Clinical Schizophrenia & Related Psychoses

Correction of Exam Stress in University Students by Short-Term Inhalation of Xenon-Oxygen Mixture

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Abstract

Background: It is known that studying at a higher educational institution is inevitably associated with the impact of constant mental overload, chronic emotional stress, and a number of other aggressive factors among which exam stress occupies a special place.

Aim: To study the efectiveness of treating exam stress in students with short-term inhalation of xenon-oxygen mixture.

Materials and methods: The study involved 100 healthy male volunteers–5th year students of a higher educational institution. Of these, 50 volunteers aged 22-25 and weighing 75.0 kg ± 4.3 kg constituted the main group, and the control group was represented by 50 healthy volunteers aged 20-24 weighting 4.0 kg ± 2.9 kg. The study of the level of exam stress, hormonal status and the state of the tone of the autonomic nervous system in both groups was carried out according to a single protocol in four stages: Stage I–a month before the exam; Stage II–30 minutes before the exam; Stage III–immediately before the exam after inhalation of air-oxygen mixture at the concentration of 1:1 at the gas flow of 10 l/min for the control group and of xenon-oxygen mixture at the concentration of 1:1 at the gas flow of 10 l/min for the main group; Stage IV–a day after the exam.

Statistical analysis: Statistica 6.0 was used for statistical processing of the research results. All the available data samples were tested in terms of normal distribution by the value of the coefficients of asymmetry and kurtosis. The hypothesis of the normality of distributions of random variables was accepted if the coefficients of asymmetry and kurtosis in absolute value did not exceed their standard deviations 3 times and 5 times, respectively. For each sample, the mean value of the trait (X) and the mean error of the mean value (m) were calculated. The Wilcoxon test was used to assess the reliability of sample differences. Differences were considered valid at $P<0.05$.

Results: Short-term inhalation of xenon-oxygen mixture significantly improves the psychophysiological parameters of the student's emotional-volitional sphere: the level of reactive and personal anxiety decreases, the level of stress-limiting hormone-insulin increases, and the sympathetic and parasympathetic effects on the cardiovascular system decrease.

Conclusion: Short-term inhalation of xenon-oxygen mixture increases the level of hormones of adaptation and resistance of the body, has a pronounced anti-stress effect, and reduces the level of pathological adaptive reactions in the conditions of exam stress in students, which reflects a decrease in the level of reactive and personal anxiety.

Keywords: Exam stress • Spielberger questionnaire • Insulin • Cortisol • Kerdo index • Xenon

Introduction

Despite the more than a century-long history of the discovery and description (by Hans Selye) of the signs of stress, domestic and foreign scientific literature still argues upon the definition of stress and the etiology of its occurrence and classification. In particular, according to Markov, occupational stress is consistently realized from anxiety (in the onset of development) through fatigue to the development of severe clinical symptoms of depression and anxiety initiated by stress [1].

It is known that studying at a higher educational institution is inevitably associated with the im-pact of constant mental overload, chronic emotional stress and a number of other aggressive factors, among which exam stress is especially important [2-5], interfering with success in educational activity and leading, ultimately, to a halt in personal development and to psychosomatic disorders [3,6].

Kiseleva et al. define exam stress as a reflection of an uncertain learning situation where the outcome of an exam is not yet known. A study of the level of pre-exam stress by the authors on a ten-point scale revealed that 47% of students experienced maximum stress during the examination session, 32% of the students experienced an average level of stress, and 21% of students noted that they did not experience a feeling of pre-exam stress [7]. The study conducted by Demidova et al. showed a difference in anxiety levels among 50 first-year students. According to the researchers, a high level of anxiety was detected in 50% of students, an average level of situational anxiety was found in 26% of cases, and a low level of anxiety was recorded in 24% of the examined. According to the authors, high anxiety among first-year students is associated with adaptation to new social conditions [2]. The work by Tarasova assesses the dynamics and characteristics of the level of anxiety in students over five years of study at a higher educational institution. The authors found that the severity of anxiety is determined by the characteristics of the student's socialization in various courses and is most pronounced in the first and final years. In particular, in the first year of study, student behavior is aimed at adapting to a collective lifestyle, which is characterized by a lack of skill in predicting the unmotivated risk of the consequences of their actions. Distinctive features of anxiety

among graduate students are a departure from the collective form of social behavior at the university and the emergence of new life priorities related to the uncertainty of a place in the future profession, material support and family status [8], which indicates the absence of a mature identity in the vast majority of graduate students at the time of graduation [9]. Along with the psychological assessment of the personality profile in conditions of anxiety and exam stress of students, a number of works present the dynamics of changes in the functional activity of body systems at various levels of anxiety and the severity of pre-exam stress in students during their studies at a higher education-al institution [3,4,10-13]. Universal indicators of adaptive processes in the body are those of systemic hemodynamics which allow predicting functional state and adaptive capabilities. According to a number of studies, students during the winter and summer examination sessions showed a significant increase in heart rate, systolic and cardiac output [4,10,13]. The works by Chrzanowska et al. and Pryanichnikova evaluate the vegetative functions of students during the examination session. During exam stress, the following are registered: changes in electrical resistance and skin temperature, increased sweating, tachypnea, tachycardia and arterial hypertension, narrowing/expansion of blood vessels, digestive system disorder, hypersalivation, changes in pupil diameter, brain electrical activity and menstrual irregularities in female students [11,12]. The most common clinical manifestations of exam stress are anxiety and depression, fatigue, and insomnia. With a high level of stress, the student's behavior changes, manifested in erratic, uncoordinated movements and gestures, confused and unclear speech, which are replaced by general inhibition, stiffness and refusal of activity under excessive pressure [12]. Ganesh et al. studied the stress level in 100 (49 male and 51 female) medical 1st year students on the reaction of systemic hemodynamics: heart rate, systolic and diastolic blood pressure and its effect on the cognitive function using the time of sound and visual response to the exam and three months after passing the exam. The study showed that exam stress is manifested by various disorders of the cardiovascular system and cognitive function, which are more pronounced in female students. According to researchers, compared with men, women had a significantly increased heart rate. The time of sound and visual reactions, reflecting cognitive function, was significantly increased in female students, which negatively affected the exam results. The authors believe that differences in the reaction of systemic hemodynamics in women are associated with excessive activation of the sympathetic nervous system of women during the examination period, and the cause of cognitive dysfunction in female students is an increased level of adrenaline and glucocorticoids in blood [3]. Thus, provoked by exam stress, an imbalance in the state of higher nervous activity causes a number of reversible dynamic disorders of humoral homeostasis.

The existing medical, physiotherapeutic, homeopathic, and psychotherapeutic methods of treating adaptive disorders due to academic stress in students [14-17] are not without flaws – they require time for obtaining therapeutic effect and, in some cases, are comparable to the placebo effect. In particular, in a randomized, blind, placebo-controlled clinical trial, Ahmad et al. evaluates aromatherapy with lavender oil for male pharmacist students under academic stress. Aromatherapy with lavender oil reduces stress levels and systemic (blood pressure and heart rate) hemodynamics, yet the authors did not reveal significant differences in the nature of the stool, the severity of headache and in the integral hemodynamic parameters, compared with placebo1.

At the same time, treatment of stress with sedatives, hypnotics, tranquilizers, anxiolytics, beta-blockers, antidepressants and phenothiazines, when taken continuously, causes unwanted side effects in everyday life. The existing situation is further aggravated by the fact that self-medication of exam stress is quite widespread in the student community, as evidenced by numerous publications. In particular, Al-Shagawi et al. assessed the frequency of self-treatment of exam stress among male students of pharmaceutical and medical colleges of Imam Abdulrahman bin Faisal University. According to the authors, 63.8% of the students surveyed used caffeine for self-treatment of exam stress, and 17.8% of the respondents used nicotine as an anti-

stress. The prevalence of self-medication among student pharmacists was 31.58%, and medical college students self-medicated academic stress in 29.20% of cases [18].

The results of self-medication of stress in students are presented by Al Rasheed et al. who conducted a 5-month cross-sectional study of the frequency of academic stress and the prevalence of self-medication among female students at medical and pharmaceutical colleges at Dammam State University. According to researchers, the most common means of self-treatment of stress among students was caffeine in the form of coffee, tea and energy drinks (49.5% of all the students surveyed). Caffeine use among medical college students was in 59.09% and among pharmaceutical college students in 29.69% of cases [19]. According to Melaku et al. of the 329 examined medical students at Jimm University in Ethiopia, 35.6% of respondents drank alcohol to self-treat academic stress [20]. Similar results are presented in by Kalayu et al. – 36.4% of students drank alcohol under exam stress [15]. Seipone et al. report that 58% of medical students of the University of Botswana use it as a means of relieving exam stress [21]. In addition, students use cigarettes in 9.5% of cases, and in 17.7% of cases, chewing kata leaves to stay awake, to increase concentration and better assimilation of material [20,22].

Thus, initiated by exam stress, disturbances in the state of higher nervous activity and disorders of humoral homeostasist urgently dictate the need for practical corrective methods which would provide a quick anti-stress effect without undesirable consequences in everyday life. The authors of the present study believe that an alternative to existing methods of treating exam stress (and even more so to self-medication) is short-term inhalation of xenon in sub-narcotic doses, since Lachmann et al., Burov et al., Naumov et al., Vovk et al. clearly demonstrate the possibility of using xenon in treating various adaptive disorders [23-25]. Scientific and technological progress has given medicine the opportunity to use the unique properties of inert gases as universal anesthetics. Earlier studies of its action on the mechanisms of neurohumoral regulation during anesthesia [23] suggest the possibility of using xenon in the treatment of various adaptive disorders [24]. Xenon is a monatomic gas, colorless and odorless, chemically inert, not undergoing any biotransformation in the body [23] and excreted mainly by the lungs. Its serial number in the periodic table is 54, the molecular weight is 131.29, and it has a closed outer electronic shell (2-8-18-18-8), density at the temperature of 0°C and the pressure of 1 atm. It amounts to 5.897 kg/m^3 (4 times more than air and 3.2 times more than nitrous oxide). The solubility of Xe in water at the temperature of 37.0°C is 0.085, in oil it is 1.7. The solubility coefficient of oil/water is 20 [24-29]. The most comprehensive explanation of its mechanism is the combination of its properties: the ability to change the functional state of presynaptic membranes, reduce the production of humoral transmitters and cause blockade of synaptic transmission. At the same time, changes in the functional state of the membrane of nerve cells are easily reversible, since there are no signs of toxic effects during acute and chronic inhalation exposure to xenon at the maximum permissible concentration [24-28]. Thus, xenon, being an inert gas, has a high narcotic strength due to very weak solubility in blood and to high lipotropicity. It practically does not affect organ blood flow and does not significantly change the level of the main biochemical parameters of blood, enzymes, and its electrolyte composition. Xe is devoid of allergenic and carcinogenic properties and does not inhibit the function of the neuroendocrine system-on the contrary, it increases the level of adaptation hormones and body resistance and has a pronounced anti-stress effect manifested in a decreased level of pathological adaptation reactions. Against the background of xenon therapeutic anesthesia, the psychophysiological parameters of the emotional-volitional sphere of patients significantly improve (the level of reactive and personal anxiety decreases). However, to date, issues about the method of using xenon inhalation in emotional stress in optimally acceptable and economical concentrations are still unresolved.

The research aimed to analyze the effectiveness of treating exam stress in

students with short-term inhalation of a xenon-oxygen mixture.

Materials and Methods

Design and study participants

Inclusion criteria: male gender, voluntary informed consent for examination and treatment, age between 22 and 25, no neurological or mental disorders in the anamnesis, no medication 6 months prior to the examination, no endocrinological and cardiovascular diseases, body weight more than 79 kg and less than 82 kg, lack of bad habits (smoking, drinking alcohol), no consummation of tea, coffee and other stimulating drinks 3 hours before the examination, and no participation in other studies.

Exclusion criteria: age younger than 22 years and older than 25 years, history of neurological or mental disorders, taking any medication 6 months prior to the examination, endocrinological and cardio-vascular diseases, body weight less than 79 kg and more than 82 kg, dependence on tobacco or alcohol, consummation of tea, coffee and other stimulating drinks 3 hours before the examination, participation in other studies, lack of voluntary informed consent for examination and treatment.

Measurement and data acquisition tool

The study involved 100 healthy male volunteers – 5th year students of a higher educational institution. Of these, 50 healthy volunteers aged 22-25 and weighing 75.0 kg ± 4.3 kg constituted the main group. The control group was represented by 50 healthy volunteer's aged 20-24 weighting 74.0 kg ± 2.9 kg. The terms, duration of the examination session and the number of exams in the compared groups were identical. The study of the level of exam stress, hormonal status and the state of the tone of the autonomic nervous system in both groups was carried out according to a single protocol in four stages: Stage I – a month before the exam; Stage II – 30 minutes before the exam; Stage III immediately before the exam after inhalation of air-oxygen mixture at the concentration of 1:1 at the gas flow of 10 l/min for the control group and of xenon-oxygen mixture at the concentration of 1:1 at the gas flow of 10 l/min for the main group; Stage IV – a day after the exam. At each stage of the study, venous blood sampling for studies of hormonal status, psychophysiological tests, and assessment of the tone of the autonomic nervous system in the groups were performed in the morning, on an empty stomach, and before and after inhalation of xenon-oxygen mixture in the main group and the oxygen-air mixture in the control group. To exclude additional emotional stress caused by the reaction to anesthesia equipment, an inhalation mask, and the surrounding environment, the inhalation of oxygen-air mixture was performed once a day for 2-3 minutes using a mask from the anesthesia apparatus 'Polinarkon-2P' (Russia) after a 3-minute denitro-genation with oxygen with the gas flow of 5 l/min through a half-open system. Tissue oxygen saturation during inhalation was monitored using a Siemens SC 6000 bedside monitor (Germany). After denitro-genation, 5 minutes before the exam, both groups inhaled the respective mixtures. The procedure lasted 2.0 minutes ± 0.5 minutes in both groups. The state of the students of the main group during the inhalation of the xenon-oxygen mixture was evaluated by pronounced euphoria, muscle relaxation, moderate expansion of the pupils and the appearance of horizontal nystagmus [4,6,30].

Exam stress assessment

The level of exam stress at the stages of the study in the main and control groups was evaluated by adapted Yu.L.Khanin scale reactive (situational) and personal anxiety scale by Ch.D. Spielberger [7]. When interpreting the indicators, the following assessments of the level of anxiety were used: up to 30 points – low, 31-44 points – moderate; 45 and more – high [7,31].

Study of hormonal status indicators

The content of insulin and cortisol in the blood serum in the main and control groups was studied using commercial kits for radioimmunoassay (insulin Rio-INS-PG-125 I IBOH, RB; cortisol sterone-K-125 I IBOH, RB). Blood was taken for analysis in the morning, on an empty stomach from the cubital vein, and 50-60 minutes after inhalation. All the analysis methods were performed according to the instructions attached to the sets. Radiometry of the samples was performed on automatic gamma counters NZ 322 (Hungary) and CLINI GAMMA 1272 SINGL (LKB, Sweden). The concentration of the deter-mined hormones and the quality control of the methods were calculated according to special programs (QUALITY CONTROL) using intralaboratory control sera. The cortisol content was expressed in nmol/l, insulin in international units per liter (mU/l).

Study of the autonomic nervous system tone

To assess the quantitative ratio of sympathetic and parasympathetic influences on the cardiovascular system in the main and control groups, the Kerdo vegetative index (VI) was used, which was calculated by the formula:

$$VI = 100*(1 – DAD/Pulse),$$

where DAD is diastolic blood pressure (mmHg); Pulse – heart rate (beats per min.).

The Vegetative Index (VI) from 0 to 7% reflects the balance of the effects of the sympathetic and parasympathetic parts of the autonomic nervous system on the cardiovascular system (normotonia). Sympathicotonia is indicated by a value of VI>7%, and negative values of VI indicate parasympathicotonia [32].

Research Ethics

Healthy volunteers signed an informed consent form to participate in the examination according to the WMA Declaration of Helsinki and approved by the Local Ethical Committee of Goldberg Research Institute of Pharmacology and Regenerative Medicine.

The research was carried out on the own equipment of the Scientific Research Institute of Pharma-cology and Regenerative Medicine. The examination included the analysis of complaints, case histories, and clinical checkup. A general examination was carried out in physical examination. Growth (m) and body mass (kg) were measured. Blood pressure (BP) level was studied in accordance with international recommendations by means of a 24-hour monitoring of BP using Meditech ABPM-04 (Meditech, Hungary). Blood chemistry test was done with the use of common laboratory techniques.

Statistical Analysis

Statistica 6.0 was used for statistical processing of the research results. All the available data samples were tested in terms of normal distribution by the value of the coefficients of asymmetry and kurtosis. The hypothesis of the normality of distributions of random variables was accepted if the coefficients of asymmetry and kurtosis in absolute value did not exceed their standard deviations 3 times and 5 times, respectively. For each sample, the mean value of the trait (X) and the mean error of the mean value (m) were calculated. The Wilcoxon test was used to assess the reliability of sample differences. Differences were considered valid at P<0.05.

Results

The results of assessing the level of examination stress, hormonal status and autonomic nervous system tone in the analyzed groups at the stages of the study are presented in the table below. The obtained data did not reveal any significant differences in the Kerdo index value, reflecting the sympathetic and parasympathetic effects on the cardiovascular system in the main and control groups 30 days before the exam (Stage I of the study). Along with this, a low degree of examination stress during the intercessional period (Stage I of the study) was recorded in the control group in 82% of the examined and in 80% of the students of the main group (P>0.05).

The frequency of a high degree of examination stress in the main and control groups at the first stage of the study also did not differ significantly and amounted to 6% and 8%, respectively (P>0.05). A moderate degree

of exam stress at this stage of the study was found in 10% of students in the control group and in 14% in the main group (P<0.05). At the same time, there were no significant differences in the level of the stress-realizing hormone cortisol and the stress-limiting hormone insulin, as well as their ratio in the main and control groups 30 days before the exam (Stage I of the study) (Table 1).

Table 1. Dynamics of the degree of exam stress, indicators of hormonal status and autonomic nervous tone in the analyzed groups at the stages of the study (X ± m).

Research indicators	30 days before the exam	30 minutes Before the exam	5 minutes before the exam after inhalation of the mixture	24 hours after exam
	Stage I	Stage II	Stage III	Stage IV
Indicators of hormonal status in the control group (n=50)				
Cortisol, nmol/L	454.7 ± 41.4	794.5 ± 51.8[a]	789.4 ± 46.8[a]	597.6 ± 42.4
Insulin, IU/L	17.5 ± 2.7	22.7 ± 3.1[a]	23.1 ± 2.9[a]	19.8 ± 2.7
Cortisol/insulin	25.9 ± 3.7	35.0 ± 4.1[a]	34.2 ± 4.3[a]	30.2 ± 3.9
Indicators of hormonal status in the main group (n=50)				
Cortisol, nmol/L	491.9 ± 36.7	759.6 ± 41.2[b]	521.2 ± 40.4[b,x]	473.2 ± 41.6
Insulin, IU/L	18.1 ± 2.5	22.1 ± 3.0[b]	19.6 ± 2.74[x]	17.8± 2.9[x]
Cortisol/insulin	27.2 ± 3.6	34.4 ± 4.5[b]	40.3 ± 5.1[b,x]	33.6 ± 4.7
Indicators of the tone of the autonomic nervous system in the control group (n=50)				
Sympathicotonia	9.94 ± 1.35	10.96 ± 1.62	8.25 ± 0.87	7.32 ± 0.36[a]
Eutotonia	5.67 ± 1.15	6.80 ± 0.90	4.25 ± 0.71[a]	3.88 ± 0.67[a]
Parasympathicotonia	-4.96 ± 0.72	-3.82 ± 0.40	-5.61 ± 1.03[a]	-4.36 ± 1.10
Indicators of the tone of the autonomic nervous system in the main group (n=50)				
Sympathicotonia	9.56 ± 1.31	10.87 ± 1.03	4.68 ± 0.93[b,x]	7.06 ± 0.22[b]
Eutotonia	5.45 ± 1.20	6.65 ± 0.84	3.17 ± 0.64[b,x]	3.52 ± 0.54[b,x]
Parasympathicotonia	-4.68 ± 0.93	-3.75 ± 0.32[b]	-6.54 ± 0.40[b]	-4.52 ± 0.99
The degree of exam stress in the control group (n=50)				
Low, n	41	2[a]	4[a]	2[a]
Moderate, n	5	12[a]	12[a]	10[a]
High, n	4	36[a]	34[a]	38[a]
The degree of exam stress in the main group (n=50)				
Low, n	40	1[b]	2[b,x]	40[x]
Moderate, n	7[x]	11	41[b,x]	8
High, n	3	38[b]	7[a,b]	2[x]

Notes: n – number of observations; X – average value of the indicator; m – standard error of the average value of the indicator; IU/L – international units / liter; rel. un – relative units; a – significant differences (p<0.05) indicator from Stage I in the control group; b – significant differences (p<0,05) indicator from Stage I in the main group; x – significant differences (p<0.05) indicator of the main group from the values of the indicator of the control group at each stage of the study.

Compared with Stage I of the study, 30 minutes before the exam (Stage II of the study), a significantly significant decrease in the vegetative Kerdo index was recorded in patients with initial parasympathicotonia by 29% in the control group and by 19.9% in the main group (P<0.05). The analysis of the Kerdo index value for eutotonia and sympathicotonia at Stage II showed no significant differences in its value in the main and control groups, compared with Stage I (Table 1). Assessment of the level of exam stress in the control group 30 minutes before the exam (Stage II of the study) showed a significant de-crease in the low degree of exam stress and an increase in moderate and high degree of stress compared to Stage I. Other dynamics of the degree of examination stress was established at Stage II in students of the main group. In particular, the frequency of a low degree of stress was found in 2% of respondents, against 41% established at Stage I (P<0.05). A high degree of stress was recorded in 76% of students, against 6% detected at Stage I (P<0.05). Notably, there are no significant differences in the frequency of detecting a moderate degree of exam stress at Stage II, compared with Stage I (P>0.05).

The dynamics of the studied indicators of hormonal status in the main and control groups at Stage II, in comparison with Stage I, showed a significant increase in the level of stress-realizing and stress-limiting hormones in both groups (Table 1). Compared with the intercessional period (Stage I), 5 minutes before the exam after inhalation of air-oxygen mixture in the control group and xenon-oxygen mixture in the main group of students (Stage III), a low degree of exam stress during the intercessional period was recorded in the control group, 8% versus 82% in the control group and 4% versus 80% in the main group (P<0.05). The frequency of a high degree of exam stress in the main and control groups at Stage III significantly differed and amounted to 14% and 68%, respectively (P<0.05). At the same time, a moderate degree of exam stress at this stage was found in 24% in the control group and in 82% in the main group (P<0.05).

After inhalation of air-oxygen mixture and xenon-oxygen mixture in the respective groups (Stage III), compared with Stage I, a significant increase in the Kerdo index was recorded with the initial parasympathicotonia by 25%

in the control group and 39% in the main group (P<0.05). A comparative analysis of the value of the vegetative index, indicating eutotonia at Stage III, showed a significant decrease in the value of this indicator in the main and control groups by 41% and 25%, respectively (P<0.05). The indicator of the Kerdo vegetative index, which reflects the level of sympathicotonia at Stage III, showed a significant decrease in the control group by 17% and 51% in the main group, compared with Stage I (P<0.05). An intergroup analysis of the values of the Kerdo index at Stage III showed that in the main group, compared with the control group, the value of the vegetative index decreased by 43% with sympathicoto-nia (P<0.05) and 25% with eutotonia (P<0.05). No significant differences in the Kerdo index value for par-asympathicotonia at this stage of the study were revealed (Table 1).

Assessment of the level of exam stress in the control group 24 hours after the exam (Stage IV) showed a significant decrease in the low degree of exam stress and an increase in moderate and high degree of stress compared to Stage I. In students of the main group at Stage IV stage, different dynamics of the degree of exam stress were recorded. The frequency of a low degree of stress was detected in 2% of respondents, against 41% established at Stage I (P<0.05). A high degree of stress was recorded in 4% of students, against 6% detected at Stage I (P>0.05). Notably, there are no significant differences in the frequency of detecting a moderate degree of exam stress in the main group 24 hours after the exam, in comparison with Stage I (P>0.05).

The dynamics of the studied indicators of hormonal status in the main and control groups 24 hours after the exam, in comparison with Stage I, showed a significant increase in the level of stress-realizing and stress-limiting hormones in both groups (Table 1). 24 hours after the exam, in comparison with Stage I, no significant differences in its value were recorded in the examined control and main groups with the initial parasympathicotonia. At the same time, a statistically significant decrease in the Kerdo index was found among respondents in the control and main groups by 26.3% and 26,%, respectively (P<0.05). Compared with Stage I, students with initial eutotonia showed a decrease in the values of the autonomic index by 31.5% in the control group and by 35.4% in the main group (Table 1). A comparative analysis of the value of the Kerdo index showed that 5 minutes before the exam, after inhalation of air-oxygen mixture, students in the control group with sympathicotonia detected at Stage II recorded a significant de-crease of 24.7%, in case of eutotonia by 37.5% and of parasympathicotonia by 46.8% (P<0.05). A similar dynamics of changes in the values of the vegetative index was found in students of the main group. In particular, after inhalation of xenon-oxygen mixture in volunteers of this group with sympathicotonia established at Stage II, a statistically significant decrease in the Kerdo index was found to be 56.9%, in individuals with etonotonia by 52.3%, and in the examined group with parasympathicotonia by 74.4% (Table 1). Along with this, after 24 hours after the exam, no statistically significant differences in the values of the vegetative index in the control and main groups were revealed (Table 1).

Discussion

The main prerequisite for the present study was the work of Markov. As mentioned above, occupational stress is consistently realized from anxiety (in the onset of development) through fatigue to severe clinical symptoms of depression and anxiety initiated by stress [28]. Exam (situational) stress among students in a higher educational institution is an objective obstacle to successful educational activities and is associated with the impact of constant mental stress [32,33], chronic emotional stress and a number of other aggressive factors [1,20,21,33]. The authors of the present research believe that the cognitive component is consistently manifested in emotional stress and/or anxiety with a low degree of severity of the situational (exam) stress and the development of fatigue characteristic of those examined with an average degree of exam stress. At the same time, a high degree of exam stress is the cognitive equivalent of clinically pronounced depression and/or anxiety. The dynamic complex of psychophysiological reactions of students of the main group obtained in the study after inhalation of xenon-oxygen mixture is associated with the neurophysiological mechanisms of action of

this inert gas. In particular, a study by Booker et al. showed that one of the biophysical mechanisms of xenon is its ability to inhibit glutamateergic transmission, significantly modulating the processes of neuronal excitability and synaptic plasticity [34,35], apparently, mainly due to the limitation of the excessive stimulation of the NMDA glutamate receptors un-der stress. Moreover, Xe is known to compete with glycine, a co-activator of NMDA receptor [26-29]. Ac-cording to the results, the most likely basis for the mechanism of xenon in psychoemotional stress is the improvement of blood circulation in highly vascularized tissues (brain, adrenal gland tissue, etc.). Cumulating in brain tissues due to its high solubility in lipids, Xe directly reduces the activity of the releasing factor of the producing cells of the hypothalamus, which acts as the highest center organizing the vegetative components of emotions [32].

Conclusion

Short-term inhalation of xenon-oxygen mixture significantly improves the psychophysiological parameters of the student's emotional-volitional sphere: the level of reactive and personal anxiety decreases, the level of stress-limiting hormone-insulin increases, and the sympathetic and parasympathetic effects on the cardiovascular system decrease, which reflects a decrease in the level of reactive and personal anxiety.

Declaration of Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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