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ORIGINAL ARTICLE

Vegetative status of children as a territorial bio-indicator of ecological safety

O.I. Furdychko[1], O.V. Mudrak*[2], O.V. Yermishev[3], H.V. Mudrak[4]

[1]Institute of Agroecology and Environmental Management NAAS of Ukraine, 12 Metrolohichna St, Kyiv, 03143, Ukraine,
[2]Vinnytsia Academy of Continuing Education, 13 Hrushevskyi St, Vinnytsia, 21050, Ukraine,
[3]Vasyl' Stus Donetsk National University, 21 600-Richya St, 21021, Vinnytsia, Ukraine,
[4]Vinnytsia National Agrarian University, 3 Soniachna St, Vinnytsia, 21008, Ukraine

**Corresponding author E-mail: ov_mudrak@ukr.net*

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The quantity of environment contaminators (pollutants) and their combinations cannot be counted and specified. Consequently, the current situation needs a change of principles of ecological control. In our case, the indicators of functional health of child population and levels of its vegetative disorders appear as integral bioindicators of individual health (dynamic stability of functional-vegetative homeostasis) and characterize the ecological dynamics in regions of compact settlement. Environmental certification of children functional health could define the region with a pre-crisis or crisis state of the environment. Vegetative levels (vegetative coefficients, k-V of functional-vegetative homeostasis testify to vegetative health (norm), or prevalence of sympathetic and parasympathetic activity. Permanent functional voltage distorts the pathogenesis of functional-vegetative adaptation and requires specific monitoring in the form of "Functional-ecological expertise" (FEE) of selected staff. The basis of the FEE methodology developed by us is "Functional-vegetative diagnostics" (FVD) by the method of V.G. Makats. The diagnostic complex "BIOTEST-12M" (Diagnostic complexes VITA-01-M and computerized system VITA-01-Biotest) serves as the technical tool of the FVD. Indicators of - vegetative coefficients (k-V = ΣSA: ΣPSA; (levels of vegetative balance, sympathetic, or parasympathetic activity) act as integral bioindicators of internal homeostasis and its dependence on the conditions of the environment. The criterion of FEE is a systemically dependent comparison of inhibition of the functional activity of the organism (parasympathetic activity (PA), vegetative equilibrium (VE) and sympathetic activity (SA) and can be calculated for children in particular region. This, we suggested the integral characteristic of territorial ecological state and the levels (zones) of ecological pressure.

Key words: Vegetology; Vegetative Nervous System (VNS); Functional-vegetative homeostasis; Functional-vegetative diagnostics (FVD); Children

Introduction

The anthropoecological approach is promising for environmental indication. It can evaluate the impact of environmental conditions on a population: its spatial structure, population dynamics, gene pool, adaptive capabilities, growth, development and aging processes (Van den Brink et al., 2018). It was established that environmental factors gain one of the first places among the factors affected the health (genetic, climatic, endemic, epidemiological, professional, social) (Prescott et al., 2019; Góralczyk & Majcher, 2019). The analysis of the influence of environmental factors on human health (neutral, positive, negative) should be carried out using any units of measurement. What parameters do adequately characterize the anthropoecological status of the area.

One of the most important areas it is the analyze of regional population incidence. However, firstly, a sufficient number of people are often observed in medical institutions outside their area and there is no statistics on their diseases in the community. Secondly, the diseases are often associated with the side effects of medical pharmaco-chemical agents (up to 30% of hospital days), and this does not directly affect the influence of negative environmental factors. Thirdly, it is impossible to accurately determine the share of the "guilt" of the regional environmental situation in the development of most diseases. Fourth, many diseases (for example, oncological diseases) occur latently for decades and, due to the time gap between the onset of the disease and its clinical manifestations, cannot be used as an adequate anthropoecological criterion. Fifth, the picture of morbidity is distorted by the fact that some of the working-age population today is out of economic considerations (low pay for disability days, the threat of reductions, etc.) does not seek help from medical institutions. Thus, the incidence rates of the population of a particular region cannot be an exhaustive argument of the environmental characteristics of a given territory.

An important task of the hygienic assessment of the "environment - health" system is to determine the complex anthropogenic load (Rezende & Bozinovic, 2019). Complex anthropogenic man-made urban environment consists of multifactor indicators - quantitative characteristics of the main environmental factors that determine the real load on the human body (Hennig et al., 2018). These are indicators of chemical and biological pollution of air, water and soil, level of noise, electromagnetic and ionizing radiation (WHO, 2016; Iszatt et al., 2016; Spicer et al., 2019). The determined value of the complex load on the body can be quantified by one indicator related to the hygienic standard - in this case, a value equal or less than acceptable level. The development of methods for the rapid medical diagnosis of large population is currently difficult; however, certain conceptual principles of its organization can be identified. Along with anthropometric data and heart rate variability indicators, the methods of electro-puncture diagnostics (EPD) are widely used to assess the level of population health (Makats et al., 2018). The basis of these methods is the theory of close relationship between the functional state of the internal organs and human systems with electrical resistance at certain biologically active zone (points) (BAZ) on the surface of the body. Scientific substantiations have been found for many concepts and laws of ancient oriental physicians, though acupuncture and reflex diagnosis are recognized by WHO as scientific and recommended issue in public health practice. The existence of the projection of the internal organs on the skin, the auricle, the iris, the surface of the tongue has been proved. The interrelation between internal organs and skin is confirmed by the presence of Zakharyin-Ged zones, pain points of Mac-Burney, Mac-Kenzie, Vidal, and Boas. Obviously, the most indicative "indicator" of environmental distress is the children's organism (Zheng et al., 2016; Vrijheid et al., 2016). Children are the most convenient objects for medical and environmental monitoring, as their bodies react to lower concentrations of toxic substances more quickly than the adult's body, and therefore children are more susceptible to regional environmental factors. Besides, they practically do not leave the living area. Children's body is also a marker of hypersensitivity to xenobiotics (Russ & Howard, 2016). Biological monitoring and identification of children with hypersensitivity to chemical agents is more important than expanding the environmental monitoring programs to determine the concentration of various chemical agents.

Apart from environmental influences, the adult deal with many other important factors: work activity (10–15 hours during the day with travel time) outside the area of residence, professional and interpersonal conflicts, financial distress, career problems, and ingrained irrational stereotypes of behavior. Thus, we can conclude that ratio of environmental factors affected the children is much greater than for the adults.

Material and Methods

The methodology of functional-vegetative diagnostics (FVD) elaborated by V. G. Makats (2016) allowed to identify acupunctural channels and discovers a previously unknown human functional-vegetative system. This method was approved for application in medical practice by the Academic Council of the Ministry of Health of Ukraine and by the joint session of the State Problem Commissions (SPC) of Paediatrics, Obstetrics and Gynaecology, Quantum Medicine, Haematology and Transfusiology, New Medical Technology and New Diagnostic Tools (Minutes No. 1, 08–01 of 11 September 1994).

Currently, this is the only "electropunctural" diagnostics, results of which are stable and comparable in time. It is based on previously unknown biophysical phenomena. "Electropunctural" diagnostics has original standardization and is directed at the evaluation of functional-vegetative homeostasis: correlation of syndromes of sympathetic (YANG) and parasympathetic (YIN) activity. The diagnostic complex "BIOTEST-12M", which consists of two diagnostic complexes VITA-01-M and the computerized system VITA-01-Biotest, serves as the technical component of the FVD. The latter does not use traditional external power sources and the SPC "New medical technology and new methods of diagnostics, prevention and rehabilitation" by the Ministry of Health of Ukraine (Minutes No. 5 of 25 December 25 1991) and Scientific Council of Ministry of Health of Ukraine (record No. 1. 08–01, 11 January 1994) was approved for practical use.

The reliability of the obtained data was estimated by means of parametric and nonparametric statistics. The analysis of the results was carried out with computer programs "Search". The system VITA-01-M does not require metrological standardization because (Makats at al., 2016; Yermishev, 2019): (1) the FVD methodology does not require external sources of power; (2) the voltage of the closed individually-diagnostic circuit does not exceed the level of the membrane potential (0.03–06 V); (3) analysis is needed not for absolute values of diagnostic indices, but for a relative correlation of the total activity of functional systems of YANG/YIN groups (syndromes of sympathetic/parasympathetic activity of functional systems). Reasonability of functional-vegetative examination of children is confirmed by the programme "A two-stage system for rehabilitation of vegetative disorders in children residing in the zone of ecological control of Ukraine" (conducted according to the Resolution of the Cabinet of Ministers of Ukraine No. 1861/4, 4 April 1997 and No. 12010/87, 01 June 1999). The received data in mV (millivolts) or in mkA (microampere) of FVD is transformed into average values.

Changes in the physiological state of the body are manifested by the transformation of electro-skin resistance in certain functionally-active zones (FAZ) of the skin, which topographically coincide with the course of 12 classical acupuncture meridians (functional systems) – the bladder (BL), the gall bladder (GB), the stomach (ST), the small intestine (SI), the lymphatic system (TE), the large intestine (LI), which form a sympathetic orientation of the autonomic balance, and the spleen and pancreas (SP), the liver (LR), the kidney (KI), the lungs (LU), the pericardium (PS), and the heart (HT), which form the parasympathetic orientation of the autonomic balance. The relative ratio of the sum of indicators of total sympathetic activity to parasympathetic activity determines the orientation of the vegetative balance. The correlations between changes in electrical conductivity in 24 representative FAZ (characterizing the state of the meridian as a unity) and the state of classical acupuncture meridians "determining" the functional state of their respective internal organs and systems of the organism are used for the diagnosis. We determined the overall bioelectric activity of functional systems of SA and PA groups, and the vegetative coefficient of their interdependency (k-V = $\sum$ SA : $\sum$ PA (Makats at al., 2017; Yermishev, 2017). From the point of view of vegetative homeostasis, the latter points to the correlation of sympathetic and parasympathetic functional activity. Functional autonomic systems ("acupuncture channels") are based on the international acupuncture nomenclature (IAN) suggested by the WHO.

The following zones (levels) of functional-vegetative homeostasis are scientifically based on the coefficients of functional-vegetative homeostasis (Table 1). FVD was held twice in the first half of the day (from 10:00 till 12:00). The bioelectric activity of 12 symmetric pairs of functional active skin zones (24 FAZs) was studied. Attention was drawn to the dynamics of the levels of the vegetative equilibrium (LVE) and to the direction of the dispersion of levels of integral vegetative homeostasis over the years of life.

Results and Discussion

It would be perfectly great if we immediately draw attention at the fact that the quantity of environment contaminators (pollutants) and their combinations cannot be counted and specified. That is why, current situation needs a change of principles of ecological control. One of them is "bioindication", which is conditioned by integral response of organism to ecological influence (Serrano & Oliveira at al., 2019). In our case, indicators of functional health of child population and levels of its vegetative disorders appear as integral bioindicators of individual health (dynamic stability functional-vegetative homeostasis) and characterize ecological dynamics in the region of compact habitation. Environmental certification of the functional health of the children population locates the region with a pre-crisis or crisis state of the environment. It predicts the functional health of children and their dependence on environmental pressures (prevention of critical situations).

Table 1. Zone (levels) of functional-vegetative homeostasis.

Value of k	Zone of functional attention	Symbol of zone
to 0.75	syndrome of significant parasympathetic prevalence	PA-s
0.76-0.86	syndrome of expressed parasympathetic prevalence	PA-e
0.87-0.94	functional compensation zone of the parasympathetic activity	FcP
0.95-1.05	zone of functional vegetative equilibrium	VE
1.06-1.13	zone of functional compensation of sympathetic activity	FcS
1.14-1.26	syndrome of expressed sympathetic prevalence	SA-e
≥ 1.26	syndrome of significant sympathetic prevalence	SA-s

Vegetative levels (vegetative coefficients (k-V) of functional-vegetative homeostasis testify to vegetative health (norm), or prevalence of sympathetic and parasympathetic activity. A modern feature was the daily environmental-negative pressure on the health of the children's population. Radiation pollution of the environment, household electromagnetic smog, pollutants of anthropogenic origin and psychosocial stress cause permanent "integral environmental stress" (IES). Its initial influence manifests itself at the functional level and forms the basis of "endoecology". Permanent functional voltage distorts the pathogenesis of functional-vegetative adaptation and requires specific monitoring in the form of "Functional-ecological examination" (FEE) of selected staff. The basis of the FEE methodology developed is "Functional-vegetative diagnostics" (FVD) by the method of V.G. Makats and corresponds to the Human Strategy for Survival, agreed at the 2-nd UN conference on "Development and the Environment" (Rio de Janeiro, 1992) (Makats at al., 2017; Yermishev, 2017).

The criterion of the FEE of a particular region of residence of the children is a systemically dependent comparison of inhibition of the functional activity of the organism (parasympathetic activity (PA), vegetative equilibrium (VE) and sympathetic activity (SA). On this basis, an integral characteristic of the ecological state is formed and the levels (zones) of its ecological pressure.

Indicators of Functional-vegetative diagnostics (FVD) using the method of V.G. Makats - vegetative coefficients (k-V = ΣSA: ΣPA; (levels of vegetative balance, sympathetic, or parasympathetic activity) act as integral bioindicators of internal homeostasis and its dependence on the conditions of the environment.

For functional-ecological expertise (estimation) of settlements and territories of environmental control, indicators of vegetative dispersion (scattering of vegetative levels).

Today seven levels of vegetative dispersion (dispersion) children's functional health have been highlighted (Table 1). Vegetative variance (VD) documentally visualizes the state of functional health of the child population. The second (more informative) index of variance of levels of vegetative equilibrium (LVE) serves their distribution in "critical zones". Under the term "critical zones" (KZ) there are three groups of conditionally united of levels of vegetative equilibrium (LVE):

- in the zone of admissible vegetative (functional) equilibrium (VE), enter total number of cases
∑ = FcP +VE + FcS;
- in the critical area of parasympathetic activity (PA) enters total number of cases ∑ = PAs + PAe;
- in the critical area of sympathetic activity (SA) is included total number of cases ∑ = SAe + SAs.

The ratio of the parameters of PA-VE-SA testify to the state of the ecological safety of the region and the activities of public health authorities (Makats at al., 2017; Yermishev, 2017).

The zone (region) of ecological control (functional health) forms the parasympathetic (PA), permissible vegetative equilibrium (VE) and sympathetic (SA) activity (Table 2).

Table 2. Dependence of the functional ecological disturbance of the territory on the state of averaged deviations of the autonomic nervous system.

Variables	PA	VE	SA
Zone of relative functional safety (RFS)	15	70	15
Zone of high functional attention (HFA)	25	50	25
Functional voltage development Zone (FVD)	30	50	20
Zone of functional disaster development (FDD)	45	40	15
Functional disaster zone (FD)	65	25	10
Functional protection voltage zone (FVP)	10	25	65

To evaluate the deviations of the indicators of functional vegetative coefficients (k-V) population, we have developed functional-vegetative norms (passports) for each age group, taking into account gender peculiarities.

Recognizing "Functional health" is environmentally dependent; let's consider its features in separate age groups. In this case, parasympathetic and sympathetic vegetative deviations will be evaluated as a violation of the mechanisms of adaptation (the ability to adapt to survival).

When analyzing the age structure of the population it is customary to allocate the following main age groups:

1. Pre-school age (first childhood) (PSA) 3-6 years;
2. Junior school age (Second childhood) (JSA) 7-11 years;
3. Adolescent school age (Teens) (ASA) 12-15 years;
4. Juvenile school age (Youth Period) (JvSA) 16-21 years;
5. Adalt age (Mature age) (AA) 22-60 years

Pre-school age (first childhood) (PSA) 3-6 years: Age variance of vegetative levels (in %) by functional zones of preschool age (3-6 years) indicates the following (Table 3): in the zone of PA there are 28,3/35,6% of the examined children; in the VE zone 59,3/47,3%; in the zone SA 12,5/17,1% (Yermishev, 2019).

Table 3. Vegetative dispersion by Functional zones of pre-school age (PSA) in %.

Years of life	PA (PAs + PAe)	VE (FcP + VE + FcS)	SA (SAe + SAs)
3	24,1/66,3	72,4/22,2	3,4/11,1
4	17,4/20,9	69,6/62,8	13,0/16,3
5	23,9/27,4	52,2/53,2	23,9/19,4
6	47,6/27,7	42,9/50,8	9,5/21,5
M = 3-6	28,3/35,6	59,3/47,3	12,5/17,1

Here and below: */* female/male group; PA - Zone of parasympathetic activity, VE - Zone functional equilibrium, SA - Zone of sympathetic activity

With each passing year, the number of cases of PA increases, and FE - decreases. In this case, prolonged vegetative disorders (the advantage of parasympathetic, or sympathetic activity) form pathogenetic mechanisms of future functional disorders.

Junior school age (Second childhood) (JSA) 7-11 years: Vegetative age variance over the functional zones of the junior school age (JSA, 7-12 years) indicates the following (Table 4): in PA zone here are 30.9/27.6% of the examined children; in VE zone 50.4/56.0%; in SA zone 18.4/12.9%.

Table 4. Vegetative dispersion by Functional zones of junior school age (JSA) in %.

Years of life	PA (PAs+PAe)	VE (FcP + VE + FcS)	SA (SAe + SAs)
7	30.7/24.8	50.0/60.4	19.3/4.0
8	28.3/23.3	50.0/57.9	19.7/18.8
9	31.7/24.4	51.3/59.1	17.0/16.5
10	28.5/28.6	52.4/54.1	19.1/17.3
11	34.3/31.8	47.9/53.6	17.8/14.6
12	31.8/32.8	50.9/51.0	17.3/6.2
M = 7-12	30.9/27.6	50.4/56.0	18.4/12.9

By the years of life of JSA, the sexage characteristics of the vegetative dispersion have been detected.

Adolescent school age (Teens) (ASA) 12-15 years: Age variance of vegetative levels (in %) by functional zones of adolescent school age (12-15 years) indicates the following (Table 5): in the zone of PA there are 36,4/34,0% of the examined children; in the VE zone 49.9/52.9%; in the zone SA 15.8/13.8%.

Table 5. Vegetative dispersion by Functional zones of adolescent school age (ASA) in %.

Years of life	PA (PAs + PAe)	VE (FcP + VE + FcS)	SA (SAe + SAs)
13	36.0/31.6	47.9/52.5	16.1/15.9
14	33.0/36.8	51.8/53.1	15.2/10.1
15	33.9/31.4	49.9/53.1	16.2/15.5
M = 12-15	36.4/34.0	49.9/52.9	15.8/13.8

By the years of life of ASA, the sexage characteristics of the vegetative dispersion have been detected and relative sexual-age stabilization of vegetative dispersion.

Juvenile school age (Youth Period) (JvSA) 16-21 years: Age variance of vegetative levels (in %) in the functional zones of adolescence (16-21 years) indicates the following (Table 6): in the area of PA there is 24,7/42,2% of the examined children; in the zone of VE 56.4/39.3%; in the zone of SA 18.6/18.5%."

Vegetative dispersion of the Juvenile school age has pronounced sexual age features:
- With each passing year, the number of cases of PA in the male group increases, and in the female, on the contrary, decreases.
- With each passing year, the number of cases of VE in the male group decreases, and in women is predominantly increasing.

Adult age (Mature age) (AA) 22-60 years Age variance of vegetative levels (in %) by functional zones of adult age (21-60 years) indicates the following (Table 7): in the zone of PA there are 46.7/53.8% of the examined; in the VE zone 40.8/37.5%; in the zone SA 12.5/8.8%.

Table 6. Vegetative dispersion by Functional zones of juvenile school age (JvSA) in %.

Years of life	PA (PAs + PAe)	VE (FcP + VE + FcS)	SA (SAe + SAs)
16	25.3/35.3	57.0/55.0	16.3/9.7
17	17.5/28.4	57.7/58.0	24.7/13.6
18	18.2/40.0	62.0/30.0	19.8/30.0
19	17.7/50.0	58.9/25.0	23.5/25.0
20	45.0/57.1	46.4/28.6	8.6/14.3
21	23.9/56.2	45.3/29.1	9.0/15.4
M = 16-21	24.7/42.2	56.4/39.3	18.6/18.5

Table 7. Vegetative dispersion by Functional zones of adalt age (AA) in %.

Years of life	PA (PAs + PAe)	VE (FcP + VE + FcS)	SA (SAe + SAs)
M = 21-60	46.7/53.8	40.8/37.5	12.5/8.8

Over the years of life, the sex-age characteristics of the vegetative dispersion have been detected. With each passing year, the number of cases of PA increases, and VE and CA - decreases.

The current state of the human environment in Ukraine is quite complex and causes considerable concern. Although it should be noted positive changes in this aspect: reduction of air pollution by harmful substances, including sulfur dioxide, nitrogen dioxide, methane and other hazardous compounds (Mudrak, 2008); increase in capital investments in environmental protection and rehabilitation; introduction of ecological education of the younger generation (Mudrak & Mudrak, 2017).

The modern environmental situation in Ukraine has the problems appeared some decades ago. Therefore, the prospects for improving the environment now depend not so much on the intention to take environmental measures, but on the real possibilities of eliminating the consequences of the already caused environmental damage and creating a system of continuing environmental education (Mudrak &, Mudrak, 2019).

Multicomponent and multifunctional system environment-health of the population requires non-standard approaches to the study of its inherent phenomena and interactions of factors. The solution of the problem undoubtedly requires the training of heads of state structures, the application of the methodology of integrated environmental monitoring, associated with multifactor analysis of the whole set of environmental components and a set of indicators that characterize the health of the population (Mudrak et al., 2019).

The study of the ecological condition of the territory and the morbidity of the population is the basis for a deeper understanding of the relationships between these parameters, which allows to develop sanitary and health and anti-epidemic measures. The obtained results help to implement the most effective of them, as well as to implement appropriate scientifically sound proposals for their practical implementation by government agencies, enterprises, institutions and organizations.

Conclusion

Functional-vegetative health of children is ecologically dependent, is a bioindicator and is the basis of functional-ecological expertise (FEE) of the regions of ecological control. The suggested research method is non-invasive and low-cost, which allows conducting surveys of different age and sex groups and obtaining data with a minimum statistical error.

The proposed method is extremely promising in bioindication of territories contaminated with radionuclides, chemical means of plant protection, territories with contaminated objects of the hydrosphere and atmosphere, allows to estimate the total effects of all negative environmental factors on human health. The program of FEE allows grounding expert assessment of the region of habitation of children according to the indications of individual functional health. From governmental point of view, FEE personifies a certain region and characterizes the appropriate efforts of local authorities (dynamics of indexes of functional health of children would point to their quality).

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