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RELATIONSHIPS BETWEEN NORMAL OR BORDERLINE BLOOD PRESSURE AND SOME NEURAL, ENDOCRINE, METABOLIC AND BIOPHYSIC PARAMETERS IN WOMEN AND MEN

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Abstracts

Background. We conduct a systematic study of the effect of balneotherapy spa Truskavets (Ukraine) on blood pressure. The **aim** of this study is to elucidate the links between normal and marginal blood pressure, on the one hand, and some neural, endocrine, metabolic and biophysical factors on the other. **Material and research methods.** We recorded twice at ten women and ten men aged 33-76 years without clinical diagnose Blood Pressure, Heart Rate, heart rate variability (HRV), electroencephalogram (EEG), electro-skin conductance acupuncture points (ESCAP) Pg(ND), TR(X) and MC(AVL), determined the rate of electronegative nuclei of buccal epithelium (named as Electrokinetic Index) as well as plasma levels of Calcitonin, Testosterone, Cortisol, Triiod-thyronin, Cholesterol, Uric Acid, Chloride, Phosphate, Sodium, Potassium, Calcium and Magnesium. **Results.** Observed contingent characterized generally normal for a particular age or borderline high blood pressure, predominantly diastolic. In the final regression model were included 4 metabolic parameters (Cholesterol, Uric Acid, Phosphate and Calcium), 3 neural (α-rhythm Index as well as RMSSD and Triangulary Index as markers of Vagal tone) and ESCAP TR(X) Right as marker activity of endocrine system, which taken together determines Systolic Blood Pressure on 77%. Diastolic Blood Pressure determined on 74% by 7 neural parameters (4 HRV markers of Vagal and Sympathetic tone as well as α-rhythm Amplitude and Deviation and θ-rhythm Frequency), 2 biophysic parameters (ESCAP TR(X) Right and Electrokinetic Index as marker of biological age) as well as Chloride and Hender. **Conclusion.** Normal and marginal blood pressure determined by some neural, biophysical and metabolic factorss well as Hender.

Keywords: blood pressure, HRV, EEG, hormones, electrolytes, relationships.

INTRODUCTION

We conduct a systematic study of the effect of balneotherapy spa Truskavets (Ukraine) on blood pressure. We have previously shown, that at adults patients 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+}) [22]. The aim of second 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. Shown that balneotherapy causes various effects on blood pressure, which accompanied with changes in autonomic and humoral regulation and conditionized by constellation of initial parameters [23]. The aim of this study is to elucidate the links between normal and marginal blood pressure, on the one hand, and some neural, endocrine, metabolic and biophysical factors on the other.

MATERIAL AND RESEARCH METHODS

The study involved twentee volunteers – ten women and ten men aged 33-76 years without clinical diagnose. In the morning on an empty stomach recorded thrice running Blood Pressure and Heart Rate (“Omron M2 Compact”, Netherland). Then ECG in standard lead II recorded hardware-software complex “Cardiolab+VSR” (KhAI Medica, Kharkiv, Ukraine). For further analysis the following parameters heart rate variability (HRV) were selected. Temporal parameters (Time Domain Methods): the standart deviation of all NN intervals (SDNN), the square root of the mean of the sum of the squares of differences between adjacent NN intervals (RMSSD), the percent of interval differences of successive NN intervals greater then 50 ms (pNN_{50}), Triangulary Index (TI) [5]; heart rate (HR), moda (Mo), amplitude of moda (AMo), variational sweep (MxDMn) [1]. Spectral parameters (Frequency Domain Methods): power spectral density (PSD) components of HRV - high-frequency (HF, range 0,4÷0,15 Hz), low-frequency (LF, range 0,15÷0,04 Hz), very low-frequency (VLF, range 0,04÷0,015 Hz) and ultra low-frequency (ULF, range 0,015÷0,003 Hz) [5]. Expectant as classical indexes: LF/HF, LFnu=100%•LF/(LF+HF) and Baevskiy’s Stress Index (BSI=AMo/2•Mo•MxDMn) as well as Baevskiy’s Activity Regulatory Systems Index (BARSI) [1].

Simultaneosly electroencephalogram (EEG) recorded a hardware-software complex “NeuroCom Standard” (KhAI Medica, Kharkiv, Ukraine) monopolar in 16 loci (Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, P3, P4, T5, T6, O1, O2) by 10-20 international system, with the reference electrodes A and Ref tassels on the ears. Among the options considered the average EEG amplitude (μV), average frequency (Hz), frequency deviation (Hz), index (%), coefficient of asymmetry (%) and absolute (μV^2/Hz) and relative (%) PSD of basic rhythms: β (35÷13 Hz), α (13÷8 Hz), θ (8÷4 Hz) and δ (4÷0,5 Hz) in all loci, according to the instructions of the device [16,17].

Then determine the rate of electronegative nuclei of buccal epithelium (named as Electrokinetic Index) by intracellular microelectrophoresis on the device "Biotest" (Kharkov

State University), according to the method described [14]. Recorded electro-skin conductance acupuncture points Pg(ND), TR(X) and MC(AVL) Right and Left (device “Medissa”) [2].

Then determined content in plasma of blood parameters of hormonal status: cortisol, testosterone, triiod-thyronin and calcitonin (by the ELISA method with the use of analyzers "Tecan" and “RT-2100C” and corresponding sets of reagents from “Алкор Био”, XEMA Co., Ltd and DRG International Inc.); lipide spectrum of plasma: total cholesterol (by a direct method after the classic reaction by Zlatkis-Zack) and content of him in composition of α-lipoproteins (by the enzyme method by Hiller G [6] after precipitation of notα-lipoproteins; prae-β-lipoproteins (expected by the level of triaclglycerides, by a certain meta-periiodate method); β-lipoproteins (expected by a difference between a total cholesterol and cholesterol in composition α-and prae-β-lipoproteins). In the same portion plasma determined level of uric acid (by a uricase method), calcium (by a reaction with arsenazo III), magnesium (by a reaction with colgamite), phosphate (by a phosphate-molibdate method), chloride (by a mercurial-rodanide method), sodium and potassium (by the method of flaming photometry) according to instructions [4] with the use of analyzers "Reflotron" (BRD), "Pointe-180" (USA), "СФ-46" ПФМУ 4.2 (URSS) and corresponding sets of reagents. After 7 days all tests repeated.

For statistical analysis applied doubles, regression and canonical correlation analysis using the software package "Statistica 5.5" [15].

RESULTS AND DISCUSSION

According to calculations by the formula [16]:

$$|r|=\{\exp[2t/(n - 1,5)^{0,5}] - 1\}/\{\exp[2t/(n - 1,5)^{0,5}] + 1\}$$

for a sample of n=40 critical value |r| at $p<0,05$ ($t>2,00$) is 0,31.

Provisional analysis showed that the strength of correlation between diastolic and systolic pressure occupies an intermediate position between moderate and large (Fig. 1). This casts the idea that the two components blood pressure differently associated with neuroendocrine and metabolic parameters.

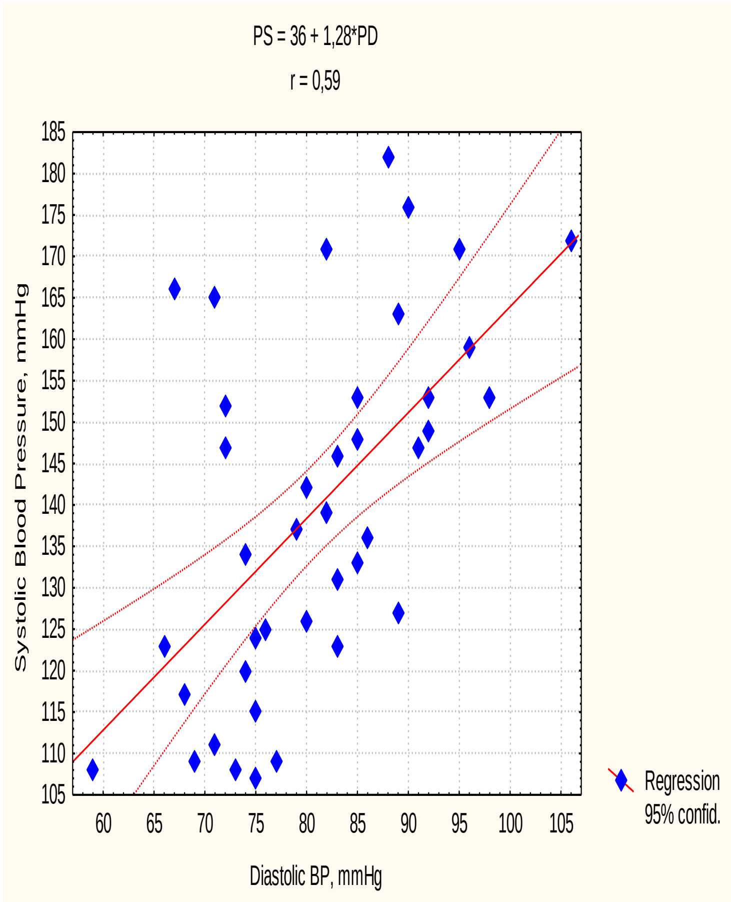

Fig. 1. Relationship between Diastolic (X-line) and Systolic (Y-line) Blood Pressure

It is known that blood pressure significantly associated with age, which was the basis for the calculation of age norms by equations [cit. by: 22]:

SBP = 0,4•Age + 109; BBP = 0,3•Age + 67.

Taking as enhanced standards range 80÷120% state that Systolic Blood Pressure in 32 cases was within it (average 102±2%), and only 8 cases exceeded the 3÷13% (an average of 8±1%), while Diastolic Blood Pressure exceeded the upper limit of normal at 2÷40% (mean 13±2%) in 20 cases out of 40, accounting for the other 20 cases 108±1% of the age norm. Thus, the observed contingent characterized generally normal for a particular age or borderline high blood pressure, predominantly diastolic. This correlation between age and age-normalized blood pressure is weak (Fig. 2).

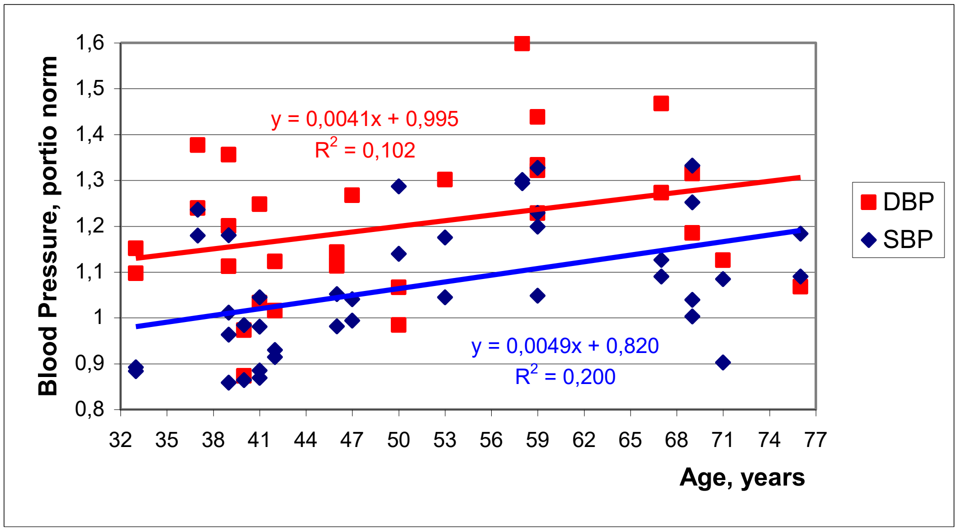

Fig. 2. Normalized levels of Diastolic and Systolic Blood Pressure in Persons various Age

Instead, current Systolic Blood Pressure correlated with age largely (Fig.3).

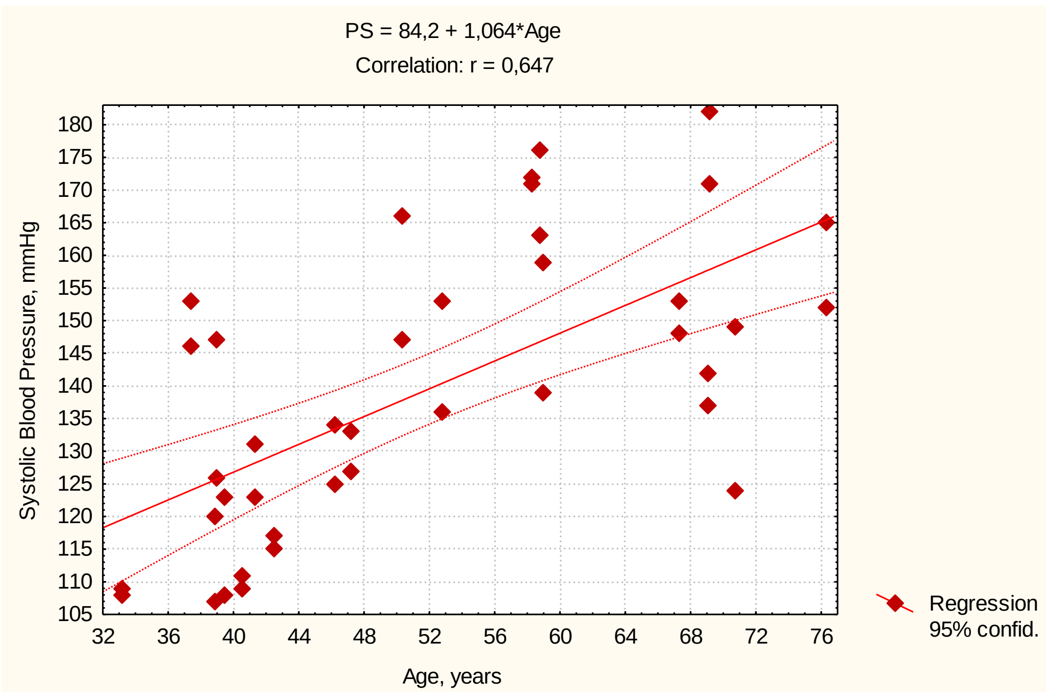

Fig. 3. Relationship between Age (X-line) and Systolic Blood Pressure (Y-line)

In order to quantify the strength of the connection Blood Pressure and Hender we estimated men as 0 and the women as 1. Detected moderate negatively relationship between Systolic Blood Pressure and Hender Index (r=-0,31). Taken together aging and hender factors determines Systolic Blood Pressure on 44% (Table 1).

Table 1. Regression Summary for Dependent Variable SBP and Independent Variables Age and Hender Index

$R=0,683$; $R^2=0,467$; Adjusted $R^2=0,438$; $F_{(2,4)}=16,2$; $p=10^{-5}$; Std. Error of estimate: 16 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(37)}$	p-level
Variables	r		Intercpt	91,7	11,3	8,10	10^{-6}
Age, years	0,65	,615	,121	1,012	,200	5,07	10^{-5}
Hender	-0,31	-,222	,121	-9,48	5,18	-1,83	,075

Dependence Diastolic Blood Pressure on the age weak (r=0,29), instead of the sex much (Fig. 4).

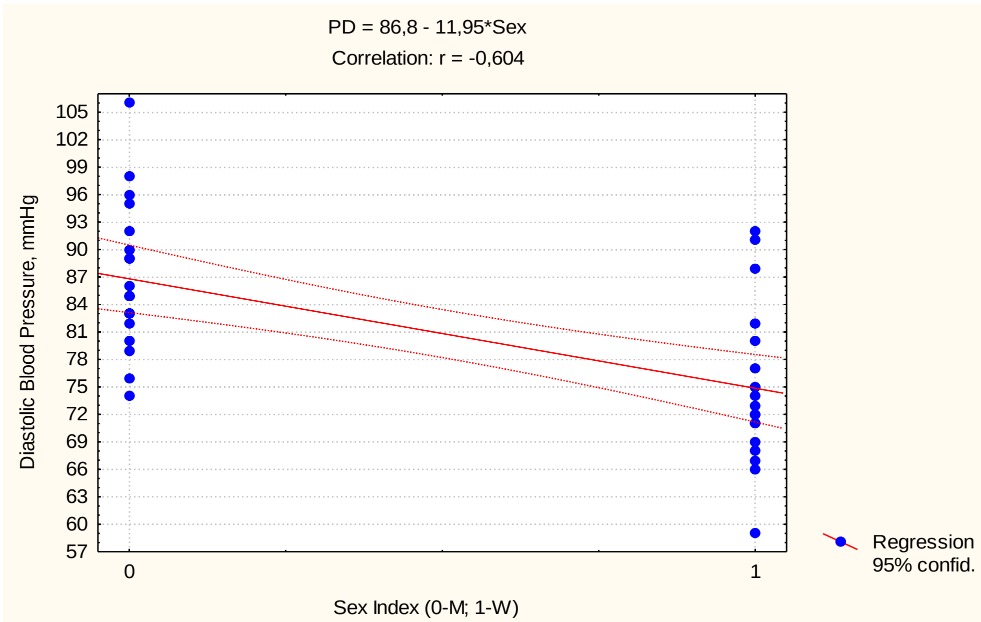

Fig. 4. Relationship between Hender Index (X-line) and Diastolic Blood Pressure (Y-line)

Taken together aging and hender factors determines Diastolic Blood Pressure on 38% (Table 2).

Table 2. Regression Summary for Dependent Variable DBP and Independent Variables Age and Hender Index

$R=0,639$; $R^2=0,409$; Adjusted $R^2=0,377$; $F_{(2,4)}=12,8$; $p<10^{-4}$; Std. Error of estimate: 7,9 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(37)}$	p-level
Variables	r		Intercpt	78	5,5	14,1	10^{-6}
Hender	-0,60	-,573	,128	-11,3	2,5	-4,49	10^{-4}
Age, years	0,29	,212	,128	,162	,098	1,66	,105

Now, examine correlationships Systolic Blood Pressure with Neuroendocrine factors. No correlation with Triiod-thyronin (r=-0,21), Testosterone (r=0,17) and Cortisol (r=0,13). Detected negatively correlationships with HRV markers of vagal tone: Variational Sweep (r=-0,37), HRV TI (r=-0,32), pNN_{50} (r=-0,23), RMSSD (r=-0,21) while positively dependence from Calcitoninemia, besides sexual normalized (r=0,34) but not current (r=0,12) (mean norm for women 5,5 ng/l, for men 13,95 ng/l). Taken together vagal tone and normalized Calcitonin determine Systolic Blood Pressure on 14,5% (Table 3, Fig. 5).

Table 3. Regression Summary for Dependent Variable SBP and Independent Variables Variational Sweep and Calcitonin (portio norm)

$R=0,435$; $R^2=0,189$; Adjusted $R^2=0,145$; $F_{(2,4)}=4,3$; $p=0,021$; Std. Error of estimate: 19,9 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(37)}$	p-level
Variables	r		Intercpt	147,8	13,1	11,3	10^{-6}
MxDMn, ms	-0,37	-,289	,155	-,081	,044	-1,86	,071
Calcitonin, pn	0,34	,248	,155	8,455	5,292	1,60	,119

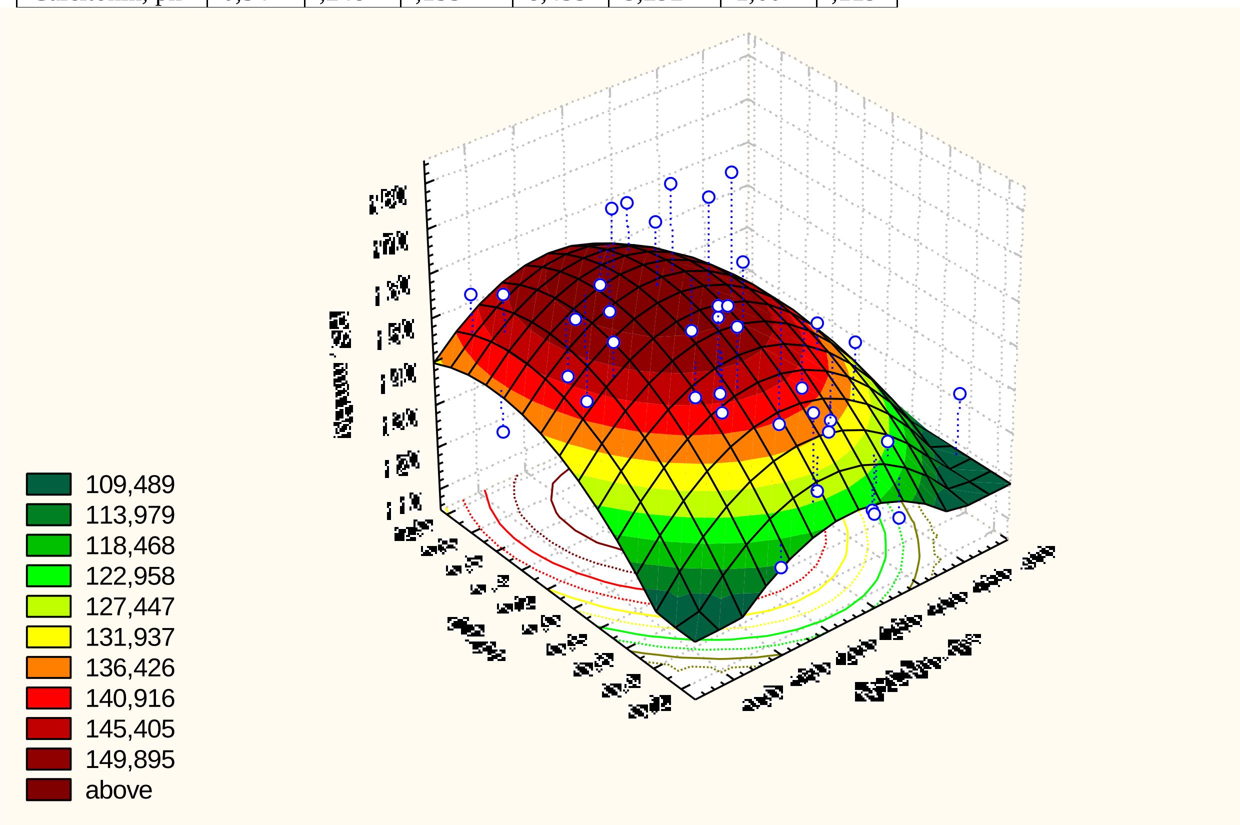

Fig. 5. Relationship between Variational Sweep (X-line), normalized Calcitoninemia (Y-line) and Systolic Blood Pressure (Z-line)

By stepwise exclusion in the final regression model were included some more 5 parameters HRV and Index of α-rhythm EEG, which taken together determine Systolic Blood Pressure on 40,5% (Table 4, Fig. 6).

Table 4. Regression Summary for Dependent Variable SBP and Independent Neuroendocrine Variables

$R=0,726$; $R^2=0,527$; Adjusted $R^2=0,405$; $F_{(8,3)}=4,3$; $\chi^2_{(8)}=25,5$; $p=0,0014$;
Std. Error of estimate:16,6 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(32)}$	p-level
Variables	r		Intercpt	367	78	4,69	10^{-4}
MxDMn, ms	-0,37	-1,223	,393	-,344	,110	-3,11	,004
PSD LF, % TP	-0,36	-,207	,136	-,334	,219	-1,52	,138
pNN_{50}, %	-0,23	-,879	,585	-1,501	,999	-1,50	,143
α-rhythm Ind, %	-0,22	-,319	,137	-,230	,099	-2,33	,027
RMSSD, ms	-0,21	1,000	,642	1,216	,780	1,56	,129
Calcitonin, pn	0,34	,436	,141	14,83	4,80	3,09	,004
Baevskiy SI, ln	0,23	-1,558	,468	-43,66	13,11	-3,33	,002
AMo, %	0,21	,709	,294	,989	,411	2,41	,022

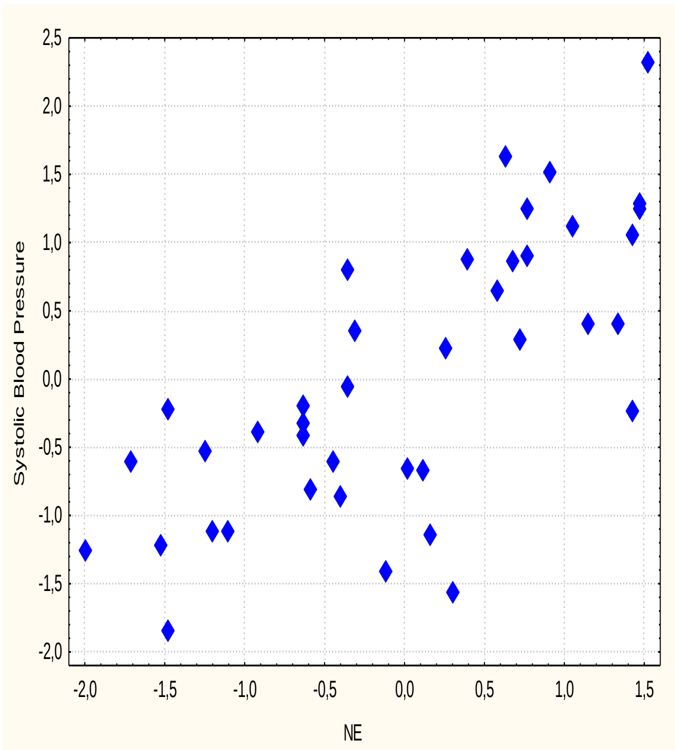

Fig. 6. Canonical correlation between Neuroendocrine factors (X-line) and Systolic Blood Pressure (Y-line)

Among biophysic parameters strong negatively correlate with Systolic Blood Pressure Electrokinetic Index (Fig. 7) as inversely marker of biological age [12,19,21].

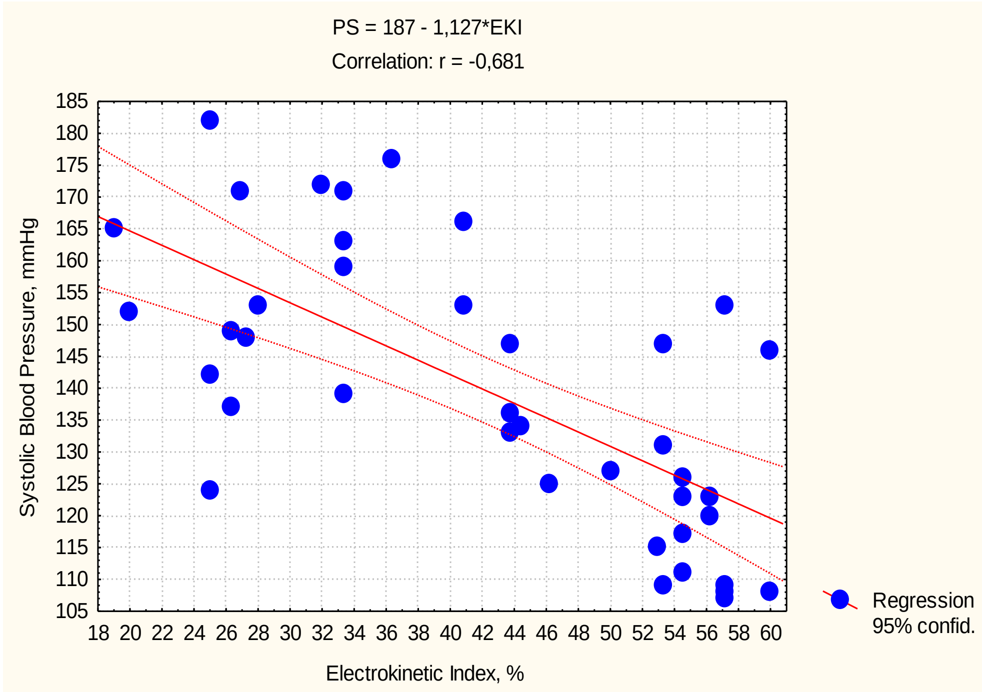

Fig. 7. Relationship between Electrokinetic Index (X-line) and Systolic Blood Pressure (Y-line)

Among electro-skin conductance of 6 points of acupuncture significant correlate with Systolic Blood Pressure MC(AVL) Left (r=0,33) and TR(X) Right (r=0,30). Last as marker activity of endocrine system [7,18] together with Electrokinetic Index determinates Systolic Blood Pressure on 50,5% (Table 5, Fig. 8).

Table 5. Regression Summary for Dependent Variable SBP and Independent Biophysic Variables

R=0,729; R^2=0,531; Adjusted R^2=0,505; $F_{(2,4)}$=20,9; $p<10^{-5}$; Std. Error of estimate: 15 mm Hg.

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(37)}$	p-level
Variables	r		Intercpt	120	30	3,98	,000312
Electrokinetic Index, %	-0,68	-,667	,113	-1,104	,187	-5,91	,000001
EC AP TR(X) Right, un.	0,30	,259	,113	1,042	,453	2,30	,027297

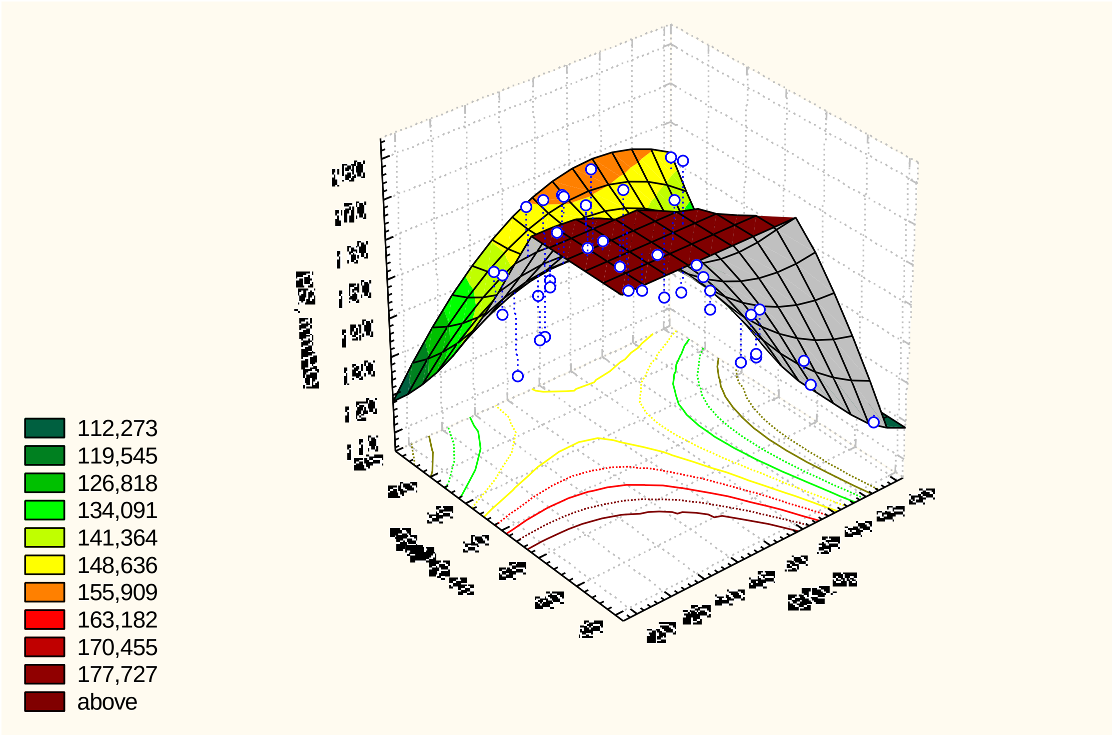

Fig. 8. Relationship between Electrokinetic Index (X-line), conductance AP TR(X) Right (Y-Line) and Systolic Blood Pressure (Z-line)

Among metabolic parameters strongest influence on Systolic Blood Pressure total Cholesterol (Fig. 9) as well as its content in low density (r=0,47) and very low density (r=0,41) Lipoproteins. Significantly or borderline correlates with Systolic Blood Pressure also Plasma Uric Acid (r=0,42) as endogenous Coffein [8], Phosphate (r=0,40) and Calcium (r=0,28) as well as $1/(Pp•Cap)^{0,5}$ Ratio (r=-0,48) as marker of Calcitonin Activity [15], $(Ku/Nau)^{0,5}$ Ratio (r=0,29) as marker of Mineralocorticoide Activity and $(Cap/Kp)^{0,5}$ Ratio (r=0,27) as marker of Sympatho-Vagal Balance [3,9].

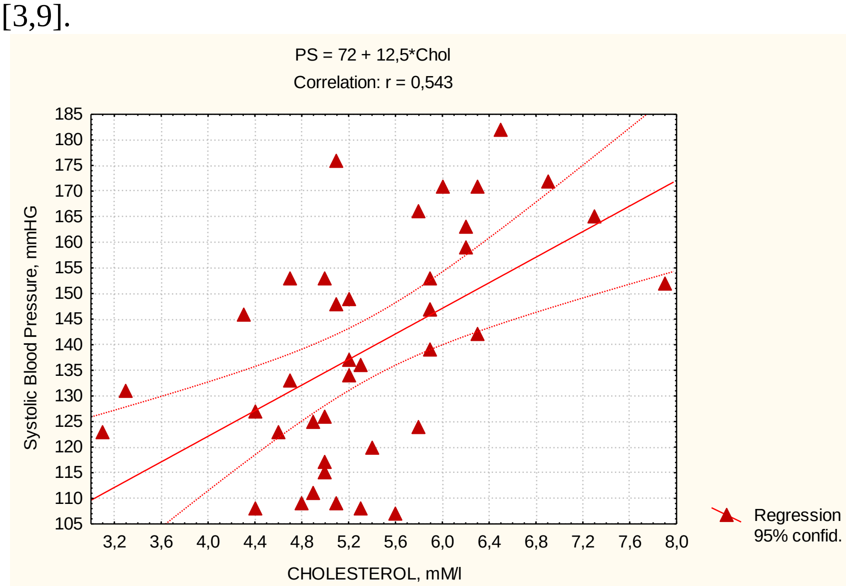

Fig. 9. Relationship between total Cholesterol Plasma (X-line) and Systolic Blood Pressure (Y-line)

By stepwise exclusion in the final regression model were included 5 metabolic and one biophysic parameters, which taken together determine Systolic Blood Pressure on 67% (Table 6, Fig. 10).

Table 6. Regression Summary for Dependent Variable SBP and Independent Metabolic and Biophysic Variables

$R=0,849$; $R^2=0,720$; Adjusted $R^2=0,670$; $F_{(6,3)}=14,2$; $\chi^2_{(6)}=44,6$; $p<10^{-6}$;
Std. Error of estimate:12,4 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(33)}$	p-level
Variables	r		Intercpt	839	279	3,00	,005042
Cholesterol, mM/l	0,54	,764	,121	17,58	2,78	6,32	,000000
Uric Acid Plasma, mM/l	0,42	,542	,112	208,25	43,20	4,82	,000031
Phosphate Plasma, mM/l	0,40	-1,542	,564	-173,02	63,32	-2,73	,010023
EC AP TR(X) Right, un.	0,30	,315	,101	1,27	,41	3,12	,003705
Calcium Plasma, mM/l	0,28	-1,112	,273	-143,05	35,17	-4,07	,000278
$CTAP=(1/Cap\bullet Pp)^{0,5}$	-0,48	-1,907	,621	-659,8	215	-3,07	,004276

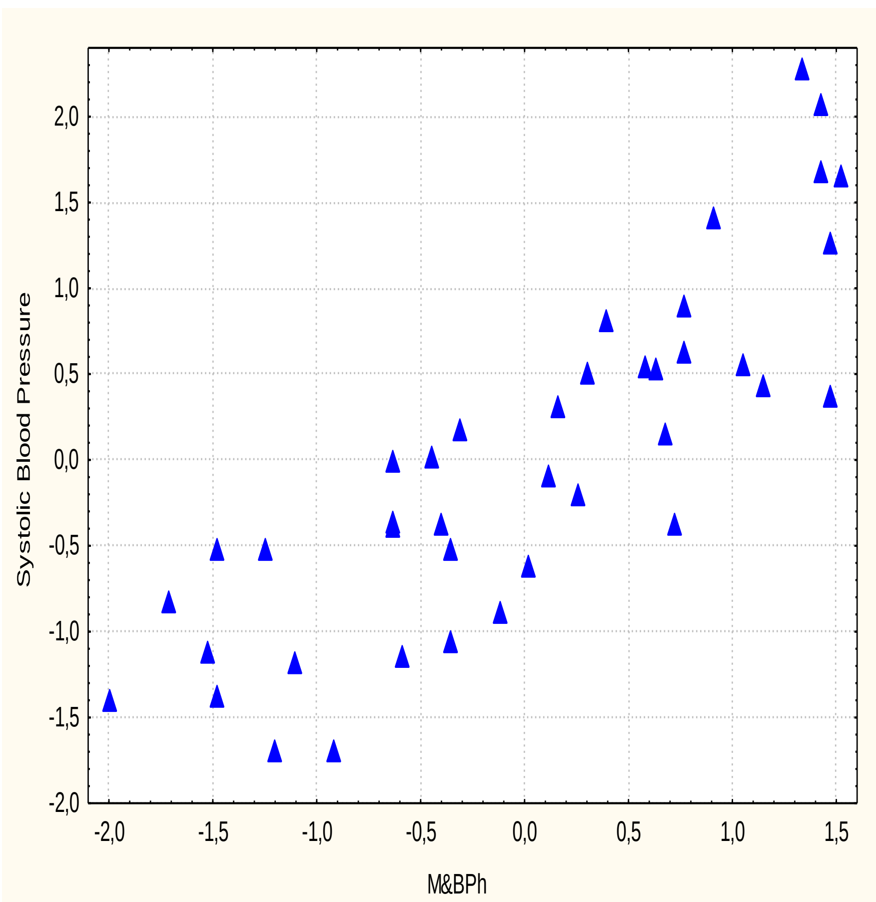

Fig. 10. Canonical correlation between Metabolic and Biophysic factors (X-line) and Systolic Blood Pressure (Y-line)

As a result of screening all parameters HRV, EEG as well as Metabolic and Biophysic parameters in the final regression model were included 4 metabolic, one biophysic and 3 neural parameters (but not age), which taken together determines Systolic Blood Pressure on 77% (Table 7, Fig. 11).

Table 7. Regression Summary for Dependent Variable SBP and Independent Neural, Biophysic and Metabolic Variables

$R=0,902$; $R^2=0,814$; Adjusted $R^2=0,767$; $F_{(8,3)}=17,0$; $\chi^2_{(8)}=57,3$; $p<10^{-6}$; Std. Er. of est.: 10 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(31)}$	p-level
Variables	r		Intercpt	73,6	34,1	2,16	,039
Cholesterol Plasma, mM/l	0,54	,685	,097	15,77	2,22	7,10	10^{-6}
Uric Acid Plasma, mM/l	0,42	,537	,096	206,3	36,9	5,58	10^{-5}
Phosphate Plasma, mM/l	0,40	,231	,085	26,0	9,6	2,71	,011
EC AP TR(X) Right, un.	0,30	,351	,085	1,413	,342	4,13	10^{-3}
Calcium Plasma, mM/l	0,28	-,570	,116	-73,4	14,9	-4,91	10^{-4}
HRV TI, units	-0,32	-,611	,134	-3,203	,704	-4,55	10^{-4}
α-rhythm Index, %	-0,22	-,363	,091	-,262	,065	-4,01	10^{-3}
RMSSD HRV, ms	-0,21	,436	,131	,530	,159	3,33	,002

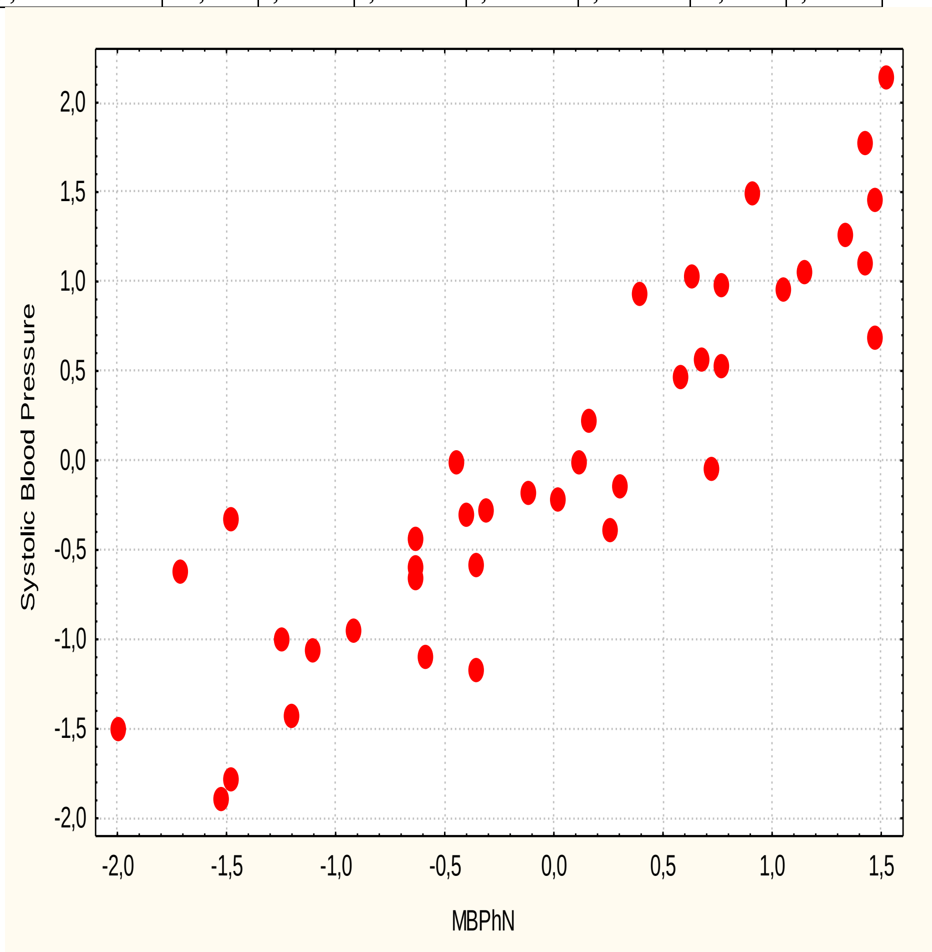

Fig. 11. Canonical correlation between Metabolic, Biophysic and Neural factors (X-line) and Systolic Blood Pressure (Y-line)

Now analyze relationships Diastolic Blood Pressure with neuroendocrine factors. They were stronger and more numerous compared with Systolic Blood Pressure. In particular, Diastolic Blood Pressure negatively correlate with HRV markers of Vagal tone: Variational Sweep (MxDMn) (r=-0,48), PS HF both absolute (r=-0,41) and relative (r=-0,31), HRV TI (r=-0,40), RMSSD (r=-0,39), pNN_{50} (r=-0,35), SDNN (r=-0,31) as well as Moda HRV (r=-0,32) while positively with HRV markers of Sympathetic tone [10,11]: relative PS VLF (r=0,30), Amplitude of Moda (r=0,41), Heart Rate (r=0,41) as well as AMo/Mo Ratio (r=0,47) and natural logarithm Baevskiy's Stress Index (r=0,50) as AMo/2•Mo•MxDMn Ratio (Fig. 12).

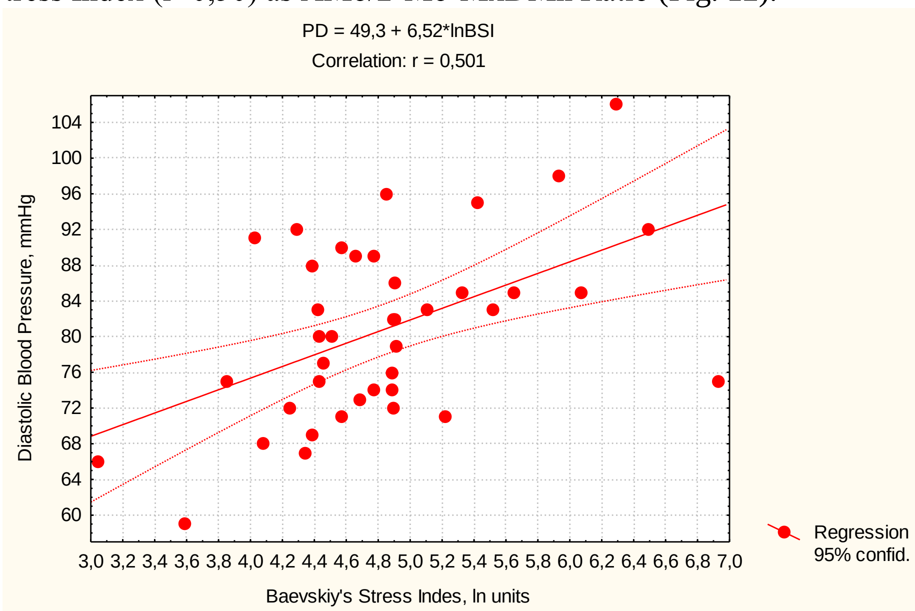

Fig. 12. Relationship between natural logarithm Baevskiy's Stress Index (X-line) and Diastolic Blood Pressure (Y-line)

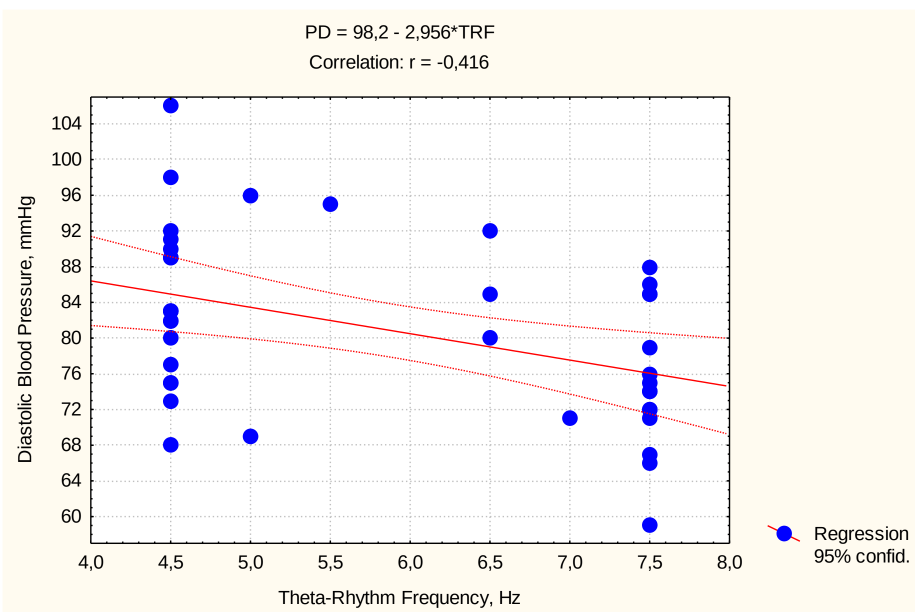

Fig. 13. Relationship between Frequency of θ-rhythm (X-line) and Diastolic Blood Pressure (Y-line)

Among parameters of EEG detected negatively correlation with Frequency of θ-rhythm (Fig. 13), Index (r=-0,41), Deviation (r=-0,40) and Amplitude (r=-0,25) of α-rhythm as well as Deviation of β-rhythm (r=-0,27) while positively correlation with Deviation (r=0,28) and Asymmetry (r=0,27) of δ-rhythm. Previously, we found significant relationships between parameters of HRV and EEG [16,17]. Taken together Baevskiy Stress Index and θ-rhythm Frequency determines Systolic Blood Pressure on 38% (Table 8, Fig. 14).

Table 8. Regression Summary for Dependent Variable DBP and Independent Neural Variables

R=0,644; R^2=0,415; Adjusted R^2=0,383; $F_{(2,4)}$=13,1; $p<10^{-4}$; Std. Error of estimate: 7,9 mm Hg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(37)}$	p-level
Variables	r		Intercpt	66,8	9,7	6,89	10^{-6}
Baevskiy Stress Index, ln	0,50	,491	,126	6,391	1,637	3,91	10^{-3}
θ-rhythm Frequency, Hz	-0,42	-,405	,126	-2,872	,893	-3,22	,003

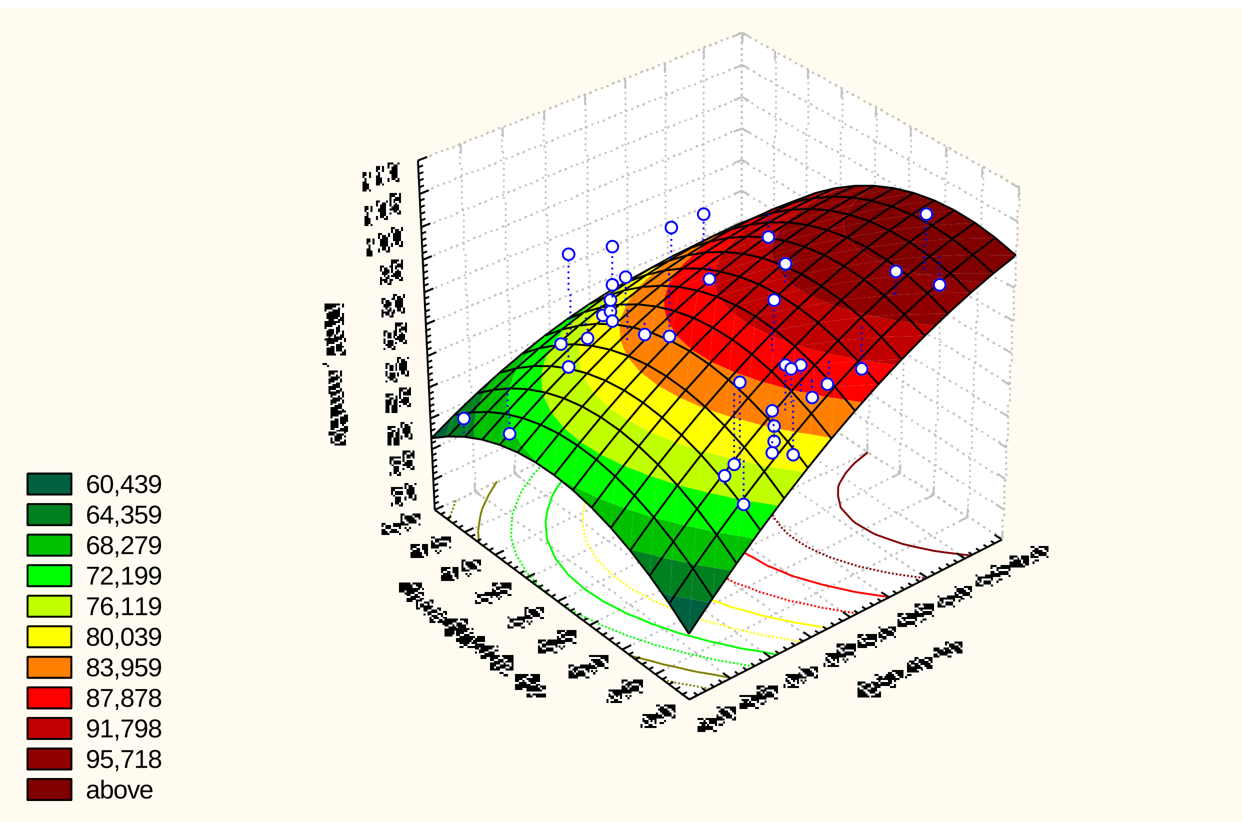

Fig. 14. Relationship between natural logarithm Baevskiy's Stress Index (X-line), Frequency of θ-rhythm (Y-line) and Diastolic Blood Pressure (Z-line)

Among hormones correlates with Diastolic Blood Pressure current Testosterone (r=0,33) and normalized (r=0,27) but not current (r=0,24) Calcitonin as well as not Triiod-thyronin (r=-0,23), and Cortisol (r=-0,07). Interesting that normalized Testosterone (mean norm for women 2,3 nM/l, for men 25 nM/l) correlate with Diastolic Blood Pressure inversely (r=-0,24).

Taken together Neuroendocrine factors determines Diastolic Blood Pressure on 67% (Table 9, Fig. 15).

Table 9. Regression Summary for Dependent Variable DBP and Independent Neuroendocrine Variables

$R=0,888$; $R^2=0,789$; Adjusted $R^2=0,670$; $F_{(14)}=6,7$; $\chi^2_{(14)}=48,2$; $p<10^{-4}$; SE of est.: 5,7 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(25)}$	p-level
Variables	r		Intercpt	406	117	3,46	,002
Baevskiy's Stress Index, ln	0,50	-3,115	1,438	-40,51	18,71	-2,17	,040
AMo/Mo HRV, units	0,47	1,971	,796	,845	,342	2,47	,020
Testosterone, nM/l	0,33	,186	,129	,374	,259	1,45	,161
PSD VLF, % Total Power	0,30	,510	,172	,285	,096	2,97	,007
Heart Rate, beats/min	0,29	-1,392	,526	-,919	,347	-2,65	,014
Calcitonin, portio norm	0,27	,221	,116	3,496	1,825	1,92	,067
δ-rhythm Asymmetry, %	0,27	,314	,125	,113	,045	2,51	,019
MxDMn HRV, ms	-0,48	-2,288	,773	-,299	,101	-2,96	,007
θ-rhythm Frequence, Hz	-0,42	-,270	,127	-1,919	,901	-2,13	,043
α-rhythm Deviation, Hz	-0,40	-,452	,123	-9,477	2,574	-3,68	,001
HRV TI, units	-0,40	,781	,274	1,900	,666	2,85	,009
Moda HRV, ms	-0,32	-1,443	,584	-,088	,035	-2,47	,021
PSD HF, % Total Power	-0,31	,520	,170	,531	,173	3,06	,005
α-rhythm Amplitude, µV	-0,25	-,313	,161	-,236	,121	-1,95	,063

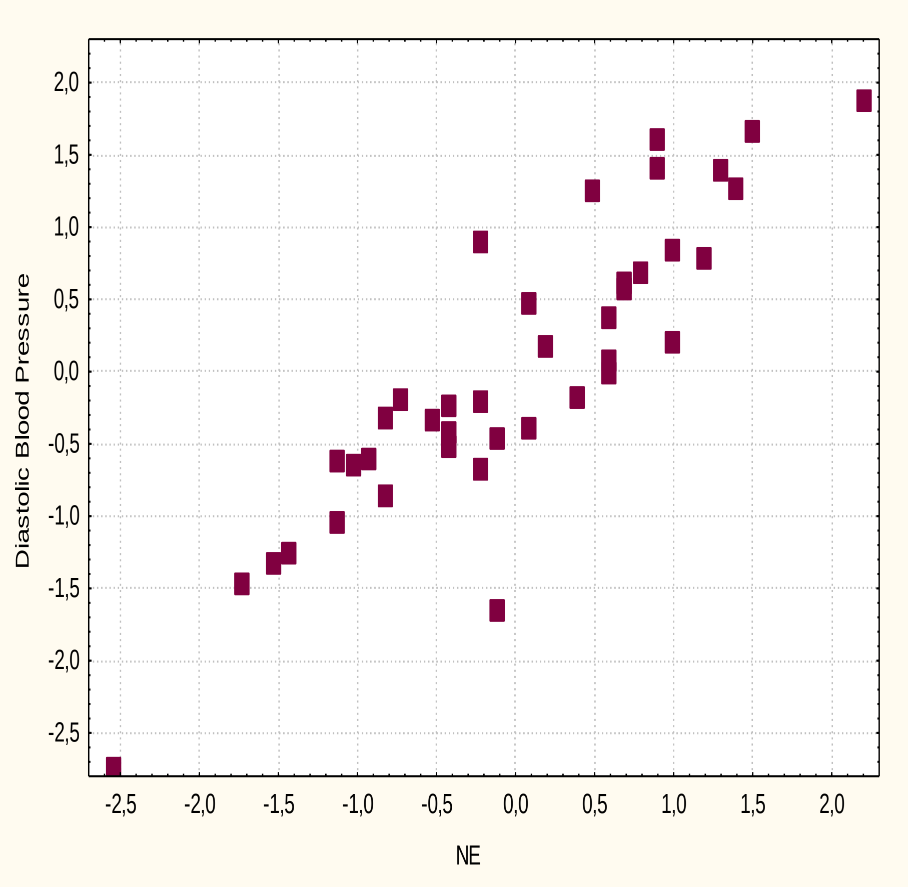

Fig. 15. Canonical correlation between Neuroendocrine factors (X-line) and Diastolic Blood Pressure (Y-line)

Among biophysic parameters significant correlates with Diastolic Blood Pressure electro-skin conductance points of acupuncture TR(X) Right (r=0,37) and Left (r=0,31) as well as Electrokinetic Index (r=-0,33). Among metabolic parameters detected significantly correlation with plasma Chloride (r=-0,39) and Sodium (r=-0,39) as well as $1/(Pp \bullet Cap)^{0,5}$ Ratio (r=-0,31). Taken together they determines Diastolic Blood Pressure on 28% (Table 10, Fig. 16).

Table 10. Regression Summary for Dependent Variable DBP and Independent Metabolic and Biophysic Variables

$R=0,579$; $R^2=0,335$; Adjusted $R^2=0,280$; $F_{(3,4)}=6,1$; $\chi^2_{(3)}=14,9$; $p=0,002$;
Std. Error of estimate: 8,5 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(36)}$	p-level
Variables	r		Intercpt	109,8	30,6	3,59	,001
Chloride Plasma, mM/l	-0,39	-,332	,141	-,484	,205	-2,36	,024
Electrokinetic Index, %	-0,33	-,326	,136	-,251	,105	-2,40	,022
EC AP TR(X) Right, un.	0,37	,263	,141	,491	,263	1,87	,070

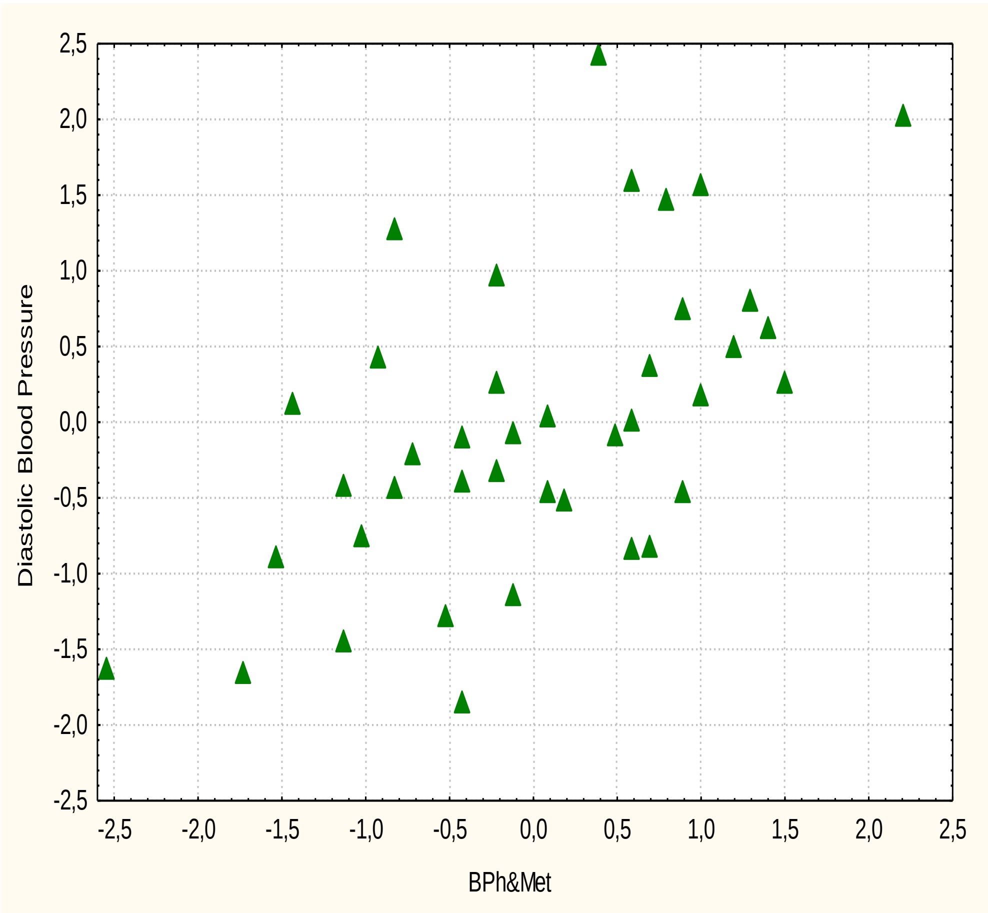

Fig. 16. Canonical correlation between Biophysic and Metabolic factors (X-line) and Diastolic Blood Pressure (Y-line)

Because screening all recorded parameters in the final regression model were included 7 Neural, 2 biophysic and one metabolic parameters as well as Hender Index, which taken together determines Diastolic Blood Pressure on 74% (Table 11, Fig. 17).

Table 11. Regression Summary for Dependent Variable DBP and Independent Neural, Metabolic and Biophysic Variables

$R=0,901$; $R^2=0,811$; Adjusted $R^2=0,737$; $F_{(11)}=10,9$; $\chi^2_{(11)}=54,1$; $p<10^{-5}$; SE of est.: 5,1 mmHg

		Beta	St. Err. of Beta	B	St. Err. of B	$t_{(28)}$	p-level
Variables	r		Intercpt	220,6	73,2	3,01	,005
Baevskiy Stress Index, ln un.	0,50	-1,844	1,248	-24,0	16,2	-1,48	,151
AMo/Mo HRV, units	0,47	1,412	,760	,606	,326	1,86	,074
EC AP TR(X) Right, units	0,37	,211	,105	,394	,196	2,01	,054
Hender Index (M=0; W=1)	-0,60	-,275	,110	-5,443	2,177	-2,50	,019
MxDMn HRV, ms	-0,48	-,861	,664	-,112	,087	-1,30	,205
θ-rhythm Frequency, Hz	-0,42	-,332	,104	-2,354	,738	-3,19	,004
α-rhythm Deviation, Hz	-0,40	-,250	,096	-5,235	2,017	-2,60	,015
Chloride Plasma, mM/l	-0,39	-,159	,093	-,233	,136	-1,71	,098
Electrokinetic Index, %	-0,33	-,304	,125	-,233	,096	-2,43	,022
PSD HF, % Total Power	-0,31	,265	,105	,270	,107	2,52	,018
α-rhythm Amplitude, μV	-0,25	-,377	,137	-,284	,103	-2,76	,010

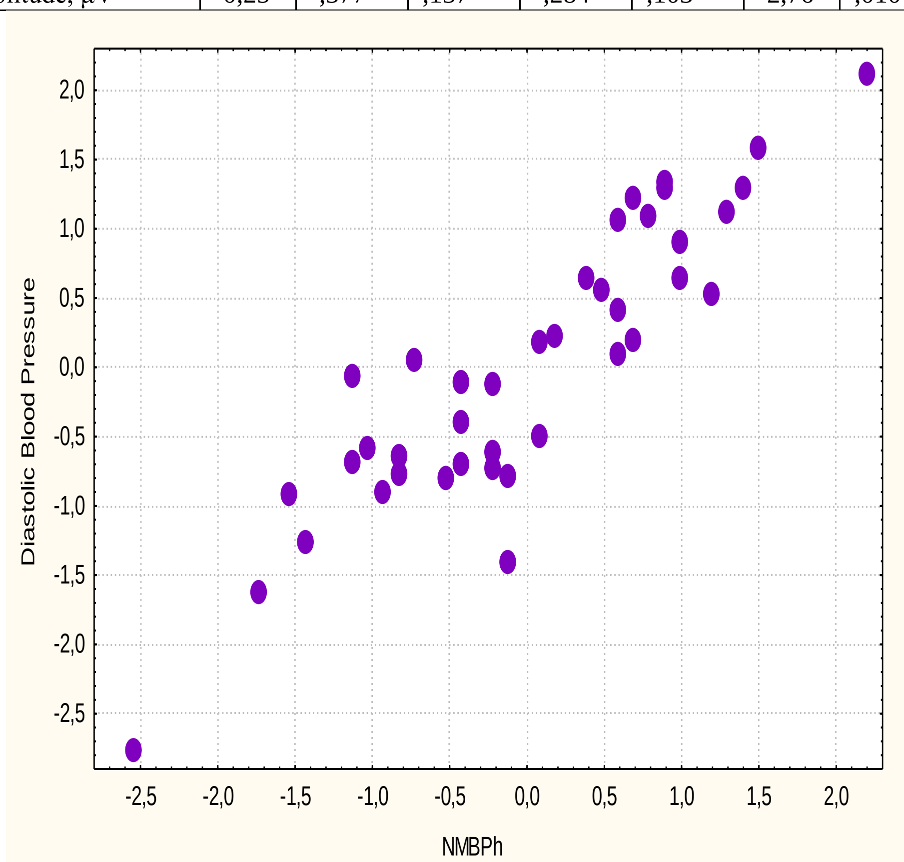

Fig. 17. Canonical correlation between Neural, Metabolic and Biophysic factors (X-line) and Diastolic Blood Pressure (Y-line)

At the final stage of the analysis we conducted canonical correlation neural, endocrine, metabolic and biophysical parameters, on the one hand, and the two parameters of blood pressure, on the other hand. It notes that the factors associated with **lower** blood pressure are rate of electronegative nuclei of buccal epithelium (inversely marker of biological age), womankind, Vagal tone, Amplitude and Deviation of α-rhythm, Frequency of θ-rhythm EEG as well as Chloridemia, while **increasing** of blood pressure directly related to Sympathetic tone, plasma levels of Cholesterol, Phosphate, Uric Acid and Calcium as well as electro-skin conductance acupuncture point right, representated endocrine system. Taken together these factors determines Blood Pressure on 87% (Table 12, Fig. 18).

Table 12. Factor Structure of Canonical Roots

Independent Variables	**Root**
Electrokinetic Index, %	**,574**
Hender Index (Men=0;Women=1)	**,573**
MxDMn HRV, ms	**,516**
HRV TI, units	**,434**
α-rhythm Index, %	**,393**
α-rhythm Deviation, Hz	**,382**
RMSSD HRV, ms	**,375**
PSD HF, % Total Power	**,286**
Chloride Plasma, mM/l	**,284**
θ-rhythm Frequency, Hz	**,260**
α-rhythm Amplitude, μV	**,225**
Baevskiy Stress Index, ln un.	**-,460**
EC AP TR(X) Right, units	**-,403**
AMo/Mo HRV, units	**-,390**
Cholesterol Plasma, mM/l	**-,361**
Phosphate Plasma, mM/l	**-,331**
Uric Acid Plasma, mM/l	**-,288**
Calcium Plasma, mM/l	**-,267**
Dependent Variables	
Diastolic Blood Pressure	**-,924**
Sistolic Blood Pressure	**-,856**
Canon. R=0,935; R^2=0,874; $\chi^2_{(36)}$=116; $p<10^{-6}$	

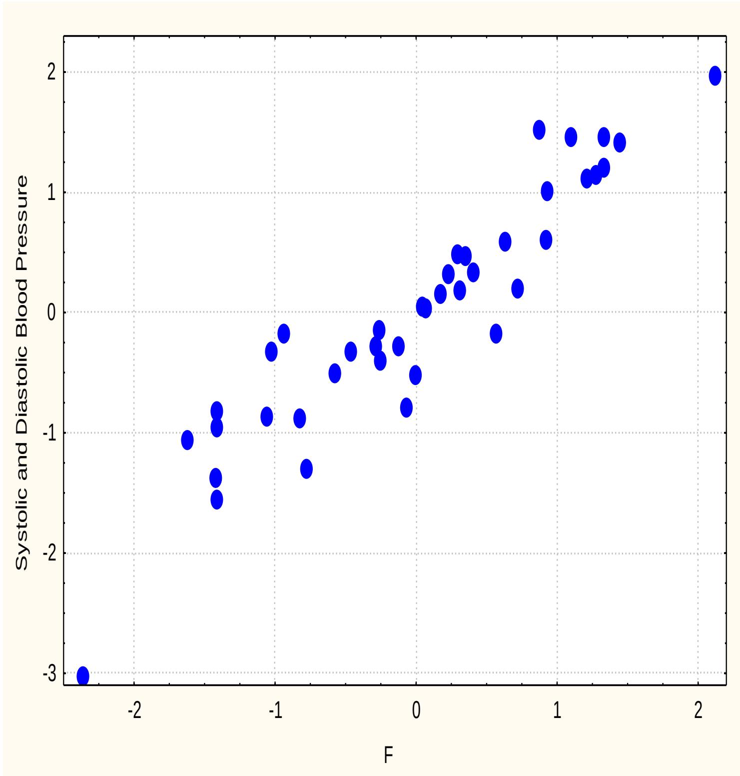

Fig. 18. Canonical correlation between Neural, Metabolic and Biophysic factors (X-line) and Systolic and Diastolic Blood Pressure (Y-line)

References

1. Baevskiy RM, Ivanov GG. Heart Rate Variability: theoretical aspects and possibilities of clinical application [in Russian]. Ultrazvukovaya i funktsionalnaya diagnostika. 2001; 3: 106-127.
2. Chukhrayev NV, Mokhon' VV, Shimkov GN, Samosyuk IZ. Manual for Electopuncture Diagnostics (Nakatani Test) [in Russian]. Kyiv: SMC "MEDINTECH". 2002. 195 p.
3. Fajda OI, Drach OV, Barylyak LG, Zukow W. Relationships between Ca/K plasma ratio and parameters of Heart Rate Variability at patients with diathesis urica // Journal of Education, Health and Sport.-2016.-6, №1.-P. 295-301.
4. Goryachkovskiy AM. Clinical Biochemistry [in Russian]. Odesa: Astroprint. 1998. 608 p.
5. Heart Rate Variability. Standards of Measurement, Physiological Interpretation, and Clinical Use. Task Force of ESC and NASPE. Circulation. 1996; 93(5): 1043-1065.
6. Hiller G. Test for the quantitative determination of HDL cholesterol in EDTA plasma with Reflotron®. Klin. Chem. 1987; 33: 895-898.
7. Hubyts'kyi VYo, Humenna OP, Barylyak LG, Bolyuk VV, Popovych IL, Maluchkova RV. Electro-skin resistance of points of acupuncture correlates with some parameters of neuroendocrine-immune complex [in Ukrainian]. Medical Hydrology and Rehabilitation. 2013; 11(2): 4-11.
8. Ivassivka SV, Popovych IL, Aksentijchuk BI, Flyunt IS. Physiological Activity of Uric Acid and its Role in Mechanism of Acting of Water Naftussya [in Ukrainian]. Kyiv: Computerpress. 2004. 163 p.
9. Kazakova M, Nemski B. Functional Diagnostics of Vegetative Nervouse System [Transl. from Bulgarian to Russian]. Functional Diagnostics in Childhood /Edit-s Kolarov S and Gatev V.-Sophia: Meditsina i Phyzkultura. 1979: 91-104.
10. Korkushko OV, Pysaruk AV, Shatylo VB. Importance of Heart Rate Variability Analysis in Cardiology: Age Aspects [in Russian]. Circulation and Hemostase. 2009; 1-2: 127-139.

11. Kotel'nikov SA, Nozdrachov AD, Odynak MM et al. Heart Rate Variability: Notions about Mechanisms [in Russian]. Fiziologiya cheloveka. 2002; 28(1): 130-140.
12. Kyrylenko IG, Fajda OI, Drach OV, Popel' SL, Popel' RL, Zukow W. Relationships between electrokinetic index of buccal epithelium and some functional and metabolic parameters at men with chronic pyelonephrite. Journal of Education, Health and Sport. 2016; 6(1): 302-314.
13. Lukovych YuR, Ohorodnyk IO, Popel SL, Krayevyi VO. Relationships between parameters of blood pressure and heart rate variability and the influence of spa Truskavets'[in Ukrainian]. Medical Hydrology and Rehabilitation. 2012; 10(4): 154-159.
14. Pat. 28113, Ukraine, NSI A61V10/00. Method of rapid testing efficiency rehabilitation of health / Shakhbazov VG, Kolupaeva TV, Shuvalov IM et al.-2000.-Bul. №5.
15. Popovych IL. Stresslimiting Adaptogene Mechanism of Biological and Curative Activity of Water Naftussya [in Ukrainian]. Kyiv: Computerpress. 2011. 300 p.
16. 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): 139-148.
17. 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): 217-240.
18. Samosyuk IZ, Lysenyuk VP, Lymans'kyi YuP, Povzhytkov AN, Bojchuk RR, Antonchenko VYa. Nontraditional Methods of Diagnostics and Therapy (Methods by Foll, Nakatani, Akabane. Homeopaty and Reflexotherapy) [in Russian]. Kyiv: Zdorovya, 1994. 240 p.
19. Shakhbazov VG, Kolupaeva TV, Nabokov AL. New method for determining biological age of man [in Russian]. Lab. delo. 1986; 7: 404-407.
20. Shkorbatov YG, Kolupaeva TV, Shakhbazov VG, Pustovoyt PA. About communication electrokinetic properties of nuclei cells of human with physiological parameters [in Russian]. Fiziologiya cheloveka. 1995; 21(2):25-27.
21. Ushakov IB, YA Kukushkin, Bogomolov AV. Physiology of labor and reliability activity of human [in Russian]. Moskwa: Nauka, 2008. 317 p.
22. 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 [in Ukrainian]. Medical Hydrology and Rehabilitation. 2013; 11(3): 50-59.
23. Vovchyna YuV, Zukow W. The influence of balneotherapy on spa Truskavets' on arterial pressure and its regulation at children. Journal of Health Sciences. 2014; 4(10): 151-160.