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**ECOLOGICAL AND COMPARATIVE ANALYSIS OF THE INFLUENCE
OF THE WEATHER FACTOR UNDER THE SIMULTANEOUS ACTION
OF HELIOMAGNETIC STORMS (HMS) ON THE VEGETATIVE BALANCE
OF GIRLS OF DIFFERENT AGES**

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The ecological role and biological nature of the mechanisms of their interaction remain unclear despite the extensive scientific data available on the impact of meteorological and heliogeophysical factors on the health and physiological parameters of the organism. It has been established that the body's response to various stressful influences is largely determined by the ratio of the tone of the sympathetic and parasympathetic divisions of the autonomic nervous system. It is the autonomic nervous system (ANS) and, above all, its sympathetic division that plays a special role in the formation of adaptive reactions of the body, the development of meteorological reactions, i.e. the autonomic nervous system is the primary site of meteorological influences that cause shifts in its balance. Determination of vegetative status and direction of vegetative activity in girls' organism was carried out by means of functional and vegetative diagnostics by V. Makats' method. We examined 186 girls, including 38 girls aged 7–11 years, 126 – aged 12–15 years and 22 – aged 16–21 years. Since the state of the autonomic nervous system is decisive in the development of meteorotropic reactions, the data of the study of vegetative tone in sunny and cloudy weather under the combined influence of heliomagnetic storms (HMS) were analysed, favourable and unfavourable weather conditions for the body were determined and the state of adaptive health of the examined children was determined. It was found that under the influence of heliometeorological factors on the organism of practically healthy young girls, age-related peculiarities of meteorological variability are observed.

It was found that the combined effect of the weather factor and geomagnetic storms (GMS) leads to changes in the functional activity and homeostasis of the body. The study of systemic age dependence revealed increased sensitivity to the weather factor with the simultaneous effect of GMS in the group of girls aged 16–21 years, which is associated with age-related physiological processes. It was also found that when the body was exposed to sunny weather under the influence of GMS, there was a significant parallel suppression of the sympathetic nervous system (SNS) (bladder (BL) pacemaker) and the parasympathetic nervous system (PNS) (spleen and pancreas (SP) pacemaker) in the groups of girls aged 12–13 and 16–21 years. The opposite reaction was found in the group of 16–21 years old under the simultaneous influence of cloudy weather and HMS. Normally, the ANS and PNS are functional antagonists, and when one is activated, the other is automatically inhibited. Only under the conditions of a super-powerful factor or several simultaneously acting on the body does a synchronous change in the activity of these autonomic nervous systems occur.

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In the analysis of changes in functional-adaptive health and adaptation coefficient under the influence of different weather under the influence of HMS, an unfavourable effect of sunny weather under the influence of HMS was revealed, characterised by an increase in the number of girls in the zone of PS activity with a simultaneous decrease in the FR zone, which indicates a negative aspect of the effect on the adaptation system and indicates the depletion of adaptive resources.

The effects of weather on the body, even with the combined effect of HMS, are easily compensated for, and a special role in this belongs to the autonomic nervous system, whose activity ensures an adequate response of the body to the effects of environmental factors. Knowledge about meteosensitivity and meteorological reactions is necessary for the development of both preventive and therapeutic measures aimed at increasing nonspecific resistance and adaptation mechanisms of the body, normalising the function of organs and systems as a basis for normal reactions to adverse environmental changes. Environmental factors, including meteorological factors, are directly related to human life and health. Each of the meteorological elements has its own biological significance. This raises the question of the impact of solar activity, weather, atmospheric conditions, and, above all, anthropogenic pollution and other environmental parameters on human health, which naturally requires a quantitative approach to risk assessment and the development of necessary management decisions.

Key words: *weather, adaptation, functional systems, autonomic nervous system.*

ЕКОЛОГО-ПОРІВНЯЛЬНИЙ АНАЛІЗ ВПЛИВУ ФАКТОРУ ПОГОДИ ЗА КОМБІНОВАНОГО ВПЛИВУ ГЕЛІО-МАГНІТНИХ БУРЬ (ГМБ) НА ВЕГЕТАТИВНИЙ БАЛАНС ДІВЧАТ РІЗНОГО ВІКУ

О. В. Єрмішев

Незважаючи на наявні обширні наукові дані про вплив метеорологічних та геліогеофізичних факторів на стан здоров'я та фізіологічні параметри організму, екологічна роль та біологічна сутність механізмів їх взаємодії залишається поки що неясною. Необхідність вибору комплексного підходу до вивчення системи «Космос-Земля-Людина» очевидна та обґрунтована, тому що в його основі лежить ідея використання сучасних технологій і каналів отримання та поширення інформації про вплив космічної погоди, мінливість стану атмосфери, електромагнітних та гравітаційних полів, антропогенних забруднень та інших параметрів навколишнього середовища, що потребує ефективного та швидкого вирішення. Встановлено, що реакція організму на різні стресові впливи значною мірою визначається співвідношенням тонусу симпатичного і парасимпатичного відділів вегетативної нервової системи. Саме вегетативній нервовій системі (ВНС) і, перш за все, її симпатичному відділу належить особлива роль у формуванні пристосувальних реакцій організму, розвитку метеотропних реакцій, тобто вегетативна нервова система є первинним місцем докладання метеорологічних впливів, що викликають зрушення в її рівновазі. Визначення вегетативного статусу та направленість вегетативної активності в організмі дівчат проводили за допомогою функціонально-вегетативної діагностики за методом В. Макаца. Нами було обстежено 186 дівчат, з яких 38 – дівчата віком 7–11 років, 126 – віком 12–15 років та 22 – віком 16–21 рік. Оскільки стан вегетативної нервової системи є визначальним в розвитку метеотропних реакцій проведено аналіз даних дослідження вегетативного тонусу у сонячну, та хмарну погоду за комбінованого впливу геліо-магнітних бурь (ГМБ), визначення сприятливих і несприятливих погодних умов для організму та визначення стану адаптаційного здоров'я обстежених дітей.

Було виявлено, що за впливу геліометеорологічних факторів на організм практично здорових молодих дівчат спостерігаються вікові особливості проявів метеолабільності.

Було виявлено, що комбінований вплив фактору погоди та геомагнітних бурь (ГМБ) призводить до змін функціональної активності і гомеостазу організму. При дослідженні системно-вікової залежності була виявлена підвищена чутливість до фактора погоди з одночасною дією ГМБ в групі дівчат 16–21 року, що пов'язано з віковими особливостями фізіологічних процесів. Також було з'ясовано, що за впливу на організм сонячної погоди за дії ГМБ спостерігалось значне паралельне пригнічення симпатичної нервової системи (СНС) (нейсмейкер сечовий міхур (BL) та парасимпатичної нервової системи (ПНС) (нейсмейкер селезінка і підшлункова залоза (SP) в групах дівчат 12–13 та 16–21 років. Протилежну реакцію було виявлено в групі 16–21 років за одночасного впливу хмарної погоди і ГМБ. В нормі СНС та ПНС є функціональними антагоністами і при активації однієї автоматично відбувається пригнічення іншої. Тільки за умов дії надпотужного чинника чи декількох одночасно на організм відбувається синхронна зміна активності цих вегетативних НС. При аналізі змін функціонально-адаптивного здоров'я та адаптаційного коефіцієнту за впливу різної погоди за дії ГМБ було виявлено несприятливий вплив на їх формування сонячної погоди за дії ГМБ, що характеризується підвищенням кількості дівчат в зоні ПС активності

з одночасним зменшенням в зоні ФР, що свідчить про негативний аспект дії на систему адаптації та свідчить про виснаження адаптаційних ресурсів. В здоровому організмі зміни фізіологічних процесів і функціональної активності систем під впливом такого фактору, як зміна погоди, навіть за комбінованого впливу ГМБ легко компенсуються і особлива роль в цьому належить вегетативній нервовій системі, діяльність якої забезпечує адекватну реакцію організму на вплив факторів зовнішнього середовища. Знання про метеочутливість і метеопатичні реакції необхідні для розробки як профілактичних, так і лікувальних заходів, спрямованих на підвищення неспецифічної резистентності та адаптаційних механізмів організму, на нормалізацію функції органів і систем як основу для нормальних реакцій при несприятливих змінах зовнішнього середовища. Чинники довкілля, зокрема і метеорологічні, мають безпосереднє відношення до забезпечення життєдіяльності та здоров'я людей. Кожен із метеорологічних елементів має своє біологічне значення. В цьому випадку виникає питання про вплив сонячної активності, погоди, стан атмосфери, і, насамперед, антропогенних забруднень та інших параметрів середовища на здоров'я людей, що, природно, вимагає кількісного підходу до оцінки ризиків та вироблення необхідних управлінських рішень.

Ключові слова: погода, адаптація, функціональні системи, вегетативна нервова систем.

Introduction

The ecological role and biological nature of their interaction mechanisms remain unclear despite the extensive scientific data available on the impact of meteorological and heliogeophysical factors on health and physiological parameters of the organism (Єрмішев та ін., 2017; Berrang-Ford et al., 2021; Campbell-Lendrum et al., 2023). The need to choose an integrated approach to the study of the Space-Earth-Human system is obvious and justified, since it is based on the idea of using modern technologies and channels for obtaining and disseminating information about the impact of space weather, variability of the atmosphere, electromagnetic and gravitational fields, anthropogenic pollution and other environmental parameters, which requires effective and rapid solution (Davis et al., 2018; Lenton et al., 2023).

Heliophysical factors influence the course of important and widespread physical and chemical processes in the biosphere, they affect many aspects of biological phenomena, which is reflected in the corresponding changes in the vital activity of most living organisms. Cosmic radiation of the hard range of the electromagnetic spectrum and high-energy particles have had a powerful impact on the biosphere in the past, often changing the course of evolution of living organisms. The main external, abiotic factors of the Earth's biosphere stability are undoubtedly solar radiation, the Earth's own magnetic field and oxygen in the atmosphere. The Sun is the main supplier of energy to our planet, and it drives most of the processes in the ecosphere. Solar energy is of the utmost importance for the Earth's biosphere as it drives the movement of the atmosphere and ocean currents and supports all life processes.

Changes in solar radiation are responsible for climate cycles (Davis et al., 2018).

The role of cosmogeophysical factors in the evolutionary adaptation of living systems is very diverse. Cosmogeophysical factors act as a weak training factor for adaptation-resistant members of the population; serve as a channel for rejecting non-viable members of the population; ensure synchronisation of individual times of biological objects in interaction with each other; are a synchroniser of the general rhythms of the population; create conditions for the generation of new information in the process of evolutionary adaptation of biosystems in general (Макац та ін., 2017; Davis et al., 2018).

It is known that active processes on the Sun cause an increase in solar wind flows and coronal mass ejections, which lead to the development of magnetic storms in the Earth's magnetosphere, one of the main elements of space weather. There are indirect signs of the impact of variations in solar and geomagnetic activity on weather and climate (Davis et al., 2018). Heliogeophysical factors and human heliometeorological reactions significantly affect the health potential both at the individual and population levels and largely determine the balance of 'human consumption' and 'human production' – a generalised indicator of population well-being (Єрмішев та ін., 2017; Chmura et al., 2018; Davis et al., 2018). This task is even more urgent in relation to the so-called environmental health, i.e. the health of the population dependent on the state of the environment, so the problem of establishing cause-and-effect relationships between the state (quality) of the environment and public health is one of the leading environmental and socially significant tasks (Єрмішев

та ін., 2017; Furdychko et al., 2020; Abbasi et al., 2023). Environmental factors, including meteorological factors, are directly related to the life and health of people. Each of the meteorological elements has its own biological significance. This raises the question of the impact of solar activity, weather, atmospheric conditions, and, above all, anthropogenic pollution and other environmental parameters on human health, which naturally requires a quantitative approach to risk assessment and the development of necessary management decisions (Henderson et al., 2018; Furdychko et al., 2020).

The aim of the study. To carry out an ecological and comparative analysis of the influence of meteorological factors under the combined action of HMS on the tone of the autonomic nervous system and the functional state of the body of PSA and ASA boys and to assess their impact on the human body.

Analysis of recent research and publications. The impact of the weather on the human body is multifaceted and not yet fully understood, but unfortunately, almost 70% of people today react to weather changes. It is known that meteorology, which is also considered a syndrome or a new disease, affects our psychological and physiological health. Meteorosensitivity is already appearing even in healthy people.

It is now recognised that solar activity (SA) affects a wide variety of processes in the biosphere, including the state of the human body (Davis et al., 2018). The main transmission link between solar flare activity and the state of living systems is the geomagnetic field (GMF) variations, the amplitude of which can increase by several orders of magnitude during 'solar storms' at high latitudes (Davis et al., 2018). This phenomenon results in a maladaptation syndrome in the human body, especially in meteorologically dependent people. The mechanism of development of meteorological reactions disrupts the stability of cell membranes, thereby affecting metabolic processes, energy balance, activation of lipid peroxidation, changes in quantitative indicators of blood cell structures, leading to exacerbation of chronic diseases, in particular the most vulnerable cardiovascular system. The tension arising in its operation can provoke the development of many pathologies (Lüthi et al., 2023). It is the sharp fluctuations in the HMS that are one of the reasons for the deterioration of the health of certain groups of people and the increased risk of death (Davis et al., 2018; Lüthi et al., 2023).

It has been proven that high SA and geophysical activity during intrauterine development and at birth reduces life expectancy by 8.4 years and increases the risk of mortality from cardiovascular diseases, in fact 'programming' the degree of vulnerability of the cardiovascular system, which is especially true for men (Zareba et al., 2021). As a rule, high SA is accompanied by HMS, which are predictors of disorders in the child's heart: disturbances in the synchronisation of daily fluctuations in the contractile force of the ventricles of the heart, a drop in the absolute values of the contractile force of the heart and blood pressure, and changes in the ultrastructure of heart cells (Zareba et al., 2021). These changes are likely to be 'remembered' (heliogeophysical imprinting) and create prerequisites for high sensitivity of the cardiovascular system not only to heliogeophysical effects, but also to other traumatic agents, which can lead to a decrease in life expectancy as a result of premature 'wear and tear' of the cardiovascular system. That is why the main target of the human body, which is affected by helio-geomagnetic activity, may be the heart and cardiovascular system in a state of pathology. The data obtained in the studies indicate that geomagnetic storms cause desynchronisation of cardiac biorhythms. Changes in the chronostucture of biorhythms are an indicator of the functional state of the body, one of the most important criteria for human physiological adaptation.

At the same time, patients with meteoropathy often have elevated levels of adrenocorticotrophic hormone (ACTH) and catecholamines (epinephrine and norepinephrine), which are stress hormones that are a humoral factor that stimulates the body's sympathetic activity, with symptoms such as palpitations, anxiety and irritability (Vicedo-Cabrera et al., 2021). For example, in healthy people, norepinephrine levels significantly increase 2 days before a magnetic storm, remain elevated during the storm, and increase again during the storm recovery phase (2 days after the storm). Adrenaline levels behave similarly. Conversely, endorphins, known as 'happy hormones', decrease, lowering the pain threshold (dopamine concentration decreases 2 days before and during the storm, and more than doubles 2 days after the storm). Another hypothesis suggests that the vagus nerve plays a role in meteorology, and its stimulation reduces weather-related symptoms in humans (Vicedo-Cabrera et al., 2021).

During periods of heliogeophysical disturbances, the haemorheological characteristics of the body tend to increase. Under the influence of the GMS, the average value of erythrocyte aggregation in humans is 1.6 times higher than on calm days, and platelet aggregation activity increases 1.4 times. An increase in the amount of catecholamines, blood viscosity, and the tendency to haemostasis forms internal factors of exacerbations of cardiovascular and circulatory system pathologies and increases the risk of mortality.

The combination of the following meteorological parameters: low average temperature and low sunshine, high humidity and high wind speed, all of these increase the risk of stroke in winter (Romanello et al., 2023).

Most often, the adverse effect of meteorological factors on the course of hypertension was detected in January, February and March against the background of low atmospheric pressure. In the winter-spring period, patients with hypertension with manifestations of meteorological variability showed an increase in sympathetic and mixed activity according to cardiac rhythmogram data (Morrison et al., 2022).

In addition to affecting human health, weather also has a significant impact on physical daily activity, which is one of the main factors in health. Thus, a meta-analysis showed that higher temperatures were associated with an increase and intensity of physical activity, while lower temperatures and heavy precipitation were associated with a decrease (Rahman et al., 2019; Zheng et al., 2021).

The study of the influence of helio- and meteorological conditions on the state of autonomic regulation of heart rate revealed a shift in the ratio of sympathetic and parasympathetic activity which has multidirectional changes and can be characterised by both relative sympathicotonia and relative parasympathicotonia. It is this multidirectionality of changes in the state of the autonomic nervous system in unstable weather conditions that is a specific pacemaker and can provoke exacerbation of most diseases of the cardiovascular system (Єрмішев та ін., 2017; Єрмішев, 2020; Berrang-Ford et al., 2021).

According to the literature review, the autonomic nervous system (ANS) is one of the main participants in the process of adaptation to any impact (Jänig, 2008; Єрмішев та ін., 2017; Єрмішев, 2020). Disruption of the autonomic regulation of the body inevitably occurs in cases of climatic maladaptation against the

background of heliogeophysical factors. These changes are especially pronounced in people with a history of vegetative-vascular disorders. There are several points of view in the scientific literature on the impact of meteorological factors on the human body. Often, researchers believe that the human body is affected by the sum of all meteorological factors, while in other cases, one leading factor is singled out from the complex of meteorological factors which determines the entire complex of changes in the human body (Gosling et al., 2017).

Considering a person as an open energy information system that is in continuous interaction with the external environment, it seems most relevant to study the impact of a set of meteorological and climatic factors on a person.

Material and methods

Using functional and vegetative diagnostics (FVD) according to the method of V. Makats, we examined 186 girls, including 38 primary school age (PSA) 7–11 years old, 126 adolescent school age 12–15 years old and 22 girls of youthful school age 16–21 years old, who underwent sanatorium rehabilitation in sanatoriums of Ukraine. The FVD was performed twice in the morning (10:00–11:00). We studied the bioelectrical activity of 12 symmetrical pairs of functionally active skin zones (24 FAZ), 12 on the arms and 12 on the legs, which reflect the functional activity of the sympathetic and parasympathetic nervous system (Єрмішев та ін., 2017; Єрмішев, 2020). FVD according to the method of V. Makats and devices for its implementation are officially authorized by the Ministry of Health of Ukraine “New Medical Equipment and New Diagnostic Methods” (№ 5 of 25.12.91; № 1.08-01 of 11.01.94) and the Academic Council of the Ministry of Health of Ukraine (№ 1.08-01 of 11.01.94) (Єрмішев та ін., 2017; Єрмішев, 2020).

VITA 01 M device is used for PVD, the voltage in the closed circuit of which does not exceed the levels of membrane potentials (1–5 μ A; 0.03–0.6 V) and which does not require external energy sources for its operation. It has 2 diagnostic electrodes, a base electrode (electron acceptor) - a convex plate made of a special alloy, pre-coated with an oxide film (5x7 cm) and a paired diagnostic electrode (electron donor) in the form of a silvered pair, which are located in ebonite cups with a diameter of 1 cm and wrapped in foam pads. The base electrode is fixed with a special belt through a wet pad (moistened

with saline) in the umbilical region (central mesogastric area (0-zone) with medium density tension to create stable examination conditions. Diagnostic electrodes are also moistened with saline. The procedure is performed in an orthostatic position. During testing, diagnostic electrodes at right angles with low pressure (at the level of touch), simultaneously contact each pair of symmetrical phases (left-right on each limb) for 1–4 seconds until stable readings in microamperes are obtained. After every 3 contacts with the FAZ, the electrodes are rewetted with saline. The data obtained in μA are converted to relative values. The obtained data are compared with the norm and a conclusion is made about the degree of deviation from it and the level of functional health disorder (Єрмішев О. В. та ін., 2017; Єрмішев, 2020). Changes in the physiological state of the body are manifested by the transformation of electrocutaneous 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), spleen and pancreas (SP), liver (LR) and kidneys (KI), which form the parasympathetic orientation of the ANS. The sympathetic orientation of the ANS is formed by the small intestine (SI), the state of the lymphatic system (TE), the large intestine (LI), the bladder (BL), the gallbladder (GB) and the stomach (ST). For diagnostics, correlations between changes in electrical conductivity in 24 representative FAZ (characterizing the state of the meridian as a whole) and the state of classical acupuncture meridians, “determining” the functional state of their corresponding internal organs and body systems, are used (Єрмішев та ін., 2017; Єрмішев, 2020). The relative ratio of the sum of the indicators of total sympathetic activity to parasympathetic activity determines the direction of the autonomic balance. The numerical result of this ratio is the adaptation-vegetative coefficient kAV (autonomic nervous system coefficient). For functional and ecological assessment of the impact of environmental factors, vegetative dispersion (scattering) is used in 3 critical zones: parasympathetic activity (PA) kAV – ≤ 0.86 ; functional-vegetative balance (FVB) kAV – $0.87 - 1.13$; sympathetic activity (SA) kAV – ≥ 1.14 , which are markers of functional health (adaptive potential) (Єрмішев та ін., 2017; Єрмішев, 2020). The mathematical and statistical analysis of the empirical results of the

observations was carried out in the Statistica 12 package. To test for the normality of the distribution of the results of the sample observations, the Kolmogorov-Smirnov and Shapiro-Wilk criteria were applied, according to which there are no grounds to reject the hypothesis of a normal distribution of samples. This indicates that it is possible to use Student’s t-test for independent variables to test the reliability of the difference in the results ($p > 0.2$ by Kolmogorov-Smirnov test and $p > 0.05$ by Shapiro-Wilk and Lillifors test). The hypotheses about the normal distribution of the samples are also confirmed by the histograms of the distribution. The application of Student’s t-test for independent variables to test the reliability of the difference in the results obtained showed that the samples have standard deviations that do not differ statistically ($p\text{-Variances} \geq 0.05$) and mean values that also do not differ statistically from normal values ($p \geq 0.05$) at the significance level of $\alpha = 0.05$.

Results and discussion

Numerous effects of the space environment on the biosphere are most clearly manifested during magnetic storms (Davis et al., 2018). In the mid-90s of the last century, a hypothesis was put forward that:

1) heliogeomagnetic rhythms, together with illumination and temperature, are the basis for the formation of the circadian (daily) endogenous biorhythm.

2) heliogeomagnetic perturbations – “failures” of heliogeomagnetic rhythms – cause an adaptive stress response in biological objects, especially in a state of instability.

As a result of many years of research, it has been found that the characteristic targets of geomagnetic and meteorological influences are the circulatory system; cardiovascular system; autonomic nervous system and lungs. Therefore, the “risk groups” for geomagnetic and meteorological influences are the population with cardiovascular pathology, especially those who have had myocardial infarction; healthy people with functional overstrain of the adaptive system; children in the period of rapid development with an unformed adaptive system and the adult population with numerous endogenous causes of maladaptation of the body (Myhre et al., 2019; Ripple et al., 2022).

Monitoring of young children has shown the presence of all “solar” periods in their spectra, with newborn infants beginning to detect the circadian rhythm (the most powerful in the

mother's body) at 5–10 months of age, while in the first month they are dominated by the 7-day rhythm. When monitoring an infant for 26 months, the spectra of its vital signs show the presence of all period's characteristic of the period of the Sun's own rotation, about 28 days, and its harmonics. The period of 1 day begins to appear only at the 5th month of monitoring (Hoxha et al., 2023).

Failures of the external synchronizer rhythms – geomagnetic storms – lead to adaptive stress such as the reaction in case of failures of the circadian rhythm phase (stabilization of the heart rate, increased blood viscosity, and a drop in the contractile force of the heart) and to meteorotropic reactions characterized by changes in vascular tone (Hoxha et al., 2023). However, space weather is not the only biotropic factor affecting human health and well-being. Usually, its influence occurs in conjunction with the influence of terrestrial weather factors, and the impact of atmospheric pressure surges P, temperature T and geomagnetic activity surges (K-index) is distributed as follows: T: K: $\Delta P = 5:4:7$ (Davis et al., 2018).

According to the literature review, the autonomic nervous system (ANS) is one of the main participants in the process of adaptation to any impact (Макац та ін., 2017; Єрмішев та ін., 2017; Єрмішев, 2020). Disorders of the autonomic regulation of the body inevitably occur

in cases of climatic maladaptation against the background of heliogeophysical factors. These changes are especially pronounced in people with a history of vegetative-vascular disorders. The scientific literature today contains several points of view on the impact of meteorological factors on the human body. Often, researchers believe that the human body is affected by the sum of all meteorological factors, while in other cases, one leading factor is distinguished from the complex of meteorological factors, which determines the whole complex of changes in the human body (Hoxha et al., 2023). Considering a person as an open energy and information system that is in continuous interaction with the environment, it seems most relevant to study the impact of a complex of meteorological factors on a person.

In the study of systemic-age dependence in the female group (FG) of PSA aged 7–11 years, it was found that the combined effect of the weather factor and geomagnetic storms (GMS) leads to changes in functional activity and homeostasis of the body (Fig. 1). It can be clearly seen that the indicators of activity of functional systems (FS) under the influence of weather and geomagnetic storms duplicate the line of normality, differ in amplitude and have the same direction. Moreover, the presence of significant changes in the studied parameters of the FS activity indicators with the normal line indicates that different weather under the influence of HMS was

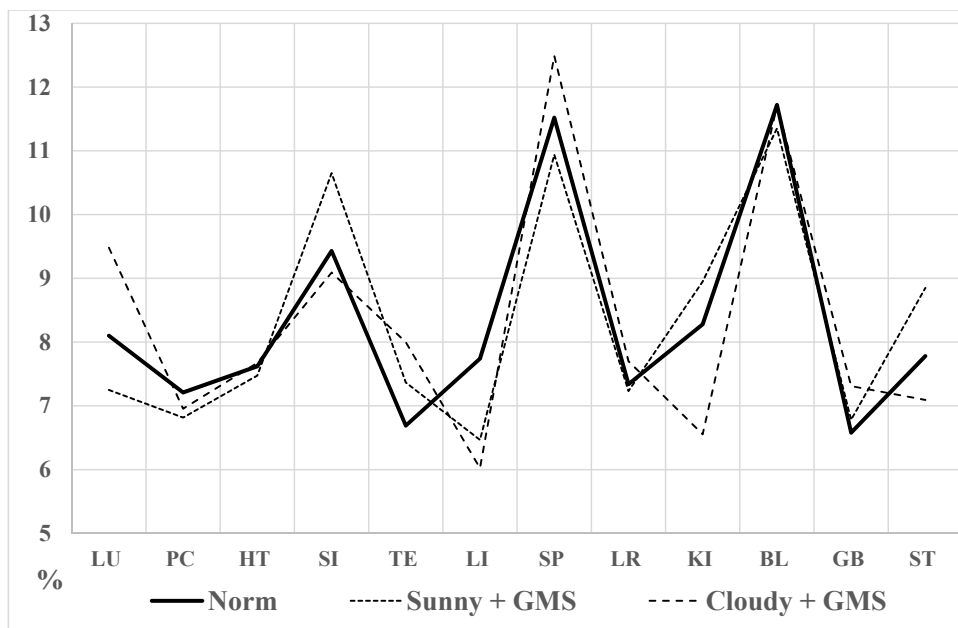


Fig. 1. Systemic-age dependence in the female group of primary school age (PSA) 7–11 years old in different weather conditions with simultaneous exposure to GMS, $p \leq 0.05$

characterised by the specificity of the effect on the body. In sunny weather, under the influence of HMS, there is an overstrain of the body's adaptation systems. Sunny weather under the influence of HMS stimulates the activity of the small intestine (SI), lymphatic system (TE) and stomach (ST). A decrease occurs in the FS of the lungs (LU), pericardium (PC), heart (HT) and large intestine (LI).

In cloudy weather under the influence of GMS, the systemic-age dependence in the LH of PSA was characterised by an increase in the activity of the FS of the lungs (LU), lymphatic system (TE), spleen and pancreas (SP) and gallbladder (GB). It inhibits the activity of the large intestine (LI), kidneys (KI) and stomach (ST).

The organism of children aged 7–11 years is characterised by physiological and functional immaturity of adaptation processes and the speed of their formation and stabilisation (Єрмішев, 2020). The rapid pace of morphological and functional development of all organs and systems, immaturity of the immune system during this period contribute to increased sensitivity of the children's body to changes in environmental factors, both environmental and physiological, as well as pathological ones.

Adolescence is a transitional stage from childhood development to the adult stage of ontogenesis. The transitional process of adolescence involves absolutely all levels of the adolescent's biological organisation, from

changes in the structure of the skeleton, respiratory system, blood circulation to the reproductive system, its functional and structural support. The pituitary gland becomes more active, physical and physiological development intensifies, and the motor system and neurohumoral relations are restructured. In adolescence, children experience sharp fluctuations in hormonal status, as well as active growth. Therefore, their meteorological sensitivity can be pronounced (Fig. 2).

In the study of systemic-age dependence in the FS of adolescent school age (ASA) of 12–16 years, it was found that weather changes under the influence of HMS lead to changes in functional activity and homeostasis of the body (Fig. 2). It was found that the obtained indicators of FS activity duplicate the normal line, differ in amplitude and have the same general direction. Thus, under the influence of sunny weather on the female body under the action of HMS, an increase in the studied parameters of the FS activity indicators relative to the age norm was found in the lungs (LU), pericardium (PC), heart (HT), small intestine (SI) and lymphatic system (TE). The activity of the FS of the large intestine (LI), liver (LR), kidneys (KI) and gallbladder (GB) was characterised by a decrease. There is also a parallel suppression of the sympathetic nervous system (bladder (BL) pacemaker) and the parasympathetic nervous system (spleen and pancreas (SP) pacemaker) (Fig. 2).

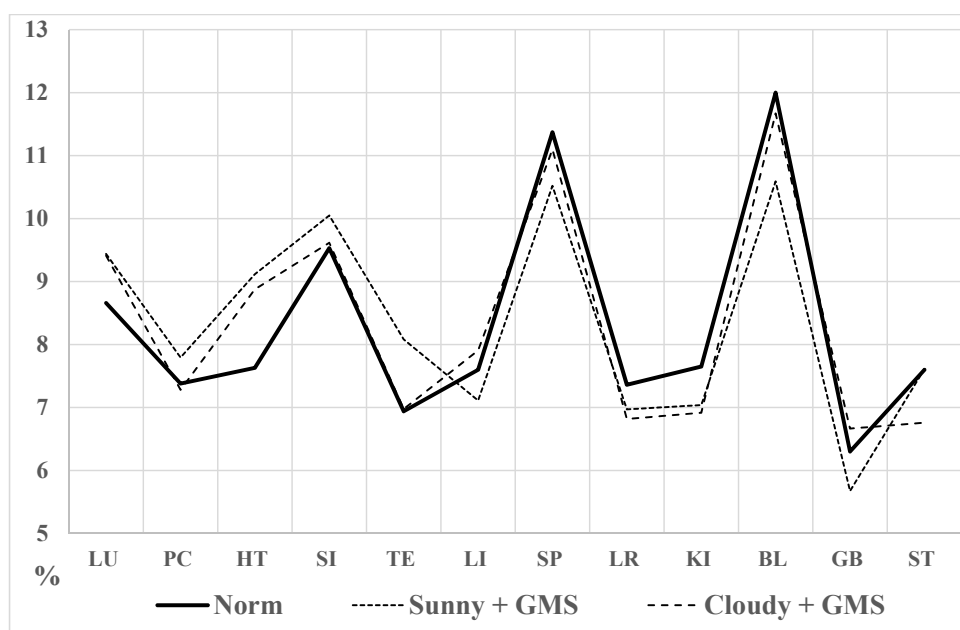


Fig. 2. Systemic-age dependence in the female group of adolescent school age (ASA) 12–15 years old in different weather conditions with simultaneous exposure to GMS, $p \leq 0.05$

In the FG of the PSH, cloudy weather under the influence of HMS caused an increase in the studied parameters of the parameters of the activity of the FS relative to the age norm in the lungs (LU) and heart (HT). A decrease in FS activity was recorded for the FS of the liver (LR), kidneys (KI) and stomach (ST) (Fig. 2).

In the study of systemic-age dependence in the group of young schoolchildren (YS) aged 16–21 years, it was found that weather changes under the influence of HMS lead to changes in functional activity and homeostasis of the body (Fig. 3). It was found that the obtained indicators of FS activity duplicate the normal line, differ in amplitude and have the same general direction and high variability of the obtained systemic results.

Thus, under the influence of sunny weather on the female organism of YSA under the action of HMS, an increase in the studied parameters of the indicators of FS activity relative to the age norm was found in the lungs (LU), pericardium (PC), heart (HT) and small intestine (SI). A decrease was observed in the FS activity of the lymphatic system (TE), large intestine (LI), liver (LR), kidneys (KI) and gallbladder (GB) and stomach (ST). There is also a parallel suppression of the sympathetic nervous system (bladder (BL) pacemaker) and the parasympathetic nervous system (spleen and pancreas (SP) pacemaker) (Fig. 3).

In FG YSA, cloudy weather under the influence of HMS caused an increase in the studied parameters of FS activity indicators relative to the age norm in the lungs (LU) and small intestine (SI). Cloudy weather under the influence of HMS stimulates the activity of the sympathetic nervous system (bladder (BL) pacemaker) and the parasympathetic nervous system (spleen and pancreas (SP) pacemaker). A decrease in FS activity was recorded for the FS of the pericardium (PS), liver (LR), kidneys (KI), gallbladder (GB) and stomach (ST) (Fig. 3).

It has been shown that under the influence of HMS there is an overstrain of the body's adaptation systems in sunny weather, which are characterised by the simultaneous suppression of the sympathetic nervous system (bladder (BL) pacemaker) and the parasympathetic nervous system (spleen and pancreas (SP) pacemaker), which was found in the FG of the ASA and the YSA. Normally, the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) are functional antagonists and when one is activated the other is automatically inhibited. Only under the conditions of a super-powerful factor or several simultaneously acting on the body does the activity of these autonomic nervous systems change synchronously.

To more accurately determine the deviations of the numerical indicators of the activity of the body's FS in different seasons of the year,

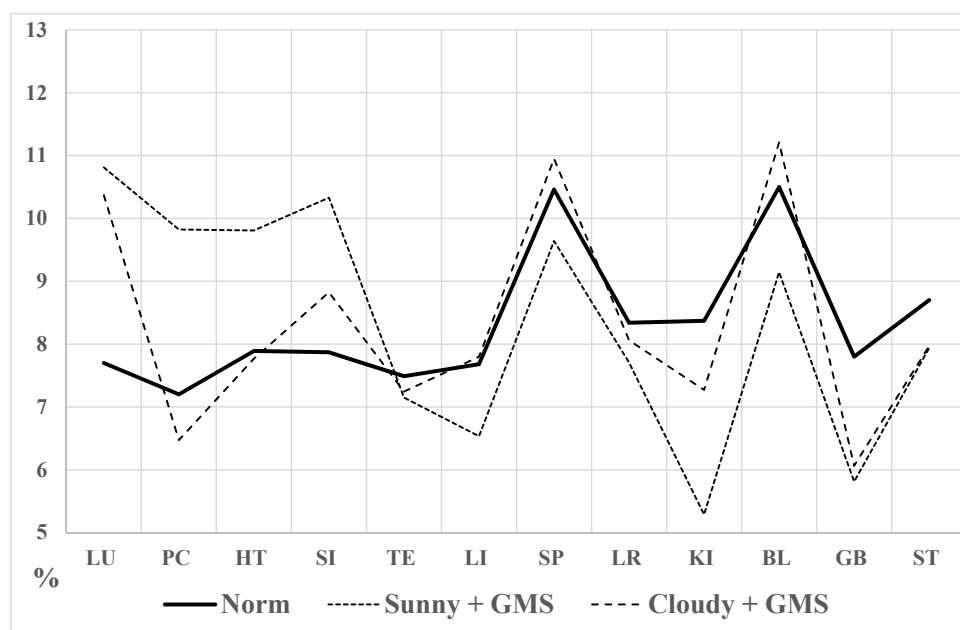


Fig. 3. Systemic-age dependence in the female group of young school age (YSA) 16–21 years old in different weather conditions with simultaneous exposure to GMS, $p \leq 0.05$

Table 1

Deviation of FVD values from the norm $\pm 10\%$ in FG groups of different ages

FS	Norm $\pm 10\%$			Weather					
				Sunny + GMS			Cloudy + GMS		
	PSA	ASA	YSA	PSA	ASA	YSA	PSA	ASA	YSA
LU	7,29-8,91	7,79-9,53	6,93-8,47	↓	=	↑	↑	=	↑
PC	6,49-7,93	6,94-8,45	6,48-7,92	=	=	↑	=	=	=
HT	6,86-8,38	6,87-8,39	7,10-8,68	=	↑	↑	=	↑	=
SI	8,49-10,37	8,58-10,48	7,09-8,66	↑	=	↑	=	=	↑
TE	6,02-7,36	6,25-7,63	6,74-8,24	=	↑	=	↑	=	=
LI	6,97-8,51	6,84-8,36	6,91-8,45	↓	=	↓	↓	=	=
SP	10,3-12,67	10,2-12,74	9,41-11,51	=	=	=	=	=	=
LR	6,61-8,07	6,62-8,09	7,51-9,17	=	=	=	=	=	=
KI	7,45-9,11	6,89-8,41	7,54-9,20	=	=	↓	↓	=	↓
BL	10,5-12,89	10,8-13,20	9,45-11,55	=	↓	↓	=	=	=
GB	5,92-7,24	5,67-6,93	7,02-8,87	=	=	↓	↑	=	↓
ST	7,01-8,86	6,84-8,36	7,83-9,57	=	=	=	=	↓	=

we compared them with the numerical value of the norm (mV) for each FS with a deviation of $\pm 10\%$. We determined the values that go beyond this physiological corridor in the direction of increase or decrease, marking them with the signs '↑' and '↓', respectively. Table 1 shows the results of deviations of FVD values from the norm $\pm 10\%$ in the FG groups of PSA, ASA and YSA.

The analysis of the results of deviations of FVD values from the norm $\pm 10\%$ in the PSA group revealed 8 deviations from the physiological corridor of the norm, among which 3 occurred in sunny weather during the HMS exposure and 5 in cloudy weather during the HMS exposure. Analysis of the results of deviations of FVD values from the norm $\pm 10\%$ in the PSA group revealed only 5 deviations from the physiological corridor of the norm, among which 3 occurred in sunny weather during the HMS 2 and cloudy weather during the HMS. Analysis of the results of deviations of FVD values from the norm $\pm 10\%$ in the YSA group revealed only 12 deviations from the physiological corridor of the norm, of which 8 occurred in sunny weather during the HMS and 4 in cloudy weather during the HMS.

The obtained array of data on the state of functional health of the population of a certain territory and the averaged information on the autonomic nervous system deviations can be used to analyse the impact on humans of both abiotic factors and possible environmental problems of the territory and its degree of environmental disturbance. As a result of the research, it was found that the main characteristic reflecting

the negative impact of environmental and internal factors is a decrease in the number of people surveyed in the zone of functional balance and an increase in the zone of parasympathetic activity. According to the criteria developed by us, the functional health of people is in the zone of conditional normality, when 50–70% of the population is in the zone of functional balance (FB) and 15–20% in the zones of sympathetic activity (SA) and parasympathetic activity (PA).

When analysing the impact of different weather under the influence of HMS on the functional and adaptive health of female groups of the Ukrainian population of different ages in comparison with the age norm, results were obtained that indicate age-related differences in the reactivity of the surveyed population. Sunny weather under the influence of HMS has the most unfavourable effect on the formation of adaptive health of the majority of the surveyed groups. The combination of these impacts increases the number of people in the PA zone and decreases in the FB zone, which indicates a negative aspect of the impact on the adaptation system and indicates the depletion of adaptation resources. With the ideal value of 15–20% of the population of compact residence being in the PA zone, we found a significant increase in this indicator, especially in the age group of the ASA population, which is 40.8%, with a simultaneous decrease in the FB zone to 44.9%. At the same time, the group of PSA girls was affected by the sunny weather under the GMS in the opposite way, increasing the number of examined children in the SA zone

to 40.0% with a simultaneous decrease in the FB zone.

In the analysis of the adaptive (functional) health of FG of the PSA and ASA groups under the combined effect of cloudy weather under the influence of the GBS, it was found that these age groups are quite adaptive to the above environmental factors. At the same time, the combined effect of cloudy weather under the influence of HMS on the age group of YSA leads to an increase in the number of people examined in the PA zone to 31.8% with a simultaneous decrease in the FB zone to 40.9% (Table 2).

When analyzing the effect of different weather under the influence of HMS on the organism of girls of different age groups by the vegetative coefficient, it was found that all groups reacted most sensitively to the combined effect of sunny weather under the influence of HMS.

Under the influence of these factors, in the FG of PSA, there is an increase in the adaptation coefficient from the norm of 0.95–1.05 to 1.09, which indicates the predominance of the SNS in the body with the formation of sympathicotonia. In the FG of the ASA and YSA, a slight parasympathicotonia was detected, characterised by a decrease in the k-AV index to 0.92 and 0.94, respectively. Under the influence of these factors, in the FG of PSA, there is an increase in the adaptation coefficient from the norm of 0.95–1.05 to 1.09, which indicates the predominance of the SNS in the body with the formation of sympathicotonia. In the FG of the PSA and YSA, a slight parasympathicotonia was detected, characterised by a decrease in the k-AV index to 0.92 and 0.94, respectively (Table 3).

Table 2
Adaptive (functional) health of women of different ages under the combined influence of weather and geomagnetic storms

	Age groups	Seasons	
		Sunny + GMS	Cloudy + GMS
SA, %	PSA	40,0	21,0
	ASA	14,3	22,6
	YSA	0	27,3
FB, %	PSA	40,0	55,3
	ASA	44,9	56,5
	YSA	77,8	40,9
PA, %	PSA	20,0	23,7
	ASA	40,8	20,9
	YSA	22,2	31,8

Table 3
Values of the adaptation (vegetative) coefficient k-AV under the combined influence of weather and geomagnetic storms (GMS)

Weather + GMS	PSA	ASA	YSA
Sunny + GMS	1,09	0,92	0,94
Cloudy + GMS	0,99	1,01	1,00

Conclusions

There are three phases in the development of meteotropic reactions: the first is the phase of clinical and physiological adaptation of the body to the effects of atmospheric and physical factors; the second is the phase of increased sensitivity to these factors, manifested by changes in neuropsychological, immune and allergic reactivity; the third is the phase of maladaptation to the weather, which is manifested in healthy people by various functional syndromes. In patients it is manifested by the appearance of clinical and subclinical reactions and exacerbations of diseases, i.e. meteotropic reactions lead to structural and functional changes in the human body, disruption of compensatory reactions which are manifested by various symptom complexes. Cells, tissues and the body as a whole mobilise mechanisms aimed at mitigating and stabilising processes that lead to the strengthening of adaptive mechanisms. It is known that the body's reaction to the weather is determined by gender, age, height, body weight, physique, temperament, diet, etc. With prolonged and repeated exposure to weather and meteorological factors, a reaction of the endocrine system occurs, which is considered as a 'stress reaction' of the general adaptation syndrome. Under their influence, enzymatic processes, the intensity of glycolysis, the level of basic metabolism change and the structure of blood and tissue colloids are disturbed. When determining the degree of climate impact on a person, it should be borne in mind that the body's response to its influence depends on the success of adaptation to weather and climate conditions.

Thus, the study of the influence of meteorological factors under the combined effect of HMS on the body of practically healthy girls of different ages gives grounds to talk about the age-related peculiarities of meteorological variability. It was also confirmed that in a healthy body, changes in

physiological processes and functional activity of systems under the influence of such a factor as weather changes with the simultaneous action of HMS are easily compensated. In these compensatory mechanisms, a special role belongs to the autonomic nervous system, whose activity ensures an adequate response of the body to the influence of environmental

factors. Knowledge about meteosensitivity and meteorological reactions is necessary for the development of both preventive and therapeutic measures aimed at increasing nonspecific resistance and adaptation mechanisms of the body, normalising the function of organs and systems as a basis for normal reactions to adverse environmental changes.

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