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# THE CONTENT OF THE MAIN CHEMICAL ELEMENTS IN BLOOD SERUM OF PRESENT-DAY EVENKS, THE INDIGENOUS ETHNIC GROUP OF THE RUSSIAN ARCTIC

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The Evenks are an indigenous people of the North of Russia. The study included 103 Evenks living in the rural area of Jilinda in the Oleneksky district of Yakutia. The concentration of 4 major elements was determined in the blood serum by mass-spectrometry: sodium (Na), magnesium (Mg), phosphorus (P), calcium (Ca). The study revealed a reduced level of calcium (72.8 mg/L) and an increased concentration of phosphorus (130.3 mg/L) in the serum of Evenks compared to the literature data, which may affect the development of diseases in this ethnic group.

**Keywords:** major elements, serum, indigenous peoples of the North, Evenks, Arctic, sodium, magnesium, phosphorus, calcium.

**Introduction.** In the conditions of the fragile nature of the Russian Arctic, 45 indigenous peoples of the North live. In Russia, a comparative analysis of the 2002 and 2010 censuses showed that 15 ethnic groups showed a slight increase in numbers, all other ethnic groups showed a sharp decrease: "Kereks" - 4, "Enets" - 227, "Uilta (Oroks)" - 295, "Chulms" - 365, "Tofalars" - 762, and "complete assimilation" of the Alyutors and Izhors was also recorded [2, 3, 8]. According to the All-Russian census of 2010, 958.5 thousand people live in Yakutia, of which the indigenous population is: Yakuts - 466.5 (48.7%), Evenks - 21.0 (2.2%), Evens - 15 ,1 (1.6%), Dolgan - 1.9 thousand people. (0.2%) [7].

Indigenous peoples of the North of Russia do not adhere to the traditional way of life in the conditions of modern socio-economic development, which entails a deterioration in health. The morbidity and mortality rates of the population of the northern regions have increased [5]. Currently, according to the Federal State Statistics Service of the Russian Federation, there is no data on the health status of the indigenous population of the North, since this information is recorded within the framework of an administrative entity.

According to the results of the All-Russian census of 2010, the number of Evenks was 37,800 people, of which 21,000 people live in Yakutia [7]. Currently, the Evenks lead a sedentary lifestyle, living in isolation in the tundra in national villages. A small number of men are engaged in reindeer herding, hunting and fishing. There is a sharp decrease in the number of domestic deer. A quarter of the population does not every day consume venison and fish products, which traditionally represented the basic part of the diet of the indigenous peoples of the North. The Evenk diet consisted of bakery, pasta and sugar [10].

The reference values of the main elements that make up human biological fluids and tissues are determined: calcium, magnesium, sodium, potassium, phosphorus, sulfur, fluorine and chlorine. Their content at different ages of a person, their role in metabolism and pathogenesis of diseases have been studied [6]. Methods of biochemical analysis have been introduced into Russian healthcare practice to determine the content of macroelements in the blood serum of patients. Unfortunately, these routine tests are carried out in the laboratories in large cities for medical reasons. Indigenous peoples of the North, living in remote villages, do not have access to such types of medical research.

In this regard, the purpose of this study was to determine the regional basic level of macroelements in the blood serum of the Evenks and to search for the dependence of the content of elements with age in the adult population.

**Materials and research methods.** The study involved 103 Evenks of the village Jilinda. The village Jilinda in the Oleneksky district of Yakutia is located beyond the Arctic Circle in the forest-tundra on the banks of the Malaya Kuonapka River, a tributary of the river Anabar. The road to the nearest village Olenek is only 300 km by winter road, there are no regular helicopter flights. The population is made up of indigenous peoples of the North - Evenks, 400 adults, 200 children. They are engaged in reindeer breeding and commercial hunting. The inhabitants of the village have lost the Evenk language, communication is conducted in the Yakut language. Written informed consent was obtained from residents prior to inclusion in the study. The survey was conducted in accordance with the principles and ethical standards established by the Declaration of Helsinki (Local Committee on Biomedical Ethics of the Yakut Science Center of Complex

**Table 1**

**Age and gender distribution of Evenk people who participated in this study**

| Age, years | Male | Female | Total |
|---|---|---|---|
| 25-29 | 1 | 2 | 3 |
| 30-39 | 7 | 10 | 17 |
| 40-49 | 8 | 12 | 20 |
| 50-59 | 15 | 19 | 34 |
| 60-69 | 8 | 18 | 26 |
| 70-79 | - | 3 | 3 |
| Total | 39 | 64 | 103 |

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Serum was separated and stored in aliquots frozen at -40°C. The content of major elements in serum was quantified by inductively coupled plasma mass spectrometry (ICP MS) using an Elan 9000 instrument (Perkin Elmer, USA) at the Institute of Tectonics and Geophysics (Khabarovsk). The content of the following 4 elements was studied: sodium (Na), magnesium (Mg), phosphorus (P), calcium (Ca). Samples were decomposed in glassy carbon crucibles by an open method. An aliquot of 0.5 ml was taken to determine the concentration. To decompose the sample, 1 ml of conc. $HNO_3$ and $H_2O_2$, after evaporation, 10 ml of 10% $HNO_3$ was added to the dry residue and heated until the precipitate was completely dissolved. After that, the solution was cooled to room temperature, transferred to a measuring tube, and adjusted with 2% $HNO_3$ to a volume of 50 ml. Calibration straight lines were built using three points: 0; 20 and 40 μg/dm$^3$, for which multielement standard solutions from Perkin Elmer were used. To reduce the influence of the matrix effect on the determination of element concentrations, the internal standard method was used, which was the indium isotope $^{115}$In, which was additionally added to all samples at a concentration of 40 μg/dm$^3$. Whenever possible, the most common isotopes with minimal isobaric and polyatomic interferences were selected to determine the concentration of elements. The content of the studied chemical elements in the blood serum was expressed in milligrams per liter (mg/L).

Statistical processing of the obtained results was carried out using the SPSS 19.0 application package. Checking the normality of the distribution of quantitative traits was carried out using the Shapiro-Wilk test. A descriptive analysis of the numerical characteristics of the traits was carried out (Me (Q25-Q75) - median (interquartile range 25 and 75). When comparing differences in groups, non-parametric assessment criteria were used (U-test according to the Mann-Whitney method). To analyze the relationship between quantitative traits, we used correlation analysis with calculation of the Spearman correlation coefficient (rs) The critical value of the significance level (p) was taken equal to 0.05.

**Results and discussion.** 103 Evenks took part in the study of the macroelement composition of the blood serum, of which 39 (37.9%) were men and 64 (62.1%) were women (Table 1). The age of the subjects was from 25 to 79 years. The mean age with standard deviations for men was 54 (41-59) years, for women - 55 (44-61) years, without statistically significant differences.

The content of the main "structural" human elements, sodium (Na), magnesium (Mg), phosphorus (P), calcium (Ca) in the blood serum of the Evenks is presented in Table 2 and Table 3. The serum content of macroelements in Evenks had a normal distribution in the sample, except for calcium.

Table 3 reflects the median values in the serum content of major elements in Evenks, the values of the literature data studied by the ICP-MS method are given. Serum sodium (Na) and magnesium (Mg) in Evenks were within the limits of literature data. The content of serum phosphorus (P) was at the level of the upper limit of literary values, and content of calcium (Ca) was low.

The content of elements was analyzed separately for male and female (Table 4). When comparing of median macroelements values by gender, no significant differences were found.

Correlation analysis the serum calcium (Ca) from age in both gender was carried out. At the same time, Evenks women showed a tendency to decrease in calcium levels with age (rs=-0.2; p=0.15) (Figure). In Evenk men, no dependence of calcium on age was found (rs=0.0003; p=0.998). The dependence of serum phosphorus (P), sodium (Na), magnesium (Mg) on age in Evenks of both genders did not differ significantly.

Sodium (Na) contains the most electrolytes in the human body. Sodium is present in all body fluids and tissues, but the highest concentration is in the blood and extracellular fluid. It plays a major role in the distribution of fluid between the extracellular and intracellular spaces. Differences in electrolyte concentrations in the cell and extracellular fluid are maintained by the mechanism of active ion transport, which is carried out with the participation of the sodium-potassium pump. Sodium is necessary for the formation of bone tissue, for the transmission of impulses in the nervous system, and muscle contractions. Removal of sodium from the body is carried out mainly with urine. In the kidneys, the ion is reabsorbed in the tubules after glomerular filtration. The activity of reabsorption of Na ions is significantly affected by the concentration of aldosterone in the body, the secretion of which by the adrenal cortex is under the control of the renin-angiotensin system [6]. For humans, the source of sodium is salt. Most get their daily intake of this element from salt. In Russian medical laboratories, the determination of sodium concentration in blood serum is carried out by the ion-selective method; a reference interval of 136-145 mmol/L (3126.6-3333.6 mg/L) is taken as

**Table 2**

**The serum content of major elements in Evenks, n=103, mg/L**

| Major element | Median | 1st Qu. 25% | 3rd Qu. 75% | Mean | SD[1] | Min | Max | Sh-W test[2] |
|---|---|---|---|---|---|---|---|---|
| Sodium | 3002.3 | 2801.5 | 3113.7 | 2972.0 | 201.3 | 2540 | 3450 | 0.220 |
| Magnesium | 17.8 | 12.5 | 22.1 | 17.7 | 5.6 | 7.5 | 33.7 | 0.182 |
| Phosphorus | 130.3 | 105.1 | 159.1 | 131.3 | 33.1 | 58.0 | 200 | 0.077 |
| Calcium | 72.8 | 51.0 | 138.6 | 111.4 | 93.7 | 14.6 | 414.7 | **0.000** |

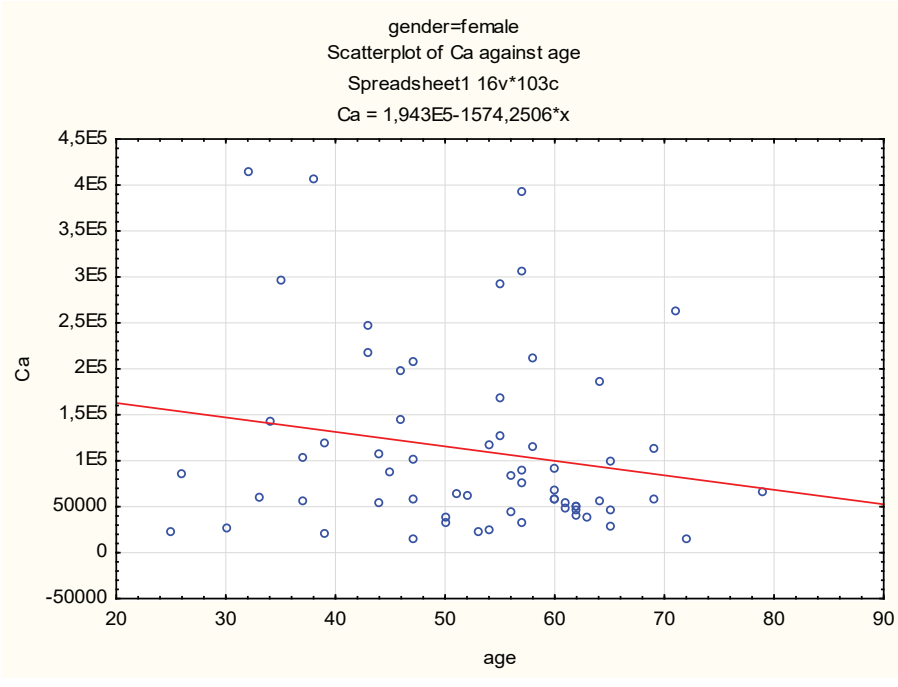
[1]SD – standard deviation.
[2]Sh-W test – Shapiro-Wilk test.

**Table 3**

**The serum content of major elements in Evenks and Literature data, mg/L**

| Major element | Evenks, n=103 | Literature data |
|---|---|---|
| | Me (Q25-Q75) | |
| Sodium | 3002.3 (2801.5-3113.7) | 2277-4320 |
| Magnesium | 17.8 (12.5-22.1) | 14.8-34.0 |
| Phosphorus | 130.3 (105.1-159.1) | 77-133 |
| Calcium | **72.8** (51.0-138.6) | 77-125 |

Me (Q25-Q75) – median (interquartile range 25 and 75)




Dependence of serum calcium in female on age

the norm [16]. In our study, the serum sodium (Na) in Evenks (3002.3 mg/L) was found to be lower when compared with the results obtained by ICP-MS in residents of Novosibirsk, Siberia - 4321 mg/L [11], in healthy adults in Germany - 4190 mg/L [27]. In Spain, in the elderly with age-related cataract, serum Na ranged from 2277-3666 mg/L [12]. The serum Na in Evenks did not differ by gender (Table 4) and did not depend on age.

Magnesium (Mg) is a mineral involved in energy production, muscle contraction, nerve impulse conduction, and bone skeleton construction. It enters the body from food, being absorbed in the small and large intestines. Magnesium is mainly concentrated in bones, cells, and tissues [6]. Its largest part (60%) is contained in the bones, forming their structure in collaboration with calcium (Ca). At the same time, Mg is a natural physiological antagonist of calcium ions. The blood contains about 1% of the total amount of magnesium [4, 6]. In Russian healthcare, the determination of magnesium in blood serum is carried out by the ion-selective method, the reference interval in adults is 0.66–1.07 mmol/L (16.05–26.01 mg/L) [16]. According to the literature data, serum magnesium by ICP-MS was found in residents of Germany - 14.75 mg/L [27], in residents of Shanghai in China - 17.9 mg/L [28], in female students in the city of Yaroslavl, Russia - 19.2 mg/L [9], residents of St. Petersburg, Russia - 19.4 mg/L [1], elderly people with eye diseases in Spain - 23 mg/L [12], population of Novosibirsk, Russia - 28.0 μg/L [11], among the elderly in Switzerland - 34.0 [17]. In residents of Jilinda, serum Mg (17.8 μg/L) is within the literature values, without differences by gender (Table 4) and age.

Phosphorus (P) plays a fundamental role in basic cellular processes, such as bioenergetics, intracellular signaling and mineralization of bones and teeth, and is part of nucleic acids and cell membranes. About 70-80% of phosphorus in the body is associated with calcium, forming the framework of bones and teeth, 10% is in the muscles and about 1% in the nervous tissue. The rest is contained in all cells of the body as an energy reserve. Normally, about 1% of all phosphorus is in the blood [6, 22]. Phosphorus, being a part of many food products, is quickly absorbed in the small intestine. In the laboratories of Russian medical institutions, inorganic phosphorus in serum is determined by colorimetry with ammonium molybdate, while the reference values are 0.74–1.45 mmol/L (22.92–44.91 mg/L) [16]. A comparison was made with the data of the Dolgans, indigenous peoples of the North, living in the village of Yuryung-Khaya. Dolgan survey was conducted by us in April 2017 according to a similar protocol. In our studies using mass spectrometry, the content of the serum macronutrient phosphorus (P) in Evenks (130.3 mg/L) (Table 3) and Dolgans (148 mg/L) [24] turned out to be higher than in mid- latitudes population (86 мг/л [1]; 115 мг/л [27], 116 мг/л [17], 111-133 мг/л [11]). The level of phosphates depends on the amount of parathyroid hormone, calcium and vitamin D. An excess of phosphorus in the blood (hyperphosphatemia) can be caused by excessive intake of the mineral from food and hypocalcemia [21, 22]. According to the literature, high levels of inorganic phosphorus in serum increase vascular calcification [15, 18, 25]. In Dolgans in Yakutia, the serum phosphorus (P) is statistically significantly higher, due to significantly higher levels in Dolgan women (151 mg/L) compared to Evenk women (123 mg/L), while no significant differences were found in men (135 mg/L in Evenks and 143 mg/L in Dolgans) (Table 4 and [24]). When studying in two age groups, in the group of elderly Dolgan women, when compared with young ones, a statistically significant high con-

Table 4

**Comparison of median element values in serum Evenks by gender, mg/L**

| Major element | Male, n=39 | | | Female, n=64 | | | p |
|---|---|---|---|---|---|---|---|
| | Me (Q25-Q75) | min | max | Me (Q25-Q75) | min | max | |
| Sodium | 3025.4 (2892.5-3128.7) | 2540 | 3330 | 2966.1 (2767.8-3100.4) | 2580 | 3450 | 0.133 |
| Magnesium | 17.3 (12.0-22.7) | 8.3 | 29.5 | 18.0 (13.0-22.0) | 7.5 | 33.7 | 0.624 |
| Phosphorus | 135.3 (112.5-164.2) | 78.0 | 198 | 123.3 (101.3-158.9) | 58.0 | 200 | 0.143 |
| Calcium | 74.7 (54.0-137.2) | 19.6 | 382.5 | 69.1 (47.6-134.9) | 14.6 | 414.7 | 0.589 |

Me (Q25-Q75) – median (interquartile range 25 and 75);
p - statistical significance of differences by the Mann-Whitney U-test.

tent of phosphorus (P) (154.60 mg/L versus 133.91 mg/L, p=0.037) was revealed, while the correlation not identified [24]. In our studies the content of phosphorus in the serum did not have significant correlations with age in both genders of the Evenks.

Calcium (Ca) is one of the most important minerals for humans. It is necessary for the contraction of skeletal muscles and the heart, for the transmission of a nerve impulse, as well as for normal blood clotting (promotes the transition of prothrombin to thrombin), to build the framework of bones and teeth. About 99% of this mineral is concentrated in the bones and only less than 1% circulates in the blood. Total calcium in the blood is the concentration of free (ionized) and its bound forms. Part of calcium leaves the body every day, being filtered from the blood by the kidneys and excreted in the urine. To maintain equality between the release and use of this mineral, about 1 g per day should be supplied [6, 21]. In the practical healthcare of Russia, the level of calcium is determined in the blood serum by the method of colorimetric photometry, the limits of the norm are 2.25–2.75 mmol/L (90.18–110.22 mg/L) [16]. According to the literature data, serum calcium (Ca) by ICP-MS was found to be 77 mg/L in German residents [27], 97.4 mg/L in female students from Yaroslavl [9], in population of the North- Western region of Russia - 83.5 mg/L [1], in the population of Novosibirsk - 122.0 μg/L [11], in the elderly in Switzerland - 125 [17], in population of Shanghai in China - 80.8 mg/L [28]. In the Evenks of Jilinda, serum calcium (Ca) (72.8 mg/L) (Table 2, 4) was found to be lower than the available literature data. This nutritional fact can be associated with a decrease in fish consumption over the past decades, with the lack of dairy products in the diet of the population of Jilinda [10]. Dairy and fish diets have been shown to reduce the risk of fractures [19, 20]. Insufficient calcium intake can be a factor that seriously increases the risk of osteoporosis [14, 23, 26]. The combined effects of inadequate daily calcium intake and vitamin D deficiency have caused low bone mineral density and increased prevalence of osteopenia and osteoporosis in postmenopausal Korean women aged 45 to 70 years [13]. Evenki women show a decrease in serum calcium with age (rs=-0.2; p=0.15) without statistical significance, which is probably related to the onset of menopause (Figure).

**Conclusions.** The study was conducted to assess the content of the main elements (Na, Mg, P, Ca) in blood serum of the Evenks, an indigenous people of the North of the Russian Federation. Major element concentrations were measured using the ICP-MS method, which allows the study of many elements simultaneously and with high sensitivity. The content of the serum major element calcium (Ca) in the Evenks (72.8 mg/L) is lower than the literature data. At the same time, in Evenk women, a tendency to a decrease in the level of calcium with age was revealed. The content of the serum major element phosphorus (P) in Evenks (130.3 mg/L), as in Dolgans living nearby, turned out to be higher than in residents of temperate latitudes, which may be due to hypocalcemia. Significant dependence of the content of serum phosphorus (P) on age in both genders of the Evenks was not revealed.

Our study revealed a reduced serum level of the element calcium (Ca) and an increase in phosphorus (P), which may affect the development of diseases in aboriginal inhabitants of the Arctic in conditions of reduced insolation and malnutrition.

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# THE RELATIONSHIP OF LIPID PROFILE AND BLOOD PRESSURE IN MEN IN THE EUROPEAN NORTH OF RUSSIA

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The paper analyzes the relationship of traditional lipid indicators and lipid indices with the level of blood pressure in men living in the European North of Russia. In apparently healthy middle-aged men, normal high blood pressure, abdominal pre-obesity, and compliance of traditional lipid indicators with reference values were revealed. At the same time, a number of lipid indices (atherogenicity coefficient (AC), the ratio of total cholesterol (TC) to high-density lipoprotein cholesterol (HDL-C), atherogenic plasma index (AIP), triglyceride/HDL-C ratio and lipid accumulation index (LAP)) appeared to be elevated.

Correlation analysis revealed the linear relationship of systolic pressure in the brachial artery with the content of Apo A-1, Apo B, TC, low-density lipoprotein cholesterol (LDL-C) and cardiovascular risk (CVR); diastolic pressure with TC, CVR and the waist-hip circumference ratio; heart rate index with waist and hip circumferences and body mass index. More number and greater strength of significant correlations were found between indicators of central hemodynamics and lipid profile. The relationships between age and length of living in the North with peripheral and central hemodynamic parameters turned out to be obvius.

Thus, male northern residents with normal high blood pressure have abdominal pre-obesity, normolipidemia but elevated lipid indices. Apparently, lipid indices are of greater prognostic significance and may be more sensitive predictors of the risk of arterial hypertension at the normal level of traditional lipid profile indicators.

Keywords: blood lipids, lipid indices, peripheral and central pressure, men, Arctic.

Correlation analysis revealed the linear relationship of systolic pressure in the brachial artery with the content of Apo A-1, Apo B, TC, low-density lipoprotein cholesterol (LDL-C) and cardiovascular risk (CVR); diastolic pressure with TC, CVR and the waist-hip circumference ratio; heart rate index with waist and hip circumferences and body mass index.

More number and greater strength of significant correlations were found between indicators of central hemodynamics and lipid profile.

The interrelations between lipid parameters and pressure level were revealed: a) positive correlation of AC with peripheral systolic and diastolic pressure, systolic pressure in the aorta, diastolic and pulse pressure, b) TC-non-HDL with systolic and diastolic pressure in the aorta, c) negative correlation of LAP with peripheral pulse pressure.

These correlations indicate that in Arctic conditions, the presence of normolipidemia and pre-obesity may be a prerequisite for the formation of normal high pressure.

**Keywords:** blood lipids, lipid indices, peripheral and central pressure, men, Arctic.

**Introduction**. In the pathogenesis of cardiovascular diseases (CVD), an important role is assigned to lipid metabolism disorders, which are determined by the content of traditional lipid indicators in the blood, such as total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C). At the same time, LDL-C is considered as the main predictor of an unfavorable prognosis of atherosclerosis and pathogenetically related CVD [14, 17], while an increased content of HDL-C in the blood is associated with a low degree of cardiovascular risk (CVR) [20]. However, it turned out that a significant increase in HDL-C is not always a protective factor [7]. It is suggested that the functional activity of HDL-C is more determined by the concentration of HC in individual HDL-C subfractions than the level of HC contained in HDL-C.

To more accurately clarify the role of lipid metabolism in the development of atherosclerosis and related diseases, their derivatives, the so-called lipid indices or combined lipid parameters (in the English literature), have increasingly been used along with traditional indicators of lipid metabolism. Most of the known indices reflect the ratio of the main classes of lipids in blood plasma, the relationship within lipid metabolism, the ratio of pro- and anti-atherogenic potential of blood [4]. It is believed that lipid indices represent the greatest strength in predicting CVD, while LDL-C may show a weak connection with the pulse wave velocity or not at all [10, 13, 18, 22].

In atherosclerosis, lipid accumulation in the intima of the arteries modulates vascular stiffness. There are isolated data on the relationship of lipids with vascular stiffness in residents of the North. In particular, it was shown that in young men, residents of Finland, the elasticity of the aorta was not associated with stan-

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