Yermishev O. V. The influence of the seasons of the year on the autonomous nervous system balance and the functional health of men of different age groups. Journal of Education, Health and Sport. 2020;10(2):241-252. eISSN 2391-8306. DOI http://dx.doi.org/10.12775/JEHS.2020.10.02.029
https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2020.10.02.029
https://zenodo.org/record/3754759

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 31.01.2020. Revised: 10.02.2020. Accepted: 28.02.2020.

THE INFLUENCE OF THE SEASONS OF THE YEAR ON THE AUTONOMOUS NERVOUS SYSTEM BALANCE AND THE FUNCTIONAL HEALTH OF MEN OF DIFFERENT AGE GROUPS

O.V. Yermishev

Vasyl' Stus Donetsk National University,
Faculty of Chemistry, Biology and Biotechnology, Department of Biophysics and Physiology
600-richya St. 21, 21021, Vinnytsia, Ukraine
Tel: +380676504433. E-mail: o.yermishev@donnu.edu.ua
ORCID iD https://orcid.org/0000-0001-5854-9678

Abstract

Introduction. It was found that the body's response to various stressful effects is largely determined by the ratio of the tone of the sympathetic and parasympathetic parts of the autonomic nervous system. It was revealed that in those days when a predominance of the parasympathetic nervous system tone was noted stressful effects caused more significant and negative changes in the body. The autonomic nervous system is also influenced by climatic factors. **Materials and methods.** 5305 males of different age were examined with the help of functional vegetative diagnostics according to the method of V. Makats. The bioelectric activity of 12 symmetric pairs of functionally active zones of the skin (24 FAZ), 12 on the hands and 12 on the feet, which reflect the functional activity of the sympathetic and parasympathetic nervous systems were studied. **Results.** In the study of systemic age dependence in all male observation groups the change of seasons of the year has been found to lead to changes in functional activity and homeostasis of the organism. The seasonal

indicators of the activity of functional systems (FS) are clearly observed to duplicate the norm line, differing in amplitude and having the same orientation. Moreover, the presence of significant changes in the studied parameters of activity indicators of FS with the norm line indicates that all seasons of the year were characterized by differences. **Conclusions**. It has been established that the season change on the body leads to significant changes in functional activity and homeostasis of men of different age groups. The dependence of these indicators indicates a species evolutionary adaptation of a human to seasonal changes in climatic conditions.

Key words: Seasons; Spring; Summer; Autumn; Winter; autonomic nervous system balance; health

The change in the seasons of the year is characteristic for some functions of the human body. This applies to body temperature, metabolic rate, the circulatory system as well as the composition of blood cells and tissues [1]. Human health is largely dependent on weather conditions. Biological rhythms with a period of one year (circannual) are traditionally called seasonal rhythms. Despite the progress in the development of the means of protection against sudden changes in environmental parameters, one-year fluctuations in biochemical, physiological and psychophysiological processes are found in humans [2, 3]. Seasonal biorhythms, covering essentially all functions, are reflected in the state of the organism as a whole, on the health and working capacity of a person. There are external and internal factors causing circannual (circadian) rhythms. These are adaptive changes in the functional state of the body, aimed at compensating for the annual fluctuations in the basic parameters of the environment and, above all, temperature, as well as the qualitative and quantitative composition of food; the reaction to signaling environmental factors - daylight hours, geomagnetic field strength, some chemical components of food [4]. Environmental factors playing the role of seasonal “time sensors” can cause significant morphofunctional changes in the body. The action of endogenous mechanisms of seasonal biorhythms being adaptive in nature provide a full adaptation of the body to seasonal changes in environmental parameters [5].

The reaction of an organ, tissue or physiological system to the action of an irritant is known to be substantially dependent on their initial state. It was found that the body's response to various stressful effects is largely determined by the ratio of the tone of the sympathetic and parasympathetic parts of the autonomic nervous system. It was revealed that in those days when a predominance of the parasympathetic nervous system tone was noted

stressful effects caused more significant and negative changes in the body. The autonomic nervous system is also influenced by climatic factors. The violations are manifested primarily in the functions of the cerebral cortex under adverse environmental influences. The effect of low air temperature, large fluctuations in atmospheric pressure, strong winds and other strong stimuli trains the nervous system, increases its ability to give a stenic (sympathicotropic) reaction to a strong stimulus, ultimately leading to a decrease in exhaustion and lability of vegetative reactions, to strengthen the normal stenic reaction to moderate stimuli and to the restoration of the type of autonomic reaction inherent in this constitution is the normal state [6, 7]. To date, the literature has not fully covered data on the influence of seasons on the vegetative balance of the human body, the ratio of the activity of the sympathetic nervous system (SNS) to the parasympathetic nervous system (PNS) one as well as functional health of the population. Aim. The aim is to investigate the influence of seasons on the autonomic balance of the human body, the ratio of sympathetic nervous system (SNS) activity to the parasympathetic nervous system (PNS) one as well as the functional health of men of different age groups.

Materials and methods of the research. 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) - lungs (LU), pericardium (PC), heart (HT), colon (C), condition of the lymphatic system (TE), large intestine (LI), spleen and pancreas (SP), liver (LR), kidney (KI), bladder (BL), gall bladder (GB) and stomach (ST). 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.

With the help of the functional-vegetative diagnostics (FVD) according to the method of V. Makats we 5305 men of different age were examined. They were having sanatorium and health improvement in sanatoriums of Ukraine. FVD was conducted in the morning (10:00–12:00). The bioelectric activity of 12 symmetric pairs of functionally active skin zones (24 FAZ), 12 on the hands and 12 on the feet, which reflect the functional activity of the sympathetic and parasympathetic nervous systems, was studied [5, 8]. The FVD according to the method of V. Makats and devices for its implementation were officially approved by the Ministry of Health of Ukraine "New Medical Equipment and New Methods of Diagnosis" (№

5 from 25.12.91; № 1.08-01 from 11.01.94) and the Scientific Council of the Ministry of Health of Ukraine (No. 1.08-01 of 11/01/94).

For FVD a VITA 01 M device is used, the voltage in the closed circuit of which does not exceed the levels of membrane potentials (1-5 μA; 0.03 - 0.6 V). The device does not require external energy sources for its operation. It has 2 diagnostic electrodes, a base electrode acceptor of electrons (AE) - a convex plate of a special alloy, pre-coated with an oxide film (5x7 cm) and 2 paired diagnostic electrodes (DE - electron donors) in the form of a silvered pair, which are located in ebonite cups with a diameter of 1 cm and wrapped with foam gaskets. The base electrode (AE) is fixed by a special belt through a moist pad (moistened with saline solution) in the umbilical region (central mesogastric area (0-zone) with medium density tension to create stable examination conditions. Diagnostic electrodes (DE) are also moistened with saline solution. The procedure is performed in the orthostatic position of a person. In the process of testing electrodes, DE are placed at right angles with a slight pressure (at the touch level), simultaneously contact with each pair of symmetric FAZ (left-right at each extremity) for 1-4 seconds to obtain stable performance in micro amperes. Electrodes are remoistened with saline solution after every 3 contacts with the FAZ. Obtained in mA data of FVD are transformed into relative values. The obtained data are compared with the norm and it is concluded about the degree of deviation from it and the level of functional health impairment [8]. Mathematical and statistical processing of the results of the observations was carried out using the method of nonparametric statistics proposed by E.A. Derevyanko to determine the magnitude of the shift of the function under the study [9].

Results and Discussions. A characteristic feature of the growth process of a child's body is its irregularity, or heterochronism, and undulation. Periods of intensified growth are replaced by some slowdown in these processes [10]. The heterochrony in the processes of development of individual systems of the body is observed not only when comparing the rate of their growth. Some parts of physiological systems also mature unevenly. Growth inequality is an adaptation produced by evolution. Rapid growth of a body in length in the first year of life is connected with the increase of weight of a body. Thus, slowdown of growth in the following years is caused by active processes of differentiation of organs, tissues, cells. The child's body develops in a specific environment, which continuously affects the child's organism and largely determines the course of its development. The course of morphological and functional rearrangements of the body of a child at different ages is subjected to the action of genetic and environmental factors. Depending on the specific environmental conditions, the development process may be accelerated or slowed so its age may come

sooner or later and have different duration. The qualitative originality of the child's organism, which changes at every stage of individual development, is manifested in everything, but, first of all, in the nature of its interaction with the environment. It should not be assumed that the biological fund the baby is born with cannot be further shaken or altered. Under the influence of the environment, certain hereditary qualities can be realized and developed if the environment contributes to it, or vice versa, inhibited.

In the study of systemic age dependence in the male group of preschool age (PS) 3-6 years, it has been found that the change of seasons of the year leads to changes in the functional activity and homeostasis of the organism (Fig. 1).

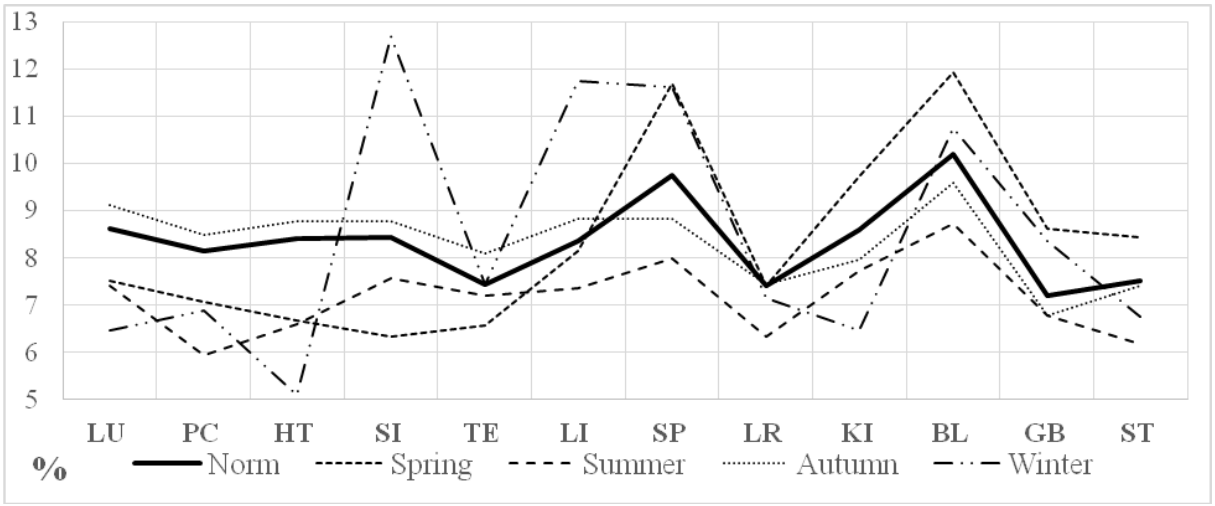

Fig. 1. Systemic age dependence in the male group of 3-6 years (preschool age (PS) in different seasons, $p \leq 0.05$.

It is clearly observed that the phased monthly activity indicators of functional systems (FS) duplicate the norm line, differing in amplitude and have the same orientation. Moreover, the presence of significant changes in the studied parameters of activity indicators of FS with the norm line indicates that all seasons of the year were characterized by differences, but the biggest ones were observed in the winter. In spring the activation of physiological functions is predicted which is manifested by an increase in the activity of FS of the spleen and pancreas (SP), kidneys (KI), bladder (BL), gall bladder (GB) and stomach (ST) and a decrease in other FS. There is a parallel activation of the sympathetic nervous system (pacemaker bladder (BL) and parasympathetic nervous system), (pacemaker spleen and pancreas (SP). In summer there is an activity decrease and in autumn the activity increase of all functional systems is observed. In winter there is an overstress of the FS activity. A significant decrease in activity

of FS of lungs (LU), pericardium (PS), heart (HT), kidneys (KI) and stomach (ST) and an increase in FS of small intestine (SI), large intestine (LI), spleen and pancreas (SP) and bladder (BL) have been revealed. In general, a rather chaotic pattern of functional dependencies may be related to the physiological and functional immaturity of the adaptation processes and the speed of their formation and stabilization in the body of children 3-6 years [10].The rapid rate of morphological and functional development of all organs and systems, the incompleteness of immunity during this period contribute to the increasing of the sensitivity of the children organism to changes in environmental factors, both for environmental physiological and pathological.

The boundaries of adolescence are quite conditional and in life there are significant individual variations in both the rate of the development and the timing of the onset of certain characteristic features of this period [11]. Adolescence in its originality and pace is sharply different from other stages of the human life. From a physiological point of view, the adolescent period is characterized by intense growth, increased metabolism, a abrupt increase in the activity of the glands of internal secretion. Adolescence is the period of puberty. The activity of the pituitary gland, especially its anterior lobe, which stimulates the growth of tissues and the functioning of other endocrine glands (genital, thyroid, and adrenal glands) is activated. Their activity causes a "jump in growth", the development of genitals and the appearance of secondary sexual characteristics. Due to the increased function of the pituitary and adrenal glands, the adaptive capacity of the body to environmental conditions improves as well as the resistance to infections, cooling, and so on. During adolescence lungs grow, breathing improves (although its rhythm remains accelerated), significantly increasing the capacity of the lungs. Increased growth of organs and tissues places increased demands on the activity of the heart. It is also growing rapidly during this period, but the growth of blood vessels is lagging behind the rate of growth of the heart. Therefore, adolescents often have high blood pressure, impaired rhythm of cardiac activity, quickly occurring fatigue and there is insufficient blood supply to the brain. Changes in the internal environment of the organism, increased functioning of the glands of the internal secretion also change the functional state of the nervous system of the teenager. The increased function of the thyroid gland increases the level of metabolism and energy consumption in the body, changes the excitability of the central nervous system, which is expressed in increased irritability, mild fatigue, sleep disorders. In addition, during this period attenuation of all types of internal inhibition is observed.

The study of system-age dependence in the male group of 12-15 years (adolescent school age (PSA) in different seasons of the year revealed that the change of seasons of the year leads to changes in functional activity and homeostasis of the organism (Fig. 2).

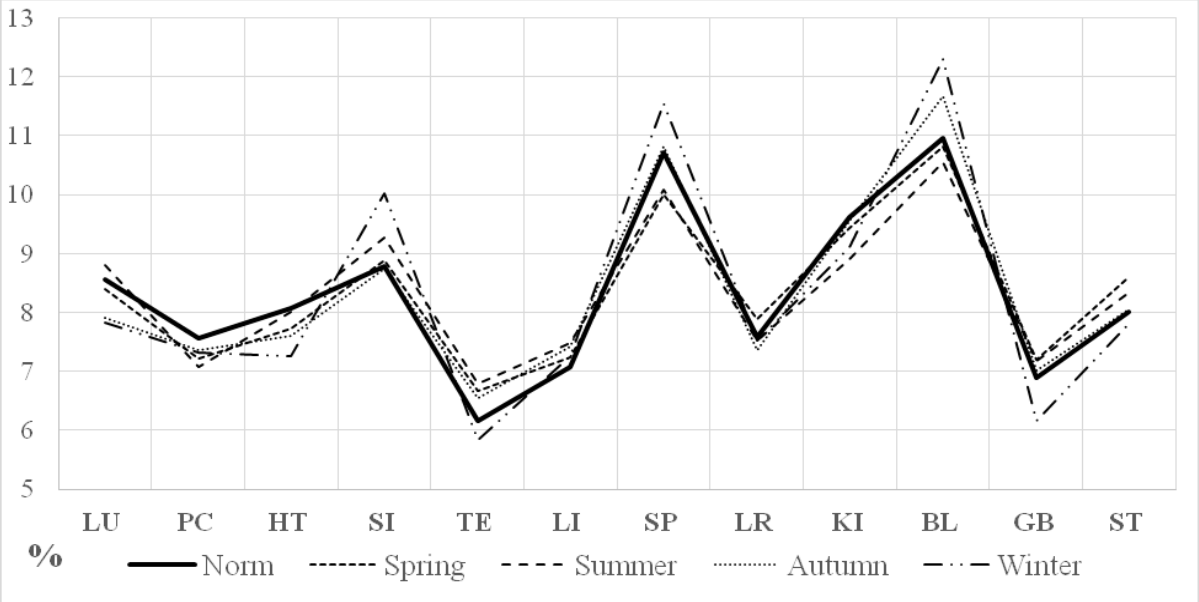

Fig. 2. Systemic age dependence in the male group of 12-15 years (adolescent school age (ASA) in different seasons, $p \leq 0.05$.

Changes in activity indicators of FS are observed with much smaller amplitude and almost coinciding with the age physiological norm. Thus, the nature and direction of changes in activity are similar, compared with the male group of 3-6 years. The analysis of the figure shows the stabilization of adaptation-adaptive mechanisms in the body of boys in this group of observations.

Although the process of human aging is a physiological process, it is accompanied by increasing age-related disorders of the structure and function of many organs and systems of the body associated with the damaging effect of various factors, both exogenous and endogenous. The aging process is associated with structural and functional changes at the molecular, cellular, organ and systemic levels which leads to a decrease in the adaptive reactions and reactivity of the organism of mature patients and is accompanied by a more severe course of all diseases. The involution processes begin after 20-25 years old (the end of body formation). They affect all cells, tissues, organs, body systems and their regulation. The first group of age-related changes includes the contractility of the myocardium and skeletal muscles, visual acuity, hearing and functioning of nerve centers, functions of the digestive

glands and internal secretion, the activity of enzymes and hormones. Blood sugar, acid-base balance, membrane potential, morphological composition of blood are in the second group of indicators etc [12]. The indicators and parameters that gradually increase with age include the synthesis of hormones in the pituitary gland (ACTH, vasopressin), sensitivity of cells to chemical and humoral substances, blood cholesterol, lecithins and lipoproteins. Homeostasis (relative constancy of the internal environment of the body) is the most important physiological characteristic of young people, for mature and elderly people it is homeorhesis (age-related changes in the basic parameters of the body). The most significant age-related changes occur in people aged 50-60 and, besides, various diseases often develop at this time. Recent studies have shown that the body's ability to adapt to the usual environmental factors changes with its age, which ultimately leads to the development of chronic stress reactions in the elderly. The activity of the hypothalamic part of the brain, which is responsible for the regulation of the internal environment of the body, does not decrease with age, though, it rather increases. This is manifested through increasing thresholds for homeostatic inhibition, metabolic disturbance and the development of chronic stress. The increase in the thresholds of perception of various irritations is, first of all, due to a decrease in the reactivity of the body of the elderly people. These age-related physiological characteristics lead to a change in homeostasis, the development of stress reactions, a deterioration in the functions of various organs and systems and a decrease in mental and physical performance. An age-related decline in the function of the endocrine glands leads to the development of three “normal” diseases of aging - hyperadaptosis, menopause and obesity. Hyperadaptosis (an excess stress reaction) develops due to an increase in the threshold of sensitivity of the hypothalamus to defense hormones, in particular, to the adrenal hormone - cortisone. Therefore, unfavorable factors which were quite tolerable at a young age, become redundant in the elderly one and hyperadaptosis occurs. A person lives in a narrower range of changes in the external and internal environment being at old age.

The study of systemic age dependence in the male group of 21-50 years old (mature age (MA)) in different seasons of the year showed that the activity of the main FS and vegetative homeostasis have a causal effect on the changes of the seasons of the year (Fig. 3). Moreover, you can identify specific features inherent in men of this age group. The maximum amplitude fluctuations of the functional activity of the systems and vegetative homeostasis are observed in spring and summer periods. In general, in all seasons there is no correspondence of indicators of FS activity in relation to the zone of the age functional norm. Such manifestations of maladaptation are most likely to be associated not only with age-related

physiological features but also with the appearance of chronic pathologies in the body. This pattern of changes in the observation group of men 21-50 years old indicates a decrease in adaptation processes associated with age-related decline in physiological and biochemical processes in the body.

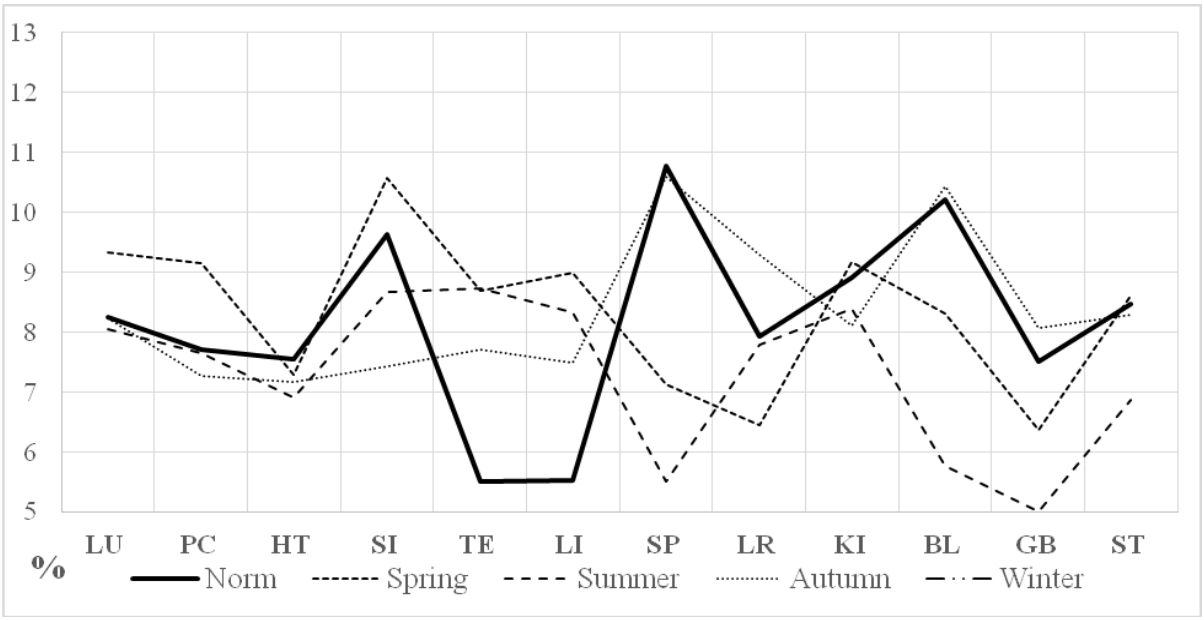

Fig. 3. Systemic age dependence in the male group 21-50 years old (MA) at different seasons, $p \leq 0.05$.

The sympathetic orientation of the autonomic nervous system (ANS) is known to be responsible for the FS of the following: the bladder (BL), the gall bladder (GB), the stomach (ST), the small intestine (SI), the lymphatic system (TE) as well as the large intestine (LI). The parasympathetic orientation of the ANS is responsible for FS of the spleen and pancreas (SP), the liver (LR), the kidney (KI), the lungs (LU), the pericardium (PS), and the heart (HT). The relative ratio of the sum of indicators of total sympathetic activity to parasympathetic activity determines the orientation of the vegetative balance. The numerical result of this correlation is the vegetative coefficient kV (the autonomic nervous system coefficient), according to which seven levels of functional health dispersion are distinguished today: PAs - the zone of significant parasympathetic activity (kV to 0.75); PAe is a zone of expressed parasympathetic activity (kV 0.76-0.86); FcP is the zone of functional compensation of parasympathetic activity (kV 0,87-0,94); VE is the zone of permissible vegetative (functional) equilibrium (kV 0,95-1,05); FcS is the zone of functional

compensation of sympathetic activity (kV 1.06-1.13); SAe is a zone of expressed sympathetic activity (kV 1,14-1,26) and SAs is a zone of significant sympathetic activity (k-V> 1,26). It is more convenient to use vegetative dispersion (scattering) across critical zones for functional and ecological assessment of environmental factors, i.e the ratio PA (PAs + PAe) - VE (FcP + VE + FcS) - SA (SAe + SAs), which are markers of functional health. It is possible to analyze the impact on humans from the received data on the status of functional health of the population of a certain territory and averaged information on the deviation of the autonomic nervous system, both abiotic factors and possible environmental problems of the territory and its degree of ecological disturbance. As a result of research works it was found out that the main characteristic reflecting the negative influence of factors of external and internal environment is the decrease in the number of people examined in the area of functional equilibrium and their increase in the area of parasympathetic activity. According to the criteria we have developed, functional health of people is in the area of conditional norms while 70% of the population are in the area of vegetative (functional) (VE). An analysis of the obtained data revealed that no age group of men meets these requirements. This indicates a violation of functional and vegetative health and leads to disadaptation of the organism under the influence of changing conditions of the external and internal environment (Table 1).

Table 1

Functional health of males of different ages (age standard)

Age groups	PA (s+e), %	VE (FcP+VE+FCS), %	SA (e+s), %
3-6 years old (PSA)	25,3	55,6	19,1
12-15 years old (ASA)	34,0	53,3	12,8
21-50 years old (MA)	53,8	37,5	8,8

Some interesting results have been obtained from the analysis of the effect of different seasons on the functional health of men in observation groups compared to the age norm. Spring and autumn have the most powerful impact on men's adaptation and the adaptation systems for PS and ASA groups. The peculiarity of men in PS groups is a significant increase in sympathetic nervous system activity in spring and winter, that is 33.3% and 36.3%, respectively. Specific features of vegetative health have been identified in a group of males being at MA. The strongest processes of maladaptation are observed in this group in spring. An increased activity of the parasympathetic nervous system was found in 65.4% of the

surveyed men. In summer and autumn, this indicator decreases to 43.8% and 48.5% respectively (Table 2).

Table 2

Functional health of males of different ages in different seasons of the year

Seasons	Critical zones								
	Parasympathetic activity PA (s+e), %			Functional equilibrium (FcP+VE+FcS), %			Sympathetic activity SA (e+s), %		
	PSA	ASA	MA	PSA	ASA	MA	PSA	ASA	MA
Spring	33,3	32,7	65,4	33,4	53,8	23	33,3	13,5	11,6
Summer	17,2	25,5	43,8	55,2	55	50	27,6	19,5	6,2
Autumn	31,3	41,9	48,5	56,3	49,5	42,4	12,6	8,6	9,1
Winter	18,2	25,4	0	45,5	63,5	0	36,3	11,1	0

Conclusions. It has been established that the season change on the body leads to significant changes in functional activity and homeostasis of men of different age groups. Activity indicators of functional systems (FS) in different seasons of the year have the same orientation duplicating line of the norm. These indicators differ in amplitude, form age-specific features of the tone of the autonomic nervous system (ANS) and the state of functional health in men of different age groups, indicating the same mechanisms of influence of seasons on the body. The dependence of these indicators indicates a species evolutionary adaptation of a human to seasonal changes in climatic conditions.

References:

1. Derevyanko O.I. Integral assessment of mental and physical performance. Methodical recommendations. Moscow: Economics; 1990: 109.

2. Makats V.G., Nagaichuk V.I., Makats E.F., Yermishev O.V. Chinese acupuncture (problems of vegetative pathogenesis) is unknown. Volume IV. Vinnytsia: Nilan-LTD, 2017: 286.

3. Oleinikova O.M., Kareva E.N., Avakyan G.G., Bogomazova M.A. Melatonin and epilepsy: analysis of the influence of geomagnetic factors. Epilepsy and paroxysmal conditions. 2015; 4: 29–34.DOI: 10.17749/2077-8333.2015.7.4.029-034)

4. Yermishev O.V., Petruk R.V., Ovchinnikova Yu.Yu., Kostyuk V.V. Functional health of children as an environmental bioindicator of Ukraine. Vinnytsia: Nilan-LTD; 2017: 226.

5. Foster R.G., Roenneberg T. Human responses to the geophysical daily, annual and lunar cycles. Curr Biol. 2008; 18 (17): 784–794. DOI: 10.1016/j.cub.2008.07.003.

6. Jänig W. Integrative Action of the Autonomic Nervous System. Neurobiology of Homeostasis. – Cambridge University Press; 2008: 636.

7. Parashar R., Amir M., Pakhare A., Rathi P. Age Related Changes in Autonomic Functions. Journal of Clinical and Diagnostic Research. 2016; 10 (3): 11–13. DOI: 10.7860/JCDR/2016/16889.7497.

8. Raible F., Takekata H., Tessmar-Raible K. An Overview of Monthly Rhythms and Clocks. Frontiers in Neurology. 2017; 8 (189): 1–14. DOI: 10.3389/fneur.2017.00189.

9. Yermishev Oleh V. Peculiarities of functional-vegetative homeostasis of preschool-age females (first childhood). Biologija. 2019; 65 (1): 56–65. DOI**:** https://doi.org/10.6001/biologija.v65i1.3987

10. Kalko E. A., Drogovoz S.M., Kononenko A.V., Kylish I.O., Toryanik E.L. The influence of daily and seasonal biorhythms on biochemical indicators of the functional activity of the liver. Bulletin of Pharmacy. 2015; 1 (67): 89–96.

11. Parshina S.S., Tokaeva L.K., Galstyan V.V. Seasonal biorhythms of intersystem interactions of hemostasis, fibrinolysis and blood rheology of healthy individuals. Psychosomatic and Integrative Research. 2019; 5(2): 0202.

12. Koroteeva T.V., Radysh I.V., Khodorovich A.M. Seasonal variation in blood hormone levels in women different ethnic groups. RUDN Journal of Medicine. 2010; 4: 250–254.