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Condition of membranes of erythrocytes of peripheral blood of elderly people with chronic tiredness and low level of tolerance to physical load

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Abstract

Purpose: The aim of the work is to study the osmotic stability and morpho-functional features of peripheral blood erythrocytes of patients with chronic fatigue syndrome depending on the level of exercise tolerance and associated risk factors. groups of factors that may be the cause, so the development of measures to eliminate them is an urgent problem today, which requires the development of effective ways to correct chronic fatigue syndrome. It is known that the peripheral part of erythron actively responds to changes that occur in the whole body after the action of various factors, including those factors that lead to chronic fatigue syndrome.
Material and methods of research. The examination was performed on the basis of the Department of Vascular Neurology of the Central Clinical Hospital of Ivano-Frankivsk. The study involved 30 patients aged 55-65 years (mean age 60.6 + 1.2 years), who were divided into 3 groups: 1 gr. included 10 patients with chronic fatigue syndrome and a high level of exercise tolerance. The 2nd group included 10 patients with chronic fatigue syndrome and the average level of exercise tolerance, the composition of 3 gr. included 10 patients with chronic fatigue syndrome associated cardiovascular pathology (angina pectoris, hypertension) and low exercise tolerance (3 gr.).
Results. It is established that chronic fatigue syndrome proceeds in 3 phases and has natural stages of development which are characterized by three groups of etiological factors and the corresponding levels of teletransitivity to physical activity, each of which corresponds to a certain erythrocyte profile and level of osmotic stability of erythrocytes which are offered to use as prognostic and diagnostic characteristics. chronic fatigue syndrome.
Conclusions. The study of the quantitative composition of peripheral blood erythrocytes and hemoglobin, as well as their ratio (color index) in patients with chronic fatigue syndrome on the background of low levels of exercise tolerance revealed a decrease in erythrocytes and hemoglobin by 42% and 25%, respectively, indicating the presence of anemic hypoxia. 2. In conditions of chronic fatigue there is a decrease in osmotic resistance of erythrocytes, as evidenced by a decrease in the number of osmotically stable erythrocytes with a gradual decrease in the concentration of NaCl solution (3.0%; 0.5%; 0.46%; 0.3%).
Key words: chronic fatigue syndrome, exercise tolerance, peripheral blood erythrocytes, osmotic resistance of erythrocytes

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Анотація

Сергій Л. Попель. Стан мембран еритроцитів периферичної крові людей похилого віку при хронічній втомі і низькому рівні толерантності до фізичного навантаження

Мета: - вивчити осмотичну стійкість і морфо-функціональні особливості еритроцитів периферичної крові пацієнтів з синдромом хронічної втоми в залежності від рівня толерантності до фізичного навантаження та асоційованих з синдромом хронічної втоми факторів ризику. Для синдрому хронічної втоми характерним є наявність декількох фаз перебігу і трьох груп факторів, які можуть бути його причиною, тому розробка заходів для їх нівелювання є актуальною проблемою сьогодення, яка потребує розробки ефективних шляхів корекції синдрому хронічної втоми. Відомо, що периферична частина еритрону активно реагує на зміни, які відбуваються в цілісному організмі після дії різних факторів, в тому числі і тих факторів, які ведуть до синдрому хронічної втоми.

Матеріал і методи. Обстеження проводили на базі відділення судинної неврології Центральної клінічної лікарні м. Івано-Франківська. В дослідженні приймали участь 30 пацієнтів віком 55-65 років (середній вік 60,6±1,2 роки), яких поділили на 3 групи: до складу 1 гр. ввійшли 10 пацієнтів з СХВ і високим рівнем толерантності до фізичного навантаження. До складу 2-ої групи ввійшли 10 пацієнтів з синдромом хронічної втоми і середнім рівнем толерантності до фізичного навантаження, до складу 3 гр. ввійшли 10 пацієнтів з асоційованою з синдромом хронічної втоми серцево-судинною патологією (стенокардія напруження, артеріальна гіпертонія) і низьким рівнем толерантності до фізичного навантаження (3 гр.).

Результати. Встановлено, що синдром хронічної втоми перебігає у 3 фази і має закономірні етапи розвитку, які характеризуються трьома групами етіологічних факторів і відповідними рівнями телерантності до фізичного навантаження, кожен з яких відповідає певному еритроцитарному профілю і рівню осмотичної стійкості еритроцитів, які пропонується використовувати в якості прогностично-діагностичних характеристик синдрому хронічної втоми.

Висновки. Дослідження кількісного складу еритроцитів периферичної крові і гемоглобіну, а також їх співвідношення (кольоровий показник) у пацієнтів при синдромі хронічної втоми на фоні низького рівня толерпньності до фізичного навантаження виявило зменшення кількості еритроцитів перифериферичної крові і гемоглобіну відповідно на 42 % і 25 % , що свідчить про наявність анемічної гіпоксії. 2. В умовах хронічної втоми спостерігається зниження осмотичної резистентності еритроцитів, про що свідчить зменшення кількості осмотично стійких еритроцитів при поступовому зменшенні концентрації розчину NaCl (3,0 %; 0,5 %; 0,46 %; 0,3 %).

Ключові слова: синдром хронічної втоми, толерантність до фізичного навантаження, еритроцити периферичної крові, осмотична резистентність еритроцитів

Аннатоция

Сергей Л. Попель. Состояние мембран эритроцитов периферической крови у людей пожилого возраста с хронической усталостью и низким уровнем толерантности к физической нагрузке

Цель: изучение осмотической стабильности и морфофункциональных особенностей эритроцитов периферической крови больных с синдромом хронической усталости в зависимости от уровня толерантности к физической нагрузке и сопутствующих факторов риска. группы факторов, которые могут быть причиной, поэтому разработка мероприятий по их устранению является актуальной проблемой на сегодняшний день, что требует разработки эффективных способов коррекции синдрома хронической усталости. Известно, что периферическая часть эритрона активно реагирует на изменения, возникающие во всем организме после действия различных факторов, в том числе тех, которые приводят к синдрому хронической усталости.

Материал и методы исследования. Обследование проводилось на базе отделения сосудистой неврологии ЦКБ г. Ивано-Франковска. В исследовании приняли участие 30 больных в возрасте 55-65 лет (средний возраст 60,6+1,2 года), которые были разделены на 3 группы: 1 гр. включены 10 пациентов с синдромом хронической усталости и высоким уровнем толерантности к физической нагрузке. Во 2-ю группу вошли 10 больных с синдромом хронической усталости и средним уровнем толерантности к физической нагрузке, состав 3 гр. включено 10 больных с синдромом хронической усталости на фоне сердечно-сосудистой патологии (стенокардия, гипертоническая болезнь) и низкой толерантностью к физической нагрузке (3 гр.).

Результаты. Установлено, что синдром хронической усталости протекает в 3 фазы и имеет закономерные этапы развития, которые характеризуются тремя группами этиологических факторов и соответствующими уровнями телетранзитивности к физической нагрузке, каждая из которых соответствует определенному эритроцитарному профилю и уровню осмотической устойчивости. эритроцитов, которые предлагается использовать в качестве прогностически-диагностических признаков синдрома хронической усталости.

Выводы. Изучение количественного состава эритроцитов и гемоглобина периферической крови, а также их соотношения (цветовой показатель) у больных с синдромом хронической усталости на фоне низкого уровня толерантности к физической нагрузке выявило снижение эритроцитов и гемоглобина на 42% и 25%. соответственно, что свидетельствует о наличии анемической гипоксии. 2. В условиях хронического утомления происходит снижение осмотической резистентности эритроцитов, о чем свидетельствует уменьшение количества осмотически стабильных эритроцитов при постепенном снижении концентрации раствора NaCl (3,0%; 0,5%; 0,46%; 0,3 %).

Ключевые слова: синдром хронической усталости, толерантность к физической нагрузке, эритроциты периферической крови, осмотическая резистентность эритроцитов

Introduction

At present, the problem of chronic fatigue and low tolerance to physical activity is acute all over the world. This is facilitated by the instability of the social situation, the economic crisis, changes in the system of personal values, and environmental factors (global warming). The total number of people with chronic fatigue syndrome reaches 200 million or 5% of the world's population [1]. The main "risk group" of people with low tolerance to physical activity includes young people and adolescents with chronic fatigue syndrome [2]. The constant accumulation of deoxidized substances in the body due to lipid peroxidation in chronic fatigue syndrome stimulates the launch of various pathological reactions affecting metabolic processes, leading to the development of cardiovascular disease and causing low tolerance to exercise. According to the World Health Organization (WHO), the clinical manifestations of chronic fatigue syndrome are: muscle and joint pain; fatigue after waking up, which indicates the lack of regenerative properties of sleep; constant headache; deterioration of health, which lasts for 24 hours after exercise, impaired concentration and memory; "Blurring" of vision; problems with the vestibular apparatus. The multifunctional role of peripheral blood erythrocytes in the mechanisms of adaptation to physical activity and compensation of negative consequences in hypoxia, gas transport processes and other vital functions explains the high informativeness of the results of studying structural and functional changes in these cells in various human conditions. At the same time, the enzyme regulation of the processes of formation and destruction of hydrogen peroxide (H_2O_2) in peripheral blood erythrocytes is an insufficiently studied aspect of hypoxia. Taking into account the data on the direct participation of reactive oxygen species and hydrogen peroxide (O_2, H_2O_2) and enzymes of the antioxidant defense system: superoxide dismutase (SOD) and catalase (CAT) in the oxygenation of hemoglobin [3, 4], is of interest changes in the activity of these enzymes, aimed at improving the structural and functional value of erythrocytes of peripheral blood, necessary for adequate transport of oxygen during exercise in chronic fatigue syndrome.

Chronic fatigue syndrome is diagnosed after 6 months of clinical signs. The disease is divided into 3 phases:

• Prodromal phase: which is characterized by symptoms of chronic fatigue, manifested by physical and mental exhaustion. At this stage, the patient can get rid of chronic fatigue syndrome by changing their lifestyle.

• Acute phase: characterized as a disease of systemic intolerance to physical activity or low tolerance to physical activity. The inability to get out of bed is compounded by impaired thinking and concentration. Characteristic attacks of panic and depression.

• Recovery phase: during which the patient tries to return to normal life, feeling tired and weak.

Etiology of the disease. The causes of chronic fatigue syndrome are classified into three groups: the first group includes psychological problems. These are stressful situations, outbursts of strong negative emotions and depression. The second group includes somatic health problems, such as: anemia; malnutrition; hypothyroidism; sleep apnea; diabetes; adiposity. The third group includes lifestyle problems: alcohol abuse; hypokinesia; caffeine abuse; irregular diet. Among the causes of chronic fatigue syndrome is not the last place overload at work and work at night. All these factors are characteristic of the daily professional activities of a teacher in higher education.

Pathogenesis

At present, the pathogenesis of chronic fatigue syndrome has not been fully elucidated. The disease is based on an abnormal level of chemicals synthesized in the system "hypothalamus - pituitary - adrenal glands". This system is responsible for controlling many physiological functions: sleep, vitality and stress reactions. At the same time, patients with chronic fatigue syndrome have low levels of serotonin and dopamine in the body. Signs of chronic fatigue syndrome often develop after a violation of the immune system. In general, the prognosis for recovery is favorable with timely medical attention. However, in the scientific literature there are no criteria for this timeliness.

Therefore, there is an urgent need to establish objective criteria for the course and predict the treatment of a patient with chronic fatigue syndrome with professional help. At long action of stress factors there is a steady disturbance of a metabolism in an organism which are the reason of many comorbid diseases and, as a consequence of decrease in level of protective forces of an organism; the level of human social activity, his ability to work and the adequacy of behavior decreases [5].

Under the action of toxic substances, conditions are created for the intensive formation of products of lipid peroxidation, which leads to the development of oxidative stress and, accordingly, to the peroxide destruction of cell membranes.

Activation of free radical oxidation processes is the basis of many pathological processes, and in particular low tolerance to exercise. It is known that hypokinesia and hypoxia as constant companions of chronic fatigue syndrome affect the key stages of intracellular metabolism and, above all, the processes of energy metabolism, which relate mainly to aerobic oxidation of fatty acids and glucose [6]. As a result of lipophilic effects of lipid peroxidation on cell structures, the properties of cell membranes, their liquid crystal structure, viscosity and stability change, which is especially evident in cells with low adaptive capacity, such as peripheral blood erythrocytes. This is accompanied by suppression of all functions and premature aging of the body.

Erythrocytes of peripheral blood, in close contact with all tissues and entering into morphological functional relationships with them, their own qualitative and quantitative adjustment reflect the physiological and pathological changes that occur throughout the body, thus causing the so-called "exquisite" (reflected) reactions as prognostic markers for a number of chronic diseases [7].

The aim of the study was to study the osmotic stability and morpho functional features of peripheral blood erythrocytes of patients with chronic fatigue syndrome depending on the level of tolerance to exercise and risk factors associated with chronic fatigue syndrome.

Material and methods

Participants

The examinations were performed on the basis of the neurological department of the Central Clinical Hospital in Ivano-Frankivsk. The study involved 30 patients aged 55-65 years (mean age 60.6 + 1.2 years), who were divided into 3 groups: 1 g. included 10 patients with chronic fatigue syndrome and a high level of tolerance to exercise. The 2nd group included 10 patients with chronic fatigue syndrome and moderate tolerance to exercise, the 3rd group included 10 patients with associated with chronic fatigue syndrome cardiovascular disease (stress angina, hypertension) and low physical tolerance. load (3 group). Among the patients were 15 teachers of higher education institutions with at least 15 years of teaching experience.

All participants were informed about the purpose of the study and gave written consent to participate in the study, which was conducted in accordance with the Helsinki Declaration of the WMA - Ethical Principles of Medical Research for Human Subjects, 2013.

Morpho-biochemical methods of erythrocyte analysis

Morphological studies of erythrocytes were performed in a scanning electron microscope "JEOL-25M-T220A" (Japan) according to the generally accepted method [3]. Used, where A is the total number of erythrocytes, B is the number of irreversibly altered forms of erythrocytes, B is the number of inversely altered forms of erythrocytes. The low level of conformational ability of erythrocytes is determined at values of erythrocyte deformation index from 1.6 to 2.5, medium - in the range of 2.6-3.9, high - at 4.0-6.0. To determine the electrolyte composition of erythrocytes in a muffle furnace at a temperature of 800 Co ash was 2 ml of erythrocyte mass. The ash was pressed, after which the surface of the mold was sprayed with carbon (≈10 nm). Determination of erythrocyte concentration of macronutrients such as sodium (Na), potassium (K), iron (Fe), magnesium (Mg) and calcium (Ca) was performed using a computer program "SELMI" and a prefix for energy-dispersive X-ray microanalysis EDAR ”On the REMMA-102E scanning electron microscope (SELMI, Ukraine) with an accelerating voltage of 20 kV in the energy range from 960 to 19600 kiloelectron-volts (keV). Morpho functional parameters and osmotic resistance of erythrocytes (WEM) were studied in the blood, which was determined by the Janowski microscopic method using descending (3%, 0.5%, 0.46%, 0.3%) concentrations of NaCl solution. The number of peripheral blood erythrocytes was determined in Goryaev's chamber. The hemoglobin concentration was determined with a hemometer. Erythrocyte sedimentation rate was determined by the unified Panchenkov micromethod [5].

The level of tolerance to physical activity was determined by cycling ergometry (cycling ergometer "Kettler" Germany) according to the PWC100 protocol.

The surface architecture of peripheral blood erythrocytes was studied using scanning electron microscopy (SEM) (electron microscope "JEOL 25A T3225"; Japan) with the preparation of samples according to the method of Romashchenko O.V., V.F. Kamenev [7] and GI Kozinets and co-authors [3]. The calculation of different morphological forms of EPA was performed according to the classification of GI Kozynets and co-authors [3]. Some of the studies were performed on a hemoanalyzer (Lab Analyt30000Plus) (Finland).

Determination of the microelement composition of EPA (nitrogen, calcium, magnesium) was performed using energy-dispersed X-ray structural scanning on the attachment for microanalysis "EDAR" to the scanning electron microscope "REMMA 202E" (Sumy, Ukraine)

Determination of erythrocyte deformability index was performed by the method of C. Tannert, V. Lux in modification Z.D. Федоровой, M.O. Kotovschikova [8]. Oxygen saturation was determined by pulse oximetry on a Jziki-Fingertip oximeter. For the clinical characteristics of patients with CFS determined the level of overall morbidity, health self-assessment index; Heart rate at rest and at FN; double product; stress index (IN); adaptive potential according to Baevsky [9]; percentage of excess body weight.

Statistical analysis

Statistical analysis was performed using the standard software package SAS 8.0 (SAS Inc., USA). Criteria t and $\chi 2$ were used. Statistical processing of quantitative indicators was performed using the computer software package "Statistica 6.0" [10]. Data are presented as arithmetic mean ± standard deviation (M ± SD). The obtained results were not subject to the law of normal distribution according to the Kolmogorov-Smirnov criterion, therefore the statistical significance of the intergroup difference was estimated using the Mann-Whitney test and the nonparametric Kruskal-Wallace test using the nonparametric Spearman correlation coefficient. The difference was considered statistically significant at a bilateral level of $p < 0.05$.

To determine the significance of the influence of qualitative value of the erythrocyte deformation index on the functional state of the cardioregulation system, a nonparametric analysis of variance of heart rate variability was performed [9] both before and after exercise at maximum aerobic capacity. The obtained data were subject to variational-statistical processing by the method of small sampling [10]. The difference was considered statistically significant at $p < 0.05$ and below.

Results

The main complaints of patients with CFS are presented in table. 1

Table 1

The structure of complaints in groups of teachers with chronic fatigue syndrome (%)

Clinical manifestations	Groups	
	Women, n = 20	Men, n = 10
Sleep disorders	85.0	14.2*
Impaired short-term memory and ability to concentrate	65.0	35.7*
Feeling of constant unexplained fatigue for 6 months or more	100	100
Depression	65.0	28.6*
Prolonged subfibrillation (37,2–37,4°C)	85.0	50.0*
Headache, muscle and joint pain	70.0	28.6*

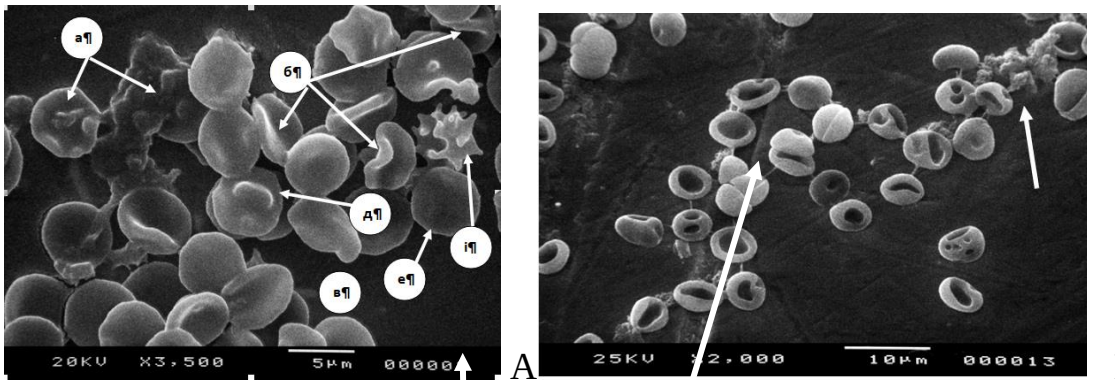
Note: * - the difference is probable at $p < 0.05$.

The state of the membrane of destabilizing processes is characterized by various criteria. This is primarily the level of functional activity of endogenous phospholipases and the dynamics of lipoperoxide accumulation. According to our results, the severity of membrane destabilizing processes increases from the minimum values in patients 1 gr. with a more favorable form of chronic fatigue syndrome and a high level of tolerance to physical activity to the maximum level in patients 2 gr. and patients 3 gr. (with a low level of tolerance to physical activity on the background of cardiovascular disease), which is manifested by the expansion of the hemogram and its change from normal, unimodal type of hemogram (Fig. 1, A) to bipolar type of peripheral blood erythrocytes (Fig. 1, B) by their corpuscular volume, with a significant shift of the distribution peak to the left (Fig. 1 B). This is closely correlated ($r = 0.93$) with the appearance of cells with irreversibly altered shape among erythrocytes (Fig. 1, A, B).

It was found that the level of tolerance to exercise 82% of patients with chronic fatigue syndrome had low physical performance, which averaged 0.87 + 0.02 W / kg, which is 25% less than the reference values. The number of peripheral blood erythrocytes depends on many factors, the general mechanism of action of which is expressed in a hypoxic state. Toxic substances (eg, lipid peroxidation products) may also be such factors [11, 12].

The results of the studies revealed significant changes in blood parameters in patients with chronic fatigue syndrome with a low level of exercise tolerance (Table 1). There is a decrease in

the number of peripheral blood erythrocytes by 42% compared to the reference values of physiological norm. Erythropenia accompanies the syndrome of chronic fatigue and is closely correlated (r = 0.87) with a decrease in hemoglobin to 90 ± 8.2 g / l (Table 1) and with hemogram (Fig. 1).



A B

Fig. 1. A. Acanthocyte (a), erythrocyte with crest (b), erythrocyte with one outgrowth (c), erythrocyte with dome (e), spherocyte (d) echinocyte (i) in patients 3 gr.
B: the arrow shows the "shadows" of erythrocytes

Table 2

Blood parameters in chronic fatigue syndrome with low tolerance to exercise compared with reference data (M ± m, n = 10)

Indexes	Physiological norm	Chronic fatigue syndrome
Erythrocytes (× 10^{12}/l)	4.5 ±0.7	2.6±0.43 P<0.001
Hemoglobin (g / l)	120.0±13.2	90.0±10.4 P<0.001
Erythrocyte sedimentation rate (mm / hour)	11.4±1.0	9.6±0.4 P<0.001
Color indicator	0.8±0.01	0.89±0.002 P<0.001

Note: P is the degree of probability of the results in relation to the control

In order to maintain homeostasis, the blood system responds not only to quantitative but also qualitative changes in its composition to any exogenous or endogenous factors [12].

As a result of the study in patients of group 3 with chronic fatigue syndrome with a low level of tolerance to exercise, specific features of the indicators of osmotic resistance of erythrocytes were established. Compared with the physiological norm with a low level of tolerance to exercise, there is a decrease in the number of erythrocytes at a concentration of NaCl 3% by 42.2%, at a concentration of 0.5% by 28.6%, at a concentration of NaCl 0.46% - by 46.2% and at a concentration of NaCl solution of 0.3% by 54.5% (Table 2).

Table 3

Indicators of osmotic resistance in different states of the body (n = 10)

Concentration NaCl	Physiological norm (the number of erythrocytes) $\bar{x}$	Chronic fatigue syndrome	Tolerance to physical activity, W / kg body weight
3%	4.5±0,9	2.6±0,04	3.0±0.04
0.5 %	2.1±0,6	1.5±0,8	1.2±0.8
0.46 %	1.3±0,1	0.7±0,03	0.5±0.03
0.3 %	1.1±0,2	0.5 ± 0,1	0.5±0.1

Our data on the decrease in the resistance of peripheral blood erythrocytes in chronic fatigue syndrome with low tolerance to exercise can be explained by the fact that the products of lipid peroxidation are included in the lipid layer of membranes, increasing the surface area of cytoplasmic membrane in erythrocytes. Therefore, the condition of peripheral blood erythrocytes is a sensitive indicator of changes in the normal course of physiological, biochemical and biophysical processes in the body, which are due to the influence of external or internal factors, including physical factors, which is exercise. Determination of osmotic resistance of erythrocytes is an important research method for diagnosis in sports medicine, used to study the mechanism of pathological processes and the impact of certain types of exercise [13]. This changes the biochemical parameters of peripheral blood erythrocytes (table 1), which is especially evident when comparing the indicators obtained in patients with low and high levels of tolerance to exercise (table 3).

Table 4

Indicators of phospholipase activity α2 and the content of lipid peroxidation products in the erythrocytes of peripheral blood of patients of group I depending on the level of tolerance to exercise (M ± m)

Indicators	High level of tolerance to physical activity, control group (n=5)	Patients with chronic fatigue syndrome, n=10	
		Low level of tolerance to physical activity (n=5)	Average level of tolerance to physical activity (n=5)
Phospholipases -α2, % hemolysis	4.44±0.22	21.9±1.73*/**	15.1±0.71*
diene conjugates, nmol ·ml	47.9±1.51	155.77±5.5*/**	121.1±2.33*
Schiff compounds, conventional units	17.89±1.03	29.33±1.11*/**	22.3±1.71*

Примітка:* – вірогідність статистичної різці між показниками з високим і низьким рівнем толерантності до фізичного навантаження (p<0,05);
** – вірогідність статистичної різці між показниками з високим і середнім рівнем толерантності до фізичного навантаження (p<0,05).

Thus, in patients with chronic fatigue syndrome, regardless of the level of tolerance to exercise, there was a multiple increase in the content of lipid peroxidation products (diene conjugates and Schiff compounds) and phospholipase-α2 activity relative to the control group (p <0.05) with a high level of tolerance to physical activity, the appearance of erythrocyte sludges in the form of "coin" columns and fibrin threads between individual erythrocytes after exercise (Fig. 2).

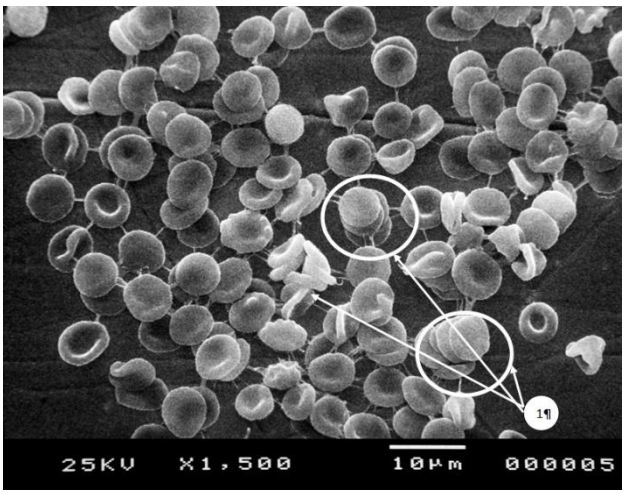


Fig. 2. Formation of local aggregates in the form of "coin columns" (1) and fibrin threads between individual erythrocytes in patients of the 3rd group with chronic fatigue syndrome, after bicycle ergometric testing according to the PWC_{100} protocol

At the same time, as the level of exercise tolerance decreases, the content of lipid peroxidation products (diene conjugates, Schiff compounds) naturally increases ($p < 0.05$) and closely correlates ($r = 0.93$) with an increase in the number of peripheral erythrocytes. blood irreversibly changed shape (Fig. 1, B), which can be a prognostically unfavorable indicator, a reason to see a doctor and a more thorough examination by a specialist.

Discussion

The idea that the level of physical performance is related to the main indicators of health [6, 7, 9], is more confirmed in patients 56 60 years (the correlation coefficient between the level of physical performance and the overall incidence is 0.345; index self-assessment of health r = -0.399, heart rate at rest - -0.382, double product 0.371, stress index r = -0.333, p = 0.001 adaptive potential - +0.319,% overweight r = -0.539, p = 0.001). In younger patients 40 to 55 years of age, such a dependence is absent, except for the relationship between the level of physical performance and the degree of risk of cardiovascular disease (r = -0.356, p = 0.006).

The degree of risk in patients aged 50-65 years is associated with overall morbidity (r = 0.311), health self-esteem index (r = 0.318; p = 0.006), blood pressure (r = -0.388), double product (r = 0.322), adaptive potential (r = –0.462), the amount of excess body weight (r = 0.463, volumetric size of the waist (r = 0.311) and pelvis (r = 0.341), as well as the level of daily motor activity (r = –0.486) ($p < 0.01$). This explains the interdependence of the PWC test with the level of exercise tolerance in people aged 50-65 years with chronic fatigue syndrome, as in most of them in the absence of physical activity, when performing PWC100 loads, active and subjective signs of inadequate response of the body (hypertension, incoordination of the cardio-respiratory system [8], feeling of tension, headache, dizziness, nausea, discomfort, etc.), which is closely correlated (r = 0.93; p = 0.006) with increasing number of irreversibly altered peripheral erythrocytes blood.

Ignorance of such patterns can lead to incorrect calculation of maximum physical performance, its ergometric and metabolic parameters. This is confirmed by statistical differences in the main indicators of morpho functional status, physical performance and morbidity in patients of different risk groups for the development of chronic fatigue syndrome and comorbid diseases [14, 15, 16] (Table 4).

Table 5

Indicators of morpho-functional status of patients 50 to 65 years with varying degrees of risk of cardiovascular disease (M ± m, n = 134)

Indexes	Degree of risk			P_{1-2}	P_{1-3}	P_{2-3}
	low	average	high			
Body weight, kg	67.2±2.14	71.4±3.06	98.3±3.17	<0.05	<0.05	<0.05
Body fat, %	15.2±0.28	18.0±0.93	22.5±1.11	<0.05	<0.05	<0.05
Kettle Index, conventional units	24.9±1.23	28.4±1.46	30.5±1.61	<0.05	<0.05	<0.05
Heart rate, beats / min	71.6±3.22	72.1±3.35	89.1±5.19	>0.05	>0.05	>0.05
Systolic blood pressure, mm Hg	123.7±4.53	124.6±3.72	131.6±9.22	>0.05	<0.05	<0.05
Diastolic blood pressure, mm Hg	76.2±3.16	79.1±3.31	84.7±3.63	<0.05	<0.05	<0.05
voltage index, conventional units	111.5±8.17	123.4±9.02	149.9±9.85	<0.05	<0.05	<0.05
Adaptive potential of the circulatory system to environmental factors, conventional units	1.5±0.09	1.6±0.12	1.7±0.15	>0.05	<0.05	<0.05
Tolerable level of physical activity, W / kg	1.3±0.05	1.1±0.03	0.84±0.02	<0.05	<0.05	<0.05
Oxygen uptake at a tolerable level of exercise, ml / min / kg^{-1}	35.1±2.03	31.4±1.82	27.7±1.53	<0.05	<0.05	<0.05
Morbidity: number of days of temporary incapacity for work	7.8±1.96	9.2±1.44	12.2±2.42	>0.05	<0.05	<0.05

Using data on morphological changes of peripheral blood erythrocytes, we propose to create an erythrocyte profile of patients to predict the risk of developing complications associated with chronic fatigue syndrome, in which the main indicators should be the level of exercise tolerance based on erythrocyte deformability index [17–22]. The main risk factors must also be taken into account (Fig. 5).

Prospects for further research

Further research may be aimed at finding ways to improve the system of cardiohemodynamic control of people with chronic fatigue syndrome, and find measures to prevent and reduce the impact of the main factors of CFS in people of all ages.

Limitation

The study was conducted among older teachers, so the data obtained relate only to the studied contingent. Additional research is needed to disseminate the data among people of other ages and social groups, as well as among representatives of other specialties.

Conclusions

1. The study of the quantitative composition of erythrocytes of peripheral blood and hemoglobin, as well as their ratio (color index) in patients with chronic fatigue syndrome on the background of low tolerance to physical fatigue revealed a decrease in erythrocytes and hemoglobin by 42% and 25%, respectively. the presence of anemic hypoxia.

2. In conditions of chronic fatigue there is a decrease in osmotic resistance of erythrocytes, as evidenced by a decrease in the number of osmotically stable erythrocytes with a gradual decrease in the concentration of NaCl solution (3.0%; 0.5%; 0.46%; 0.3%).

3. With chronic fatigue there is a deterioration of membranes in erythrocytes of peripheral blood, as evidenced by a decrease in their osmotic stability and increase in the number of irreversibly altered forms of erythrocytes of peripheral blood, as well as a decrease in erythrocytes of peripheral blood, which is closely correlated with

It should be noted that in different risk groups of chronic fatigue syndrome differ leading factors, as well as major comorbid chronic diseases.

1. In the high-risk group, the main factors are hypokinesia, overweight, hypertension, hereditary factors; along with diseases of the cardiovascular system in this risk group revealed chronic fatigue syndrome associated with chronic diseases of the endocrine, musculoskeletal and respiratory systems, which corresponds to the data of other authors.

2. In the group of medium risk the main factors are: hypokinesia, overweight, nervous and emotional overload; chronic diseases of the cardiovascular, nervous system, musculoskeletal system and senses, combined with a decrease in disc-shaped erythrocytes of peripheral blood by 35%.

3. Patients in the low-risk group have virtually no pathogenetic factors in the development of chronic diseases. Exceptions are only patients with severe hypokinesia and nervous and emotional overload, as well as diseases of the digestive system.

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Conflict of interest

The authors declare that there is no conflict of interest.

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