

Geothermal water for health state improvement: randomised controlled study

Lolita Rapolienė^{1, 2}, Lina Gedrimė², Artūras Razbadauskas², Aelita Skarbalienė²

Corresponding author: Aelita Skarbalienė, E-mail: aelita.skarbaliene@gmail.com

1. Klaipeda Seamen Health Care Center, Klaipeda, Lithuania

2. Klaipeda University, Klaipeda, Lithuania

Abstract

Introduction. Aim: to evaluate the effect of geothermal water of different mineralization on health state improvement.

Material and method. A randomized controlled single blinded parallel groups interventional study was performed. 250 participants were divided into 5 groups: 3 balneotherapy (20, 40 and 60 g/l total mineralization), 1 tap water, and 1 control group. Hydrotherapy was carried out on an outpatient on everyday basis for 5 days a week over a 2-week period. The main effect on health state was measured using SHSQ-25 questionnaire after 2 weeks and each month during 3-month follow-up period. Examination by a physician and common blood and urine tests were done after the treatment period.

Results and discussions. After a 2-week treatment, participants receiving all types of hydrotherapy showed a significant therapeutic response compared to the control group, especially in fatigue and mental state subcategories. The biggest total health enhancing effect after therapy was in seen in 40 g/l group, followed by 20 g/l group. The smallest effect was seen in tap water group. The most significant post-therapy effect during 3 months was given by 40 g/l procedures. Health self-rating after 2 weeks improved significantly only in geothermal water groups and lasted 2-3-month post-treatment. 2 weeks of balneotherapy had significant impact on Er, MCV, MCH, MPV, Eo, Tr, urine SG, and pH. According to the physician's assessment, the best results after 2 weeks were in 20 g/l group, but 40 and 60 g/l water procedures gave more residual effect.

Conclusions. The geothermal water of 40 g/l total mineralization has the best positive effect for health enhancement after 2 weeks and during 3-month period. 20 g/l water gives fast and short-term health effect, while 40-60 g/l water has long-lasting effect on health status.

Key words: *health status, balneotherapy, geothermal water, hydrotherapy,*

Introduction

In human beings health indicates the general condition of a person's mind, body and spirit. This usually means that an individual is free from illness, stress, injury or pain (1). Good health is the ability of a body to adapt to new threats and infirmities. A state of optimal health and well-being maximizes an individual's potential. Still, it is difficult to draw a line between health and illness, and dynamic transformational model was proposed - grey zone of subhealth (SHS) - the intermediate condition between health and illness that people pass through when they are becoming ill or regaining their health (2). Prevention and intervention strategies aimed at this zone are similar to the concept of preventive, predictive, and personalised medicine, which is an effective approach to the improvement of health, the prevention of disease and the treatment of an early-stage illness (2). The importance of timely prevention and early detection of disorders is increasing, as the global burden of disease is large. The measures for enhancing physical, intellectual, emotional, social,

spiritual, and environmental well-being could prevent the burden of a disease and enhance the quality of life and productivity.

Already Asclepius and Hippocrates focused medical practice on the natural approach and treatment of diseases (3). Balneotherapy is one of the basic methods of treatment widely used in the system of natural medicine. It involves treating different health problems by bathing, usually in hot springs and other mineral-rich waters. 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 the complex adjustment reactions as a result of neuroreflexive, humoral mechanisms, caused by stimulation of mechano-, thermo-, baro-, and chemoreceptors by biochemically active substances during a balneoprocedure (4). Balneotherapy has a scientific evidence-based effect on various systems of the body for a wide variety of theseverity of a disease and in subjects without major impairment: it promotes

active and healthy aging, improves immunity, impacts pain, musculoskeletal, cardiovascular, respiratory, skin, mental health problems and quality of life (5-8). However, balneotherapy for psychosomatic conditions are still poorly investigated and there is still a lack of clear conclusion about its role in the disease prevention and treatment on what medicine of the 21st century such rely as much as possible (9).

As early as the 5th century BC, the historian and physician Herodotus observed that different natural mineral springs in various parts of Greece had different therapeutic properties and he subsequently developed a rudimentary system for differentiating the therapeutic indications of various types of mineral waters. Hippocrates was also interested in the therapeutic properties of various waters, theorizing that their differing curative properties came from their differing contents of various minerals, like iron, copper, silver, gold or sulphur (10). Several models of salt water cutaneous adsorption/desorption and penetration of dissolved ions in mineral waters through the skin (osmosis and cell volume mechanisms in keratinocytes) were described and the role of these resources in stimulating cutaneous nerve receptors recently was examined (11).

There are many studies/reviews that have reported either physiological, or therapeutic, or the combination of both effects of balneotherapy on a particular system. However, we have not succeeded in finding a single report of balneotherapy's effect on the whole health status of the body. Also, there are no parallel group studies with the different total mineralization of mineral waters. These questions prompted us to do this particular study. The aim of our study was to evaluate the effect of geothermal water of different mineralization on general health status improvement.

Materials and methods

A randomized controlled single blinded (water type was known for researchers only) parallel groups interventional study was made during the period of May-September, 2018 in Klaipėda, Lithuania. Hydrotherapy procedures were carried out at the Rehabilitation Department of Klaipėda Seamen's Health Care Centre. The evaluation of participants' clinical statement at baseline, after 2 weeks of treatment and during the follow-up period was made at Klaipėda Science and Technology Park facility -

Business incubator. Interventional study was implemented in observance of the rules of good clinical practice. The study was carried out with the authorisation of Kaunas Regional Biomedical Research Ethics Committee (permission No. BE-2-1). Inclusion criteria: current workers of 18-65 years of age with no history of clinically diagnosed disease, at least 2 symptoms of distress or symptom intensity more than 2 according to the general symptom distress scale (GSDS) or SHS according to SHSQ-25. Exclusion criteria were as follows: acute neurological deficit, epilepsy, inflammatory condition, cutaneous lesion, failure of respiratory, cardiovascular systems, kidney failure, unstable metabolic disorders, severe arrhythmia, febrile infections, bleeding, and pregnancy.

Participants

After completion of questionnaires 250 individuals were selected for the study. Coding and randomisation of the respondents were applied to avoid subjective influences. An individual who was not involved in the implementation of the study arranged randomization using a computer program. 5 groups of 50 individuals per group were randomly formed: 3 groups of baths of water of different mineralisation (20, 40, 60 g/l total mineralisation water), 1 group of pure water baths, and 1 control group (without treatment). All subjects were informed about the purpose, conditions, and course of the study prior to inclusion and signed a participant's agreement. Hydrotherapy 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 changes in their daily routine or work attendance. The protocol of the study required to participate in at least 60 per cent of the treatment procedures.

The sample size was estimated using the IBM SPSS Sample Power Release software v. 3 for the stress outcome using the general symptoms distress scale (GSDS). We examined mean differences between balneotherapy and the control groups. We estimated that the sample size in both groups should be 32 subjects, with the power of 81.7% to achieve a statistically significantly different result. This computation assumes that the mean difference in the general symptoms distress between the different

hydrotherapy and the control groups would be not less than 0.8, and the standard deviation within the groups would be 1.1. This effect was selected as the least significant effect of detectable importance; any smaller effect would not be of clinical or substantial significance. We assumed that the influence of balneotherapy and control group on the difference in the mean values of the variables is valid because such

changes during the procedures are fully probable in this field of research. The mean difference of the observed variables of 0.8 (1.1) would be presented with a 95% CI of 0.25 to 1.35. Estimating the percentage of dropout, the total of 250 participants were taken.

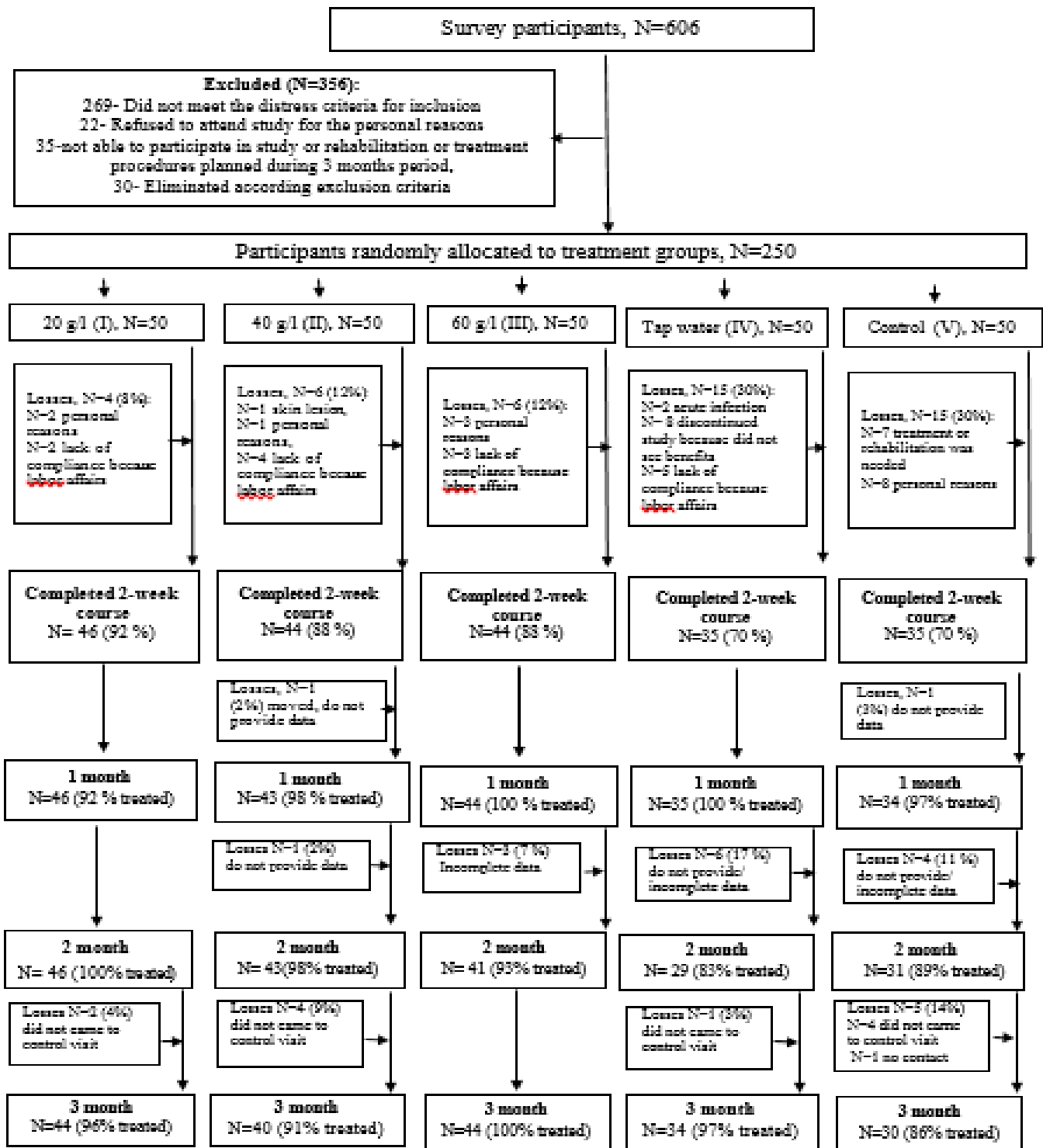
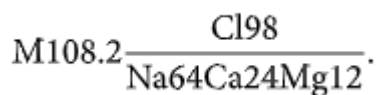


Fig. 1. Disposition of the study participants

The numbers of participants included in the analysis after treatment were as follows: total number 204 (81.6% survey participants): 46 from the geothermal group of 20 g/l total mineralization (I group), 44 in both 40 g/l (II group) and 60 g/l total mineralization (III group), and 35 in both- tap water (IV group) and control (V group). For the follow-up analysis 192 (76.8%) participants' data were taken.

Interventional procedure

Geothermal water used was highly mineralised (108 g/L Na-Cl-Ca-Mg-SO₄, pH 6.07) from Geoterma 2P (ID 25871) borehole (1135 m depth, lower Devonian layer (Devonian period started 350 million years ago and the minerals' age is about 1 million years). Water composition can be expressed by the Kurlov formula (eq./%):



Individual balneotherapy procedure was as follows: the bathtub was filled with 400 litres of geothermal

water diluted with tap water up to the planned mineralisation. In accordance with calculations of dilution baths (400 l) were prepared as follows: 20 g/l (2%) bath was filled with 73 l of geothermal water and 327 l of pure tap water; 40 g/l (4%) - 145 l geothermal and 254 l of pure tap water; 60 g/l (6%) - 218 l geothermal and 181 l pure tap water (additional warmed in special heaters). The temperature of the baths was 36 °C. The participants had baths (immersing up to the armpits) for 20 minutes monitored by the trained personnel. Each participant was told to move slightly in the bathtub. Before, during and after the procedure, SpO₂ and pulse were measured. After the procedure, it was recommended to the participants to rest in a prepared rest room and to consume fluids. 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.

The geothermal water chemical composition in groups is shown in Table 1.

Table 1. The mineral composition of geothermal water in groups

Element, mg/l	I group	II group	III group
Cl	17110	25130	38400
SO ₄	526	735	1 160
HCO ₃	190	161	125
CO ₃	0,06	0.05	0.01
Na	7124	10550	16500
K	181	255	428
Ca	2500	3550	5110
Mg	659	940	1430
Fe	<0.01	<0.01	0.04
pH	7.28	7.27	6.72

Study outcome and research tools

The primary outcome was health status change after balneotherapy with geothermal water of different salinity in comparison with tap water and no treatment. Baseline, post-therapy (after 2 weeks) and follow-up (after 1, 2, 3 months after therapy) of health status was measured by the self-assessment scale sub-health status questionnaire (SHSQ-25) (13). SHSQ-25 includes 25 items on SHS and is targeted at physiological and psychological SHS. It is a reliable

and valid instrument for measuring sub-health status. The range of the score of the SHSQ-25 is from 0 to 100 points. 0 points indicate the lowest level of SHS (good health) and 100 points indicate the highest level (poor health). Suboptimal health status is defined as the SHSQ-25 score above 35 points. The higher score of the SHSQ-25 one gets, the more severe his or her suboptimal health status is. The SHSQ-25 highlights the multidimensionality of SHS by encompassing the following domains: (1) fatigue, (2) the cardiovascular

system, (3) the digestive tract, (4) the immune system and (5) mental status. The SHSQ-25 is short and easy to complete, and, therefore, is an instrument suitable for use in both large-scale studies of the general population and routine health survey.

Subjective participant's health and wellness was assessed by 5-Likert's scale (1 - very good, 2 - good, 3 - satisfactory, 4 - bad, 5 - very bad). Overall body health state was assessed by a trained physician with the evaluation of objective body status as no change, better status, worse status, and complaints about health as no change, less complaints or more complaints.

Blood - complete blood count (CBC) - and urine tests were used to evaluate overall health: red blood cells (Er) - carry oxygen), haemoglobin (Hb) - oxygen-carrying protein in red blood cells), white blood cells (Leu) help to fight infection), platelets (Tr help with blood clotting) and other components (mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean platelets volume (MPV), leucocytes types), acidity (pH), urine specific gravity (SG).

Statistical Analysis

Table 2. Sociodemographic and clinical characteristics of the participants in groups

	I (N= 46)	II (N=44)	III (N=44)	IV(N=35)	V (N=35)	p
Age, N (%)	39.7 (10.5)	42.6 (10.4)	47.7 (9.5)	42.8 (12.8)	48.1 (12.0)	0.009
Gender, N (%)						
Men	4 (8.7)	7 (15.9)	7 (15.9)	4 (11.4)	7 (20)	0.638
Women	42 (91.3)	37 (84.1)	37 (84.1)	31 (88.6)	28 (80)	
Marital status, N (%)						
Prefer not to say	1 (2.2)	2 (4.5)				
Married	30 (65.2)	28 (63.6)	32 (72.7)	22 (62.9)	25 (71.4)	0.073
Single	11 (23.9)	8 (18.2)	4 (9.1)	7 (20)	3 (8.6)	
Divorced	4 (8.7)	6 (13.6)	4 (9.1)	6 (17.1)	3 (8.6)	
Widow			4 (9.1)		4 (11.4)	
Level of education, N (%)						
Incomplete secondary education	2 (4.3)	1 (2.3)				
Secondary	4 (8.7)	6 (13.6)	2 (4.5)	6 (17.1)	4 (11.4)	0.004
Higher	7 (15.2)	3 (6.8)	3 (6.8)	3 (8.6)	11 (31.4)	
High	1 (2.2)	6 (13.6)	3 (6.8)	2 (5.7)	2 (5.7)	
University	29 (63.0)	24 (54.5)	30 (68.2)	12 (34.3)	13 (37.1)	
PhD	3 (6.5)	4 (9.1)	6 (13.6)	11 (31.4)	5 (14.3)	
Working hours per day, N (%)						
Less than 8	21 (45.7)	26 (59.1)	23 (52.3)	15 (42.9)	15 (42.9)	0.210

Data are reported as the mean \pm SD for continuous variables, or as frequencies in the case of categorical variables. Descriptive statistics and univariate analyses were carried out using SPSS V23.0 (SPSS Inc., Chicago, Illinois, USA). Pearson χ^2 tests and independent-sample t tests were used to compare the independent variables versus dependent variables. The hypothesis about the equality of probability distribution was checked against the Mann-Whitney-Wilcoxon U nonparametric criterion, and the corresponding 95 % CIs were calculated. Wilcoxon Sign, Kruscal Wallis nonparametric tests were used also; p value <0.05 was considered to be significant for all tests.

Results

The subjects' sociodemographic and health-related issues are shown in Table 2. All groups were similar concerning gender, marital status, working and resting hours, physical activity, alcohol consumption, stress intensity, wellness and health self-rating. The study was not homogenous with respect to the participants' education, age and smoking habit.

9 -12	20 (43.5)	14 (31.8)	15 (34.1)	14 (40)	18 (51.4)	
13-16	2 (4.3)	2 (4.5)	2 (4.5)	1 (2.9)		
More than 16		2 (4.5)	2 (4.5)		2 (5.7)	
Various	3 (6.5)		2 (4.5)	5 (14.3)		
Resting hours per day, N (%)						
Less than 6	11 (23.9)	7 (15.9)	4 (9.1)	7 (20)	6 (17.1)	
7 – 8	25 (54.3)	23 (52.3)	20 (45.5)	15 (42.9)	18 (51.4)	0.067
9 – 10	8 (17.4)	8 (18.2)	14 (31.8)	8 (22.9)	1 (2.9)	
More than 10	2 (4.3)	5 (11.4)	6 (13.6)	5 (14.3)	10 (28.6)	
Various		1 (2.3)				
Smoking, N (%)						
Everyday	4 (8.7)	3 (6.8)	3 (6.8)		1 (2.9)	
Often		3 (6.8)				0.041
Occasionally	7 (15.2)	2 (4.5)	2 (4.5)	1 (2.9)	4 (11.4)	
Never	35 (76.1)	36 (81.8)	39 (88.6)	34 (97.1)	30 (85.7)	
Alcohol use, N (%)						
Everyday				2 (5.7)		
2-3 time/week	14 (30.4)	2 (4.5)	4 (9.1)		4 (11.4)	
Once per week	3 (6.5)	7 (15.9)	3 (6.8)	7 (20)	5 (14.3)	0.124
2-3 time/month	18 (39.1)	16 (36.4)	11 (25)	10 (28.6)	12 (34.3)	
Few time per year	6 (13.0)	11 (25)	22 (50)	9 (25.7)	12 (34.3)	
Never	5 (10.9)	8 (18.2)	4 (9.1)	7 (20)	2 (5.7)	
Physical activity, N (%)						
Everyday	6 (13.0)	7 (15.9)	5 (11.4)	3 (8.6)	4 (11.4)	
4-6 times/week	1 (2.2)	8 (18.2)	1 (2.3)		3 (8.6)	
2-3 times/week	13 (28.3)	11 (25)	16 (36.4)	13 (37.1)	17 (48.6)	0.080
Once per week	6 (13.0)	8 (18.2)	4 (9.1)	6 (17.1)	3 (8.6)	
2-3 times/month	7 (15.2)	3 (6.8)	6 (13.6)	3 (8.6)	2 (5.7)	
Few times/year	5 (10.9)	4 (9.1)	5 (11.4)	7 (20)	4 (11.4)	
Never	8 (17.4)	1 (2.3)	7 (15.9)	3 (8.6)	2 (5.7)	
Stress intensity, N (SD)	6.72 (2.37)	6.6 (1.95)	6.55 (2.28)	5.71 (2.38)	6.26 (1.9)	0.285
Wellness, mean rank*	113.76	101.43	98.68	97.07	99.27	0.579
Health, mean rank*	104.92	108.66	100.17	97.56	99.44	0.878

* Kruscal Wallis test

The change of health state

After 2-week treatment, participants receiving hydrotherapy (geothermal and tap water) showed a significant therapeutic response compared to the control group (Table 3). No significant change was seen in the control group. The biggest health enhancing effect after therapy was in seen in II (40 g/l) group (mean difference 11.1, $p < 0.001$), followed by I (20 g/l) group (mean difference 9.1 ($p < 0.001$)). The smallest effect was seen in IV (tap water) group (mean difference 6.6, $p < 0.001$). The significant post-therapy positive effect remained all 3 months in all hydrotherapy groups, with the biggest health state change in II (40 g/l) group.

The biggest changes after 2 weeks were seen in fatigue and mental status subscales. Significant positive changes for all subscales were made by 40

and 60 g/l geothermal water baths, and significant negative change for digestive tract was in the control group. Changes in 20 g/l and tap water groups for digestive tract were insignificant. 20 and 40 g/l geothermal water procedures reduced fatigue almost equally (4.2, $p < 0.001$ and 4.1, $p < 0.001$). Mental status most improved by 40 g/l geothermal water procedures (3.3, $p < 0.001$), followed by 20 g/l procedures (2.7, $p < 0.001$). Positive effect on the immune system was in all hydrotherapy groups (biggest in 40 g/l group (1.5, $p < 0.001$), smallest in tap water group (1.1, $p < 0.001$). A similar positive effect on the cardiovascular system was given by all hydrotherapy types. The best result for digestive tract was achieved in 40 g/l group (1.5, $p < 0.001$), and 60 g/l (0.5, $p = 0.011$) groups. No positive change in any subscale was seen in the control group.

The feeling of wellness after 2 weeks was better in all geothermal and control groups and remained better than baseline after 3 months in 20 and 40 g/l groups (Table 4). Health rating after 2 weeks enhanced

significantly only in geothermal water groups; 20 and 60 g/l water procedures effects lasted 2-month, but 40 g/l all 3-month follow-up period.

Table 3. *The change of health state in groups during study period*

Groups		Mean (SD)	Mean difference (CI lower- upper)	p
I	Before	27.24 (10.69)		
	After 2 w.	18.17 (10.26)	9.07 (5.96 to 12.17)	<0.001
	After 1 mo.	15.17 (9.56)	12.07 (9.48 to 14.66)	<0.001
	After 2 mo.	15.07 (8.59)	12.17 (8.95 to 15.40)	<0.001
	After 3 mo.	17.61 (9.76)	9.98 (6.29 to 13.66)	<0.001
II	Before	25.86 (12.06)		
	After 2 w.	14.80 (6.84)	11.07 (7.57 to 14.57)	<0.001
	After 1 mo.	12.42 (7.47)	13.58 (10.11 to 17.05)	<0.001
	After 2 mo.	13.40 (8.3)	12.79 (8.97 to 16.61)	<0.001
	After 3 mo.	13.68 (9.63)	12.29 (8.57 to 16.01)	<0.001
III	Before	23.32 (9.95)		
	After 2 w.	15.82 (7.80)	7.5 (4.57 to 10.43)	<0.001
	After 1 mo.	14.61 (8.26)	8.70 (5.94 to 11.47)	<0.001
	After 2 mo.	14.05 (10.32)	8.46 (5.04 to 11.89)	<0.001
	After 3 mo.	14.05 (8.79)	9.27 (6.29 to 12.25)	<0.001
IV	Before	23.80 (13.41)		
	After 2 w.	17.17 (10.08)	6.63 (3.89 to 9.37)	<0.001
	After 1 mo.	17.23 (11.73)	6.57 (2.95 to 10.20)	0.001
	After 2 mo.	14.10 (10.26)	10.07 (5.81 to 14.32)	<0.001
	After 3 mo.	17.12 (11.78)	6.56 (3.09 to 10.03)	0.001
V	Before	16.71 (7.31)		
	After 2 w.	16.06 (6.09)	0.66 (-1.32 to 2.63)	0.503
	After 1 mo.	13.68 (5.66)	2.79 (0.66 to 4.92)	0.012
	After 2 mo.	12.19 (6.13)	4.77 (2.15 to 7.40)	0.001
	After 3 mo.	12.73 (6.86)	3.30 (0.96 to 5.64)	0.007

The changes in SHSQ-25 subscales in all study groups after treatment period are shown in Figure 2.

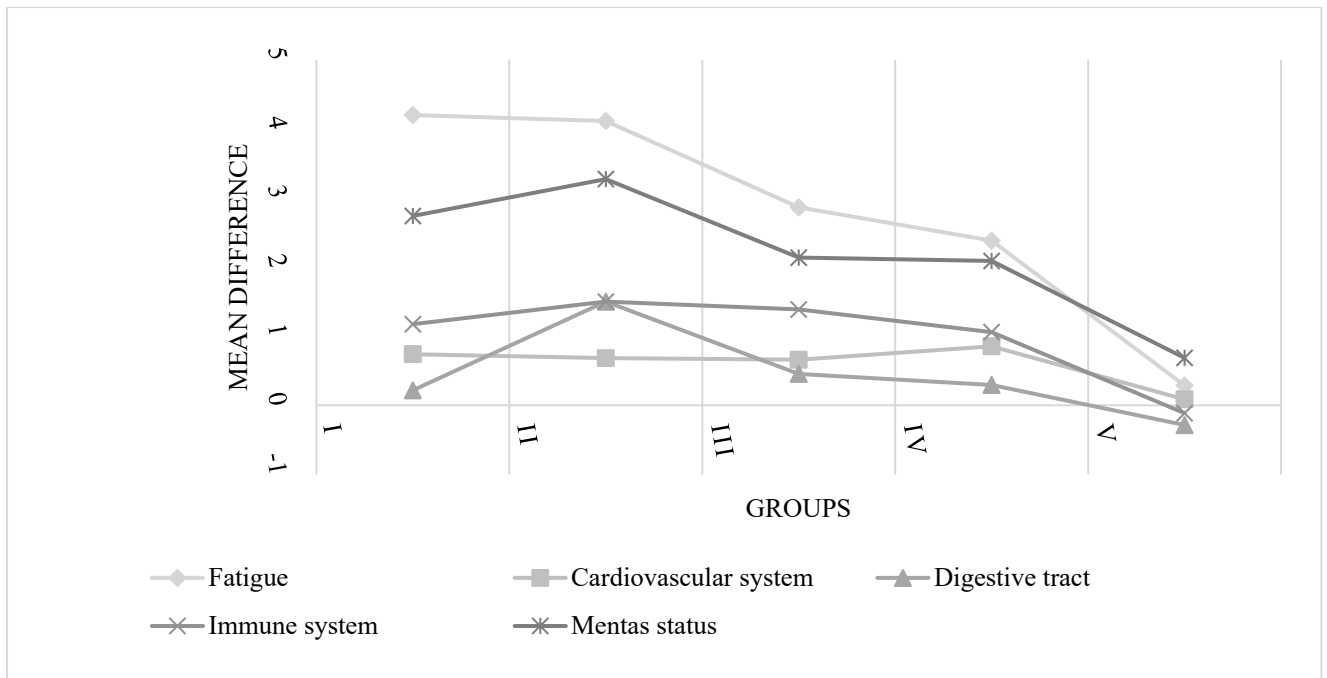


Fig. 2. Health subscales change in groups after 2-weeks treatment

Table 4. Wellness and health rating change in groups during study period

		I		II		III		IV		V	
		Z	Asymp. Sig. (2-tailed)	Z	Asymp. Sig. (2-tailed)	Z	Asymp. Sig. (2-tailed)	Z	Asymp. Sig. (2-tailed)	Z	Asymp. Sig. (2-tailed)
Wellness	2 weeks	-4.746	0.000	-4.062	0.000	-3.019	0.003	-0.905	0.366	-3.207	0.001
	1 mo	-4.004	0.000	-2.742	0.006	-2.696	0.007	-1.428	0.153	0.001	0.046
	2 mo	-2.846	0.004	-3.617	0.000	-1.968	0.049	-2.307	0.021	-2.840	0.005
	3 mo	-3.400	0.001	-3.622	0.000	-1.927	0.054	-1.937	0.053	-1.485	0.138
Health	2 weeks	-3.175	0.001	-3.989	0.000	-2.400	0.016	-1.897	0.058	-1.732	0.083
	1 mo	-2.858	0.004	-3.133	0.002	-2.000	0.046	-1.807	0.071	-1.807	0.071
	2 mo	-2.352	0.019	-2.294	0.022	-2.065	0.039	-2.798	0.005	-1.604	0.109
	3 mo	-1.633	0.102	-3.892	0.000	-1.593	0.111	-1.784	0.074	-1.232	0.218

a. Wilcoxon Signed Ranks Test

Based on positive ranks

The change in laboratory findings

After 2 weeks there were only some significant changes in laboratory findings (Table 5): 20 g/l mineralisation baths lowered Er and elevated MPV; 40 g/l water baths elevated Er and Tr and lowered MPV; 60 g/l water baths lowered MCV, MCH, and

urine SG, also elevated blood eosinophils (Eo), urine pH (less acidic). Tap water baths group showed lowered MCV, elevated Tr, lymphocytes (Lym) and monocytes (Mo). There were significantly elevated Eo, Er and Hb, lowered MPV and MCV in the control group.

Table 5. Changes of CBC and urine after 2 weeks in study groups

Parameter	Group	Mean difference	SD	CI lower	CI upper	T	p
ER	I	0.10	0.25	0.0230	0.1705	2.642	0.011
	II	-0.08	0.26	-0.1643	-0.0041	-2.120	0.040
	III	-0.06	0.20	-0.1211	0.0015	-1.967	0.056
	IV	-0.02	0.19	-0.0887	0.0512	-0.547	0.588
	V	-0.12	0.18	-0.1979	-0.0413	-3.166	0.004
MCV	I	-0.06	1.01	-0.3568	0.2438	-0.379	0.706
	II	0.30	1.07	-0.0284	0.6284	1.844	0.072
	III	0.82	0.86	0.5545	1.0774	6.294	<0.001
	IV	0.37	0.93	0.0354	0.7021	2.256	0.031
	V	0.38	0.81	0.0331	0.7321	2.270	0.033
MCH	I	-0.29	1.33	-0.6871	0.1002	-1.502	0.140
	II	0.03	0.31	-0.0656	0.1260	0.637	0.528
	III	0.24	0.27	0.1539	0.3188	5.782	<0.001
	IV	0.09	0.38	-0.0430	0.2305	1.398	0.172
	V	-0.11	0.44	-0.2985	0.0811	-1.188	0.248
HB	I	1.52	5.96	-0.2487	3.2922	1.731	0.090
	II	-1.65	5.64	-3.3867	0.0844	-1.920	0.062
	III	-0.61	5.82	-2.3842	1.1570	-0.699	0.488
	IV	-0.19	6.10	-2.3862	2.0112	-0.174	0.863
	V	-3.83	4.97	-5.9750	-1.6771	-3.692	0.001
TR	I	-2.35	91.94	-29.64910	24095344	-0.173	0.863
	II	-7.93	23.54	-15.17466	-0.68580	-2.209	0.033
	III	0.73	32.60	-9.18317	10.63772	0.148	0.883
	IV	-13.06	31.92	-24.56987	-1.55513	-2.315	0.027
	V	-4.70	17.09	-12.08671	2.69541	-1.318	0.201
MPV	I	-0.19	0.45	-0.3244	-0.0582	-2.895	0.006
	II	0.20	0.43	0.0677	0.3323	3.051	0.004
	III	0.04	0.36	-0.0701	0.1474	0.716	0.478
	IV	-3.06	17.22	-9.3725	3,2563	-0.989	0.331
	V	0.19	0.28	0.0672	0.3067	3.239	0.004
LEU	I	0.17	1.18	-0.18505	0.5177	0.953	0.346
	II	0.20	1.29	-0.19832	0.5969	1.012	0.318
	III	0.13	0.98	-0.16905	0.4291	0.877	0.386
	IV	-0.14	0.58	-0.34806	0.0724	-1.337	0.191
	V	0.05	0.87	-0.32665	0.4258	0.273	0.787
NEU	I	0.03	0.98	-0.26312	0.3262	0.216	0.830
	II	0.22	1.49	-0.24339	0.6820	0.957	0.344
	III	0.14	0.76	-0.09042	0.3774	1.238	0.223
	IV	0.05	0.47	-0.13273	0.2258	0.532	0.599
	V	0.05	0.71	-0.25903	0.3538	0.321	0.751
LYM	I	0.16	0.63	-0.03103	0.3497	1.687	0.099
	II	0.03	0.29	-0.05712	0.1238	0.744	0.461
	III	-0.04	0.43	-0.17234	0.0947	-0.587	0.560
	IV	-0.12	0.24	-0.20850	-0.0246	-2.597	0.015
	V	0.30	0.85	-0.06865	0.6678	1.687	0.106
MON	I	0.01	0.10	-0.01891	0.0416	0.755	0.454
	II	0.00	0.11	-0.02993	0.0385	0.253	0.802
	III	0.01	0.12	-0.02127	0.0501	0.815	0.419
	IV	-0.04	0.06	-0.06160	-0.0129	-3.132	0.004
	V	-0.00	0.11	-0.04746	0.0440	-0.079	0.938
EO	I	-0.02	0.24	-0.09119	0.0507	-0.574	0.569
	II	-0.19	1.05	-0.51792	0.1394	-1.163	0.251
	III	-0.03	0.08	-0.0540	-0.00415	-2.354	0.023
	IV	-0.02	0.10	-0.0571	0.01641	-1.134	0.267
	V	-0.03	0.06	-0.0576	-0.00766	-2.710	0.013
SG	I	0.24	7.41	-2.0956	2.5834	0.211	0.834
	II	1.58	8.94	-1.3586	4.5165	1.089	0.283
	III	7.22	9.39	0.0035	14.4409	2.307	0.050
	IV	2.14	9.14	-3.1337	7.4194	0.877	0.396

	V	0.28	8.82	-4.1102	4.6658	0.134	0.895
pH	I	0.01	0.75	-0.2258	0.2502	0.104	0.918
	II	-0.24	0.78	-0.4924	0.0187	-1.878	0.068
	III	-0.61	0.78	-1.2120	-0.0102	-2.345	0.047
	IV	-0.07	0.62	-0.4269	0.2841	-0.434	0.671
	V	0.08	0.77	-0.3004	0.4671	0.458	0.653

According to the physicians' clinical assessment of participants' health, the highest percentage of improved health status after 2-week treatment was in 20 g/l water group (94 %), and remain better after 3-month period in 60 g/l water group (91 %); less complains after 2 weeks were expressed by participants of 20 g/l group (100 %); positive change remained after 3 months in 40 and 60 g/l groups (93

%) (Figure 3). Less than 9 % of participants showed better health status after treatment and for more than one third (34 %) assessment was better than at baseline after 3 months. Assessment of the control group showed no changes in health status and complaints after 2 weeks, but better health status (17 %) and less complaints (9 %) were after a 3-month period.

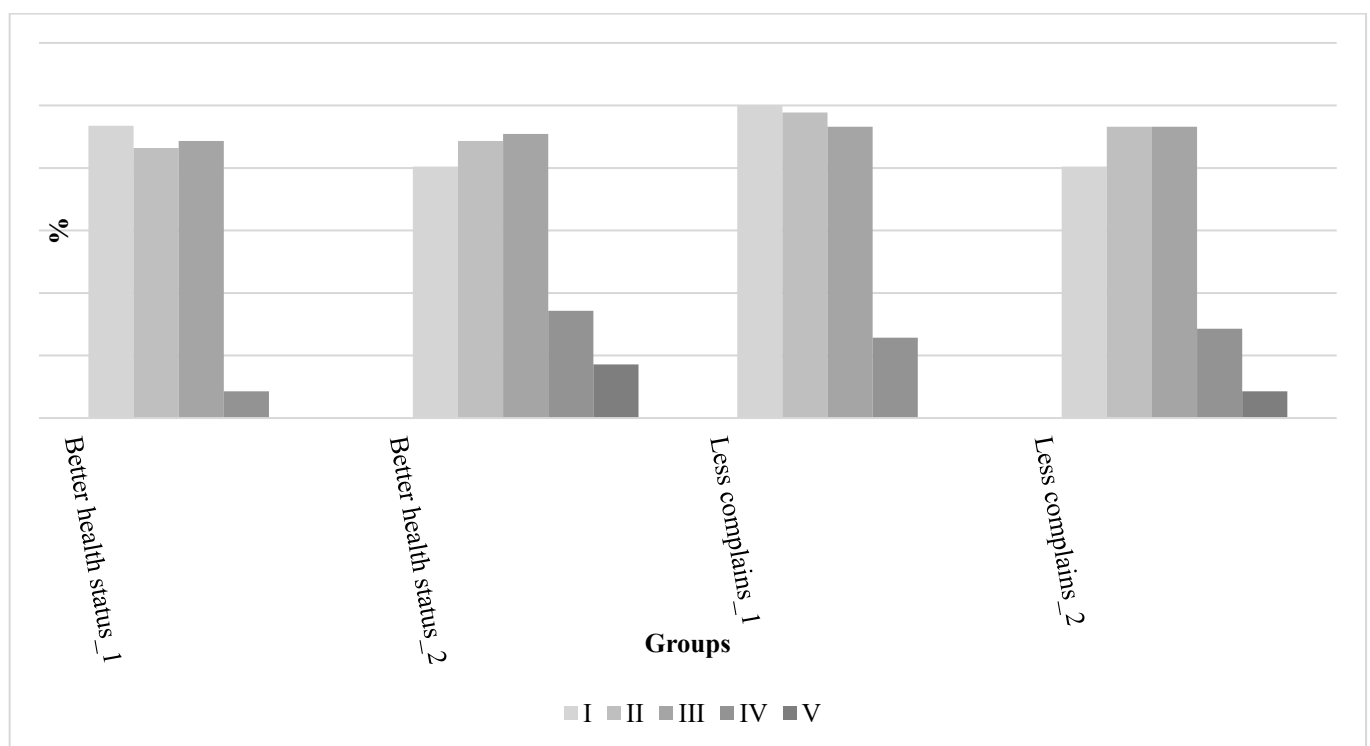


Fig. 3. Physicians' assessment of changes after 2-week and at 3-month period in study groups

Discussion

The results of the study demonstrated that the 2-week hydrotherapy with geothermal water of different total mineralisation and warm tap water had a significant positive effect on health status. All positive effects of geothermal water baths were greater than with tap water. The significant positive results in the control group were minimal - only in wellness and some laboratory findings.

Assessing changes in SHSQ-25, the best significant total positive result for health enhancement after the 2-week and 3-month follow-up was in the 40 g/l geothermal group. According to the health subscales

most affected were fatigue and mental status in all hydrotherapy groups. The geothermal water of 20 and 40 g/l total mineralisation best suits for fatigue management, 40 g/l for mental status, immunity, digestion correction, and 20 g/l and tap water for cardiovascular problems.

The feeling of wellness was most evident with the geothermal water bath, especially 20 g/l mineralisation with the significant residual effect of 3 months in 20 and 40 g/l groups. Health rating was significantly better in geothermal groups with the best after treatment and 3-month period in 40 g/l group.

Blood and urine laboratory tests did not show any special results. 2 weeks of balneotherapy had some impact on Er, MCV, MCH, MPV, Eo, Tr, urine SG and pH. Some similar changes were observed in the tap water (MCV, Tr) and control (Er, Eo, MPV, MCV) groups. Tap water made some significant changes in leukocytes types (lym., mon). MPV is a good indicator of the activity of thrombocytes which increases with the presence of emotional stress, is also a trigger of coronary events (14), so positive effect could be counted with 40 g/l water procedures (elevated Tr could be reactive because of the redistribution of Tr in the organism after procedures such as physical exercise). An explanation for the lowering of MCV and MCH after 60 g/l water procedures could be an acquired state where boosted metabolism reactions could take place (Er mitosis acceleration) as Er and Hb were growing insignificantly (except in the 20 g/l group). The lowering of SG after the 60 g/l water procedures shows decreased concentric function of the kidneys or lowered antidiuretic hormone secretion producing the diuretical effect. The change of urine pH shows change in acid-alkaline balance to alkalinizing side due to the diuretical effect or elevated alkaline elements in urine (15). These changes suggest that geothermal water of bigger mineralisation is more metabolically active and could be responsible for longer residual effects on the body.

According to the physicians' assessment the best results after 2 weeks were in the 20 g/l group, but 40 and 60 g/l water procedures had more residual effects. Our findings on geothermal water effect can be associated with other researchers' description of saline water (counteract gastric problems, increase cutaneous circulation, reduce inflammation of inflammatory and peripheral nervous system disorders), sulphated water (as a detoxicating agent, reducing gastric secretions), alkaline waters with bicarbonates, calcium, magnesium, potassium (stimulate bile, pancreas, intestines and phlegm secretion, alkalize the urine and the blood) (10). Saline water therapeutic agents have been described to act via mechanical, thermal, and chemical mechanisms (11).

Our finding of best effect for health status of 40 g/l geothermal water procedures meets with the Lithuanian recommendations to use 20–40 g/l water for optimal treatment of disorders (16). The scientific literature from 2002 to 2013 has shown that health

resort medical treatment is associated with clinical improvement in the diseases of the skin, respiratory, circulatory, digestive and nervous systems, cancer, nutritional and metabolic disorders, mental disorders, diseases of the ear, endocrine diseases, female genital diseases and nutritional deficiencies (17). Scientists believe that mineral water treatment methods compared to non-mineral similar treatments had better and longer improvements in pain, function, quality of life, clinical parameters, and others (18).

Our study about the effect of balneotherapy on the general health status using SHSQ-25 was done for the first time. Therefore we cannot compare the effect of geothermal water baths in terms of effect size? After Yang balneotherapy intervention, sleep disorders, mental stress and problems of general health (head, joint pain, leg or foot cramps, and blurred vision) were relieved significantly as compared with the control group. Fatigue, eye tiredness, limb numbness, constipation, skin allergy and women's health problems were relieved significantly in the self-comparison of the intervention group, but not between the two groups. All indications (except for bad mood, low mood, and worry or irritability) in the intervention group significantly improved, with the effect size from 0.096 to 1.302. Multiple logistic regression analysis showed that the frequency, length, and location of balneotherapy in the intervention group were the factors influencing emotion, sleep, and health condition (19).

Our previous clinical study demonstrated the positive impact of balneotherapy with 108 g/l mineralisation geothermal water on distress; it provided 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 %; also, favourable effects of balneotherapy using geothermal water on pain, sleep disturbances and intestinal problems were observed (9). Large effect sizes between geothermal water treatment versus control were found in lowering general fatigue (1.06, 95% CI -1.47 to -0.65) and in activity (-0.89, 95% CI -1.29 to -0.48), and mood (1.16, 95% CI 0.74 to 1.57); a medium effect size was seen in reducing physical (0.73, 95% CI 1.13 to -0.34) and mental fatigue (0.53, 95% CI -0.92 to -0.14) and increasing motivation (0.65, 95% CI -1.04 to -0.25) (20). Blasche G 3-week spa therapy (carbonated mineral water, hot mud packs, tub bath) study with actively working individuals also showed

change in fatigue, distress, reduced motivation, and quality of sleep (burnout symptoms). This improvement was sustained up to 3 months (21). The Dubois O study results demonstrate that balneotherapy was statistically superior to paroxetine in terms of the primary efficacy criterion: HAM-A total score (mean diff -3.7, psychic: 8 weeks -1.6, somatic -2.1, $p < 0.001$) (22).

There are separate studies and meta-analyses of hydrotherapy for the treatment of fibromyalgia syndrome. Moderate-to-strong evidence for a small reduction in pain with regard to hydrotherapy and moderate-to-strong evidence for a small improvement in health-related quality of life by HRQOL with no effect for depressive symptoms were observed, but balneotherapy showed moderate evidence for a medium-to-large size reduction in pain and moderate evidence was given for a medium improvement of HRQOL (SMD -0.78; 95% CI [-1.13, -0.43]; $P < 0.0001$; $I^2 = 0\%$). Counteracting with our general mental status improvement findings, significant effect on depressive symptoms was not found (7). Antonelli's study with knee osteoarthritis also proved that balneological interventions compared to standard treatment result in better long-term overall QoL [ES = -1.03 (95% CI -1.66 to -0.40)], pain improvement (23). It has been proven that Dead Sea and Hungarian mineral waters balneo- and climatotherapy decrease pain, improve joint function and quality of life in rheumatoid arthritis, in ankylosing spondylitis, as well as in psoriatic arthritis, and in osteoarthritis (7, 24) as well as for fibromyalgia SF-36 variables as mental health (from 51 to 70) after treatment, vitality (from 39 to 59), body pain (from 19 to 39), also severity of fatigue (from 65 to 43, VAS), general well-being (from 66 to 48), psychological well-being (anxiety, depression) were alleviated (25). In Ozkurt's study balneotherapy was found to be superior than control in terms of pain intensity, FIQ, Beck Depression Inventory, patient's global assessment, investigator's global assessment scores, and tender point count. This lasted up to 3rd month, except for the Beck Depression Inventory score and the investigator's global assessment score (26). In Baysal's study the most common benefits observed by the participants of balneotherapy treatment were muscle loosening (66.8%), reduced pain (50.7%) and relaxation-rest (49.2%). A large majority of the participants (95.5%) stated that they would recommend balneotherapy to others (27).

We have not found any significant effect on white blood cells in geothermal water groups, but in warm tap water group lymphocytes and monocytes were elevated. This is in line with Kuehn study of cold water therapy in cancer patients results where significant increases in post-treatment neutrophils, lymphocytes, and monocytes was observed. Blazickova study results were as follows: the whole-body hyperthermic water bath increased relative CD8+ lymphocyte, NK cell counts and their activity (which were probably dependent on the increased somatotrophic hormone). This contradicts Digiesi study where head-out water immersion for 30 min decreased blood viscosity and Er but without significant changes in Leu and Tr count and MCV (5). Good health is central to handling stress and living a long and active life. It may not be possible to avoid disease completely, but doing as much as we can to develop resilience and prepare the body and mind to deal with problems as they arise is a step we can all take.

We should incorporate all possible aspects of medicine including non-pharmacologic approaches in order to maintain health and prevent NCDs. These approaches include hydrotherapy and balneotherapy which can be of great importance if health promotion strategies are considered and if the FEMTEC concept is followed. This concept was developed by Santuari and Solimene who propose to focus on prevention and health promotion rather than on the concept of cure (28).

Limitations and strengths of study

Differences of some sociodemographic parameters among the groups (the fact that in the course of the study we lost younger study participants), the timing of the study (summer, people being on holidays and resting) might have given reliable positive changes among the control group participants. Addition of aromatic oils when preparing pure water baths might have had additional impact on better results. Preparation of individual baths might have caused small deviations from planned mineralisations. Since there are no standardised protocols for the study of concrete influence it is complicated to draw final conclusions and compare our results with those of other studies. We agree that to account for placebo effects, double-blind trials are best, but it is difficult to prepare such conditions as it is easy to distinguish

between the organoleptic characteristics of mineral water and control treatments with fresh water.

Strengths of our study: comparison of different total mineralisation waters in parallel groups, control with tap water and no treatment, investigating balneotherapy effects on people without disease to find preventative measures or strengthen body health. This allows to offer recommendations how to apply certain procedures to guarantee a person's physical and psychological well-being.

Conclusions

- Two- week hydrotherapy has a significant positive effect on health status, especially fatigue and mental subscales.
- Effects of geothermal water baths are greater than with tap water.
- The geothermal water of 40 g/l total mineralisation has best positive effect on health enhancement after 2 weeks and after a 3-month follow-up.
- 20 and 40 g/l total mineralisation best suits for wellness and fatigue management, 40 g/l - for mental status, immunity, digestion correction, and 20 g/l and tap water - for cardiovascular problems.
- 20 g/l water gives fast and short-term health effect, while 40-60 g/l water has long-lasting effect on health state.

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