Immediate responses of the autonomic nervous system to the balneofactors, their neuro-endocrine-immune accompaniments and predictors

I.L. POPOVYCH
Bohomolets’ Institute of Physiology of National Academy of Sciences, Kyiv, Ukraine
E-maul: i.popovych@biph.kiev.ua

Introduction. In previous studies of the Truskavets’ Scientific School of Balneology, it has been shown that in response to the use of Bioactive Water Naftussya (BAWN) the activity of the autonomic nervous system changes. However, the nature of the reaction is ambiguous and is conditioned by the constellation of the initial parameters of the body [15,16,24,28]. The immediate reactions of diuresis, gastric and pancreatic secretion, hemodynamics were also interspersed [2, 6, 9, 27, 28, 31]. In the context of the adaptogenic concept of the mechanism of action BAWN [22], it is also shown that the polyversive reactions of the autonomic nervous system are accompanied by changes in some parameters of the electroencephalogram, immunogram of blood and levels of adaptation hormones in it [14-16, 24, 28]. However, the issue of the specificity of immediate effects of BAWN on the nervous, endocrine and immune systems, that function interconnected as a triple complex [15, 21, 22, 28], is still relevant. The answer to this question can be obtained by comparing the reactions of the autonomic nervous system to BAWN with reactions to ordinary (daily) water - on the one hand, and other natural adaptogens - on the other hand. This is the objective of this study.

Material and Methods. The objects of the observation were 15 volunteers-men (aged 26÷60 years, M±SD: 44±12 years) without any clinical diagnose but with a moderate dysfunction of neuroendocrine-immune complex (dysadaptation).

At first volunteers filled in a questionnaire with the purpose of estimation of the level of the trait anxiety [29]. Then EEG was recorded for 25 sec by means of the hardware-software complex ‘NeuroCom Standard’ (producer 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 on tassels of the ears. Among the options the average EEG amplitude (μV) was considered as well as the modal frequency (Hz), frequency deviation (Hz), index (%), coefficient of asymmetry (%), absolute (μV²/Hz) and relative (%) power spectrum density (SPD) 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. In addition, the Laterality Index (LI) for SPD of each rhythm was calculated using the formula [18]:

\[ LI, \% = \frac{\sum [200 \cdot (\text{Right} - \text{Left})/(\text{Right} + \text{Left})]}{8}. \]

For each locus the Entropy (h) of normalized SPD was also calculated by using classical CE Shannon’s formula [30]:

\[ h = - [\text{SPDa} \cdot \log_2 \text{SPDa} + \text{SPDδ} \cdot \log_2 \text{SPDδ} + \text{SPDθ} \cdot \log_2 \text{SPDθ} + \text{SPDδ} \cdot \log_2 \text{SPDδ}] / \log_2 4 \]

© Popovych I.L., 2017
Then the electrocardiogram in II lead was recorded for 7 min to assess the parameters of the heart rate variability (HRV) (the hardware-software complex “CardioLab+HRV” “KhAI-MEDICA”, Kharkiv). For further analysis the following parameters HRV were selected: a) Bayevskiy’s parameters: heart rate (HR), the moda (Mo), the amplitude of moda (AMo), variational sweep (MxD-Mn), Stress Index (BSI=AMo/2•Mo•MxD-Mn) as well as the Activity Regulatory Systems Index (BARSII) [1]; b) Temporal parameters (Time Domain Methods): the standard deviation of all NN intervals (SDNN), the square root of the sum of the squares of differences between adjacent NN intervals (RMSSD), the percent of interval differences of successive NN intervals is greater than 50 ms (pNN50), triangularity index (TNN); c) Spectral parameters (Frequency Domain Methods): SP of HRV bands: 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) [4, 10].

The Leukocytogram counted up in the portion of capillary blood and its Adaptation as well as Strain Indexes by I.L. Popovych were calculated [3, 20]. The phagocytic function of neutrophils can be judged by the activity (percent age of neutrophils, in which found microbes - Phagocytic Index, Phi), intensity (number of microbes absorbed in one phagocyte - Microbial Count, MC) and the completeness (percentage of dead microbes - Killing Index, KI) [5, 8, 22] of phagocytosis museum culture Staphylococcus aureus (ATCC N 25423 F49) obtained from the Truskavets’ Laboratory of Hydrogeological Regime-Operational Station spa. Based on these parameters the bactericidal capacity of blood neutrophils (BCCN) was calculated by using the formula [22]:

\[
\text{BCCN}(10^9\text{Micr}/L) = \text{Leukocytes}(10^9/L) \cdot \text{Neutrophils} \cdot \Phi I \cdot \text{MC}(\text{Micr/Phag}) \cdot \text{KI} \%
\]

The immune status was evaluated on a set of I and II levels recommended by the WHO. For phenotyping subpopulations of lymphocytes such methods were used as the method of rosette formation and indirect immunofluorescent binding reaction of monoclonal antibodies from the company “Sorbent” (RF) with visualization under the fluorescent microscope. T-cellular immunity was assessed by the following parameters: blood levels of a subpopulation of “active”, theophilline resistance and sensitive T-lymphocytes as well as lymphocytes phenotype of CD3^+CD4^+(T-helper) and CD3^+CD8^+ (T-cytolytic). In addition CD16^-lymphocytes (natural killers) were determined. The state of the humoral immunity was evaluated by the content of CD19^+ B-lymphocytes and concentration of immunoglobulins classes G, A, M in serum (the radial immunodiffusion method) and circulating immune complexes (with polyethylene glycol precipitation method) by using standardized methods described in the manual [17].

In plasma of venous blood the content of principal adaptation Hormones was determined such as Cortisol, Testosterone and Triiodothyronine (by the ELISA with the help of the analyzer “Tecan”, Oesterreich) and the corresponding sets of reagents from “AlkorBio”, RF as well as Na^+ and K^+ (by the method of flaming photometry with the use of “SF-46” PFMU 4.2 for evaluating the Mineralocorticoide activity as (Na/K)^0.5 Ratio [24].

After the registration on Basal Level 5 volunteers for some days consumed 200 mL of Control Waters (distillated, filtered, well), Water Naftussya from the layers of Truskavets’ and Skhidnyts’a, while 10 volunteers consumed 5 mL of Phytocomposition “Balm Cryms’kyi” (it is identified as an adaptogen [19]) sol-uted in 195 mL of daily Water. All tests were repeated in an hour and a half.

Normal values have been borrowed from the instructions for devices and sets as well as databases of the Truskavets’ Scientific School.

Results were processed by using the software package “Statistica 5.5”.

Results and discussion. The cohort characterized by dysadaptation was observed, high frequentlyties of Dysharmonious General Adaptation Reactions
(53.7%) and Distress (11.1%) were documented, Popovych’s Leukocytary Adaptation Index (1,03±0,08 points vs range of norm 1,46÷1,95) has decreased, while Popovych’s Leukocytary Strain Index (0,35±0,07 vs 0 in norm) has increased as well as Bayevskiy’s Stress Index (5,34±0,15 vs 4,82±0,03 ln units in norm) and Bayevskiy’s Activity Regulatory Systems Index (4,62±0,82 units vs range of norm 0÷3).

As the integral response criterion of the autonomic nervous system, Bayevskiy’s Stress Index is changing based on our preliminary data [25] that this HRV parameter correlates with EEG parameters more closely than the LF/HF ratio: R=0.80 vs 0.56. The preliminary analysis confirmed the polyvariant nature of the vegetotropic reactions to the stimulus, namely: Bayevskiy’s Stress Index has increased in half of observations, while in 39% it decreased, and only in 11% was not significantly changed. Despite the expectations, no differences were found between the effects of all applied stimuli, so they were not considered separately at the next stage of the analysis.

The vagotonic reaction is accompanied by the increase of Variational Sweep (Table 1), SDNN, Triangular Index and SP LF band HRV (Table 2) in combination with the decrease of Amplitude of Moda (Table 1). On the contrary, the sympathetic response is associated with the decrease of Variational Sweep, Moda, SDNN, RMSSD, pNN50, Triangular Index and SP of all bands HRV in combination with the increase of Amplitude of Moda, Heart Rate and Bayevskiy’s Activity Regulatory Systems Index. The neutral vegetotropic reaction has not changed any of the parameters of the HRV, which is quite understandable.

### Table 1

| Variables                      | Term       | Immediate vegetotropic reaction (n) | Normatives (n=54) |
|--------------------------------|------------|-------------------------------------|-------------------|
| Bayevskiy’s Stress Index, ln units | Before     | 5.92 ± 0.30*                        | 4.82 ±0.03        |
|                                | After      | 5.35 ± 0.22*                        |                   |
|                                | Change     | -0.57 ± 0.14*                       |                   |
|                                |            | 5.53 ± 0.22*                        |                   |
|                                |            | 5.57 ± 0.19*                        |                   |
|                                |            | +0.04 ± 0.04                        |                   |
|                                |            | 4.86 ± 0.12                         |                   |
|                                |            | 5.37 ± 0.11*                        |                   |
|                                |            | +0.61 ± 0.08*                       |                   |
| Amplitude of Moda, %          | Before     | 66 ± 5*                             | 37.8 ±1.3         |
|                                | After      | 51 ± 4*                             |                   |
|                                | Change     | -15 ± 3*                            |                   |
|                                |            | 55 ± 6*                             |                   |
|                                |            | 55 ± 6*                             |                   |
|                                |            | 0 ± 2                               |                   |
|                                |            | 43 ± 3                              |                   |
|                                |            | 58 ± 4*                             |                   |
|                                |            | +15 ± 3*                            |                   |
| Variational Sweep, msec       | Before     | 160 ± 21*                           | 252 ± 8           |
|                                | After      | 185 ± 22*                           |                   |
|                                | Change     | +25 ± 9*                            |                   |
|                                |            | 154 ± 19*                           |                   |
|                                |            | 147 ± 17*                           |                   |
|                                |            | -6 ± 7                              |                   |
|                                |            | 210 ± 12*                           |                   |
|                                |            | 170 ± 118                           |                   |
|                                |            | -40 ± 8*                            |                   |
| Moda, msec                    | Before     | 784 ± 34*                           | 864 ±14           |
|                                | After      | 772 ± 36*                           |                   |
|                                | Change     | -12 ± 18                            |                   |
|                                |            | 728 ± 45*                           |                   |
|                                |            | 728 ± 31*                           |                   |
|                                |            | 0 ± 37                              |                   |
|                                |            | 808 ± 27                            |                   |
|                                |            | 750 ± 26*                           |                   |
|                                |            | -58 ± 17*                           |                   |
| Heart Rate, beats/min         | Before     | 76.8 ± 3.5                          | 69.3 ± 1.5        |
|                                | After      | 77.9 ± 3.1*                         |                   |
|                                | Change     | +1.1 ± 1.5                          |                   |
|                                |            | 80.4 ± 4.1*                         |                   |
|                                |            | 81.7 ± 2.8*                         |                   |
|                                |            | +1.3 ± 3.2                          |                   |
|                                |            | 74.6 ± 2.3                          |                   |
|                                |            | 80.0 ± 2.6*                         |                   |
|                                |            | +5.4 ± 1.5*                         |                   |

* Average values that are significant (p < 0.05) differ from normal, are indicated.

Regarding the concomitant changes in the hormones of adaptation, a significant increase in Testosterone levels has been observed after the vagotonic reaction and a tendency towards the decrease in the sympathetic response, however, with the neutral reaction the changes have been uncertain. Equally uncertain were the changes on levels of Cortisol and Triiodothyronine as well as the Mineralocorticoid activity (Table 3). The Popovych’s Leukocytary Strain index was also significantly reduced only in the vagotonic response which reflects the decrease in the deviation from the optimum zone of elements of Leukocytogram, mainly monocytes.
### Table 2
Comparative characteristics of Temporal and Spectral parameters of Heart Rate Variability

| Variables   | Term   | Immediate vegetotropic reaction (n) | Normatives (n=54) |
|-------------|--------|-------------------------------------|------------------|
|             |        | Vagotonic (21)                      | Neutral (6)      | Sympathotonic (27) |
| SDNN, msec  | Before | 35 ± 3*                             | 34 ± 5*          | 47±3*             | 57 ± 2 |
|             | After  | 41 ± 5*                             | 32 ± 4*          | 36±3*             |         |
|             | Change | +6 ± 2*                             | +3 ± 3           | -11±2#            |         |
| RMSSD, msec | Before | 22 ± 3*                             | 16 ± 3*          | 28 ± 3            | 32 ± 3 |
|             | After  | 23 ± 3*                             | 16 ± 2*          | 22 ± 3*           |         |
|             | Change | +1 ± 1                              | 0 ± 3            | -6 ± 2#           |         |
| pNN50, %    | Before | 5,3 ± 2,5                           | 1,6 ± 1,0*       | 8,8 ± 2,7         | 10,6 ± 2,2 |
|             | After  | 5,9 ± 2,6                           | 1,6 ± 0,6*       | 4,8 ± 2,1         |         |
|             | Change | +0,6 ± 0,4                          | 0,0 ± 0,9        | -4,0 ± 1,5*       |         |
| Triangular Index, units | Before | 7,4 ± 0,7*                          | 7,9 ± 1,1*       | 10,9 ± 0,8        | 11,2 ± 0,3 |
|             | After  | 9,2 ± 0,9*                          | 8,0 ± 0,9*       | 8,6 ± 0,7*        |         |
|             | Change | +1,9 ± 0,3*                         | +0,1 ± 0,7       | -2,2 ± 0,4*       |         |
| HF, msec²   | Before | 234 ± 100                           | 100 ± 33*        | 453 ± 146         | 413 ± 76 |
|             | After  | 278 ± 132                           | 105 ± 30*        | 275 ± 92          |         |
|             | Change | +44 ± 33                            | +5 ± 32          | -178 ± 68*        |         |
| LF, msec²   | Before | 581 ± 102                           | 322 ± 132*       | 921 ± 120         | 741 ± 53 |
|             | After  | 748 ± 132                           | 328 ± 118*       | 641 ± 110         |         |
|             | Change | +167 ± 65                           | +6 ± 42          | -280 ± 119*       |         |
| VLF, msec²  | Before | 441 ± 72                            | 611 ± 123*       | 1005 ± 57*        | 1495 ± 118 |
|             | After  | 764 ± 287                           | 572 ± 154*       | 573 ± 120*        |         |
|             | Change | +323 ± 253                          | -40 ± 44         | -432 ± 79*        |         |
| ULF, msec²  | Before | 71 ± 22                             | 172 ± 50         | 170 ± 42          | 122 ± 17 |
|             | After  | 141 ± 56                            | 120 ± 60         | 70 ± 20           |         |
|             | Change | +70 ± 51                            | -52 ± 54         | -100 ± 41*        |         |
| Bayevskiy's Activity Regulatory Systems Index, units | Before | 4,5 ± 0,8*                          | 3,6 ± 0,9*       | 2,8 ± 0,5*        | 1,5 ± 0,2 |
|             | After  | 4,1 ± 0,7*                          | 4,6 ± 0,9*       | 4,5 ± 0,5*        |         |
|             | Change | -0,4 ± 0,5                          | +1,0 ± 0,7       | +1,7 ± 0,4*       |         |

### Table 3
Comparative characteristics of principal Hormonal and Leukocytary markers of General Adaptation Reactions

| Variables   | Term   | Immediate vegetotropic reaction (n) | Normatives (n=54) |
|-------------|--------|-------------------------------------|------------------|
|             |        | Vagotonic (21)                      | Neutral (6)      | Sympathotonic (27) |
| Cortisol, nM/L | Before | 644 ± 95*                           | 553 ± 114        | 496 ± 40           | 405 ± 23 |
|             | After  | 526 ± 64                            | 538 ± 186        | 432 ± 53           |         |
|             | Change | -118 ± 87                           | -15 ± 151        | -64 ± 46           |         |
| (Nap/Kp)⁶ as Mineralocorticoid Activity, units | Before | 6,64 ± 0,06*                        | 6,47 ± 0,07*     | 6,53 ± 0,02*       | 5,65 ± 0,11 |
|             | After  | 6,58 ± 0,03*                        | 6,45 ± 0,09*     | 6,54 ± 0,02*       |         |
|             | Change | -0,07 ± 0,05                        | -0,03 ± 0,07     | +0,01 ± 0,02       |         |
| Triiodothyronine, nM/L | Before | 1,87 ± 0,04*                        | 1,73 ± 0,06*     | 1,90 ± 0,04*       | 2,20 ± 0,09 |
|             | After  | 1,84 ± 0,04*                        | 1,81 ± 0,06*     | 1,89 ± 0,03*       |         |
|             | Change | -0,03 ± 0,02                        | +0,07 ± 0,11     | -0,01 ± 0,03       |         |
| Testosterone, nM/L | Before | 24,2 ± 1,9                          | 27,2 ± 3,9       | 28,2 ± 1,5         | 25,2 ± 1,2 |
|             | After  | 27,1 ± 2,0                          | 20,4 ± 3,6       | 24,7 ± 1,7         |         |
|             | Change | +2,9 ± 1,4*                         | -6,8 ± 4,7       | -3,4 ± 2,3         |         |
Among the parameters of Phagocytosis, no significant changes were detected in all variants of the vegetotropic reaction (Table 4). Among the parameters of Cellular Immunity, only T-cytolytic Lymphocytes level has elevated significantly by sympathetic response (Table 5).

**Table 4**

Comparative characteristics of parameters of Phagocytosis

| Variables          | Term         | Immediate vegetotropic reaction (n) | Normatives (n=54)|
|--------------------|--------------|-------------------------------------|-----------------|
|                    | Vagotonic (21) | Neutral (6) | Sympathotonic (27) |                      |
| Total Leukocytes, 10^9/L | Before      | 6,36 ± 0,41 | 6,21 ± 0,24 | 6,11 ± 0,27 | 5,78 ± 0,33 |
|                    | After        | 6,68 ± 0,39 | 6,21 ± 0,45 | 6,35 ± 0,34 |                      |
|                    | Change       | +0,31 ± 0,57| 0,00 ± 0,50 | +0,24 ± 0,39 |                      |
| Neutrophiles, %    | Before       | 60,1 ± 1,3* | 53,6 ± 2,8 | 59,7 ± 1,2 | 56,5 ± 1,8 |
|                    | After        | 59,3 ± 1,3 | 53,6 ± 2,9 | 58,9 ± 1,3 |                      |
|                    | Change       | -0,8 ± 1,2 | 0,0 ± 2,7 | -0,8 ± 0,9 |                      |
| Phagocytosis Index, % | Before     | 87,1 ± 1,2* | 85,7 ± 1,3* | 86,8 ± 0,9* | 80,0 ± 1,5 |
|                    | After        | 86,7 ± 0,9* | 86,0 ± 1,2* | 86,7 ± 0,9* |                      |
|                    | Change       | -0,4 ± 1,2 | +0,3 ± 1,8 | -0,1 ± 0,9 |                      |
| Microbial Count, % | Before       | 14,4 ± 0,6 | 14,5 ± 1,3 | 14,1 ± 0,5 | 14,4 ± 0,8 |
| Microbas/Phagocyte | After        | 14,4 ± 0,6 | 15,5 ± 1,9 | 13,9 ± 0,6 |                      |
|                    | Change       | 0,0 ± 0,6 | +1,0 ± 1,6 | -0,3 ± 0,5 |                      |
| Killing Index, %   | Before       | 32 ± 4 | 33 ± 4 | 38 ± 2 | 40 ± 2 |
|                    | After        | 31 ± 3* | 31 ± 5 | 35 ± 2 |                      |
|                    | Change       | 0 ± 2 | -2 ± 4 | -3 ± 2 |                      |
| Bactericidal Capacity, 10^9 Microbas/L | Before | 14,6 ± 1,7 | 13,2 ± 1,5 | 16,6 ± 1,2 | 15,0 ± 0,9 |
|                    | After        | 15,3 ± 2,0 | 12,7 ± 1,9 | 15,0 ± 1,2 |                      |
|                    | Change       | +0,8 ± 1,8 | -0,5 ± 1,5 | -1,6 ± 1,3 |                      |

**Table 5**

Comparative characteristics of parameters of Cellular Immunity

| Variables          | Term         | Immediate vegetotropic reaction (n) | Normatives (n=54)|
|--------------------|--------------|-------------------------------------|-----------------|
|                    | Vagotonic (21) | Neutral (6) | Sympathotonic (27) |                      |
| Total Lymphocytes, 10^9/L | Before      | 2,31 ± 0,13* | 2,23 ± 0,07* | 2,23 ± 0,10* | 1,96 ± 0,04   |
|                    | After        | 2,26 ± 0,10* | 2,24 ± 0,16 | 2,26 ± 0,09* |                      |
|                    | Change       | -0,05 ± 0,12| 0,00 ± 0,13 | +0,03 ± 0,11 |                      |
| “Active” T-Lymphocytes, % | Before     | 26,6 ± 1,1* | 26,8 ± 1,5 | 25,6 ± 0,6* | 29,6 ± 0,8 |
|                    | After        | 25,4 ± 0,6* | 27,2 ± 2,0 | 25,4 ± 0,8* |                      |
|                    | Change       | -1,2 ± 0,7 | +0,4 ± 0,6 | -0,2 ± 0,7 |                      |
| Theophilline resistance T-Lymphocytes, % | Before | 21,9 ± 0,8* | 30,0 ± 4,5 | 21,9 ± 1,2* | 33,2 ± 1,2 |
|                    | After        | 22,1 ± 0,9* | 28,7 ± 3,1 | 23,1 ± 1,2* |                      |
|                    | Change       | +0,2 ± 1,0 | -1,3 ± 3,1 | +1,2 ± 1,2 |                      |
None of the parameters of Humoral Immunity has changed significantly for all variants of the vegetotropic reaction (Table 6).

Table 6
Comparative characteristics of parameters of Humoral Immunity

| Variables               | Term            | Immediate vegetotropic reaction (n) | Normatives (n=54) |
|-------------------------|-----------------|-------------------------------------|-------------------|
|                         | Vagotonic (21)  | Neutral (6)                        | Sympathotonic (27) |
| CD19+ B-Lymphocytes, %  | Before          | 22.6 ± 0.9                         | 22.0 ± 2.7        | 21.5 ± 0.9 |
|                         | After           | 21.3 ± 1.0                         | 23.0 ± 2.2        | 20.8 ± 1.0 |
|                         | Change          | -1.3 ± 1.1                         | +1.0 ± 3.0        | -0.8 ± 1.4 |
|                         |                 | 21.5 ± 0.9                         | 20.8 ± 1.0        | -0.8 ± 1.4 |
| Immuno-                 | Before          | 1.52 ± 0.09*                       | 1.45 ± 0.29       | 1.36 ± 0.09* |
| globulins M, g/L        | After           | 1.61 ± 0.12*                       | 1.20 ± 0.23       | 1.48 ± 0.08* |
|                         | Change          | +0.10 ± 0.11                       | -0.25 ± 0.24      | +0.12 ± 0.08 |
|                         |                 | 1.45 ± 0.29                        | 1.20 ± 0.23       | +0.12 ± 0.08 |
| Immuno-                 | Before          | 12.9 ± 1.3                         | 15.0 ± 3.6        | 12.7 ± 1.3 |
| globulins G, g/L        | After           | 11.6 ± 1.2                         | 16.5 ± 2.8        | 11.7 ± 1.4 |
|                         | Change          | -1.4 ± 1.4                         | +1.6 ± 1.7        | -1.0 ± 1.0 |
|                         |                 | 12.7 ± 1.3                         | 11.7 ± 1.4        | -1.0 ± 1.0 |
| Immuno-                 | Before          | 1.40 ± 0.07*                       | 1.19 ± 0.15*      | 1.27 ± 0.05* |
| globulins A, g/L        | After           | 1.37 ± 0.13*                       | 1.60 ± 0.43       | 1.26 ± 0.06* |
|                         | Change          | -0.03 ± 0.14                       | +0.40 ± 0.41      | -0.01 ± 0.23 |
|                         |                 | 1.27 ± 0.05*                       | 1.26 ± 0.06*      | -0.01 ± 0.23 |
| Circulating            | Before          | 74 ± 24                            | 42 ± 4            | 38 ± 3* |
| Immune Complexes, units| After           | 52 ± 11                            | 35 ± 5*           | 33 ± 3* |
|                         | Change          | -22 ± 20                           | -7 ± 5            | -4 ± 3 |
|                         |                 | 54 ± 5                            | 54 ± 5            | 54 ± 5 |

Since the number of registered EEG parameters is 164, we limited its number to only 15, and then their changes have been proved to be characteristic of the vegetotropic reactions (Table 7). As it can be seen, the vagotonic reaction is associated with the significant increase in the β-rhythm Index and the decrease in its SPD in locus T5. Instead, the sympathetic response is accompanied by the decrease in the Frequency of α-rhythm and its SPD in the loci T5 and F7 as well as by the increase in the Entropy of SPD in locus O1.

Now let’s turn to the presentation of the results of the already mentioned discriminant analysis which was conducted to identify the parameters of the neuroendocrine-immune complex, among the totality of changes three variants of the vegetotropic reaction differ significantly among themselves, that is, they are discriminational [13].

The program (forward stepwise) included 27 parameters (variables) in the model. In addition the Baevskiy’s Stress Index, 3 parameters of HRV, 15 of
**EEG** and 7 of **Immunity** as well as Testosterone were identified as recognizable (Table 8).

**Comparative characteristics of selected parameters of EEG**

| Variables | Term | Immediate vegetotropic reaction (n) | Normatives (n=54) |
|-----------|------|-----------------------------------|------------------|
|           |      | Vagotonic (21) | Neutral (6) | Sympathotonic (27) |                  |
| T5-α SPD, μV²/Hz | Before | 75±22 | 114±59 | 122±28 | 134±16 |
|             | After | 80±22 | 163±108 | 97±21 | 75±11² |
|             | Change | +4±9 | +50±51 | -25±11² | 36,8±2,3 |
| T5-α SPD, % | Before | 26,8±3,7 | 38,1±8,3 | 35,5±3,9 | 36,8±2,3 |
|             | After | 29,6±4,2 | 37,0±10,5 | 30,3±3,1 | 30,3±3,1 |
|             | Change | +2,8±2,4 | -1,1±6,5 | -5,2±2,0² | -5,2±2,0² |
| T5-β SPD, % | Before | 46±4 | 35±8 | 39±4 | 36,8±2,4 |
|             | After | 37±4 | 33±10 | 39±4 | 39±4 |
|             | Change | -8,4±3,0² | -1,4±4,6 | -5±3,7 | -5±3,7 |
| F7-θ SPD, μV²/Hz | Before | 14,5±3,2 | 12,2±3,0 | 13,8±1,7 | 16,0±1,6 |
|             | After | 14,0±2,3 | 11,1±3,5 | 20,4±3,8 | 20,4±3,8 |
|             | Change | -0,5±3,0 | -1,1±4,7 | +6,6±3,5 | +6,6±3,5 |
| Fp1-δ SPD, % | Before | 21,8±3,6 | 10,6±1,7 | 18,0±2,3 | 18,9±1,4 |
|             | After | 23,5±4,7 | 37,2±16,1 | 22,1±3,7 | 22,1±3,7 |
|             | Change | +1,7±5,4 | +26,6±16,3 | +4,1±4,1 | +4,1±4,1 |
| Frequency of α-rhythm, Hz | Before | 10,64±0,19 | 10,58±0,27 | 10,52±0,18 | 10,43±0,08 |
|             | After | 10,48±0,22 | 11,08±0,52 | 10,48±0,15 | 10,48±0,15 |
|             | Change | -0,17±0,23 | +0,50±0,34 | -0,24±0,06² | -0,24±0,06² |
| Asymmetry of β-rhythm, % | Before | 24±5 | 28±10 | 16±2 | 20±1,5 |
|             | After | 17±2 | 28±10 | 17±3 | 17±3 |
|             | Change | -7,4±4,9 | -0,3±5,6 | +0,4±2,2 | +0,4±2,2 |
| F8-β SPD, μV²/Hz | Before | 77±22 | 43±15 | 66±14 | 69±9 |
|             | After | 66±20 | 46±13 | 51±7 | 51±7 |
|             | Change | -11±18 | +3±6 | -15±12 | -15±12 |
| F4-δ SPD, μV²/Hz | Before | 150±70 | 54±14 | 77±14 | 89±9 |
|             | After | 85±14 | 119±69 | 229±141 | 229±141 |
|             | Change | -65±65 | +65±78 | +152±143 | +152±143 |
| F7-α SPD, % | Before | 25±3 | 29±7 | 32±3 | 31,7±2,0 |
|             | After | 28±4 | 33±8 | 26±3 | 26±3 |
|             | Change | +3,2±2,6 | +4,1±7,3 | -6,4±2,3² | -6,4±2,3² |
| Fp1-α SPD, % | Before | 34±4 | 41±9 | 40±3 | 44,0±2,2 |
|             | After | 36±5 | 28±11 | 36±3 | 36±3 |
|             | Change | +2,0±2,8 | -13±9 | -3,6±2,5 | -3,6±2,5 |
| Index of β-rhythm, % | Before | 76,1±6,0 | 91,3±5,7 | 92,0±2,8 | 87,9±1,8 |
|             | After | 88,6±2,0 | 94,2±2,4 | 89,9±3,0 | 89,9±3,0 |
|             | Change | +12,5±6,0² | +2,8±5,8 | -2,0±4,0 | -2,0±4,0 |
| Entropy of SPD in O1 | Before | 0,74±0,04 | 0,78±0,05 | 0,71±0,03 | 0,68±0,02 |
|             | After | 0,76±0,04 | 0,70±0,06 | 0,76±0,03 | 0,76±0,03 |
|             | Change | +0,03±0,04 | -0,08±0,06 | +0,05±0,00² | +0,05±0,00² |
| Entropy of SPD in F4 | Before | 0,82±0,03 | 0,87±0,05 | 0,85±0,02 | 0,83±0,01 |
|             | After | 0,86±0,02 | 0,83±0,04 | 0,85±0,03 | 0,85±0,03 |
|             | Change | +0,03±0,03 | -0,04±0,04 | 0,00±0,03 | 0,00±0,03 |
| Entropy of SPD in P4 | Before | 0,84±0,03 | 0,83±0,04 | 0,79±0,03 | 0,76±0,01 |
|             | After | 0,78±0,03 | 0,79±0,05 | 0,80±0,02 | 0,80±0,02 |
|             | Change | -0,06±0,02² | -0,05±0,05 | +0,01±0,02 | +0,01±0,02 |
The program (forward stepwise) included 27 parameters (variables) in the model. In addition the Baevskiy’s Stress Index, 3 parameters of HRV, 15 of EEG and 7 of Immunity as well as Testosterone were identified as recognizable (Table 8).

**Table 8**

| Variables currently in model | Wilks’ $\Lambda$ | Partial $\Lambda$ | F-remove | p-level | Tolerance |
|-----------------------------|------------------|------------------|-----------|---------|-----------|
| Baevskiy’s Stress Index, ln units | .023 | .788 | 3.4 | .051 | .125 |
| Triangulary Index, units | .021 | .857 | 2.1 | .145 | .348 |
| T5-α SPD, $\mu V^2/Hz$ | .022 | .808 | 3.0 | .070 | .379 |
| T5-β SPD, % | .027 | .657 | 6.5 | .005 | .220 |
| F7-θ SPD, $\mu V^2/Hz$ | .026 | .683 | 5.8 | .009 | .259 |
| Fp1-δ SPD, % | .019 | .957 | .6 | .579 | .103 |
| Frequency of α-rhythm, Hz | .031 | .579 | 9.1 | .001 | .298 |
| Stub Neutrophils, % | .024 | .755 | 4.1 | .030 | .313 |
| Popovych’s Adaptation Index, points | .024 | .748 | 4.2 | .027 | .025 |
| Asymmetry of β-rhythm, % | .022 | .830 | 2.6 | .098 | .370 |
| CD8+CD3+ T-cytolyc Lymphoc., % | .021 | .835 | 2.5 | .106 | .365 |
| Entropy of SPD in O1 | .026 | .700 | 5.4 | .012 | .294 |
| Popovych’s Strain Index, units | .030 | .605 | 8.2 | .002 | .256 |
| Testosterone, nM/L | .021 | .859 | 2.1 | .149 | .030 |
| F8-δ SPD, $\mu V^2/Hz$ | .022 | .820 | 2.7 | .084 | .424 |
| F4-δ SPD, $\mu V^2/Hz$ | .018 | .984 | 0.2 | .816 | .215 |
| F7-α SPD, % | .039 | .459 | 14.7 | .000 | .089 |
| Fp1-α SPD, % | .029 | .621 | 7.6 | .003 | .059 |
| T5-α SPD, % | .021 | .832 | 2.5 | .100 | .317 |
| LF SP, msec$^2$ | .022 | .808 | 3.0 | .069 | .287 |
| IgA, g/L | .022 | .806 | 3.0 | .067 | .261 |
| IgM, g/L | .020 | .895 | 1.5 | .249 | .435 |
| Entropy of SPD in F4 | .023 | .793 | 3.3 | .055 | .168 |
| “Active” T-Lymphocytes, % | .021 | .851 | 2.2 | .134 | .302 |
| Entropy of SPD in P4 | .020 | .903 | 1.3 | .279 | .403 |
| Index of β-rhythm, % | .019 | .920 | 1.1 | .355 | .608 |

The recognition information contained in the listed variables is condensed in two discriminant roots, 62% in the first and 38% in the second. The values of individual roots were calculated by adding products of discriminant variables to their Raw Coefficients plus the Constant (Table 9) makes it possible to visualize each vegetotrophic reaction together with its neuroendocrine-immune accompaniment in a two-dimensional information space of radicals (Fig. 1).
Table 9

Summary of Stepwise Analysis and Coefficients and Constants for Canonical Variables

| Variables currently in the model | Parameters of Wilks’ Statistics | Standardized Coefficients | Raw Coefficients |
|----------------------------------|----------------------------------|---------------------------|-----------------|
|                                  | F to enter | p-level | Λ | F-value | p-level | Root 1 | Root 2 | Root 1 | Root 2 |
| Baevskiy's Stress Index, ln un. | 33,3 | 10^-6 | .434 | 33,3 | 10^-6 | -1,201 | .699 | -2,413 | 1,405 |
| Triangulary Index, units         | 5,2 | .009 | .360 | 16,7 | 10^-6 | .627 | .269 | .332 | -1,143 |
| T5-α SPD, μV/Hz                  | 2,6 | .088 | .326 | 12,3 | 10^-6 | -.277 | .725 | -.004 | .011 |
| T5-β SPD, %                      | 2,6 | .082 | .293 | 10,2 | 10^-6 | -.1097 | .761 | -.066 | .046 |
| F7-α SPD, μV/Hz                  | 4,9 | .012 | .243 | 9,7 | 10^-6 | -.1084 | .454 | -.068 | .028 |
| Fp1-β SPD, %                     | 3,8 | .029 | .208 | 9,1 | 10^-6 | -.427 | .549 | -.017 | -.022 |
| Frequency of α-rhythm, Hz        | 3,1 | .055 | .183 | 8,6 | 10^-6 | -.002 | 1,301 | -.001 | 1,087 |
| Stub Neutrophils, %              | 2,5 | .097 | .165 | 8,1 | 10^-6 | .085 | -.964 | .045 | -.518 |
| HF SP, msec^2                    | 2,3 | .113 | .149 | 7,6 | 10^-6 | .534 | -.012 | .00196 | -.45 \times 10^4 |
| Popovych's Adaptation Index      | 2,7 | .080 | .132 | 7,4 | 10^-6 | -1,274 | 3,228 | -1,911 | 4,841 |
| Asymmetry of β-rhythm, %         | 2,6 | .084 | .117 | 7,2 | 10^-6 | -.306 | .671 | -.018 | .040 |
| CD8+CD3+ T-c Lymphocytes         | 3,7 | .034 | .099 | 7,3 | 10^-6 | -.703 | -.111 | -.192 | -.030 |
| Entropy of SPD in O1             | 2,1 | .141 | .089 | 7,0 | 10^-6 | -.432 | -1,013 | -.2803 | -6,571 |
| Popovych’s Strain Index, units   | 2,1 | .135 | .080 | 6,9 | 10^-6 | .055 | 1,359 | -.120 | 2,939 |
| Testosterone, nM/L               | 1,8 | .174 | .073 | 6,7 | 10^-6 | -1,162 | 2,058 | -.115 | .204 |
| F8-β SPD, μV^2/Hz                | 2,2 | .129 | .065 | 6,6 | 10^-6 | .630 | -.291 | .009 | -.004 |
| F4-β SPD, μV^2/Hz                | 1,8 | .173 | .059 | 6,4 | 10^-6 | .290 | .002 | 51 \times 10^{-6} | 3 \times 10^{-6} |
| F7-α SPD, %                      | 1,8 | .188 | .054 | 6,3 | 10^-6 | .610 | 2,625 | .048 | .206 |
| Fp1-α SPD, %                     | 4,9 | .014 | .041 | 6,8 | 10^-6 | -.558 | -2,719 | -.040 | -.193 |
| T5-α SPD, %                      | 2,0 | .147 | .037 | 6,8 | 10^-6 | -.302 | -.734 | -.027 | -.065 |
| LF SP, msec^2                    | 1,9 | .168 | .033 | 6,7 | 10^-6 | -.039 | .895 | -.8 \times 10^{-6} | .00199 |
| IgA, g/L                         | 1,8 | .181 | .029 | 6,6 | 10^-6 | .218 | .918 | .365 | 1,538 |
| IgM, g/L                         | 1,2 | .305 | .027 | 6,4 | 10^-6 | .357 | .393 | .755 | .831 |
| Entropy of SPD in F4             | 1,7 | .198 | .024 | 6,4 | 10^-6 | .842 | .845 | 5,241 | 5,259 |
| “Active” T-Lymphocytes, %        | 1,7 | .205 | .021 | 6,3 | 10^-6 | -.347 | -.678 | -.108 | -.211 |
| Entropy of SPD in F4             | 1,3 | .300 | .019 | 6,2 | 10^-6 | -.515 | -.071 | -4,929 | -.677 |
| Index of β-rhythm, %             | 1,1 | .355 | .018 | 6,0 | 10^-6 | .305 | .239 | .013 | .010 |

| Constants | .2698 | .0003 |
|-----------|-------|-------|

Discriminant Properties 62% 38%

It can be seen that all three clusters are delimited so clearly that they do not need to compute Mahalanobis distances between them.

The placement of points of the cluster of the vagotonic reaction in the positive region of the first root reflects the increase (meaningful or as a tendency) in this situation parameters correlate with this root positively and reduce the parameters that are associated with it negatively. Instead, the opposite localization along the axis of the first root of the sympathetic cluster reflects the opposite or less noticable changes of the same parameters (Table 1).
Fig. 1. Localization of individual values of roots of vegetotropic reactions together with its neuroendocrine-immune accompaniment in a two-dimensional information space of radicals

**Table 10**

| Variables currently in the model | Root 1 | Root 2 | Means of Changes by Vegetotropic Reaction |
|----------------------------------|--------|--------|------------------------------------------|
|                                  |        |        | Vagotonic | Neutral | Sympathotonic |
| Triangular Index, units          | .364   | -.015  | +1.9±0.3  | +0.1±0.7 | -2.2±0.4  |
| Stub Neutrophils, %              | .175   | .002   | +1.13±0.38 | +0.42±0.86 | -0.80±0.37 |
| LF SP, msec²                     | .156   | .003   | +167±65    | +6±42    | -280±119  |
| HF SP, msec²                     | .139   | .024   | +44±33     | +5±32    | -178±68   |
| F7-α SPD, %                      | .131   | .052   | +3.2±2.6   | +4.1±7.3 | -6.4±2.3  |
| T5-α SPD, %                      | .118   | -.100  | +2.8±2.4   | -1.1±6.5 | -5.2±2.0  |
| T5-α SPD, µV/Hz                  | .091   | .128   | +4±9       | +50±51   | -25±11#   |
| Index of β-rhythm, %             | .103   | -.25   | +12.5±6.0  | +2.8±5.8 | -2.0±4.0  |
| Testosterone, nM/L               | .096   | -.103  | 2.9±1.4    | -6.8±4.7 | -3.4±2.3  |
| Baevskiy’s Stress Index, ln units| -.394  | .047   | -0.57±0.14 | +0.04±0.04 | +0.61±0.08 |
| Entropy of SPD in P4             | -.111  | -.19   | -0.06±0.02 | -0.05±0.05 | +0.01±0.02 |
| Popovych’s Strain Index, units   | -.081  | .135   | -0.29±0.14 | +0.24±0.23 | -0.03±0.05 |
| T5-β SPD, %                      | -.077  | .034   | -8.4±3.0  | -1.4±4.6 | -0.5±3.7  |
| CD8+CD3+ Tc-Lymphocytes, %       | -.114  | -.059  | -1.1±0.8   | -1.7±1.9 | +1.3±0.6  |
| Asymmetry of β-rhythm, %         | -.076  | .035   | -7.4±4.9   | -0.3±5.6 | +0.4±2.2  |
| F7-θ SPD, µV²/Hz                 | -.078  | -.030  | -0.5±3.0   | -1.1±4.7 | +6.8±3.5  |
| F4-δ SPD, µV²/Hz                 | -.064  | .012   | -65±65     | +65±78   | +152±143  |
| Active T-Lymphocytes, %          | -.052  | .053   | -1.2±0.7   | +0.4±0.6 | -0.2±0.7  |
| IgA, g/L                         | .005   | .103   | -0.03±0.14 | +0.40±0.41 | -0.01±0.23 |
| Popovych’s Adaptation Index, points | .051  | .084   | +0.16±0.10 | +0.49±0.31 | -0.01±0.15 |
| Frequency of α-rhythm, Hz        | -.011  | .074   | -0.17±0.23 | +0.50±0.34 | -0.24±0.06 |
The localization of the points of a neutral cluster along the axis of the first root in its quasi-zero zone reflects, as a rule, quasi-zero changes of the mentioned parameters, but with many exceptions. On the contrary, along the axis of the second radical, the neutral cluster is distanced very clearly from the other two, which, in turn, are not delimited completely. This reflects the increase in the values of the parameters positively correlated with the second root and the decrease in the values of negatively correlated with its parameters in comparison with quasi-zero changes in both the vagotonic and sympatotonic vegetotropic reactions.

By means of calculating the classifying functions for their coefficients and constants (Table 11) as well as individual values of postprandial changes, the selected discriminant variables allow to identify retrospectively the variant of the vegetotropic reaction to the stimulus without mistakes.

Table 11

| Variables currently in the model | Vagotonic | Neutral | Sympatotonic |
|---------------------------------|-----------|--------|--------------|
|                                 | \( p=0.39 \) | \( p=0.11 \) | \( p=0.50 \) |
| Baevskiy’s Stress Index, ln units | -5.701 | 9.881 | 9.438 |
| Triangular Index, units | 1.357 | -4.222 | -6.966 |
| T5-α SPD, \( \mu V^2/Hz \) | -0.027 | 0.066 | 0.006 |
| T5-β SPD, % | -0.207 | 0.273 | 0.212 |
| F7-θ SPD, \( \mu V^2/Hz \) | -0.205 | 0.153 | 0.214 |
| Fp1-α SPD, % | 0.041 | -0.078 | 0.130 |
| Frequency of α-rhythm, Hz | -0.734 | 7.082 | -1.118 |
| Stub Neutrophils, % | 0.934 | -2.896 | 0.373 |
| HF SP, msec² | 0.0029 | -0.0018 | -0.0087 |
| Popovych’s Adaptation Index, points | -6.171 | 32.98 | 7.903 |
| Asymmetry of β-rhythm, % | 0.096 | 0.232 | 0.034 |
| CD8+CD3+ T cytolytic Lymphocytes, % | -0.430 | -0.212 | 0.695 |
| Entropy of SPD in O1 | 3.971 | -36.92 | 16.96 |
| Popovych’s Strain Index, units | 3.862 | 16.99 | -2.927 |
| Testosterone, nM/L | 0.359 | 1.368 | 0.439 |
| F8-8 SPD, \( \mu V^2/Hz \) | 0.027 | -0.025 | -0.031 |
|                     |       |       |       |
|---------------------|-------|-------|-------|
| F4-δ SPD, μV²/Hz    | .0023 | .0011 | -.0008|
| F7-α SPD, %         | -.109 | 1.266 | -.278 |
| Fp1-α SPD, %        | .171  | -1.124| .298  |
| T5-α SPD, %         | -.045 | -.453 | .078  |
| LF SP, msec²        | -.0019| .0116 | -.0004|
| IgA, g/L            | .086  | 10.32 | -1.224|
| IgM, g/L            | .518  | 4.780 | -3.507|
| Entropy of SPD in F4| 18.89 | 44.80 | -9.331|
| “Active” T-Lymphocytes, % | -.390 | -1.661| .133  |
| Entropy of SPD in P4| -26.87| -20.54| 2.054 |
| Index of β-rhythm, %| .0358 | .0799 | -.0365|
| Constants           | -6.758| -21.97| -6.16 |

Fig. 2 illustrates the previously mentioned complete absence of differences between the three stimuli within each variant of the vegetotropic response to them. If the similarity of reactions to bioactive waters Naftussya and phytoadaptogen was expected due to the presence of polycyclic hydrocarbons in both stimuli [7, 11, 12, 22, 23], then the vegetotropic activity of ordinary waters caught me by surprise.

![Fig. 2](image-url)
The hypothesis should be accepted that the vector of the vegetotropic reaction as well as its absence, is due not to the properties of the stimulus, but to the state of the autonomic reactivity of a person and not at all, especially at the time of using the fluid.

The procedure of the discriminatory analysis of registered initial parameters revealed their constellation (2 of HRV, 21 of EEG and 8 of Immunity as well as Trait anxiety) which allows to predict each of the three variants of the vegetotropic reaction accurately (Table 12).

**Table 12**

Coefficients and constants for classification of functions and means of predictors of various vegetotropic reaction

| Variables-predictors currently in the model | Coefficients for reactions | Means of predictors of reaction | Norm levels |
|--------------------------------------------|---------------------------|--------------------------------|-------------|
|                                           | V  | N  | S  | Sympath | Vagotonic | Neutral |             |
| Amplitude of Moda, %                      | 6.54 | 6.90 | 7.11 | 43±3 | 66±5 | 55±6 | 37.8±1.3 |
| C4-0 SPD, %                               | -36.15 | -34.69 | -39.25 | 9.6±0.7 | 12.8±1.1 | 11.5±1.8 | 9.4±0.3 |
| Asymmetry of δ-rhythm, %                  | -11.57 | -11.16 | -12.61 | 16.2 | 24.59 | 28±10 | 20±1.5 |
| Entropy of SPD in C4                      | 2476 | 2357 | 2512 | 0.84±0.02 | 0.89±0.02 | 0.89±0.03 | 0.83±0.01 |
| Circulating Immune Comp, un               | .95 | .93 | .96 | 38±3 | 74±24 | 42±4 | 54±5 |
| C4-δ SPD, %                               | -12.966 | -11.30 | -12.52 | 20.2±2.2 | 25.1±2.5 | 21.4±2.3 | 21.6±1.2 |
| “Active” T-Lymphocytes, %                 | 1.17 | 1.16 | 1.17 | 25.6±0.6 | 26.6±1.1 | 26.8±1.5 | 29.6±0.8 |
| Triangular Index, units                   | 44.12 | 43.97 | 47.85 | 10.9±0.8 | 7.4±0.7 | 7.9±1.1 | 11.2±0.3 |
| Stub Neutrophils, %                       | 97.97 | 96.59 | 104.6 | 4.30±0.36 | 2.86±0.37 | 3.52±0.28 | 3.50±0.23 |
| Asymmetry of α-rhythm, %                 | 3.80 | 3.26 | 3.98 | 18.4±2.4 | 14.7±1.1 | 10.3±0.6 | 17.0±1.1 |
| Index of δ-rhythm, %                      | -2.89 | -2.35 | -2.97 | 92.0±2.8 | 76.1±6.0 | 91.3±5.7 | 87.9±1.8 |
| O1-α SPD, %                               | 5.40 | 5.01 | 5.74 | 48±5 | 33±5 | 44±8 | 48±3 |
| Killing Index of Neutroph, %              | 10.68 | 10.01 | 10.96 | 38±2 | 32±4 | 33±4 | 40±2 |
| 0-Lymphocytes, %                          | -13.65 | -11.81 | -14.11 | 16.2±1.7 | 14.2±1.2 | 12.9±4.0 | 8.0±0.8 |
| Laterality Index of α-rhythm,%            | -3.20 | -3.51 | -3.66 | -3±4 | +8±4 | -14±3 | -2±2 |
| Fp1-δ SPD, %                              | 29.80 | 28.33 | 31.37 | 18±3 | 22±4 | 11±2 | 18.9±1.4 |
| Immunoglobulins A, g/L                    | -37.90 | -63.88 | -73.40 | 1.27±0.05 | 1.40±0.074 | 1.19±0.15 | 1.90±0.06 |
| T3-δ SPD, %                               | -1.66 | -1.96 | -2.07 | 21±3 | 27±4 | 18±4 | 20.2±1.4 |
| Frequency of θ-rhythm, Hz                | 127.6 | 115.4 | 130.3 | 6.4±0.3 | 6.6±0.2 | 5.8±0.6 | 6.5±0.1 |
| F8-5 SPD, μV/Hz                           | 1.14 | 1.03 | 1.20 | 43±10 | 82±35 | 21±6 | 71±14 |
| P3-0 SPD, %                               | 26.86 | 24.01 | 29.41 | 9.0±0.9 | 10.0±1.2 | 7.3±0.9 | 7.6±0.3 |
| Fp1-5 SPD, μV/Hz                          | -2.72 | -2.63 | -2.82 | 51±13 | 87±40 | 21±5 | 63±13 |
| F4-5 SPD, μV/Hz                           | .22 | .19 | .31 | 77±14 | 150±70 | 55±14 | 89±9 |
| T4-5 SPD, μV/Hz                           | -.11 | -.19 | -.54 | 48±7 | 80±28 | 43±10 | 73±12 |
| F7-5 SPD, μV/Hz                           | -.02 | -.15 | -.15 | 40±8 | 60±19 | 31±8 | 72±14 |
| T6-5 SPD, μV/Hz                           | -3.06 | -2.71 | -3.08 | 38±7 | 59±21 | 30±8 | 64±11 |
| Laterality Index of δ-rhythm, %           | 3.13 | 2.97 | 3.32 | -7±9 | 0±8 | -16±6 | +1±4 |
| Trait anxiety, points                     | -5.15 | -5.31 | -6.20 | 46.9±1.2 | 48.4±1.5 | 45.8±3.0 | 38.0±1.2 |
| Theophill resistance T-Lym, %             | 3.14 | 4.10 | 3.84 | 22.0±1.2 | 21.9±0.8 | 30.0±4.5 | 33.2±1.2 |
| Eosinophils, %                            | -28.89 | -24.40 | -32.21 | 3.50±0.15 | 3.33±0.21 | 4.83±1.14 | 3.50±0.23 |
| Entropy of SPD in F8                      | -415 | -344 | -417 | 0.78±0.03 | 0.76±0.05 | 0.86±0.05 | 0.76±0.02 |
| Deviation of δ-rhythm, Hz                 | 74.18 | 68.43 | 71.30 | 0.79±0.05 | 0.76±0.07 | 0.92±0.15 | 0.70±0.03 |
| Constants                                 | -3214 | -3019 | -3407 | | | | |
As we can see (Fig. 3) the sympathetic response to the stimulus has developed in the cases of minimum/maximum for a sample of initial values of the parameters associated with the first root. The neutral response is determined by the minimum/maximum values of the parameters associated with the second root, whereas the predictors of the vagotonic reaction are the maximal/minimal of these parameters.

**Conclusion.** The vector of the vegetotropic reaction as well as its absence is due not to the properties of the stimulus, but to the state of autonomic reactivity of a person, and not at all, especially at the time of using the fluid.

**Acknowledgement.** I express my sincere gratitude to my colleague T.A. Korolyshyn as well as the administration of the JSC ‘Truskavets’kurort’ and the clinical sanatorium ‘Moldova’ for help in recording EEG and HRV and carrying out immuno-enzyme analysis. Special thanks to the volunteers who have become my friends.

**Compliance with ethical standards.** Tests of patients were conducted in accordance with the Declaration of Helsinki (1975), which was revised and complemented in 2002 and the directive of the Science Research Ethics Committee. During the tests the informed consent has been taken from all participants’ parents and all necessary measures have been used for providing the anonymity of participants.

Authors state no conflict of interests.

**REFERENCES**

1. *Baevskiy RM, Ivanov GG*. Heart Rate Variability: theoretical aspects and possibilities of clinical application [in Russian]. Ultrasound and Functional Diagnostics. 2001;3:106-27.
2. *Balanovsky VP, Popovych IL, Karpynets SV*. About ambivalence-equilibratory character of influence of curative water Naftussya on organism of human [in Ukrainian]. Dopovidi ANU. Matematichni, pryrodnychi, tehnichni Nauky. 1993;3:154-8.
3. *Barylyak LG, Malyuchkova RV, Tolstanov OB, Tymochko OB, Hryvnyak RF, Ukhryn MR*. Comparative estimation of informativeness of leucocytary index of adaptation by Garkavi and by Popovych. Medical Hydrology and Rehabilitation. 2013;11(1):5-20.
4. *Berntson GG, Bigger JT, Eckberg DL, Grossman P, Kaufman PG, Malik M, Nagaraja HN, Porges SW, Saul JP, Stone PH, Van der Molen MW*. Heart Rate Variability: Origins, methods, and interpretive caveats. Psychophysiology. 1997;34:623-48.
Immediate responses of the autonomic nervous system to the balneofactors, their neuro-endocrine-immune accompaniments and predictors

I.L. POPOVYCH
Bohomolets’ Institute of Physiology of National Academy of Sciences, Kyiv, Ukraine
email: i.popovych@biph.kiev.ua

Introduction. In previous studies it has been shown that in response to the intake of Bioactive Water Naftussya (BAWN) the activity of the autonomic nervous system changes and the vector of the reaction is ambiguous. However, the issue of the specificity of immediate effects of BAWN on the nervous as well as endocrine and immune systems is still relevant. This is the objective of this study.

Material and Methods. The object of the observation was 15 volunteers-men (aged 26÷60, M±SD: 44±12 years) without any clinical diagnose but with a moderate dysfunction of neuroendocrine-immune complex (dysadaptation). At the beginning volunteers filled in a questionnaire with the purpose of estimationing the level of the trait anxiety. Then HRV and EEG were recorded. The content of principal adaptation hormones such as Cortisol, Testosterone and Triiodothyronine as well as parameters of Immunity were determined in blood. After registration 5 volunteers of the basic level consumed some days 200 mL of Control Water (distillated, filtered, well), Water Naftussya from layers Truskavets’ and Skhidnyts’a while 10 volunteers consumed 5 mL of Phytocomposition ‘Balm Cryms’kiy’ (it is identified as an adaptogen) soluted in 195 mL of daily Water. all tests were repeated in an hour and a half.

Results. It has been confirmed that the polyvariant nature of the vegetotropic reactions to the balneofactors, namely Bayevskiy’s Stress Index has increased in half of the observations, while in 39% it has decreased and only in 11% has not changed significantly. No differences were found between the effects of all applied stimuli. The method of discriminant analysis revealed 27 parameter change which are characteristic of vegetotropic reactions (Bayevskiy’s Stress Index, 3 parameters of HRV, 15 of EEG and 7 of Immunity as well as Testosterone). It has been revealed that initial parameters (2 of HRV, 21 of EEG and 8 of Immunity as well as trait anxiety) allowed to predict each of the three variants of the vegetotropic reaction accurately.

Conclusion. The vector of the vegetotropic reaction as well as its absence, is not due to the properties of the stimulus, the time of the use of the balneofactor, but to the state of autonomic reactivity of a person.

Key words: balneofactors, neuroendocrine-immune complex, immediate reactions.