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THE INFLUENCE OF BALNEOTHERAPY ON SPA TRUSKAVETS' ON ARTERIAL PRESSURE AND ITS REGULATION AT CHILDREN

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Abstract

Background. It is known that balneotherapy on spa Truskavets' causes various effects on autonomous and endocrine systems, which, in turn, plays impact role in regulation of arterial blood pressure. The aim of this study was to investigate the effect of balneotherapy on the arterial blood pressure and to elucidate the role autonomic system and some other factors as predictors and/or regulators nature of this influence. **Methods**. We registrated at 25 girls and 22 boys 10-16 years old before and after two weeks balneotherapy systolic and diastolic blood pressure, HRV by Baevskiy, duration of delay of breathing after inspiration (Stange's test) and expiration (Hench's test), Teslenko's orthostatic test, Anfimov's proof test, routine clinical blood analysis as well as leukocytogram of peripheral blood, from which calculated Popovych's both strain index and adaptation index. **Results.** At 24 children changes in meanarterial pressure (MAP) did not exceed ±2 mm Hg, at 11 MAP decreased by 6,2±1,1 mm Hg, and at 12 rose by 4,4±0,8 mm Hg. Changes in MAP accompanied with changes in thrombocytes blood level (r=0,55) and Hench's expiration test (r=-0,41). It is detected 12 parameters, changes in which are specific (accuracy of classification: 87%) to different effects of balneotherapy on MAP. Changes in MAP are determined by initial level of MAP (r=-0,54) as well as vagal tone (r=-0,24) and lymphocytes blood level (r=0,19). It is detected 19 initial parameters, constellation of which allows forecast character of effect of balneotherapy on MAP with accuracy of 100%. **Conclusion.** Balneotherapy on spa Truskavets' causes various effects on blood pressure, which accompanied with changes in autonomic and humoral regulation and conditionized by constellation of initial parameters.

Keywords: blood pressure, HRV, thrombocytes, leukocytogram, spa Truskavets', children.

INTRODUCTION

Data on the effect on blood pressure as a course of balneotherapy on spa Truskavets' [1,3,7,15,20,21,25,29], so a single use of its main components bioactive water Naftussya [3,27] generally indicate the nature of the effect of normalizing, that is, to reduce the high and increasing reduction in blood pressure, while normal values vary vague and unimportant, which corresponds to low of initial value [28]. However, the analysis of individual changes in blood pressure often found substantial deviations from the low of initial value, indicating that about conditionizing role not only initial value of blood pressure, but also other factors. We have previously shown, that character of change in blood pressure in half an hour after drinking of bioactive water Naftussya is conditioned by both initial value of blood pressure and hender as well as by 9 initial perameters of hemodynamics and 6 parameters of exchange of cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) [27]. These studies have been conducted on adults, whereas in children they still have not been conducted. The aim of this study was to investigate the effect of balneotherapy on arterial blood pressure in children and to elucidate the role autonomic system and some other factors as predictors and/or regulators nature of this influence.

MATERIALS AND METHODS

The study included 25 girls and 22 boys 10-16 years old, arrived at the rehabilitation of the spa Truskavets' from the territories of Ukraine that are contaminated with radionuclides. At admission and after two weeks of balneotherapy (drinking of bioactive water Naftussya, application of ozokerite, mineral bathes [1,17]) recorded systolic and diastolic blood pressure ("Omron M4-I", Netherland), heart rate variability (HRV) by Baevskiy [2] ("Cardio", Kyiv), duration of delay of breathing after inspiration (Stange's test) and expiration (Hench's test), Teslenko's orthostatic test [10], Anfimov's proof test [24], clinical blood analysis as well as leukocytogram (LCG) of peripheral blood, on basis of which the calculated Popovych's strain index and adaptation index [5,9]. Statistical processing carried out with the help of the software package "Statistica 5.5".

RESULTS AND DISCUSSION

Ascertained (Table 1) that after completion of balneotherapy meanarterial pressure in 51% of children has not changed, however, in 23% of children had declined by 8% ($p<0,001$), and in 26% increased by 6% ($p<0.001$). Thus diastolic pressure reduced to a greater extent than the systolic pressure: -10% vs -5%, whereas higher meanarterial pressure accompanied nearly identical component changes both (+5,5% vs +7%). When recalculations individual values due to pressure on hender and age was found that changes in systolic pressure are normalizing character. Clearly reduced diastolic pressure was increased to the level of moderately reduced, however, initially declined moderately reduced even more. Interestingly, the heart rate significantly decreased in children with stable meanarterial pressure, whereas the two other groups of children reduction heart rate had a tendency character. As a result, contrary to expectations, pattern changes Kerdö's vegetative index, calculated for values heart rate and diastolic pressure, not corresponds pattern changes meanarterial pressure.

Table 1. Clusters of changes in parameters of Blood Pressure and Heart Rate at children caused by balneotherapy on spa Truskavets'

Parameters	Term	Clusters of Changes in Meanarterial Pressure		
		Decrease (n=11)	Not significant (n=24)	Increase (n=12)
Meanarterial Pressure, mm Hg	Before After Change	82,4±2,6 76,2±2,0 -6,2±1,1*	72,9±1,2 72,9±1,2 0,0±0,5	71,9±1,8 76,4±2,1 +4,4±0,8*
Blood Pressure Systolic, mm Hg	Before After Change	116,4±4,6 110,5±3,8 -5,9±2,0*	101,7±2,1 101,7±2,1 0,0±0,9	97,5±2,8 104,2±3,1 +6,7±2,2*
Blood Pressure Diastolic, mm Hg	Before After Change	65,5±2,0 59,1±1,6 -6,4±1,5*	58,5±0,9 58,5±0,9 0±0,5	59,2±1,5 62,5±1,9 +3,3±0,9*
Blood Pressure Systolic, % of norm	Before After Change	108±4 102±3 -6±2*	95±2 95±2 0±1	91±3 97±3 +6±2*
Blood Pressure Diastolic, % of norm	Before After Change	91±2 81±2 -10±2*	82±1 82±1 0±1	82±2 87±3 +5±1*
Heart Rate, beat/min	Before After Change	76,5±0,9 72,9±1,7 -3,6±2,0	79,6±1,3 73,4±2,2 -6,2±1,5*	77,0±0,5 72,9±2,0 -4,1±2,2
Kerdö's Vegetative Index (1-BPd/HR)•100	Before After Change	14,6±2,1 19,8±2,4 +5,3±2,5*	26,2±1,3 19,0±2,0 -7,2±1,7*	23,0±2,3 13,8±2,9 -9,2±2,9*

And it is quite unexpected, contrary to previous studies [20,21], it turned out, that pattern changes of Baevskiy's stress index as integral marker of autonomic regulation is **inverted** to pattern changes in meanarterial pressure. However, one should bear in mind a very large variability in changes of Baevskiy's stress index (Table 2).

On the other hand, a surprise at first glance, were significant relationships between change in meanarterial pressure and Hench's expiration test (Table 2, Figure 1) as well as thrombocytes blood level (Table 3, Figure 2). However, on further consideration of such ties seem to be quite natural. Thus, there is a perception [6], that Hench's test reflexes not so much resistance to hypoxia as the severity of inhibitory processes in CNS, or rather, inhibition of insriratory neurons. From these positions implies that changes in meanarterial pressure are caused by changes in inhibitory activity of reticular formation neurons. It is known about relationships between parameters EEG and HRV reflexes activity of suprasegmentary and autonomic neural structures respectively [18,19].

Table 2. Accompanying changes in parameters of HRV and some other tests at children with various changes in meanarterial pressure

Parameters	Term	Clusters of Changes in Meanarterial Pressure		
		Decrease (n=11)	Not significant (n=24)	Increase (n=12)
Baevskiy's Stress Index (AMo/2Mo•ΔX)	Before	58±15	128±20	128±43
	After	92±29	141±17	94±19
	Change	+34±31	+13±26	-34±47
Moda HRV (Mo), sec	Before	0,92±0,05	0,80±0,03	0,84±0,03
	After	0,91±0,04	0,82±0,02	0,83±0,04
	Change	-0,01±0,03	+0,02±0,03	-0,01±0,05
Sympathetic Tone (AMo), %	Before	31±3	39±3	37±4
	After	33±4	40±2	36±3
	Change	+2±4	+1±3	-1±4
Vagal Tone (ΔX), sec	Before	0,37±0,03	0,28±0,03	0,25±0,03
	After	0,34±0,05	0,24±0,02	0,29±0,03
	Change	-0,03±0,04	-0,04±0,03	+0,04±0,03
Hench's Expiration Test, sec	Before	26±3	28±2	36±5
	After	41±5	33±2	33±4
	Change	+15±4*	+5±2*	-3±5
Stange's Inspiration Test, sec	Before	44±4	42±3	48±6
	After	47±6	48±4	52±6
	Change	+3±4	+6±3*	+4±4
Teslenko's Orthostatic Test, points	Before	5,2±0,5	3,3±0,4	4,7±0,4
	After	4,8±0,4	2,9±0,2	3,6±0,6
	Change	-0,4±0,6	-0,4±0,3	-1,1±0,7
Anfimov's Proof Test, signes/2 min	Before	280±26	275±17	314±27
	After	315±30	326±16	352±33
	Change	+35±13*	+51±7*	+38±10*
Anfimov's Proof Test, mistakes/2 min	Before	2,8±1,1	3,5±0,7	3,2±0,7
	After	3,1±0,6	2,4±0,4	1,3±0,5
	Change	+0,3±0,4	-1,1±0,7	-1,9±0,7*

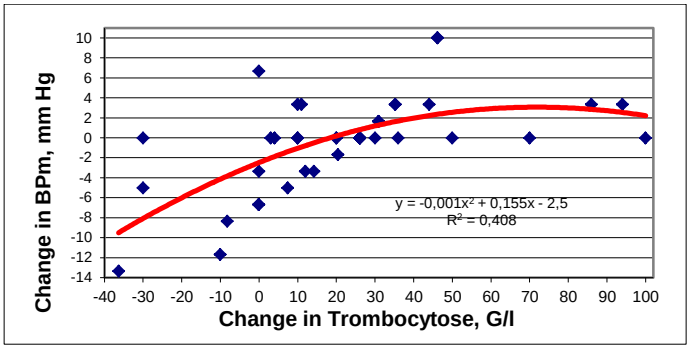


Figure 1. Relationship between change in trombocytose (axis of X) and meanarterial pressure (BPm, axis of Y) at children caused by balneotherapy on spa Truskavets

Table 3. Accompanying changes in parameters of Hemogram and Leukocytogram at children with various changes in Meanarterial Pressure

Parameters	Term	Clusters of Changes in Meanarterial Pressure		
		Decrease (n=11)	Not significant (n=24)	Increase (n=12)
Thrombocytes level, G/l	Before	256±14	239±7	237±13
	After	253±14	265±8	276±12
	Change	-3±5	+26±5*	+39±8*
Haemoglobin level, g/l	Before	128,9±1,9	129,0±0,9	130,8±1,0
	After	128,9±1,4	129,6±0,7	130,7±0,9
	Change	0,0±0,7	+0,6±0,4	-0,1±0,4
Leukocytes level, G/l	Before	5,48±0,34	5,86±0,24	5,72±0,23
	After	5,49±0,33	5,89±0,16	5,99±0,22
	Change	+0,01±0,15	+0,03±0,18	+0,27±0,20
Eosinophils[1], %	Before	2,1±0,4	3,6±0,4	2,8±0,6
	After	2,8±0,7	3,1±0,4	3,4±0,5
	Change	+0,7±0,7	-0,5±0,5	+0,6±0,4
Stab Neutrophils[2], %	Before	3,4±0,3	3,5±0,3	3,3±0,4
	After	2,5±0,9	2,9±0,3	3,6±0,8
	Change	-0,9±0,4*	-0,6±0,4	+0,3±0,7
Segmented Neutrophils[3], %	Before	55,8±3,1	54,0±1,5	49,3±2,4
	After	53,9±2,3	54,3±1,2	50,1±2,3
	Change	-1,9±2,5	+0,3±1,8	+0,8±2,5
Lymphocytes[4], %	Before	34,1±3,0	35,1±1,2	41,6±2,1
	After	38,1±1,9	35,6±0,8	39,1±2,1
	Change	+4,0±1,3*	+0,5±1,2	-2,5±1,9
Monocytes[5], %	Before	3,6±0,4	3,8±0,4	3,5±0,5
	After	3,0±0,6	4,0±0,4	4,2±0,8
	Change	-0,6±0,5	+0,2±0,5	+0,7±0,9
Entropy of Leukocytogram $H=-\Sigma_{i=5}^{n} p_i \cdot \log_2 p_i$	Before	0,61±0,01	0,65±0,01	0,63±0,01
	After	0,61±0,02	0,64±0,01	0,65±0,02
	Change	0,00±0,02	-0,01±0,01	+0,02±0,02
Number Elemens of Strain in Leukocytogram	Before	1,2±0,2	1,7±0,2	1,6±0,2
	After	1,8±0,2	2,0±0,2	2,4±0,1
	Change	+0,6±0,2*	+0,3±0,3	+0,8±0,2*
Popovych's Strain Index of Leukocytogram	Before	0,15±0,02	0,25±0,05	0,23±0,03
	After	0,27±0,06	0,27±0,05	0,32±0,03
	Change	+0,12±0,06*	+0,02±0,08	+0,09±0,04*
Popovych's Adaptation Index of Leukocytogram	Before	0,63±0,09	0,85±0,07	0,67±0,06
	After	0,72±0,11	0,75±0,05	0,53±0,04
	Change	+0,09±0,07	-0,10±0,08	-0,14±0,06*

Next, have long known that thrombocytes (plateles) are the source of vasoconstricting factors (serotonin, thromboxane etc), so it is likely that changes in thrombocytes blood level are accompanied by changes in plasma levels of vasoconstricting factors.

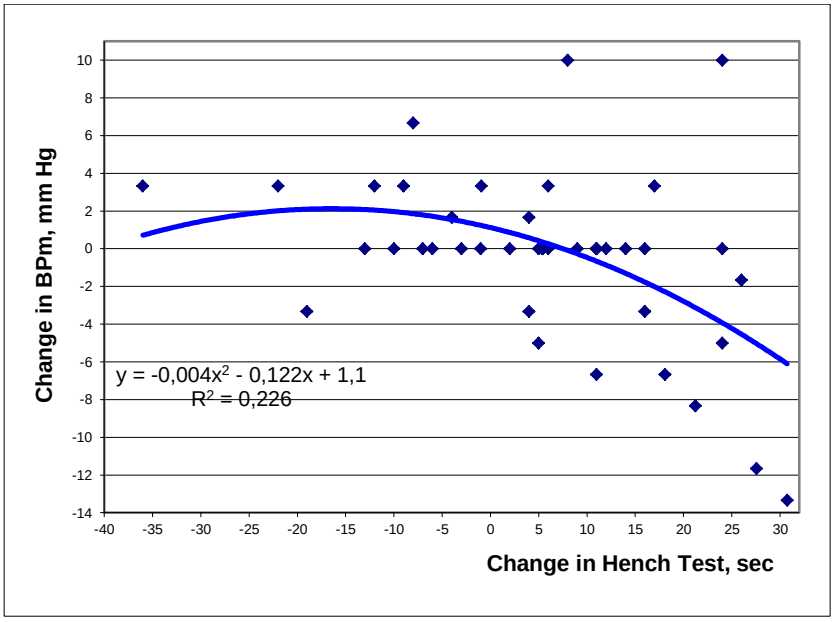
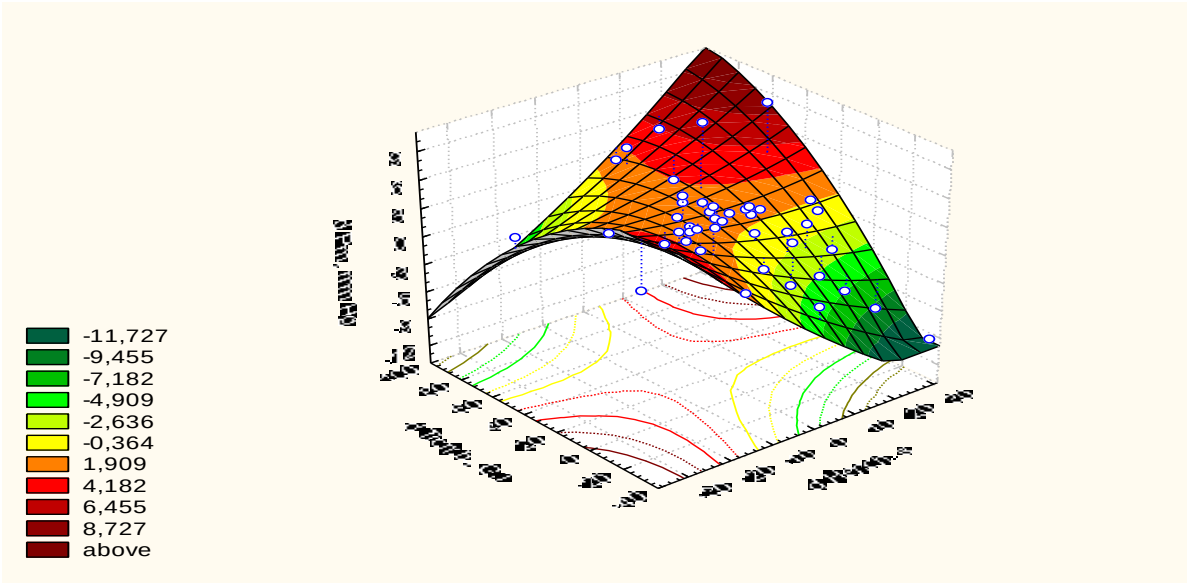


Figure 2. Relationship between change in thrombocytose (axis of X) and meanarterial pressure (BPm, axis of Y) at children caused by balneotherapy on spa Truskavets'



R=0,665; R^2=0,442; Adjusted R^2=0,417; $F_{(2,4)}$=17,4; $p<10^{-5}$; m=±3,3 mm Hg

	Beta	St. Err. of Beta	B	St. Err. of B	$t_{(44)}$	p-level
Interception			-1,49	0,67	-2,23	0,031
delta Trombocytes, G/l	0,524	0,113	0,083	0,018	4,65	$<10^{-4}$
delta Hench Test, sec	-0,380	0,113	-0,123	0,036	-3,37	0,002

Figure 3. Relationship between change in Hench test (axis of X), trombocytose (axis of Y) and meanarterial pressure (axis of Z) at children caused by balneotherapy on spa Truskavets'

Joint dynamics of humoral and neural factors represented by thrombocytes level and Hench's test respectively determinates changes in meanarterial pressure on 42% (Figure 3).

In order to identify yet other parameters which change specific to different effects of balneotherapy on meanarterial pressure, was conducted discriminant analysis (method forward stepwise [11]). The program is included in model 12 discriminant variables (Table 4).

Table 4. Discriminant function analysis summary of changes of parameters specific to different effects of balneotherapy on meanarterial pressure at children

Step 12, N of variables in model: 12; Grouping: 3 groups;Wilks' Lambda: 0,218; approx. $F_{(24,4)}$=3,14; $p<10^{-4}$

Variables in model (their changes)	Wilks' Lambda	Partial Lambda	F-remove (2,33)	p-level	Tole-rancy
Thrombocytes level	0,326	0,669	8,17	0,001	0,789
Hench's Test	0,367	0,593	11,33	0,0002	0,535
Vagal Tone (ΔX)	0,338	0,644	9,12	0,0007	0,238
Stab Neutrophils level	0,277	0,786	4,49	0,019	0,229
Lymphocytes level	0,231	0,943	1,00	0,377	0,580
Moda HRV	0,258	0,844	3,05	0,061	0,634
Heart Rate	0,241	0,904	1,76	0,188	0,707
Stange's Test	0,265	0,822	3,57	0,040	0,502
Elements of Strain LCG	0,262	0,830	3,37	0,047	0,390
Popovych's Strain Index	0,249	0,873	2,40	0,107	0,186
Signes in Proof Test	0,234	0,930	1,24	0,302	0,870
Sympathetic Tone (AMo)	0,234	0,932	1,20	0,315	0,327

The discriminant information is condensed in two canonical roots (Table 5). The major root contains 76% discriminant properties and, as evidenced by the structural coefficients for canonical variables (correlations variables - canonical roots), as expected, straight representes changes in duration of delay of breathing after expiration and inversely representes changes in blood level of thrombocytes. However, here also included patterns changes in sympathetic tone and stab neutrophils level.

Table 5. Results of discriminant analysis of changes of parameters specific to different effects of balneotherapy on meanarterial pressure at children

Changes in discriminant variables currently in the model	Parameters of Wilks' statistics			Coefficients for canonical variables				Changes in parameters specific to different changes in MAP		
	Λ	F	p<	Raw		Structural		MAP- n=11	MAP± n=24	MAP+ n=12
				Root 1	Root 2	Root 1	Root 2			
Hench's Test, sec	0,520	8,3	10^{-4}	0,086	-0,021	**0,36**	-0,22	+15±4	+5±2	-3±5
Sympathetic Tone, %	0,234	3,3	10^{-3}	0,005	0,014	**0,03**	0,23	+2±4	+1±3	-1±4
Thrombocytes, G/l	0,702	9,3	10^{-3}	-0,026	0,029	**-0,41**	0,43	-3±5	+26±5	+39±8
Stab Neutrophils, %	0,421	5,6	10^{-4}	-0,293	-0,637	**-0,05**	-0,27	-0,9±0,4	-0,6±0,4	+0,3±0,7
Vagal Tone, sec	0,467	6,5	10^{-4}	-9,940	-6,603	-0,16	-0,17	-0,03±0,04	-0,04±0,03	+0,04±0,03
Stange's Test, sec	0,315	4,2	10^{-4}	-0,055	-0,039	-0,02	**-0,20**	+3±4	+6±3	+4±4
Signes in Proof Test	0,248	3,5	10^{-4}	2,896	3,049	-0,01	**-0,16**	+35±13	+51±7	+38±10
Moda HRV, sec	0,380	5,0	10^{-4}	0,037	0,082	0,23	**-0,09**	-0,01±0,03	+0,02±0,03	-0,01±0,05
Popovych's Strain Ind	0,268	3,7	10^{-4}	-0,689	-0,575	-0,08	**-0,16**	+0,12±0,06	+0,02±0,08	+0,09±0,04
Elements of Strain	0,285	4,0	10^{-4}	-0,063	-0,000	-0,03	**0,08**	+0,6±0,2	+0,3±0,3	+0,8±0,2
Heart Rate, beat/min	0,344	4,6	10^{-4}	3,581	3,026	0,03	**0,10**	-3,6±2,0	-6,2±1,5	-4,1±2,2
	Constant			-0,066	-1,386					
Chi-square tests with successive roots removed	r_1^*=0,81; Wilks' Λ=0,22; $\chi^2_{(24)}$=59; $p<10^{-4}$			Means of Roots of canonical variables		**Root 1** 76%		+1,50	+0,37	-2,12
	r_2^*=0,61; Wilks' Λ=0,62; $\chi^2_{(11)}$=18; p=0,079					**Root 2** 24%		-1,06	+0,70	-0,44

The calculation of values of individual unstandardized canonical scores of roots by summation the multiplications of individual variables on the raw coefficients for canonical variables plus constants (see Table 5) allows vizualisation all the children on the plane of the two roots (Figure 4).

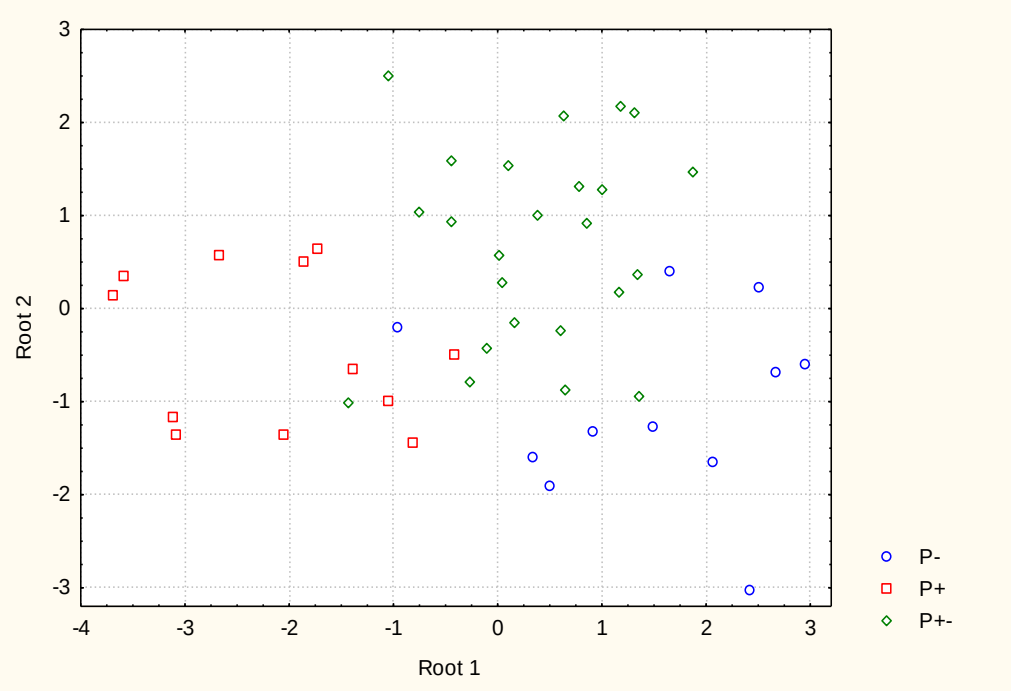


Figure 4. Unstandardized canonical scores of roots of changes in parameters characterized various effects of balneotherapy on meanarterial pressure (P) at children

It is seen that children, liable to increase of MAP, localized in the negative zone (centroide:-2,12) axis of root 1. This reflects increasing of thrombocytose and tendency to reduction of Hench's test. Opposite effect accompanied with increasing of Hench's test and tendency to reduction of thrombocytose illustrated the placement in the positive zone (centroide:+1,50) axis of major root. Neutral effect on MAP (P±) corresponds to intemediate localization (centroide:+0,37). Downward pattern follows the dynamics of sympathetic tone, and the rising pattern follows the dynamics of stab neutrophils level. In general, exist two opposite pattern of changes (d):

dMAP->dMAP±>dMAP+ and dMAP-<dMAP±<dMAP+.

However, along the axis of minor root 2 (that contains 24% discriminant properties and is weakly structurated) effects of alternative habitats overlap, whereas neutral effect is illustrated highest placing (centroide:+0,70), reflecting an both maximal increase in duration of delay of breathing after inspiration and in quantity registered signes in proof test and decrease in heart rate as well an minimal changes in quantity elements of strain and Popovych's strain index LCG. Changes in these parameters were approximately the same as with a decrease and an increase in MAP and different from those in a stable MAP. Two opposite pattern of changes looks as:

dMAP-≈dMAP+<dMAP± and dMAP-≈dMAP+>dMAP±.

It is known that Stange's test reflexes resistance to hypoxia [4,6] and elements of strain in leukocytogram reflexes dysturbances in relationships (dysharmony) between major hormones of adaptation (corticoadrenals, gonades and thyroide) [5,9,17]. It is shown that balneotherapy on spa Truskavets' causes various effects on resistance to hypoxia [4], leukocytogram and immunogram [8,9,12,16,17,26]. One must therefore assume that Anfimov's proof test affect cytokines released from immunocytes, since the psychotropic effects of cytokines are well known [22,23]. When account is taken of these provisions it seems that when balneotherapy causes maximal release of nootropic cytokines in combination with the absence of significant changes in the relationships between hormones of adaptation, MAP remained stable, whereas dysharmonizing effects of balneotherapy in conjunction with insufficiently pronounced stimulation of release of nootropic cytokines accompanied with those or other changes in MAP.

In general, all three clusters are mutually separated. Squared Mahalanobis distances (D^2_M) between clusters P- and P+ average 14,4 (F=4,7; $p<10^{-3}$), P-and P±: 4,7 (F=2,03; p=0,053), P+and P±: 8,0 (F=3,7; p=0,001).

The calculation of classification functions (Table 6) makes it possible to aggregate changes discriminant parameters retrospectively identify children with an increase in MAP with an accuracy of 92% (one error per 12 persons), with a decrease in MAP with an accuracy of 82% (two errors on 11 persons), and with stable MAP to within 88% (three errors on 24 children). Overall classification accuracy is 87%.

Table 6. Classification functions for accompaniment of various effects of balneotherapy on MAP

Change in Variables	MAP-	MAP+	MAP±
Thrombocytes	-0,023	0,088	0,057
Hench's Test	0,166	-0,159	0,032
Vagal Tone	-14,49	17,45	-14,89
Stab Neutrophils LCG	-0,432	0,236	-1,221
Lymphocytes LCG	0,103	0,018	0,205
Moda HRV	6,69	-4,41	7,98
Heart Rate	-0,131	0,043	-0,137
Stange's Test	-0,076	0,151	-0,006
Elements of Strain LCG	-0,513	1,628	-0,746
Popovych's Strain Index	3,07	-5,54	5,17
Signes in Proof Test	0,042	0,032	0,061
Sympathetic Tone	-0,040	0,079	-0,028
Constant	-3,81	-5,01	-4,03

Table 7. Results of discriminant analysis of parameters conditionizing various effects balneotherapy on MAP
N of variables in model: 19; Grouping: Changes in MAP; Wilks' Lambda: 0,035; approx. $F_{(38,5)}=5,99$; $p<10^{-4}$

Discriminant variables-predictors currently in the model	Parameters of Wilks' statistics			Coefficients for canonical variables				Means of parameters conditionizing different changes in Meanarter. Pres.		
	Λ	F	p<	Raw		Structural		MAP- n=11	MAP+ n=12	MAP± n=24
				R1	R2	R1	R2			
MA Pressure, mm Hg	0,352	7,0	10^{-6}	0,782	-0,448	**-0,16**	0,26	82,4±2,6	71,9±1,8	72,9±1,2
BP systolic, % of norm	0,037	6,3	10^{-6}	-0,252	0,210	**-0,14**	0,34	108±4	91±3	95±2
BP diastol., % of norm	0,080	6,3	10^{-6}	0,482	0,230	**-0,13**	0,14	91±2	83±2	82±1
Teslenko Orthostatic Ind.	0,191	7,0	10^{-6}	-0,056	-0,102	**-0,11**	-0,23	5,2±0,5	4,7±0,5	3,3±0,4
Vagal Tone (ΔX), sec	0,538	7,8	10^{-4}	-14,27	6,293	**-0,09**	0,22	0,37±0,03	0,25±0,03	0,28±0,03
Body Weight, kg	0,035	6,0	10^{-6}	-0,069	0,188	**-0,07**	0,02	50,8±3,5	45,5±2,3	44,0±2,1
Body Weight, % of norm	0,071	6,1	10^{-6}	-0,041	-0,088	**-0,06**	-0,02	109±6	103±3	100±3
Thrombocytes level, G/l	0,062	6,0	10^{-6}	-0,035	-0,012	**-0,05**	0,08	256±14	237±13	239±7
Kerdö Vegetative Index	0,667	11	10^{-4}	1,340	0,060	**0,19**	-0,01	15±2	23±2	26±1
Sympathotone (AMo), %	0,052	6,2	10^{-6}	0,073	0,056	**0,07**	0,01	31±3	37±4	39±3
Entropy of Leukogram	0,154	6,2	10^{-6}	2,853	-1,416	**0,07**	0,04	0,61±0,01	0,63±0,01	0,65±0,01
Popovych's Adaptat. Ind.	0,298	6,7	10^{-6}	3,692	-0,688	**0,07**	0,15	0,63±0,09	0,67±0,06	0,85±0,07
Hender Index	0,042	6,4	10^{-6}	-1,317	0,273	**0,05**	-0,06	0,36±0,15	0,58±0,15	0,58±0,10
Body Temperature, ^{0}C	0,420	7,6	10^{-5}	8,084	1,829	**0,07**	0,07	36,2±0,07	36,3±0,08	36,4±0,05
Heart Rate, beats/min	0,108	5,6	10^{-6}	-1,150	-0,006	**0,07**	0,17	77±1	77±1	80±1
Lymphocytes level, %	0,224	7,2	10^{-6}	0,072	-0,099	0,02	**-0,41**	34±3	42±2	35±1
Hench's Expirat. Test, s	0,170	6,6	10^{-6}	-0,051	-0,034	0,01	**-0,31**	26±3	36±5	28±2
Proof Test, signes/2 min	0,118	5,9	10^{-6}	-0,005	-0,010	-0,00	**-0,20**	280±26	314±27	275±17
Haemoglobin level, g/l	0,130	6,2	10^{-6}	-0,085	0,052	0,02	**-0,05**	128,9±1,9	130,8±1,0	129,0±0,9
	Constant			-295	-65,2					
Chi-square tests with successive roots removed	r_1^*=0,966; Wilks' Λ=0,035; $\chi^2_{(38)}$=118; $p<10^{-6}$			Means of Roots of canonical variables		**Root 1** 94%		-6,25	+0,24	+2,75
	r_2^*=0,696; Wilks' Λ=0,516; $\chi^2_{(18)}$=23; p=0,183					**Root 2** 6%		+0,49	-1,60	+0,58

The question arises why the same treatment causes various changes MAP? Obviously because children are different, but rather varies with respect their reactivity to balneotherapy. Using the same discriminant analysis, we identified 19 initial parameters conditionizing different effects of balneotherapy on MAP.

Results, reflected on Table 7 and Figure 5, show that the MAP decreased in those children whose initial levels of MAP, as well as normalized systolic and diastolic blood pressure, Teslenko's orthostatic index, vagal tone, actual and normalized body weight as well as thrombocytes level were to fetch maximum, whereas initial levels Kerdö's vegetative index, sympathetic tone, entropy of leukocytogram, Popovych's adaptation index and body temperature were minimal. Was minimal and hender index, calculated for the algorithm: boys=0, girls=1, reflecting the predominance of boys. Children whose MAP was increased or remained stable, characterized by smaller or larger values of the discriminant variables, information on which is condensed to the major root, not differing significantly among themselves (patterns: MAP->MAP+≈MAP± and MAP-<MAP+≈MAP±). But the differences between the groups were found on the variables, associated with minor root. As you can see, MAP was increased in children with a maximum for the sample values in blood lymphocytes and haemoglobin, and Hench's and proof tests, whereas the children of the other two groups the rates were about the same (pattern: MAP+>MAP-≈MAP±).

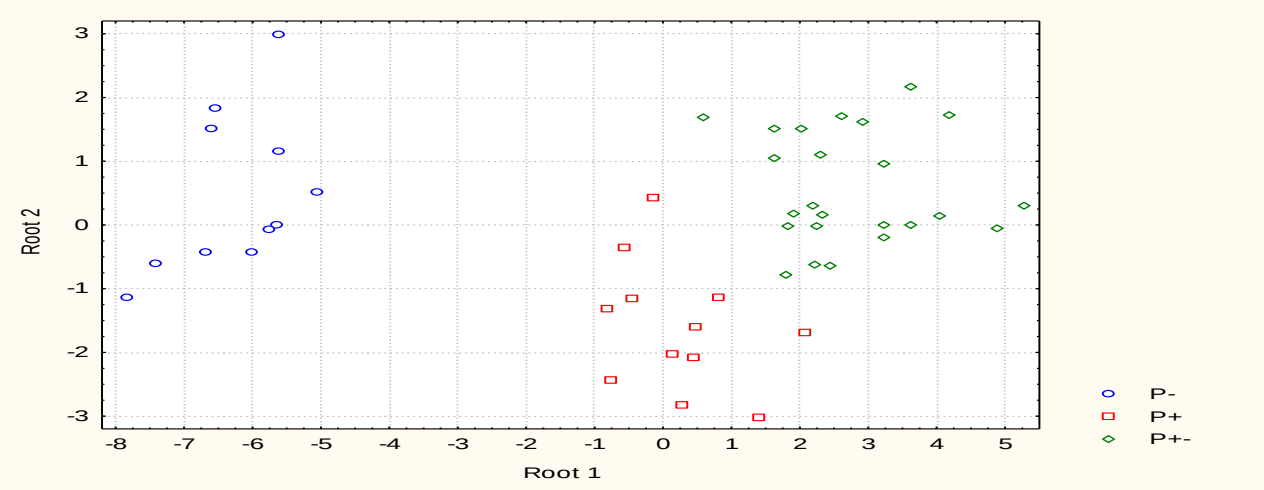


Figure 5. Unstandardized canonical scores of roots of initial parameters conditionizing various effects of balneotherapy on meanarterial pressure at children

In general, all three clusters are clearly mutually separated. D^2_M between clusters MAP- and MAP+ average 49,6 (F=8,1; $p=10^{-6}$), MAP- and MAP±: 86,5 (F=18,7; $p<10^{-6}$), MAP+ and MAP±: 11,8 (F=2,7; p=0,009).

Calculation of classification functions (Table 8) allows forecast character of effect of balneotherapy on MAP with accuracy of **100%!**

Table 8. Classification functions for forecast various effects of balneotherapy on meanarterial pressure at children

Variables-predictors	MAP-	MAP+	MAP+-
Kerdö's Vegetative Index, units	420,4	429,0	432,5
Vagal Tone (ΔX), sec	-3533	-3639	-3661
Body Morning Temperature, ^{0}C	3034	3083	3107
Meanarterial Pressure, mm Hg	254,6	260,6	261,6
Popovych's Adaptation Index, units	853,9	879,3	887,0
Lymphocytes level of LCG, %	13,7	14,4	14,4
Teslenko's Orthostatic Index, units	16,3	16,1	15,8
Hench's Expiration Test, sec	-16,2	-16,5	-16,7
Entropy of Leukocytogram (LCG)	562,1	583,6	587,6
Haemoglobin level, g/l	-23,8	-24,4	-24,5
Anfimov's Proof Test, signes/2 min	-2,0	-2,0	-2,0
Heart Rate, beats/min	-351,8	-359,3	-362,1

Blood Pressure diastolic, % of norm	151,3	153,9	155,6
Body Weight, % of norm	-11,4	-11,5	-11,8
Thrombocytes level, G/l	-10,9	-11,1	-11,3
Sympathetic Tone (AMo), %	27,8	28,1	28,4
Hender Index (Male=0, Female=1)	-361,4	-370,5	-373,2
Blood Pressure systolic, % of norm	-76,2	-78,3	-78,4
Body Weight, kg	-21,0	-21,9	-21,6
Constant	-55227	-56987	-57871

It turns out that it is possible to predict not only the character, but also the value of the individual reaction of MAP to balneotherapy. Initial level of MAP determinates its change on 29% (Figure 6).

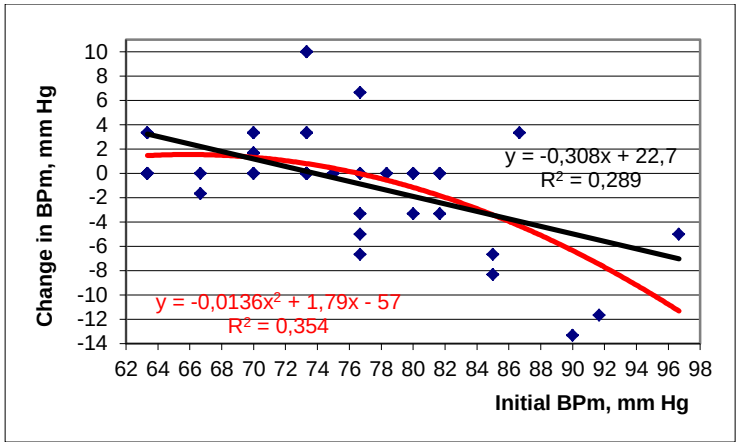
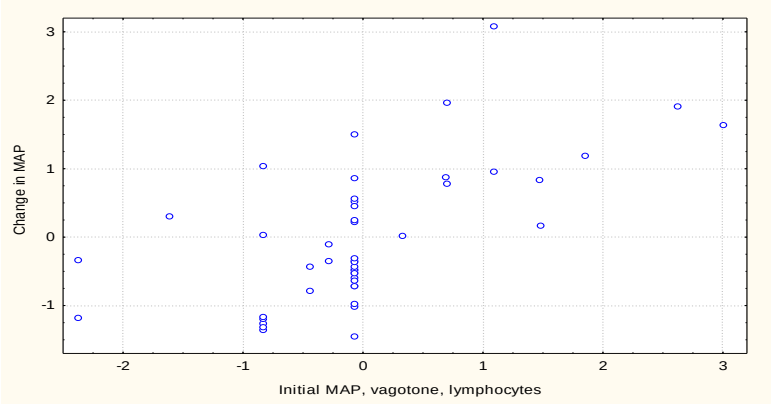


Figure 6. Correlation between initial level of meanarterial blood pressure (axis of X) and changes in meanarterial blood pressure caused by balneotherapy (axis Y)

Given the weak relationships between changes in MAP and initial levels both vagal tone and lymphocytes measure of determination increases to 34% (Figure 7).



R=0,618; R^2=0,382; Adjusted R^2=0,339; $F_{(3,4)}$=8,9; $\chi^2_{(3)}$=21; $p=10^{-4}$; Std. Error of estimate dMAP: 3,6 mm Hg

Interception	β	SE of β	B	SE of B	$t_{(43)}$	p-level	r dMAP/ Initial levels
Initial levels of			22,73	6,13	3,71	0,0006	
MAP, mm Hg	-0,542	0,120	-0,311	0,069	-4,51	0,00005	-0,54
Vagal Tone (ΔX), s	-0,261	0,120	-9,620	4,433	-2,17	0,035	-0,24
Lymphocytes, %	0,147	0,120	0,086	0,070	1,22	0,228	0,19

Figure 7. Canonical correlation between initial levels of meanarterial blood pressure, vagal tone and lymphocytes blood level (axis of X) and changes in meanarterial blood pressure caused by balneotherapy (axis Y)

CONCLUSION

We have shown that blood pressure in children react to course of balneotherapy on spa Truskavets' is ambiguous. However, this naturally polyalternativeness conditionized by constellation initial parameters of hemodynamics, autonomic regulation, hemogram, leukocytogram etc, as well as hender. This is fully consistent with the concept Truskavetsian scientic school of balneology about polyvariety effects on the body factors spa Truskavets' [4,7,12,13,14,16,17,25,26].

REFERENCES

1. Alyeksyeyev OI, Shymonko IT, Orlov OB. Therapy and Rehabilitation on Spas Truskavets' and Skhidnytsya.-Kyiv: Zdorovya, 1994.-176 p. [in Russian].
2. Baevskiy RM, Ivanov GG. Heart rate variability: theoretical aspects and possibilities of clinical application // Ultrasound and functional diagnostics.-2001.-№3.- P. 106-127. [in Russian].
3. Balneocardioangiology / Eds. Popovych IL, Ruzhylo SV, Ivassivka SV, Aksentiychuk BI.-Kyiv: Computerpress, 2011.-229 p. [in Ukrainian].
4. Barylyak LG**,** Babylyuk RV, Popovych IL, Korolyshyn TA, Nesterova LF. Influence of balneotherapy on spa Truskavets' on resistance to hypoxia for children with dysfunction of neuroendocrine-immune complex // Medical Hydrology and Rehabilitation.-2011.-9, №4.- P. 4-38. [in Ukrainian].
5. Barylyak LG**,** Malyuchkova RV, Tolstanov OB, Tymochko OB, Hryvnak RF, Uhryn MR. Comparative estimation of informativeness of leucocytary index of adaptation by Garkavi and by Popovych // Medical Hydrology and Rehabilitation.- 2013.-11, №1.- P. 5-20.
6. Berezovsky VA. Natural and Instrumental Orotherapy.-Donets'k: Publisher Zaslavskiy AYu, 2012.-304 p. [in Russian].
7. Chebanenko OI, Chebanenko LO, Popovych IL. Polyvariety balneoeffects of factors spa Truskavets' and their forecast.-Kyiv: UNESCO-SOCIO, 2012.- 496 p. [in Ukrainian].
8. Chebanenko OI, Popovych IL, Chebanenko LO. Adaptogene essence of balneophytotherapy.-Kyiv: UNESCO-SOCIO, 2013.- 380 p. [in Ukrainian].
9. Chornobyl', adaptive defensive systems and rehabilitation / Eds. Kostyuk PG, Popovych IL, Ivassivka SV et al.-Kyiv: Computerpress, 2006.-348 p. [in Ukrainian].
10. Druz' VA. Sporting Training and Organism.-Kyiv: Zdorovya, 1980.-128 p. [in Russian].
11. Klecka WR. Discriminant analysis (Seventh printing, 1986) // Factor, discriminant and cluster analysis.-M.: Finansy i statistica, 1989.- P. 78-138. [Translated from English in Russian].
12. Kozyavkina OV. Vegetotropic effects of bioactive water Naftussya at children with dysfunction of neuro-endocrine-immune complex, those endocrine-immune accompaniment and opportunity of their forecasting // Medical Hydrology and Rehabilitation.- 2011.-9,№2.- P. 24-39. [in Ukrainian].
13. Kozyavkina OV, Barylyak LG. Ambivalent vegetotropic effects of bioactive water Naftussya and opportunity of their forecasting in rats // Medical Hydrology and Rehabilitation.-2008.-6, №3.-C. 123-127.
14. Kozyavkina OV, Popovych IL**,** Zukow W. Immediate vegetotropic effects of bioactive water Naftussya and those neuro-endocrine-immune accompaniment in healthy men // Journal of Health Sciences.-2013.-3, №5.-P. 391-408
15. Lukovych YuR, Ohorodnyk IO, Popel SL, Krayevyi VO. Relationships between parameters of blood pressure and heart rate variability and the influence of spa Truskavets' // Medical Hydrology and Rehabilitation.- 2012.-10,№4.-P. 154-159. [in Ukrainian].
16. Popovych IL. Bioactive water Naftussya.-Truskavets': JSC „Truskavets'kurort", 2013.-33 p. [in Ukrainian].
17. Popovych IL. Stresslimiting adaptogene mechanism of biological and curative activity of water Naftussya.-Kyiv: Computerpress, 2011.-300 p. [in Ukrainian].
18. Popovych IL, Kozyavkina OV, Kozyavkina NV, Korolyshyn TA, Lukovych YuS, Barylyak LG. Correlation between Indices of the Heart Rate Variability and Parameters of Ongoing EEG in Patients Suffering from Chronic Renal Pathology // Neurophysiology.-2014.-46,№2.-P. 139-148.
19. Popovych IL**,** Lukovych YuS, Korolyshyn TA, Barylyak LG**,** Kovalska LB, Zukow W. Relationship between the parameters heart rate variability and background EEG activity in healthy men // Journal of Health Sciences.-2013.-3, №4.-P. 217-240.

20. Shakhbazova LV, Mosij GYe, Tkachuk SP, Shakhbazov OB. The dynamics of blood pressure daily profile and heart rate variability in patients with essential hypertension during treatment on spa Truskavets' // Medical Hydrology and Rehabilitation.- 2005.-3,№4.- P. 44-47. [in Ukrainian].

21. Shakhbazova LV, Mosij GYe, Shakhbazov OB, Pavelko OM. The peculiarities of dynamics and correction of arterial hypertension in patients with accompanied vegetative dysfunction on spa Truskavets' // Medical Hydrology and Rehabilitation.- 2006.-4,№3.- P. 65-68. [in Ukrainian].

22. Sheiko VI, Makarenko MV, Ivanyura IO. Condition of higher nervous activity and immune system after vilosen administration // Fiziol. z.- 2007.-53,№2.- P. 65-69. [in Ukrainian].

23. Uchakin PN, Uchakina ON, Tobin BW, Yershov FI. Neuro-endocrine immunomodulation // Vestnik Ross. AMN.-2007.-№9.-P. 26-32. [in Russian].

24. Vadzyuk SN, Shuhan TB. Mental capacity: methods of investigation, changes and correction.-Ternopil': Bogdan, 2000.- 170 p. [in Ukrainian].

25. Vis'tak HI, Kozyavkina OV, Popovych IL**,** Zukow W. Vegetotropic effects of bioactive water Naftussya spa Truskavets' and their thyroide, metabolic and haemodynamic accompaniments at the women / // Journal of Health Sciences.-2013.-3, №10.-P. 557-582.

26. Vis'tak HI, Popovych IL. Vegetotropic effects of bioactive water Naftussya and their endocrine-immune support in female rats // Medical Hydrology and Rehabilitation.-2011.-9,№2.-P. 40-58. [in Ukrainian].

27. Vovchyna YuV, Lukovych YuR, Matiyishyn GYo, Hryvnak RF, Tymochko OO, Andrusiv OV, Burkovs'ka MM. Hemodynamic variants term effects of bioactive water Naftussya on blood pressure, their electrolyte accompaniment and the ability to forecast // Medical Hydrology and Rehabilitation.-2013.-11,№3.-P. 50-59. [in Ukrainian].

28. Wilder JF. Stimulus and response: the low of initial value.-Bristol: J Wright and Sons Ltd., 1967.-352 p.

29. Yessypenko BYe. Physiological action of mineral water "Naftussya".-Kyiv: Naukova dumka, 1981.-216 p. [in Russian].