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Clinical Study

The Reduction of Distress Using Therapeutic Geothermal Water Procedures in a Randomized Controlled Clinical Trial

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Stress is an element of each human's life and an indicator of its quality. Thermal mineral waters have been used empirically for the treatment of different diseases for centuries. *Aim of the Study*. To investigate the effects of highly mineralised geothermal water balneotherapy on distress and health risk. *Methodology*. A randomized controlled clinical trial was performed with 130 seafarers: 65 underwent 2 weeks of balneotherapy with 108 g/L full-mineralisation bath treatment; the others were in control group. The effect of distress was measured using the General Symptoms Distress Scale. Factorial and logistic regression analyses were used for statistical analysis. *Results*. A significant positive effect on distress ($P < 0.001$) was established after 2 weeks of treatment: the number of stress symptoms declined by 60%, while the intensity of stress symptoms reduced by 41%, and the control improved by 32%. Health risks caused by distress were reduced, and resources increased, whereas the probability of general health risk decreased by 18% ($P = 0.01$). *Conclusion*. Balneotherapy with highly mineralised geothermal water reduces distress, by reducing the health risk posed by distress by 26%, increasing the health resources by 11%, and reducing probability of general health risk by 18%. Balneotherapy is an effective preventive tool and can take a significant place in integrative medicine.

1. Introduction

Stress is an important element of our lives which depends on social, economic, psychological, physical, and intellectual aspects of development and change and is an index of the quality of life [1]. The presence of some stress should prompt changes, progress, and creativity, while the high levels of stress or long-term stress, if uncontrolled, causes health problems, reduces the capacity to work, and diminishes the quality of life (Figure 1) [1–4]. Stress is widespread: in 2012, 87% of adults in the USA and Great Britain agreed that stress is a serious health problem; 63% had acquaintances who had faced health consequences due to stress, and more than 4 out of 10 experienced stress themselves [4]; in Canada more than 6 employees out of 10 who indicated great levels of stress consider that the main reason of stress is work (2010) [5]. There is cumulating evidence that socioeconomic status (disparities in income, education, occupation, etc.) accounts for substantial variance in all-cause and disease-specific morbidity and mortality rates and for prevalent psychopathologies of mood [1, 6]. Stress is widespread among health and education system workers, other civil service workers, and seafarers [7–10]. According to studies, 28.3 to 63.5% of seafarers experience stress at work [11]. It is influenced by the lack of sleep, bad quality of sleep, long working hours, extended work, work not according to biorhythms, lack of rest, big load, noise, heat, vibration, restricted movement, dehydration, time zone and climate change, absence of medical professionals, irregular sexual life, social exclusion, and other factors [11–13].

Individual reactions to stress may display in emotional, cognitive, pathological, physiological, and behavioural symptoms. Once in a stressful situation, the body's different systems: skin, respiratory, digestive, endocrine, cardiovascular, and nervous systems, begin to react [1, 4, 14–16]. These processes, which are a part of systematic efforts, are activated in order to restore an individual's homeostasis [17].

A survey of stress in America revealed that 31% of people are doing a poor/fair job at recovering fully or recharging

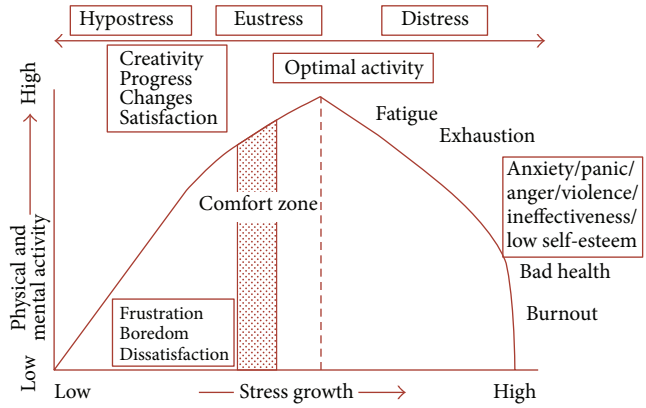


Figure 1: Human response to stress curve (*according to Nixon P: Practitioner 1979, Yerkes RM, Dodson JD).

after they have been stressed out [18]. Currently, there are no absolutely efficient and optimal stress removal methods. A wide range of interventions are proposed: primary psychological help after acute stress, search for the existing psychosocial stressors (situations, supportive family members, and community service), stress reduction (breathing techniques, progressive muscle relaxation, cultural equivalents, and hobbies), social assistance (personal strength and skills, stimulation to return to the social environment, emotional support, and warning for damaging decisions), reduction of insomnia, hyperventilation, sensorimotor dissociation (yoga, meditation, reiki, and electrotherapy), regulation of work and rest schedule, psychological training, cognitive behavioural therapy, eye movement desensitisation and reprocessing, reflexology, relaxing therapies, massages, acupuncture, aromatherapy, music therapy, balneotherapy, medication, and so forth [19–25].

Balneotherapy (Latin *balneum*, bath) has been defined as the use of natural mineral waters, natural peloids and mud, and natural sources of different gases (CO_2, H_2S, and Rn) for medical purposes such as prevention, treatment, and rehabilitation [26]. Thermal mineral waters have been used empirically for the treatment of different diseases for centuries [25, 27]. In recent decades in the world, this branch of medicine is experiencing a major transformation due to scientific evidences of the effects of mineral water, which restores confidence in the old therapeutic procedures and eliminates prejudice.

The essence of balneotherapy effects is local changes caused by the direct influence of mechanical, thermal, and chemical factors through the skin and mucous membranes and complex adjustment reactions as a result of neuroreflexive, humoral mechanisms, caused by stimulation of mechano-, thermo-, baro-, and chemoreceptors by biochemical active substances during the balneoprocedure [28]. Due to the thermal effect, blood flow in the skin, subcutaneous tissue, muscles, and organs is increasing, increasing also the production of physiologically active substances that act on the nervous and endocrine systems, promote angiogenesis, and reduce ischemia [29, 30]. Hydrostatic pressure and buoyancy affect muscle tone and joint mobility, reducing the load and decreasing pain intensity. Redistribution of blood reduces peripheral resistance and increases diuresis and cerebral blood flow, which can improve brain functions, including cognition and memory [29, 31, 32] and stress reactivity, coping, and recovery processes [1]. Immersion in water affects the autonomic nervous system by reducing sympathetic power, thus reducing anxiety [31]. The transport of chemicals through the skin is a complex process. Venier, Larese, and Filon's studies show that metallic ions can easily permeate the skin (nickel, cobalt, and chromium) [33]. Human skin is permeable to Mg, Ca, K, Cu, Br, Rb, Ca, Fe, Pb, Cd, and Zn ions [34–37] and sulfates and nitrate anions [35]. Factors influencing percutaneous absorption through the skin include (1) physicochemical properties of the test compound, (2) skin properties and metabolism, (3) dose and volume of test substance, and (4) duration of exposure [38]. Sweating and skin hydration have been reported to increase dermal absorption. Over the decades, a large number of data have been generated on the percutaneous penetration of a wide range of chemicals, pesticides, cosmetics, and pharmaceuticals [38]. During balneotherapy studies, effects on hormones, cytokines, cell populations, C-reactive protein, haptoglobulin, substance P, matrix metalloproteinases, oxidative/antioxidant system, β-2-microglobulin, nitrogen oxide, insulin growth factor-1 (IGF1), transforming growth factor β (TGF-β) levels, opioid secretion, modification of SERT receptors were determined [39–43]. The overall effect of the application of balneofactors depends on their physical properties, as well as on the way of their implementation [25, 27, 28, 40]. Although the full mode of the effect of balneotherapy is still unclear, its efficacy appears confirmed by reviews [44, 45].

It was demonstrated that balneotherapy affects cardiovascular, musculoskeletal, endocrine, autonomic nervous, and other systems and brings positive results for public health [25, 26, 46, 47]. According to the results shown by studies, the improvement of clinical parameters is significantly greater with thermal mineral water than with tap water [48–53].

Natural mineral water is a general term applied to both spring and other underground continental waters (from deep-seated water wells). Due to the high temperature and high mineralisation, geothermal resources, such as hot springs or geothermal water from well, take an important

place in the sectors of health and wellness [54]. About 25% of the direct use of geothermal water in the world is attributed to balneotherapy and bathing (2010) [54, 55].

According to the medical dictionary, health risk is a disease precursor associated with a higher than average morbidity or mortality rate. Health risk, as an integral phenomenon, consists of the deviation of the majority of an organism's functions from normal, which is provoked by many factors. One of most significant factors is distress [3, 17]. By applying probabilistic analysis to human health risk assessments, we can effectively characterize variability and uncertainty in risk, which can lead to enhanced site decision-making for intervention effectiveness. Quantifying and qualifying of integral risk, as integrated risk governance, are stressed in documents and publications [56–59]. We can account distress as a hazardous factor risk, and its health impact is also intervention impact on the change of health risk by using systemic approach where the health process development depends on positive and negative factors. Positive factors increase health recourses, while negative ones increase the risk. Depending on the health resources and risk profile, health development can take a balanced (normal), positive, or negative character [60, 61].

As balneotherapy affects the majority of the organism's functions positively including the stress-related ones, we can make the hypothesis that balneotherapy has an integral effect and can affect health risk positively.

Aim of the study was to investigate the effects of highly mineralised geothermal water balneotherapy on distress and health risk.

2. Materials and Methods

The clinical trial was carried out in Klaipėda Seamen's Hospital Maritime Medicine Centre, and in Klaipėda Seamen's Health Care Centre, Klaipeda, Lithuania (2012). This open-label randomized controlled trial was implemented in observance of the rules of good clinical practice; protocol was approved by the regional Research Ethics Committee. Participants were 130 male seafarers aged between 25 and 64 years, working at sea for more than 5 years. All subjects were informed about the purpose, conditions, and course of the study prior to inclusion and signed participants' agreement. Criteria for exclusion were acute organic neurological deficit, neoplastic or inflammatory lesion, decompensated cardiovascular disease, unstable metabolic disorders, febrilic infections, and cutaneous suppuration. The coding and randomisation of the respondents were applied to avoid subjective influences. The 130 studied participants were randomized into two groups: the geothermal water group (65) and the control (65) group. An individual who was not involved in the implementation of the study arranged the randomization according to the numbered series of prefilled envelopes.

65 participants underwent the course of 6 to 10 balneotherapy procedures, while the rest of the respondents were a part of the control group and did not receive any treatment. Balneotherapy was carried out on an outpatient on an everyday basis, for 5 days a week over a 2-week period, without changing their daily routines or going to work. The participants of the control group were not given any therapy and lived their usual life with no change in their daily routine or work attendance.

Table 1: The mineral composition of geothermal water.

Element	Concentration, mg/L
Cl^-	66930
Na^+	27580
Ca^{2+}	8990
Mg^{2+}	2630
SO_4^{2-}	1330
K^+	690
HCO_3^-	74
Br	60.62
N	22
Fe	12.14
B	6.501
Si^{4+}	4.886
Li^+	1.200
Cr	1
F^-	0.91
Mn^{2+}	0.501
H_2S	0.33
Cu^{2+}	0.167
Zn^{2+}	0.062
Total amount of dissolved mineral substances, mg/L	108224

Balneotherapy procedure was as follows: the bathtub was filled with 200 liters of geothermal water. The participants had baths (immersing up to the armpits) for 15 minutes monitored by the trained personnel. Each participant was told to move slightly in the bathtub. After the baths, participants were recommended to gently dry the skin with a towel and not to shower for about one hour to prolong the effects of the procedure [25].

Geothermal water was naturally warm (34.6°C on average) with highly mineralised (108 g/L) geothermal Na-Cl-Ca-Mg-SO_4 mineral water (pH 6.07) from Geoterma 2P (ID 25871) borehole (1135 m depth, lower Devonian layer, and mineral age of about 1 million years). Water composition can be expressed by the Kurlov formula (ekv/%):

$$\mathrm{M108.2}\frac{\mathrm{Cl98}}{\mathrm{Na64Ca24Mg12}}. \quad (1)$$

Volumetric activity of radon in the water was 29 ± 5 Bq/L. The water composition is shown in Table 1.

2.1. Study Outcome. Distress and health risk change after balneotherapy with geothermal water. Baseline and post-therapy (after 2 weeks) distress symptoms, their severity, and the management of them were measured by the self-assessment scale General Symptoms Distress Scale (GSDS) [29, 62].

Table 2: Demographic and basic clinical characteristics of the groups.

Sociodemographic characteristics	Geothermal group $N = 65$	Control group $N = 65$
Age, average (SD)	46.5 (10.6)	46.2 (9.3)
Period of service, average (SD)	22.5 (11.4)	22.4 (9.9)
Health-related factors		
BMI, average (SD)	27.1 (2.9)	28.7 (5.1)
Morbidity, *N* (%)	59 (92.2)	34 (68.0)
Use of medication, *N* (%)	19 (29.7)	23 (46.9)
Good subjective health condition, *N* (%)	33 (50.8)	27 (54.0)
Smoking, *N* (%)	27 (42.2)	24 (48)
Alcohol at work once in several weeks, *N* (%)	8 (12.9)	1 (2.0)
Frequent stress, *N* (%)	16 (24.6)	12 (24.5)
Stress intensity, VAS, average (SD)	3.9 (1.6)	3.6 (1.7)
Frequent pain, *N* (%)	4 (6.2)	3 (6.0)
Pain intensity, VAS, average (SD)	3.05 (1.6)	2.4 (1.6)
Fatigue intensity (7-point scale), average (SN)	3.4 (1.3)	3.3 (1.0)
Insufficient quality of sleep, *N* (%)	21 (32.3)	12 (24.5)

No follow-up assessment was made because of participants' group specifics and unpredictable compliance during sea period. Distress was identified by marking in the survey the symptoms that the patients currently experienced out of 12 symptoms given, prioritizing them, marking how distressing each symptom is to them and how well they are able to manage their symptoms on a scale of 1 to 10.

The risk formed by distress was identified by latent factors consisting of the relationships' correlation between distress survey symptoms. Latent factors were calculated using factorial analysis. As the values of the factors vary from +3 to −3 on average, negative values were assigned to distress risk, while positive values were assigned to the resources.

2.2. Statistical Analysis. To describe the data, we calculated index averages and standard deviations (SD). To determine the accuracy and reliability of the statistical evaluation, we calculated confidence intervals with the confidence level of 0.95. Calculations were done using SPSS 21 statistical program. For comparisons, means before and after used paired-samples t-test. For comparisons means between geothermal and control groups used Student's t-test. To assess the quantitative symptoms, the arithmetic mean and its 95% confidence interval (CI) were calculated, while the logistic regression method was used to evaluate the interconnection of factors. The probability ratios (PR) and their 95% confidence intervals (CI) were calculated. The probability ratio is considered statistically reliable if the unit is not in the confidence interval of 95%. The factorial analysis method was used to search for common latent factors characterising distress and risk. The factorial positive and negative values and their percentile distribution were calculated and evaluated. The main components method was applied for determining the factors by applying the varimax method of the coordinates' rotation. The suitability of variables for factorial analysis was verified by Kaiser-Meyer-Olkin (KMO) criterion. Variables with generality less than 0.3 were not included into the factorial analysis. The factorial analysis evaluated the correlation between the symptoms. A common latent factor contained more information than any symptom under investigation.

3. Results

The groups of the respondents were similar in age, family status, period of service, and subjective assessment of health, as well as stress, pain, and fatigue intensity. A higher incidence of diseases, bad sleep quality, and alcohol use were observed in the geothermal group. Representatives of the control group had a higher body mass index (BMI), were taking more medications, and were smoking more frequently. Participants' characteristics are provided in Table 2.

Study results regarding the change of distress after 2 weeks were favourable to balneotherapy.

Assessment of the geothermal group using a GSDS revealed that, after two weeks, a statistically significant positive effect was established in all three distress elements ($P < 0.001$): the general amount of stress symptoms decreased by 2.52 (60%), and the intensity of stress symptoms declined by 2.16 (41%), while the stress management improved by 1.85 points (32%) (Table 3). The control group had no significant changes.

In the geothermal group, the distress symptoms significant for health risk were investigated using factorial analysis; latent factors forming distress risk were searched for. Twelve GSDS symptoms were used for analysing seafarers' distress; eleven symptoms met the conditions of the factorial analysis (the symptom of vomiting was not significant). Four latent factors of distress were investigated; they explained 57.22% of the total variance (Table 4).

The first factor connecting the three symptoms that covered the characteristics related to the central nervous system was attributed to the mental latent factor. It accounted for 15.75% of total variance; factor values ranged from −1.61 to 4.59. Positive values were determined for 32.7% of respondents. The second factor, that integrated the three

Table 3: Comparison of the effect on distress in the study's groups.

		Geothermal group $N = 55$		Control group $N = 50$	
		Average (SD)	P value	Average (SD)	P value
Number of symptoms	Before	4.35^{**} (1.85)	<0.001	3.32^{**} (1.77)	0.722
	After	1.71^{***} (1.38)		3.38^{***} (1.31)	
Intensity of symptoms	Before	5.41^{***} (1.78)	<0.001	3.82^{***} (1.83)	0.894
	After	3.16^{*} (1.95)		3.80^{*} (1.29)	
Control of symptoms	Before	5.64^{*} (1.99)	<0.001	6.44^{*} (2.05)	0.033
	After	7.62^{***} (2.21)		6.00^{***} (1.68)	

For comparisons, means before and after used paired-samples t-test.
For comparisons, means between geothermal and control groups used Students t-test:
$^{*}P < 0.05$, $^{**}P < 0.01$, and $^{***}P < 0.001$.

Table 4: Factorial distribution of seafarers' distress symptoms before treatment.

Symptoms (descending order of factorial weights)	Factorial weight			
	(1) Mental	(2) Dyspeptic	(3) Respiratory	(4) Asthenia
Symptoms more related to factor 1				
Anxiety	0.806			
Depression	0.730			
Sleep disturbances	0.500	0.462		
Symptoms more related to factor 2				
Intestinal problems		0.865		
Pain		0.547		
Lack of concentration		0.499		
Symptoms more related to factor 3				
Shortness of breath			0.776	
Nausea			0.761	
Cough			0.481	
Symptoms more related to factor 4				
Lack of appetite				0.879
Fatigue				0.413
Eigen value	1.73	1.70	1.62	1.23
Percentage of the variance explained	15.75	15.52	14.76	11.19
Min	−1.6149	−1.5174	−2.0484	−2.0169
Max	4.5899	6.8986	6.0918	6.3526
Percentage of negative values	67.3	64.8	81.0	73.5
Percentage of positive values	32.7	35.2	19.0	26.5

symptoms, which partially characterised the digestive activity, was named dyspeptic. This distress latent factor accounted for 15.52% of total variance. The values of this factor ranged from −1.52 to 6.9; positive values of the symptoms were determined in 35.2% of respondents. The third factor that integrated the three symptoms that were related by their attributes to respiratory system problems was named the respiratory latent factor. It accounted for 14.76% of total variance; the values ranged from −2.05 to 6.09; positive symptoms were determined in 19% of respondents. The fourth factor that integrated the two symptoms which were related to the respondent's general well-being and loss of strength was named the asthenia latent factor. It accounted for at least −11.19% of the variance; the values ranged from −2.02 to 6.35; the positive values were determined in 26.5%.

The analysis of the factorial distribution of distress after balneotherapy treatment (Table 5) revealed that ten out of twelve symptoms met the conditions of the factorial analysis. Symptoms of anxiety and depression lost their influence on the distress risk; vomiting gained influence. During the analysis, the four latent factors that accounted for 59.24% of the total variance were distinguished. The factors were formed out of somewhat different groups of symptoms (several factors were regrouped). The priorities have changed over the course of the therapy, but we kept the same latent factor names based on the main symptom.

The first factor connecting the four symptoms that covered the symptoms related to the digestive system was attributed to the dyspeptic latent factor. It accounted for 17.06% of the total variance; factor values ranged from

Table 5: Factorial distribution of seafarers' distress symptoms after treatment.

Symptoms (descending order of factorial weights)	Factorial weight			
	(1) Dyspeptic	(2) Mental	(3) Respiratory	(4) Asthenia
Symptoms more related to factor 1				
Nausea	0.781			
Vomiting	0.719			
Pain	0.515	0.406		
Sleep disturbances	0.467			
Symptoms more related to factor 2				
Lack of concentration		0.833		
Intestinal problems		0.735		
Symptoms more related to factor 3				
Cough			0.836	
Fatigue			0.778	
Symptoms more related to factor 4				
Lack of appetite				0.832
Shortness of breath				0.651
Eigen value	1.70	1.51	1.41	1.29
Percentage of the variance explained	17.06	15.15	14.13	12.9
Min	−0.8572	−1.5750	−1.4881	−1.4396
Max	9.1293	7.0946	4.4552	6.1276
Percentage of negative values	72.0	76.0	64.0	73.7
Percentage of positive values	28.0	24.0	36.0	23.3

Table 6: Risk of general health condition affected by distress in seafarers before the treatment.

Independent variables*	B	S.E	Wald criterion	df	P	Exp(B)	95% GS, CI
GSDS_1_number	0.589	0.116	25.816	1	0.000	1.802	1.436–2.262
GSDS_1_intensity	−0.210	0.105	4.021	1	0.045	0.810	0.660–0.995
GSDS_1_control	−0.087	0.081	1.154	1	0.283	0.917	0.783–1.074
Constant	−0.959	0.806	1.416	1	0.234	0.383	

*GSDS: General Symptoms Distress Scale; number of stress symptoms, intensity, and control of stress symptoms.

0.85 to 9.13; positive values were determined for 28% of respondents. The second factor that integrated the two symptoms, which partially characterised the consequences of metal dysfunctions, was named mental. This distress latent factor accounted for 15.15% of the total variance. The values of factor ranged from −1.58 to 7.09; positive values of the symptoms were determined in 24% of respondents. The third factor that integrated the two symptoms related to respiratory system problems was named the respiratory latent factor. It accounted for 14.13% of the total variance; the values ranged from −1.49 to 4.45; positive symptoms were determined in 36% of respondents. The fourth factor has integrated the two symptoms which are more related to asthenia latent factor. It accounted for at least −12.9% of the variance; the values ranged from −1.44 to 6.13; the positive values were determined in 23.3%.

An assessment of the impact of the change in distress symptoms after a course of balneotherapy with geothermal water showed qualitative changes: the latent mental risk factor lost its total variance and moved to second place.

Balneotherapy's impact on distress-related health risks and resources was positive: it reduced health risk induced by all distress latent factors and increased resources induced by mental and dyspeptic factors. Resources induced by respiratory and asthenia factors were slightly reduced (Figure 2). As a result of the balneotherapy course, the overall distress health risk decreased by 26% (from 7.17 to 5.34), while the resources increased by 11% (from 23.93 to 26.85).

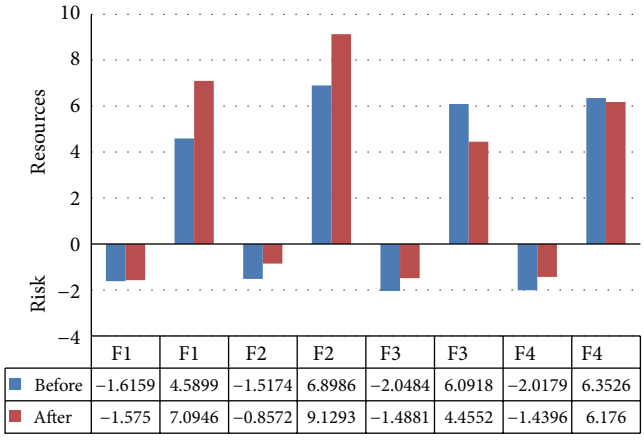
Tables 6 and 7 provide the general health overall risk situation before and after the balneotherapy treatment, including the distress-independent variables (the number of symptoms and the intensity of symptoms and their control). The odds ratio presented in column Exp(B) shows that the evolution of the risk possibility gains 1.

An evaluation of the results of the change in general health condition risks induced by distress shows that balneotherapy reliably reduced the probability of the risk of

Table 7: Risk of general health conditions affected by distress in seafarers after the treatment.

Independent variables*	B	S.E	Wald criterion	df	P	Exp(B)	95% GS, CI
GSDS_2_number	0.388	0.150	6.706	1	0.010	1.475	1.099–1.978
GSDS_2_intensity	−0.048	0.130	0.134	1	0.714	0.953	0.739–1.231
GSDS_2_control	−0.161	0.095	2.849	1	0.091	0.851	0.706–1.026
Constant	−0.079	0.929	0.007	1	0.932	0.924	

*GSDS: General Symptoms Distress Scale; number of stress symptoms, intensity, and control of stress symptoms.



	F1	F1	F2	F2	F3	F3	F4	F4
Before	−1.6159	4.5899	−1.5174	6.8986	−2.0484	6.0918	−2.0179	6.3526
After	−1.575	7.0946	−0.8572	9.1293	−1.4881	4.4552	−1.4396	6.176

Figure 2: Factorial distribution of changes in distress for health resources and risks. *F1: mental, F2: dyspeptic, F3: respiratory, F4: asthenic latent factors.

general health condition deterioration induced by the number of distress symptoms by 18% (before treatment, the probability of health deterioration was 1.802 times; after treatment, it was 1.475 times).

4. Discussion

Our clinical study has demonstrated the positive impact of balneotherapy with geothermal water on distress: the overall number of distress symptoms reduced by 60%, and their intensity by 41%, while the stress management has increased by almost 32%. A computer analysis showed the advantage in the geothermal group compared with the control group. We have received positive qualitative changes after balneotherapy: the explanatory variance of the latent mental factor decreased; anxiety and depression have lost value in risking health. Balneotherapy resulted in positive preventative results: the reduction of health risks and the growth of health recourses; the probability of distress-induced general health deterioration decreased by 18%. Our study showed the favourable effects of balneotherapy using geothermal water on pain, sleep disturbances, intestinal problems, loss of appetite, and shortness of breath (decreased factorial weight). After the treatment, the explanatory variance of all the latent factors was greater; that is, other systems' dysfunctions have shown potentially less impact after the therapy (cardiovascular, sensomotoric systems, and so forth, possibly improved). Perhaps a longer intervention would contribute to the reduction of other symptoms even more significantly.

According to the research data, the most significant distress symptoms in seafarers are lack of appetite, intestinal problems, and anxiety; four latent factors have been forming the manifestation of stress in the representatives of seafarers' lifestyle. The most important health risk factor for the seafarers was the mental factor, followed by dyspeptic, respiratory, and asthenia factors with certain attributes characteristic to each. In other words, the stress of seafarers can be identified and evaluated using anxiety, depression, and sleep scales. It would be advisable to measure these symptoms periodically (during a yearly health inspection). This research has shown that distress symptoms selected in GSDS reflect the larger part of the distress symptoms forming health risks. Established common latent distress risk factors of seafarers may be used in diagnostics or evaluations of the effects of treatment. These results could help in preparing rehabilitation programs for seafarers and other employees experiencing high levels of stress at work. It is advisable to improve the psychological environment, avoid conflicts, improve working conditions, reduce requirements, apply stress management strategies, and use recreational measures more frequently for saving human resources.

Our study method is used in the research of the effect of balneotherapy for the first time. Therefore, we cannot compare in terms of size of geothermal water baths effect. The influence of balneotherapy on health risks induced by stress has not been studied. Generally speaking, due to the heterogeneity of the balneotherapy study designs, methodological flaws, and the publication bias, a definitive conclusion about mineral water therapeutic power is not possible to state. The majority of the published papers focus on balneotherapy for musculoskeletal disorders [40, 44, 45, 48, 50–53], although an increasing number of publications report its application in other clinical fields: the drug sparing effect of balneotherapy can be utilized in psychiatry [63]; it is also useful in cardiovascular rehabilitation [64, 65], dermatology [66], and treatment of other diseases.

Based on the numerous Hungarian and non-Hungarian tap water-controlled studies, it can be stated that thermal mineral water alleviates pain caused by different musculoskeletal diseases regardless of the qualitative and quantitative composition of the mineral water; minerals might act on skin nerve endings and thereby achieve long-lasting gate control [48]. In comparison with tap water, treatment with alum-containing water demonstrated significantly greater progress,

as reflected by the relief of pain elicited by handling the uterus and improvement of psychic status [49]. The duration of improvement after balneotherapy varies considerably, from two-three weeks to 40 weeks and even one year [25, 27, 48, 50–53].

According to M. Vitale on the basis of PubMed data, most of the researches on the effects of balneotherapy in the period from 2000 to 2013 were devoted to inflammation and skin related issues, while little of the research involved the nervous system and cell apoptosis [28]. To this day, there is inadequate evidence for the use of mineral water for psychoneurological diseases. Research of D. Marazziti and others emphasizes a marked effect of balneotherapy on the production of serotonin in blood, which improves the patient's psychoemotional state and relieves depression [67]. Ch. F. Roques' review discusses the effect of balneotherapy on generalised anxiety (50% improvement or recovery, the amount of the effect: 0.75, and duration: 6 months) [68], which is complemented by the studies of Dubois et al. [63]; Xiu and coauthors have proven mineral water to improve the state of mind in pilots: decreased scales of tension, anger, fatigue, and confusion ($P < 0.05$) [37]; an average impact of balneotherapy on stress reduction was demonstrated by Japanese scientists [20], whereas Blasche et al.'s study on pilots showed reduction in the burnout symptoms [69].

Lithuania, compared to its neighbouring countries, is distinguished by favourable geothermal conditions, particularly in the western part of the country. The most promising places in terms of balneology due to high temperature and mineralisation are the Lower Devonian and the Cambrian aquifers [70], from which resources can be used for balneotherapy to reduce the population's health risks and increase health resources.

The medicine of the 21st century is predicted to be dominated by such preventive activities. This may be a great chance and a very important message for future spas.

5. Conclusions

(1) Balneotherapy reduces health risks by neutralizing the negative effect of factors of dyspeptic, respiratory, and asthenic nature and by reducing the number of distress symptoms.

(2) Balneotherapy, using high mineralisation geothermal water, seems to be an effective preventative tool for managing the likelihood of health risks and increasing health resources.

(3) Balneotherapy is a safe, easily accessed nonpharmacological method of regulating the body autonomously, which could have a significant place in integrative medicine once more widely studied and standardised.

Methodological Strengths and Limitations

To our knowledge, this study is the first to explore the effects of geothermal mineral water of a very high concentration. We first used the integrated analysis of distress symptoms' influence on health risk and examined balneotherapy's effect on health risks, resources, and the probability of the evolution of general health conditions. The limitations of our study are the evaluation of the effects covering only one profession, the subjective measures of stress, the open-label, and no follow-up. Our study stimulates further research in this area.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1] B. S. McEwen and P. J. Gianaros, "Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease," *Annals of the New York Academy of Sciences*, vol. 1186, pp. 190–222, 2010.

[2] P. P. Roy-Byrne, K. W. Davidson, R. C. Kessler et al., "Anxiety disorders and comorbid medical illness," *General Hospital Psychiatry*, vol. 30, no. 3, pp. 208–225, 2008.

[3] J. L. McLauglin, *Stress, fatigue and workload: determining the combined affect on human performance [Ph.D. thesis]*, University of Central Florida, Orlando, Fla, USA, 2007.

[4] S. Cohen, D. Janicki-Deverts, and G. E. Miller, "Psychological stress and disease," *Journal of the American Medical Association*, vol. 298, no. 14, pp. 1685–1687, 2007.

[5] S. Crompton, "What's stressing the stressed? Main sources of stress among workers," Statistics Canada, June 2014, http://www.statcan.gc.ca/pub/11-008-x/2011002/article/11562-eng.htm.

[6] V. Lorant, D. Deliège, W. Eaton, A. Robert, P. Philippot, and M. Ansseau, "Socioeconomic inequalities in depression: a meta-analysis," *American Journal of Epidemiology*, vol. 157, no. 2, pp. 98–112, 2003.

[7] European Agency for Safety and Health at Work, *OSH in Figures: Stress at Work. Facts and Figures. European Communities*, European Agency for Safety and Health at Work, Luxembourg City, Luxembourg, 2009.

[8] R. Kuodytė-Kazėlienė, I. Užaitė, R. Palinauskienė, A. Kuznikovas, L. Šerytė, and R. Ulianskienė, "Prevalence of stress, depression and anxiety in healthcare and education workers in Panevezys town," *Medicinos teorija ir praktika*, vol. 13, no. 4, pp. 479–484, 2007.

[9] R. T. B. Iversen, "The mental health of seafarers," *International Maritime Health*, vol. 63, no. 2, pp. 78–89, 2012.

[10] J. Sąlyga, "Lifestyle of Lithuanian seamen at the sea: fatigue, stress and related factors," *Sveikatos Mokslai*, vol. 2, pp. 1664–1669, 2008.

[11] L. Rapolienė and J. Sąlyga, "Seafarer's psychoemotional stress and rehabilitation," *Sveikatos Mokslai*, vol. 22, no. 3, pp. 83–87, 2012.

[12] БогдановРБ, *Central hemodynamics and psychoemotional state of Russian seafarers during the work in foreigner ships [Doctor dissertation]*, Arkhangelsk, Russia, 2011.

[13] S. Lileikis, "Negative emotional experiences of seafarers: characteristics and guidelines for their prevention," *Acta Pedagogica Vilnensia*, vol. 20, pp. 201–206, 2008.

[14] К. В. Судаков and П. Е. Умрюхин, *Systemic Basis of Emotional Stress*, ЙЭОТАР-Медиа, Moscow, Russia, 2012.

[15] J. F. Thayer and R. D. Lane, "Claude Bernard and the heart-brain connection: further elaboration of a model of neurovisceral

integration," *Neuroscience and Biobehavioral Reviews*, vol. 33, no. 2, pp. 81–88, 2009.

[16] B. M. Kudielka and S. Wüst, "Human models in acute and chronic stress: assessing determinants of individual hypothalamuspituitaryadrenal axis activity and reactivity," *Stress*, vol. 13, no. 1, pp. 1–14, 2010.

[17] J. G. Buckwalter, A. Rizzo, and B. S. John, "Analyzing the impact of stress: a comparison between a factor analytic and a composite measurement of allostatic load," in *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC '11)*, pp. 1–12, 2011.

[18] American Psychological Association, *Stress in America: Our Health at Risk*, American Psychological Association, Washington, DC, USA, 2012.

[19] A. J. Crum, P. Salovey, and S. Achor, "Rethinking stress: the role of mindsets in determining the stress response," *Journal of Personality and Social Psychology*, vol. 104, no. 4, pp. 716–733, 2013.

[20] M. Sekine, A. Nasermoaddeli, H. Wang, H. Kanayama, and S. Kagamimori, "Spa resort use and health-related quality of life, sleep, sickness absence and hospital admission: the Japanese civil servants study," *Complementary Therapies in Medicine*, vol. 14, no. 2, pp. 133–143, 2006.

[21] R. McCaffrey, "Music listening: its effects in creating a healing environment," *Journal of Psychosocial Nursing and Mental Health Services*, vol. 46, no. 10, pp. 39–44, 2008.

[22] Cotton DHG, *Stress Management—An Integrated Approach to Therapy*, Brunner/Mazel, New York, NY, USA, 18th edition, 1990.

[23] B. Hannigan, D. Edwards, and P. Burnard, "Stress and stress management in clinical psychology: findings from a systematic review," *Journal of Mental Health*, vol. 13, no. 3, pp. 235–245, 2004, http://www.informaworld.com/smpp/ftinterface?content=a713663721&rt=0&format=pdf.

[24] D. Villani, F. Riva, and G. Riva, "New technologies for relaxation: the role of presence," *International Journal of Stress Management*, vol. 14, no. 3, pp. 260–274, 2007.

[25] VŠĮ Lithuanian resort research center, "Standardized recommendation for mineral water use in resorts for wellness, prevention, treatment and rehabilitation," VŠĮ Lietuvos kurortologijos tyrimų centras, Druskininkai, Lithuania, 2008.

[26] C. Gutenbrunner, T. Bender, P. Cantista, and Z. Karagülle, "A proposal for a worldwide definition of health resort medicine, balneology, medical hydrology and climatology," *International Journal of Biometeorology*, vol. 54, no. 5, pp. 495–507, 2010.

[27] N. Altman, *Healing Springs: The Ultimate Guide to Taking the Waters*, Healing Arts Press, 2000.

[28] C. E. Bouvier, J. Lieber, U. Solimene, and M. Vitale, in *Proceedings of the European Thermal Meeting*, Enghien-les-Bains, France, 2013.

[29] C. Ekmekcioglu, Physiological Actions of Spa therapy on different systems of the body, Aix-Les-Bains, 2006.

[30] Y. Akasaki, M. Miyata, H. Eto et al., "Repeated thermal therapy up-regulates endothelial nitric oxide synthase and augments angiogenesis in a mouse model of hindlimb ischemia," *Circulation Journal*, vol. 70, no. 4, pp. 463–470, 2006.

[31] B. E. Becker, K. Hildenbrand, R. K. Whitcomb, and J. P. Sanders, "Biophysiologic effects of warm water immersion," *International Journal of Aquatic Research and Education*, vol. 3, pp. 24–37, 2009.

[32] Y. Nagasawa, S. Komori, M. Sato et al., "Effects of hot bath immersion on autonomic activity and hemodynamics: comparison of the elderly patient and the healthy young," *Japanese Circulation Journal*, vol. 65, no. 7, pp. 587–592, 2001.

[33] J. Kielhorn, S. Melching-Kollmuß, and I. Mangelsdorf, *Dermal Absorption: WHO/International Programme on Chemical Safety, Environmental Health Criteria*, World Health Organization, Geneva, Switzerland, 2005, http://www.who.int/ipcs/publications/ehc/ehc235.pdf.

[34] R. H. Waring, *Report on Magnesium Sulfate Across the Skin*, School of Biosciences, University of Birmingham, Birmingham, UK, 2014, http://www.mgwater.com/transdermal.shtml.

[35] H. Laudańska, A. Lemancewicz, M. Krętowska, T. Reduta, and T. Laudański, "Permeability of human skin to selected anions and cations—in vitro studies," *Research Communications in Molecular Pathology and Pharmacology*, vol. 112, no. 1–4, pp. 16–26, 2002.

[36] J. Shani, S. Barak, D. Levi et al., "Skin penetration of minerals in psoriatics and guinea-pigs bathing in hypertonic salt solutions," *Pharmacological Research Communications*, vol. 17, no. 6, pp. 501–512, 1985.

[37] L. Xu, R. Shi, B. Wang et al., "Effect of 3 weeks of balneotherapy on immunological parameters, trace metal elements and mood states in pilots," *Journal of Physical Therapy Science*, vol. 25, no. 1, pp. 51–54, 2013.

[38] EFSA Panel on Plant Protection Products and their Residues (PPR), "Guidance on dermal absorption," *EFSA Journal*, vol. 10, no. 4, p. 2665, 2012.

[39] Y. Ohtsuka, J. Nakaya, and T. Oikawa, "Stress relieving effect and immunological changes by balneotherapy with a simple themals," *The Journal of The Japanese Society of Balneology, Climatology and Physical Medicine*, vol. 65, pp. 121–127, 2002.

[40] A. Fioravanti, L. Cantarini, G. M. Guidelli, and M. Galeazzi, "Mechanisms of action of spa therapies in rheumatic diseases: what scientific evidence is there?," *Rheumatology International*, vol. 31, no. 1, pp. 1–8, 2011.

[41] S. Baroni, D. Marazziti, G. Consoli, M. Picchetti, M. Catena-Dell'Osso, and A. Galassi, "Modulation of the platelet serotonin transporter by thermal balneotherapy: a study in healthy subjects," *European Review for Medical and Pharmacological Sciences*, vol. 16, no. 5, pp. 589–593, 2012.

[42] M. Oláh, Á. Koncz, J. Fehér et al., "The effect of balneotherapy on C-reactive protein, serum cholesterol, triglyceride, total antioxidant status and HSP-60 levels," *International Journal of Biometeorology*, vol. 54, no. 3, pp. 249–254, 2010.

[43] T. Bender, J. Bariska, R. Vághy, R. Gomez, and I. Kovacs, "Effect of balneotherapy on the antioxidant system—a controlled pilot study," *Archives of Medical Research*, vol. 38, no. 1, pp. 86–89, 2007.

[44] T. Harzy, N. Ghani, N. Akasbi, W. Bono, and C. Nejjari, "Short- and long-term therapeutic effects of thermal mineral waters in knee osteoarthritis: a systematic review of randomized controlled trials," *Clinical Rheumatology*, vol. 28, no. 5, pp. 501–507, 2009.

[45] M. E. Falagas, E. Zarkadoulia, and P. I. Rafailidis, "The therapeutic effect of balneotherapy: evaluation of the evidence from randomised controlled trials," *International Journal of Clinical Practice*, vol. 63, no. 7, pp. 1068–1084, 2009.

[46] A. Nasermoaddeli and S. Kagamimori, "Balneotherapy in medicine: a review," *Environmental Health and Preventive Medicine*, vol. 10, no. 4, pp. 171–179, 2005.

[47] A. Fraioli, G. Mennuni, M. Grassi et al., "SPA treatments of diseases pertaining to internal medicine," *Clinica Terapeutica*, vol. 161, no. 2, pp. e63–e79, 2011.

[48] T. Bender, G. Bálint, Z. Prohászka, P. Géher, and I. K. Tefner, "Evidence-based hydro- and balneotherapy in Hungary—a systematic review and meta-analysis," *International Journal of Biometeorology*, vol. 58, no. 3, pp. 311–323, 2014.

[49] L. Zámbó, M. Dékány, and T. Bender, "The efficacy of alum-containing ferrous thermal water in the management of chronic inflammatory gynaecological disorders—a randomized controlled study," *European Journal of Obstetrics Gynecology and Reproductive Biology*, vol. 140, no. 2, pp. 252–257, 2008.

[50] K. Horváth, Á. Kulisch, A. Németh, and T. Bender, "Evaluation of the effect of balneotherapy in patients with osteoarthritis of the hands: a randomized controlled single-blind follow-up study," *Clinical Rehabilitation*, vol. 26, no. 5, pp. 431–441, 2012.

[51] I. K. Tefner, A. Németh, A. Lászlófi, T. Kis, G. Gyetvai, and T. Bender, "The effect of spa therapy in chronic low back pain: a randomized controlled, single-blind, follow-up study," *Rheumatology International*, vol. 32, no. 10, pp. 3163–3169, 2012.

[52] G. P. Bálint, W. W. Buchanan, A. Ádám et al., "The effect of the thermal mineral water of Nagybaracska on patients with knee joint osteoarthritis—a double blind study," *Clinical Rheumatology*, vol. 26, no. 6, pp. 890–894, 2007.

[53] C. Kovács, M. Pecze, Á. Tihanyi, L. Kovács, S. Balogh, and T. Bender, "The effect of sulphurous water in patients with osteoarthritis of hand. Double-blind, randomized, controlled follow-up study," *Clinical Rheumatology*, vol. 31, no. 10, pp. 1437–1442, 2012.

[54] *World Energy Resources: Geothermal World Energy Council*, 2013, http://www.worldenergy.org/wp-content/uploads/2013/10/WER_2013_9_Geothermal.pdf.

[55] A. P. W. Hodder, Geothermal waters: a source of energy and metals. Department of Earth Sciences, University of Waikato) XIII-Water-AGeothermal-10, lien, http://nzic.org.nz/ChemProcesses/water/13A.pdf.

[56] U.S. Environmental Protection Agency, "Human health risk assessment. Strategic research action plan 2012–2016," Tech. Rep. EPA 601/R-12/007, U.S. Environmental Protection Agency, 2012.

[57] T. Assmuth, M. Hildén, and C. Benighaus, "Integrated risk assessment and risk governance as socio-political phenomena: a synthetic view of the challenges," *Science of The Total Environment*, vol. 408, no. 18, pp. 3943–3953, 2010.

[58] Integrated Risk Assessment, January 2015, http://www.who.int/ipcs/methods/risk_assessment/en/.

[59] Integrated Assessment of Health Risks from Environmental Stressors in Europe (INTARESE), http://www1.imperial.ac.uk/publichealth/departments/ebs/projects/eresh/intarese.

[60] J. Geiss, D. Wortmann, and F. Zuber, *Nachhaltige Entwicklung—Strategie für das 21. Jahrhundert?* Leske + Budrich, Opladen, Germany, 2003, https://www.dbu.de/phpTemplates/publikationen/pdf/101106090257133.pdf.

[61] A. Juozulynas, A. Jurgelas, A. Venalis, J. Salyga, R. Stukas, and V. Dobrovolskij, *Health Integrity and Management*, Druka, Klaipėda, Lithuania, 2014.

[62] T. A. Badger, C. Segrin, and P. Meek, "Development and validation of an instrument for rapidly assessing symptoms: the general symptom distress scale," *Journal of Pain and Symptom Management*, vol. 41, no. 3, pp. 535–548, 2011.

[63] O. Dubois, R. Salamon, Ch. Germain et al., "Balneotherapy versus paroxetine in the treatment of generalized anxiety disorder," *Complementary Therapies in Medicine*, vol. 18, no. 1, pp. 1–7, 2010.

[64] E. D. Pagourelias, P. G. Zorou, M. Tsaligopoulos, V. G. Athyros, A. Karagiannis, and G. K. Efthimiadis, "Carbon dioxide balneotherapy and cardiovascular disease," *International Journal of Biometeorology*, vol. 55, no. 5, pp. 657–663, 2011.

[65] L. Xu, R. Shi, B. Wang et al., "21-day balneotherapy improves cardiopulmonary function and physical capacity of pilots," *Journal of Physical Therapy Science*, vol. 25, no. 1, pp. 109–112, 2013.

[66] N. Riyaz and F. R. Arakkal, "Spa therapy in dermatology," *Indian Journal of Dermatology, Venereology and Leprology*, vol. 77, no. 2, pp. 128–134, 2011.

[67] D. Marazziti, S. Baroni, G. Giannaccini et al., "Thermal balneotherapy induces changes of the platelet serotonin transporter in healthy subjects," *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, vol. 31, no. 7, pp. 1436–1439, 2007.

[68] C. F. Roques, "Balneotherapy research in France," *Anales de Hidrologia Medica*, vol. 5, no. 2, pp. 161–173, 2012.

[69] G. Blasche, V. Leibetseder, and W. Marktl, "Association of spa therapy with improvement of psychological symptoms of occupational burnout: a pilot Study," *Forschende Komplementarmedizin*, vol. 17, no. 3, pp. 132–136, 2010.

[70] Institute of Geology and Geography, *Balneology Prospects. Geothermal Energy Resource Potential Interpretation and Justification, As Well As Opportunities for Usage for Energy Generation in Western Lithuanian Regions*, Institute of Geology and Geography, Vilnius, Lithuania, 2008, http://www.enmin.lt/lt/activity/veiklos_kryptys/atsinaujantys_energijos_saltiniai/Geotermines_energijos_potencialas.pdf.