.0)	−3.34	0.001*
Pulse (beats/min)	80.0 (18.0)	88.0 (16.0)	−4.81	<0.001*	88.0 (16.0)	−4.93	<0.001*

*P < 0.05; IQR: Interquartile range; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Table 3. Differences between pulmonary function parameters of patients before and after balneotherapy.

	Balneotherapy (n = 98)		Z values	P
	Before Median (IQR)	After Median (IQR)		
Pulmonary function test				
FEV1	2.26 (1.36)	2.52 (1.24)	−3.18	0.001*
FVC	2.04 (1.30)	2.11 (1.16)	−2.39	0.017*
FEV1/FVC	78.80 (17.92)	80.90 (16.35)	−3.35	0.001*
PEF	3.02 (2.27)	3.89 (2.48)	−4.53	<0.001*

*P < 0.05; IQR: Interquartile range; FEV1: Forced expiratory volume in 1 s; FVC: Forced vital capacity; FEV1/FVC: Ratio of FEV1 to FVC; PEF: Peak expiratory flow.

related to SBP, DBP, and pulse changes were similar to the results of other studies. Moreover, it was observed that SBP decreased after the 10th minute during balneotherapy, DBP decreased, and pulse increased continuously from the first minutes of balneotherapy. According to the results, it was concluded that balneotherapy could be used for regulating cardiovascular responses, especially hypertension, in patients with chronic musculoskeletal disorders as an alternative treatment. However, healthcare professionals are recommended to be alert in risky populations at these minutes of SBP and DBP decreases during balneotherapy.

Furthermore, there are studies in the literature evaluating the acute and cumulative effects of balneotherapy. However, few studies related to acratothermal and thermomineral waters have presented improvements on pulmonary function (20,27). Cımbız et al. (14) revealed that no significant change in pulmonary function tests in patients with musculoskeletal disorders occurred after the 1st session of balneotherapy. Kesiktas et al. (20) also presented that balneotherapy in addition to electrotherapy improved dyspnea scale and spirometric measurements in patients with fibromyalgia after 15 sessions and at the 6-month follow-up. A report from China indicated that a 21-day balneotherapy program had a significant effect on cardiopulmonary function and physical capacity of healthy male pilots (28). In our study, improvements in pulmonary functions were revealed after 10 sessions of balneotherapy. This might be considered as an additional positive effect for patients with musculoskeletal disorders. In the current study, we did not investigate whether our patient group had a restriction for pulmonary functions in comparison to healthy people. However, to our knowledge, as the literature pointed out, there might be some pulmonary restrictions in patients with musculoskeletal disorders as well as functional problems (3,4,20). Therefore, these pulmonary improvements might lead to further effects on functionality for these patients. Moreover, because of the improvements in FEV1, FVC, FEV1/FVC, and PEF values, balneotherapy as an additional therapy might be recommended for patients with pulmonary problems.

The current study had some limitations. First of all, the cumulative effects of a 2-week balneotherapy program were assessed in this study. The literature mostly mentioned the use of balneotherapy for 3–4 weeks. Socioeconomic conditions restricted the treatment duration to 10 sessions. Second, we could not follow the patients for long-term gains. Third, echocardiographic measurements were not administered in the present study. Further studies can indicate improvements in cardiac responses measured by echocardiography and Holter monitors in larger groups by long-term follow-ups.

In conclusion, balneotherapy may be effective on acute, process-related, and cumulative peripheral cardiac responses and may improve pulmonary function in patients with musculoskeletal disorders. Therefore, balneotherapy, as an alternative treatment, could be suggested for improving peripheral cardiac responses and pulmonary functions in patients with musculoskeletal disorders.

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