Gaichuk L. M., Zelenska K. O., Leshchina I. V. Psychiatry and narcology in medical practice: a master of medicine. - K .: All-Ukrainian specialized publishing house "Medicine", 2019. - 344 p.

14. Maruta N. O., Khobzei M. K., Voloshin P. V. State of mental health of the population and prospects for the development of psychiatric care in Ukraine // Mental health. - 2013. - No. 7 (86). - S. 66-75.

15. Oderysheva EB, Obidin I. Yu. Internet addiction as a hidden form of other addictions. Materials scientific-practical. conf. with international participation "The world of addiction: chemical and non-chemical addictions, associated mental disorders." - SPb., 2012.- S. 99-100.

16. Ustinova NA Determinants of deviant behavior in modern adolescents. Collection of scientific papers "Actual problems of personality development." - 2016. - pp. 148-157.

17. Kharchenko D. M. Officials pouring into psychosomatic problems. Scientific newsletter of Mykolaiv State University of the Name of V.O. Sukhomlinsky. Ser. : Psychological sciences. - 2013.- T. 2.- No. 11. - S. 302-306.

18. Yagnyuk K. V. Formulation of a case of psychotherapy: significance for clinical practice // Journal of practical psychologist. - 2009. - No. 2. - P. 191–203.

19. Anthony M., Espen A., Boonen H., Colder M., Coulson M., Johan E. Scholars' open debate paper on the WHO ICD-11 Gaming Disorder proposal. Journal on Behavioral Addictions. - 2017. - P. 267-270. doi:10.1556/2006.5.2016.088n

20. Engel G. L. From biomedical to biopsychosocial: being scientific on the human domain / G. L. Engel // Psychosomatics. — 1997. — Vol. 38, № 6. — P. 521-528. PMID: 9427848

21. Levenstein S. The very model of a modern ethiology: a biopsychosocial view on peptic ulcer // Psychosom. Med.- 2000. - Vol. 62, № 2. - P. 176-185. PMID: 10772394.

Робота надійшла в редакцію 14.05.2021 року.
Рекомендована до друку на засіданні редакційної колегії після рецензування

УДК 612.822.3.087:612.017.1]-047.44
DOI https://zenodo.org/deposit/5084748

Oleksandr O. Popadynets', Anatoliy I. Gozhenko, Igor L. Popovych, Nataliia S. Badiuk

CORRELATES ENTROPY OF GAS-DISCHARGE IMAGE WITH THE ENTROPIES OF EEG, IMMUNOCYTOGRAM AND LEUKOCYTOGRAM

Ukrainian Research Institute for Medicine of Transport of the Ministry of Health of Ukraine, Odessa

Gozhenko A. I. - https://orcid.org/0000-0001-7413-4173
Popovych I. L. - https://orcid.org/0000-0002-5664-5591
Badiuk N. S. - https://orcid.org/0000-0002-8290-0605

Summary. Popadynets' O. O., Gozhenko A. I., Popovych I. L., Badiuk N. S. **CORRELATES ENTROPY OF GAS-DISCHARGE IMAGE WITH THE ENTROPIES OF EEG, IMMUNOCYTOGRAM AND LEUKOCYTOGRAM. Background.** In implementing the project of verification gas discharge visualization (kirlianography, biophotonics) method, we documented the significant correlation of the gas discharge image parameters with the parameters of electroencephalogram, heart rate variability (HRV), dexterity and spasticity of brush, blood pressure, as well as blood levels of adaptive hormones.

As part of a project to investigate the physiological nature of entropy, we have shown that EEG entropy is related to a number of its amplitude-frequency and spectral parameters, as well as to the parameters HRV, blood leukocytogram and immunocytogram and their entropies. The **purpose** of this study is to analyze the relationships between the entropies of the listed information systems. **Material and research methods.** The object of observation were 20 volunteers: 10 women and 10 men aged 33-76 years without clinical diagnose but with dysfunction of neuro-endocrine-immune complex and metabolism. We registered twice kirlianogram by the method of GDV by the device of "GDV Chamber" ("Biotechprogress"), EEG ("NeuroCom Standard", KhAI Medica), HRV ("CardioLab+HRV", "KhAI-Medica"), Leukocytogram and Immunocytogram. Than we calculated the entropies of the listed information systems. **Results**. By stepwise exclusion, 5 variables were included in the canonical GDV root structure, and 6 variables were included in the root EEG structure. Overall, GDI entropy determines the SPD EEG entropy by 33%. The additional inclusion in the dependent set the parameters of HRV, LCG and ICG entropies gives a increase in determination to 48%. HRV entropy was found outside the model. **Conclusion.** We have documented the relationship between the entropy parameters of electroencephalogram, blood leukocytogram and immunocytogram but not HRV on the one hand, and gas-discharge images on the other. However, the question of the causal nature of this relationship remains open. What is primary: electrical activity of the brain, excretion of cytokines and hormones by immunocytes, or emission of photons and free electrons by acupuncture points (circulation of vital energy)?

Key words: gas-discharge visualization; electroencephalogram; heart rate variability; leukocytogram, immunocytogram; entropy.

Introduction. In implementing the project of verification gas discharge visualization (kirlianography, biophotonics) method proposed by KG Korotkov [10,11], we documented the significant correlation of the gas discharge image (GDI) parameters with the parameters of electroencephalogram [2, 3, 9, 12], HRV [2, 3, 4, 12], dexterity and spasticity of brush [2, 12], blood pressure, as well as blood levels of adaptive hormones [1, 4]. As part of a project to investigate the physiological nature of entropy, we have shown that EEG entropy is related to a number of its amplitude-frequency and spectral parameters, as well as to the parameters HRV, blood leukocytogram and immunocytogram and their entropies [6, 14-19, 21].

The purpose of this study is to analyze the relationships between the entropies of the listed information systems.

Material and methods. The object of examination: 20 volunteers (10 women and 10 men), aged 33-76 years without clinical diagnose but with dysfunction of neuro-endocrine-immune complex and metabolism, characteristic for premorbid state. In the morning on an empty stomach we registered kirlianogram by GDV method with the device "GDV Chamber" ("Biotechprogress", SPb, RF). The first base parameter of GDV is Area of gas discharge image (GDI) in the right, frontal and left projections registered both with and without polyethylene filter. The second base parameter is the Shape coefficient (ratio of square of length of external contour of GDI toward its area), which characterizes the measure of serration/fractality of external contour. The third base parameter of GDI is entropy [10, 11]. The most recent set of parameters was selected for further analysis.

Than we recorded EEG (hardware-software complex "NeuroCom Standard", KhAI Medica) 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 the tassels of ears. Among the options considered the normalized (%) spectral power density (SPD) in the standard frequency bands: 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.

Simultaneously we recorded electrocardiogram in II lead (hardware-software complex "CardioLab+HRV", "KhAI-Medica") to assess the parameters of HRV. For further analysis (Frequency Domain Methods) were selected normalized (%) spectral power (SP) bands 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) [15].

We calculated for HRV and each locus EEG the Entropy (h) of normalized SPD using

formulas [22] based on classic CE Shannon's formula:

$hHRV = - [SPHF \bullet \log_2 SPHF + SPLF \bullet \log_2 SPLF + SPVLF \bullet \log_2 SPVLF + SPULF \bullet \log_2 SPULF] / \log_2 4$;

$hEEG = - [SPD\alpha \bullet \log_2 SPD\alpha + SPD\beta \bullet \log_2 SPD\beta + SPD\theta \bullet \log_2 SPD\theta + SPD\delta \bullet \log_2 SPD\delta] / \log_2 4$

In portion of capillary blood we counted up Leukocytogram (LCG) (Eosinophils, Stub and Segmentonucleary Neutrophils, Lymphocytes and Monocytes) and calculated its Entropy (h) using formula:

$hLCG = - [Lym \bullet \log_2 Lym + Mon \bullet \log_2 Mon + Eos \bullet \log_2 Eos + SNN \bullet \log_2 SNN + StubN \bullet \log_2 StubN] / \log_2 5$

For phenotyping subpopulations of lymphocytes used the methods of rosette formation with sheep erythrocytes on which adsorbed monoclonal antibodies against receptors CD3, CD4, CD8, CD22 and CD16 from company "Granum" (Kharkiv) with visualization under light microscope with immersion system [21]. Next we calculated also the Entropy of Immunocytogram (ICG) using formula:

$hICG = - [CD4 \bullet \log_2 CD4 + CD8 \bullet \log_2 CD8 + CD22 \bullet \log_2 CD22 + CD16 \bullet \log_2 CD16] / \log_2 4$

Every day four people were tested. A week later, all the tests were repeated. Results processed using the software package "Statistica 5.5".

Results and discussion

According to the formula:

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

for a sample of 40 observations critical value of correlation coefficient module at $p<0,05$ ($t>2,02$) is 0,31, at $p<0,01$ ($t>2,70$) is 0,41, at $p<0,001$ ($t>3,55$) is 0,52.

In the first stage of the analysis a correlation matrix is created (Table 1).

Table 1. Correlation matrix for Entropies of gas-discharge image, spectral power density EEG loci, HRV, leukocytogram and immunocytogram

Entropy	Right GDI	Right GDI (f)	Frontal GDI	Frontal GDI (f)	Left GDI	Left GDI (f)
Right GDI	1,00	,46	,71	,42	,58	,31
Right GDI (f)	,46	1,00	,50	,69	,49	,64
Frontal GDI	,71	,50	1,00	,58	,77	,36
Frontal GDI (f)	,42	,69	,58	1,00	,50	,64
Left GDI	,58	,49	,77	,50	1,00	,44
Left GDI (f)	,31	,64	,36	,64	,44	1,00
Fp2	,09	,10	,18	,16	,08	,06
F4	,08	-,07	,16	-,04	,07	-,14
F8	-,01	-,19	-,02	**-,24**	-,07	**-,46**
T4	-,22	-,08	-,06	**-,27**	-,02	-,16
C4	,03	-,07	-,06	-,04	-,17	-,19
T6	,17	-,01	,03	-,12	-,05	-,08
P4	**,24**	,20	,19	**,27**	,13	,02
O2	,21	,21	-,02	,06	,04	,11
Fp1	-,00	-,07	-,06	,11	-,15	,05
F3	,19	,14	**,28**	,19	**,25**	-,02
F7	-,03	-,03	,08	,10	-,19	-,11
T3	-,22	-,05	-,07	-,08	-,24	-,22
C3	,01	-,14	-,17	-,11	**-,24**	-,19
T5	,10	-,17	-,07	-,10	-,07	-,14
P3	,20	,12	,09	,20	,04	,05
O1	,16	,24	,13	**,31**	,17	,19
HRV	-,10	-,05	-,08	-,24	-,21	-,10
LCG	**,30**	-,08	**,30**	,18	,18	,14
ICG	-,25	-,18	-,26	-,21	-,27	**-,30**

To visualize correlations we should decide concerning factor (argument) and effective (function) parameters. As stated in the previous article, in terms of mathematics it does not matter, while in terms of physiology there is the perennial problem of cause and effect. We have chosen as a factor GDV parameters [4].

As a result of the screening, the most significant relationship was found between the GDI entropy (filtered) in the **left** projection and the SPD EEG entropy in the **right** lateral frontal locus (Fig. 1). Unfortunately, intrigue about cross-linking such as the corticospinal pyramid tract has been dispelled by other facts.

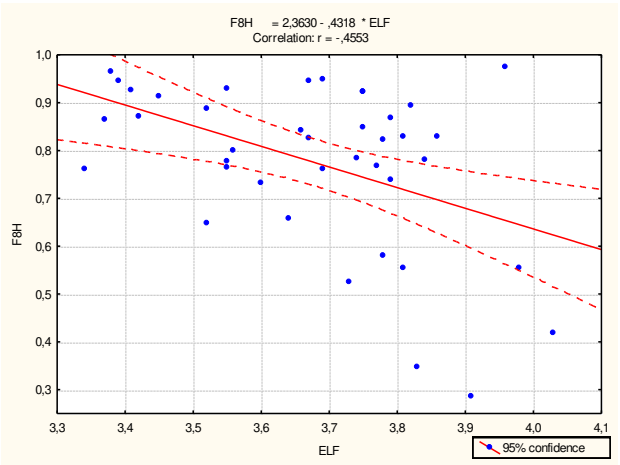
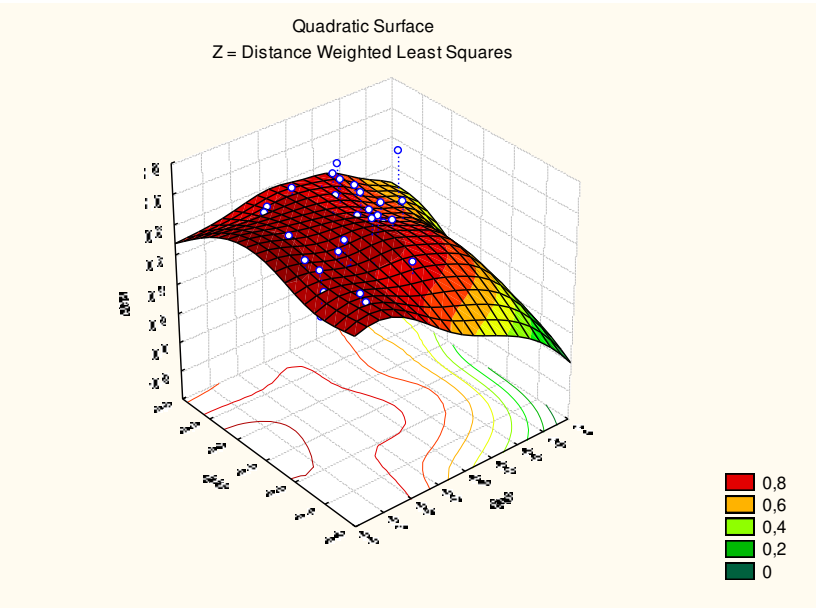


Fig. 1. Scatterplot of correlation between the entropy GDI (filtered) on the Left projection (X-axis) and the entropy in F8 locus EEG (Y-axis)

The inclusion in the multiple regression model of the second, by the power of the link, variable brought about the aesthetic pleasure of the three-dimensional image (Fig. 2), but no more, judging by R.



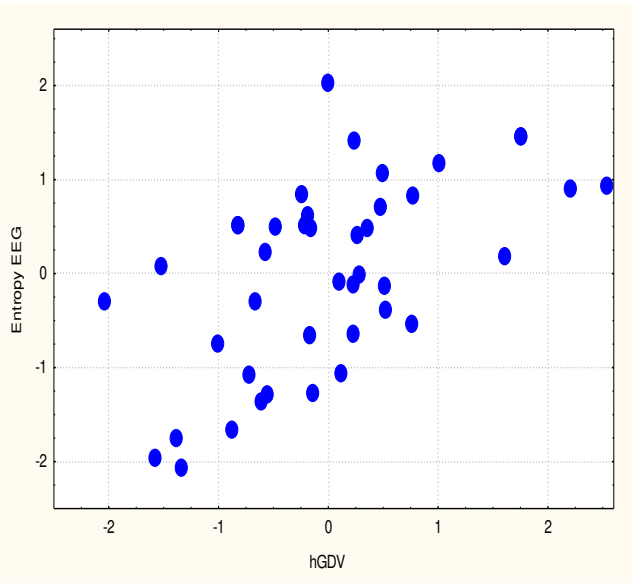
F8h=2,22-0,472•ELf+0,081•EFf; R=0,458; R^2=0,210; $F_{(2,4)}$=4,9; p=0,013

Fig. 2. Scatterplot of dependence of entropy in F8 locus EEG (Z-axis) on entropies GDI (filtered) on the Left (X-axis) and Frontal (Y-axis) projections

In the next step, the canonical correlation between the entropy indices of the gas-discharge image taken without a filter and with a filter in three projections, on the one hand, and SPD 16 EEG loci, on the other, was analyzed.

By stepwise exclusion, 5 variables were included in the canonical GDV root structure, and 6 variables were included in the root EEG structure. Judging by the factor loadings, the causal root represents directly, mainly, the entropy of GDI (with filter) in the left projection, while the entropy of GDI (without filter) in the right projection reflects inversely.

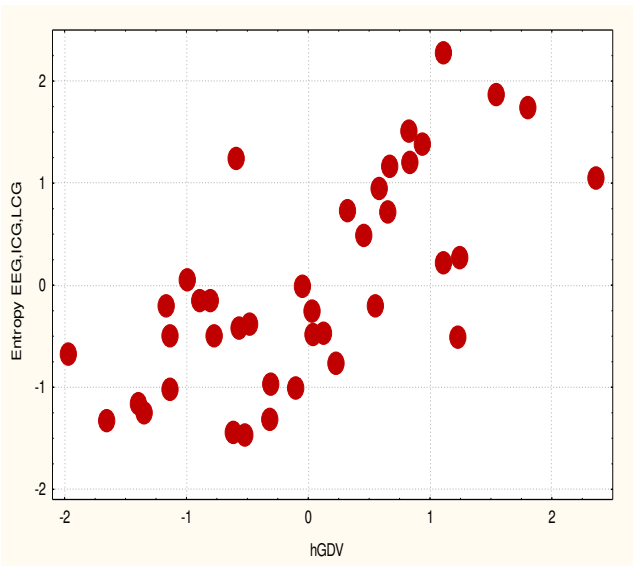
On the other hand, the EEG root reflects the SPD entropy at five loci inversely and only one directly. Overall, GDI entropy determines the SPD EEG entropy by 33% (Fig. 3).



R=0,575; R^2=0,330; $\chi^2_{(30)}$=38; p=0,158; Λ Prime=0,341

Fig. 3. Scatterplot of canonical correlation between Entropy of GDI (X-line) and EEG (Y-line)

The additional inclusion in the left set parameters of HRV, LCG and ICG entropies gives a significant increase in the canonical relationship between the roots. This changes the factor structure of the roots. Contrary to expectations, HRV entropy was found outside the model (Figure 4).



R=0,699; R^2=0,489; $\chi^2_{(48)}$=54; p=0,262; Λ Prime=0,181

Fig. 4. Scatterplot of canonical correlation between Entropy of GDI (X-line) and EEG as well as LCG&ICG (Y-line)

Conclusion

We have documented the relationship between the entropy parameters of electroencephalogram, blood leukocytogram and immunocytograms on the one hand, and gas-discharge images on the other. However, the question of the causal nature of this relationship remains open. What is primary: electrical activity of the brain, excretion of cytokines and hormones by immunocytes, or emission of photons and free electrons by acupuncture points [10, 11] (circulation of vital energy [20])?

Acknowledgment

We express sincere gratitude to administration of JSC "Truskavets'kurort" and "Truskavets' SPA" for help in conducting this investigation.

Accordance to ethics standards

Tests in patients are conducted in accordance with positions of Helsinki Declaration 1975, revised and complemented in 2002, and directive of National Committee on ethics of scientific researches. During realization of tests from all participants the informed consent is got and used all measures for providing of anonymity of participants.

For all authors any conflict of interests is absent.

References:

1. Babelyuk VYe. The parameters of gaz discharge visualization (kirlianogram) appropriately associated with some psychophysiological and endocrine parameters of healthy men. Medical Hydrology and Rehabilitation. 2013; 11(1): 21-30.

2. Babelyuk VY, Dubkova HI, Korolyshyn TA, Mysula IR, Popovych DV, Popovych IL, Zukow W. Relationships between caused by Kozyavkin© method changes in parameters of manual function and electroencephalogram, heart rate variability as well as gas discharge visualization in children with spastic form of cerebral palsy. Journal of Education, Health and Sport. 2018; 8(4): 159-194.

3. Babelyuk VYe, Dubkowa GI, Korolyshyn TA, Holubinka SM, Dobrovol's'kyi YG, Zukow W, Popovych IL. Operator of Kyokushin Karate via Kates increases synaptic efficacy in the rat Hippocampus, decreases C3-θ-rhythm SPD and HRV Vagal markers, increases virtual Chakras Energy in the healthy humans as well as luminosity of distilled water in vitro. Preliminary communication. Journal of Physical Education and Sport. 2017; 17(1): 383-393.

4. Babelyuk VE, Gozhenko AI, Dubkova GI, Babelyuk NV, Zukow W, Kovbasnyuk MM, Popovych IL. Causal relationships between the parameters of gas discharge visualization and principal neuroendocrine factors of adaptation. Journal of Physical Education and Sport. 2017; 17(2): 624-637.

5. Dobrovol's'kyi YuG, Gozhenko AI, Babelyuk VYe, Popovych IL. Method of water structuredness study with discharge-optical device and demonstration possibility of energy-information influence on it operator [in Ukrainian]. Water: Hygiene and Ecology. 2013; 2(1): 120-135.

6. Gozhenko AI, Popadynets' OO, Zukow WA, Popovych IL. Differences in parameters of the EEG and HRV in the humans with various levels of the entropy of EEG, HRV, immunocytogram and leukocytogram. In: Collection of Proceedings of the Scientific and Practical Conference: Galician Readings "Contemporary ideas on the pathogenesis of inflammation: local and systemic mechanisms" (Ivano-Frankivs'k, 19-20 September). Ivano-Frankivs'k. IFNMU; 2019: 73-74.

7. Gozhenko AI, Sydoruk NO, Babelyuk VYe, Dubkowa GI, Flyunt VR, Hubyts'kyi VYo, Zukow W, Barylyak LG, Popovych IL. Modulating effects of bioactive water Naftussya from layers Truskavets' and Pomyarky on some metabolic and biophysic parameters at humans with dysfunction of neuro-endocrine-immune complex. Journal of Education, Health and Sport. 2016; 6(12): 826-842.

8. Heart Rate Variability. Standards of Measurement, Physiological Interpretation, and Clinical Use. Task Force of ESC and NASPE. Circulation. 1996; 93(5): 1043-1065.

9. Kindzer BM, Babelyuk VY, Babelyuk NV, Popovych IL, Dubkova GI, Dobrovolskyi YG, Korsuns'kyi IH, Korolyshyn TA, Litosh S, Kindzer H, Zukow W. The device for electrostimulation "VEB-1" modulates parameters of electroencephalogram and gas discharge

visualization. Science and society. Proc of the 11th internat. confer. Acent Grafics Communications and Publishing. Hamilton, Canada; 2019: 159-171.

10. Korotkov KG. Basics GDV Bioelectrography [in Russian]. SPb.: SPbGITMO(TU), 2001. 360 p.

11. Korotkov KG. Principles of Analysis in GDV Bioelectrography [in Russian]. SPb. Renome; 2007: 286 p.

12. Kozyavkina OV, Kozyavkina NV, Voloshyn TB, Hordiyevych MS, Lysovych VI, Babelyuk VY, Dubkova HI, Korolyshyn TA, Mysula IR, Popovych DV, Zukow W, Popovych IL. Caused by Kozyavkin© method changes in hand function parameters in children with spastic form of cerebral palsy and their EEGs, HRVs and GDVs accompaniments. Journal of Education, Health and Sport. 2018; 8(10): 11-30.

13. Lapovets' LYe, Lutsyk BD. Handbook of Laboratory Immunology [in Ukrainian]. L'viv; 2002: 173 p.

14. Popadynets' OO, Gozhenko AI, Zukow W, Popovych IL. Relationships between the entropies of EEG, HRV, immunocytogram and leukocytogram. Journal of Education, Health and Sport. 2019; 9(5): 651-666.

15. Popadynets' OO, Gozhenko AI, Zukow W, Popovych IL. Interpersonal differences between of the entropies of EEG, HRV, immunocytogram and leukocytogram. Journal of Education, Health and Sport. 2019; 9(6): 534-545.

16. Popadynets' OO, Gozhenko AI, Zukow W, Popovych IL. Peculiarities of spectral parameters of EEG, HRV and routine parameters of immunity in patients with various levels of the entropy of EEG, HRV, immunocytogram and leukocytogram. Journal of Education, Health and Sport. 2019; 9(8): 617-636.

17. Popadynets' OO, Gozhenko AI, Badiuk NS, Zukow W, Popovych IL. Interpersonal differences between caused by adaptogens changes in the entropies of eeg, hrv, immunocytogram and leukocytogram. In: Rehabilitation Medicine and Health-Resort Institutions Development. Proceedings of the 19th International Applied Research Conference (Kyïv, 11-12 December 2019). Edited by O. Gozhenko, W. Zukow. Toruń, Kyiv. 2019: 51-53.

18. Popadynets' OO, Gozhenko AI, Badiuk NS, Zukow W, Kovbasnyuk MM, Korolyshyn TA, Popovych IL. Relationships between changes in entropy of the EEG and parameters of the immunity. Pedagogy and Psychology of Sport. 2020; 6(1): 24-40.

19. Popadynets' O, Gozhenko A, Badyuk N, Popovych I, Skaliy A, Hagner-Derengowska M, Napierata M, Muszkieta R, Sokołowski D, Zukow W, Rybałko L. Interpersonal differences caused by adaptogen changes in enropies of EEG, HRV, immunocytogram, and leukocytogram. Journal of Physical Education and Sport. 2020; 2(20); P. 982 – 999.

20. Puchko LG. Multidimensional Medicine. Systen of Self-diagnosis and Self-healing of Human [in Russian]. 10th ed, rev and ext. Moskva. ANS; 2004: 432 p.

21. Zukow W, Popadynets' OO, Gozhenko AI, Popovych IL. Interpersonal differences in parameters of the EEG and HRV in the humans with various levels of the entropy of the EEG, HRV, immunocytogram and leukocytogram. Journal of Education, Health and Sport. 2019; 9(7): 448-466.

Робота надійшла в редакцію 26.04.2021 року.
Рекомендована до друку на засіданні редакційної колегії після рецензування