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COMPARATIVE CHARACTERISTICS OF MICROELEMENT STATUS IN ADOLESCENT GIRLS

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Abstract. The article presents data on the study of the microelement status of the blood in girls aged 11 to 17 years, depending on the phase of the menstrual cycle. A comparative characterization of the microelemental blood picture in girls and women of fertile age is provided. The results indicate that the level of ME in the blood of practically healthy girls fluctuates regularly, both in terms of age and the days of the menstrual cycle.

Keywords: *microelements, adolescent girls, menstrual cycle, luteal phase.*

СРАВНИТЕЛЬНАЯ ХАРАКТЕРИСТИКА МИКРОЭЛЕМЕНТНОГО СТАТУСА У ДЕВОЧЕК-ПОДРОСТКОВ

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Аннотация. В статье представлены данные исследования микроэлементного статуса крови у девочек 11–17 лет в зависимости от фазы менструального цикла. Приведена сравнительная характеристика микроэлементной картины крови у девочек и женщин фертильного возраста. Полученные результаты свидетельствуют о том, что уровень МЭ в крови практически здоровых

девочек закономерно колеблется как в зависимости от возраста, так и от дней менструального цикла.

Ключевые слова: микроэлементы, девочки-подростки, менструальный цикл, лютеиновая фаза.

It is well known that during adolescence, the body actively grows, body weight increases, and the skeletal and muscular systems, as well as the nervous and endocrine systems, are formed, requiring more nutrients than at any other age. Microelements (ME) are important components of the human body, their role and significance are difficult to overestimate. They form the basis of comfortable life and the functioning of various processes in the body [2, 8, 12].

ME are chemical elements that are present in our body in very small quantities. These are the components of an ancient and complex physiological system that exist regularly in the evolution of a living organism and participate in the regulation of all vital functions, at all stages of their development [1, 4, 6]. The leading role in the study of microelements belongs to academician V. I. Vernadsky. He scientifically substantiated the impossibility of animal and plant life without microelements. These issues were further developed in the works of A. P. Vinogradov, A. I. Venchikov, A. O. Voynar, V. V. Kovalsky, G. A. Babenko, L. R. Nozdryukhina, and other scientists [3, 5,11].

Bioelements are part of 182 enzymes out of 660 known, participate in immunogenesis, are an integral part of hormones, contribute to the detoxification of toxic substances, regulate oxidation-reduction reactions, affect growth, development and reproduction, blood formation, vitamin metabolism, osmotic pressure, and the colloidal state of cellular proteins. The main sources of microelements are plant-based products that absorb elements from the soil and water [7, 9,10].

Purpose of the study: To study the microelement status of blood in "practically healthy" girls aged 11 to 17 years depending on the phase of the menstrual cycle.

To exclude the influence of existing extragenital diseases (EGD) on ME status, we tried to identify girls with minimal EGD and infectious pathology. It should be noted that during the study of patients, there were no exacerbations of chronic diseases.

Material and methods: The study was conducted on 27 girls aged 12 to 16 years, recognized as practically "practically" healthy. The control group consisted of 20 women of fertile age, who were also considered "practically" healthy. The study of ME blood composition was carried out at the Republican Center for Forensic Examination.

To determine ME, blood serum, erythrocyte samples were burned in concentrated nitric acid, aliquot was taken and diluted with 1% nitric acid to working concentrations, and precipitated by centrifugation. The microelement composition of the samples prepared by the method described above was determined on the AT 7500 a (Agilent 7500 a. inductively coupled Plasma Mass Spectrometer, Japan, 2021) device: gas-carrier argon, power 1310 W, integration time 0.1 s. The ME content in biological media is expressed in mcg%. Essential MEs - chromium, manganese, iron, cobalt, copper, zinc, selenium, molybdenum, iodine - were determined. Toxic - beryllium, aluminum, cadmium, mercury, lead. Blood sampling from patients was carried out in the morning hours, with simultaneous examination of the general blood count and hormones.

A comprehensive study of ME concentration in blood serum and erythrocytes during the follicular (7th day), ovulatory (14th day), and luteal (21st day) phases of the ovarian cycle was conducted. The study was conducted in all patients during the follicular (7-day), ovulatory (14-day), and luteal (21-day) phases of the ovarian cycle.

Results and their discussion. The study results showed that the content of trace elements in the blood of conditionally healthy girls has its own characteristic features compared to similar ME indicators of women of fertile age (Table. 1.).

Table 1.

Comparative analysis of the microelement composition of blood in conditionally healthy girls and women of fertile age

ME	Adolescent Girls		Fertile-age women	
	Blood serum	Erythrocytes	Blood serum	Erythrocytes
Essential microelements				
Cr	56,7±2,4	66,2±4,8	71,8±5,3**	84,8±6,5***
Mn	11,2±0,9	23,4±2,1	17,4±1,1*	32,4±2,1**
Fe	136,4±9,3	48,3±3,1	142,4±9,8	74,6±5,6***
Co	5,3±0,4	17,3±1,3	8,4±0,72**	26,3±1,8***
Cu	154,8±12,4	120±8,6	152,6±11,3	164,7±12,4**
Zn	121±8,9	623±36,2	154,6±12,7*	942±63,4***
Se	14,1±0,63	18,6±0,9	8,1±0,62*	24,4±1,8**
Mo	1,2±0,09	1,1±0,08	1,3±0,09	2,1±0,1**
I	7,6±0,6	22,8±1,7	14,8±1,1***	37,4±2,4**
Ni	7,8±0,43	16,3±1,2	10,6±0,9*	22,3±2,1**
Toxic microelements				
Be	0,53±0,02	0,2±0,08	0,76±0,04*	0,36±0,02***
Al	253±24,6	268±33,1	448±28,3***	434±31,6***
Cd	23,6±1,9	26,7±3,1	30,6±2,4**	31,9±2,6**
Hg	0,31±0,08	0,22±0,02	0,47±0,02**	0,4±0,024***
Pb	30,6±2,8	23,1±1,8	42,6±3,1**	38,3±2,9***

Note: * - $P < 0.05$; ** - $P < 0.01$ compared to the indicators of women of fertile age.

As can be seen from Table 1, a significant decrease in the concentration of essential MEs such as manganese, iron, cobalt, copper, zinc, molybdenum, and iodine ($P<0.05$ - 0.01) is observed. At the same time, the greatest decrease in the level of essential ME is observed in erythrocytes ($P<0.001$). This outcome of the obtained results is likely related to the age characteristics of the examined groups (Figure 1). Thus, correlation analysis revealed a close direct correlation between blood serum zinc concentration and estradiol levels in the girls' group ($r=0.58$). Moreover, the concentration of toxic ME also has a significantly reduced level in the group of conditionally healthy girls and in comparison with women of fertile age, both in blood serum and in erythrocytes (P<0.05 - 0.001). This outcome indicates the possibility of gradual accumulation of toxic ME in the human body.

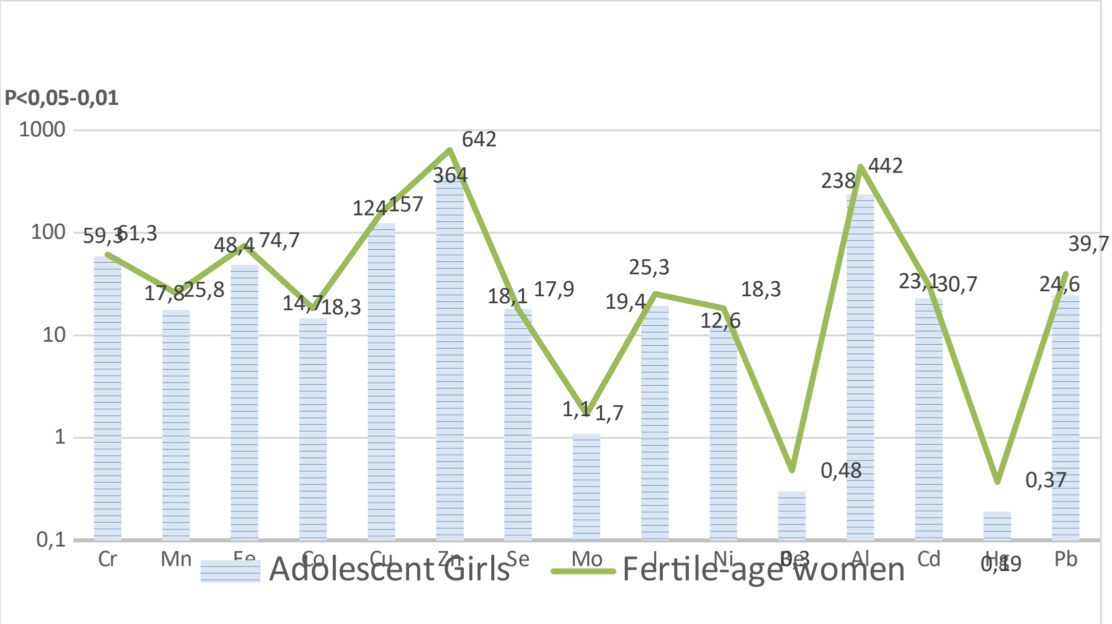

Figure 1. Comparative analysis of the content of trace elements in the blood of conditionally healthy girls and women of fertile age, mcg%

Studies have shown that significant changes in the ME status of the blood in girls are observed depending on the day of the menstrual cycle. The level of many essential ME increases on the 14th day of the menstrual cycle, which begins to decrease on the 21st day of the menstrual cycle, reaching a maximum decrease by the 1st-3rd days of the cycle.

Table 2

Dynamics of blood microelement composition in healthy girls depending on the day of the menstrual cycle

ME	Menstrual cycle days							
	1-3 days		7 th day		14 th day		21 th day	
	Blood serum	Erythrocytes	Blood serum	Erythrocytes	Blood serum	Erythrocytes	Blood serum	Erythrocytes
Essential microelements								

Cr	56,7±2,4	66,2±4,8	58,1±3,6	65,3±4,5	71,7±6,3**	67,2±4,1	60,3±3,9*	65,6±5,1
Mn	11,2±0,9	24,3±2,1	13,3±0,9	24,1±2,1	16,8±1,3*	25,3±1,9*	12,6±1,3	23,4±1,1*
Fe	136,4±9,3	48,3±3,1	128,6±11,3	51,6±4,8	138±11,6	55,3±4,1**	127,3±19,6	52,3±4,2*
Co	5,3±0,4	17,3±1,3	5,8±0,31	18,4±1,2	6,2±0,6	19,3±1,2*	6,0±0,56	17,2±1,8
Cu	154,8±12,4	120±8,6	121±9,6*	128,3±11,4	109±8,6***	131,4±12,1*	113,6±10,6**	128±10,3*
Zn	121±8,9	623±36,2	127,4±11,3	646±48,3	144,8±9,8**	778±54,6***	136,3±11,8	726,3±53,1**
Se	14,1±0,63	18,6±0,9	15,2±1,3	19,1±1,3	14,6±1,6	23,6±1,9*	12,3±0,9	17,6±1,1
Mo	1,2±0,09	1,1±0,08	1,1±0,08	1,3±0,09	0,9±0,008*	1,1±008	1,3±0,07	1,1±0,08
I	7,6±0,6	22,8±1,7	7,8±0,5	24,6±1,8	9,6±0,7**	28,6±2,1	8,3±0,6*	22,7±2,0
Ni	7,8±0,43	16,3±1,2	7,6±0,51	17,6±1,3	7,6±0,3	17,9±1,1*	7,3±0,3	17,1±1,3
Toxic microelements								
Be	0,53±0,02	0,2±0,08	0,51±0,032	0,22±0,09	0,5±0,05	0,24±0,018	0,49±0,04	0,25±0,019*
Al	253±24,6	268±33,1	268±18,3	236±18,6*	251±19,6	230±20,8**	273±26,3*	254±22,4
Cd	23,6±1,9	26,7±3,1	25,3±2,1	24,8±2,2	22,2±2,6*	24,1±1,9*	24,6±1,8	27,3±2,2
Hg	0,31±0,08	0,22±0,02	0,33±0,07	0,18±0,02	0,3±002	0,17±0,02*	0,3±0,02	0,19±0,01

Pb	30,6±2,8	23,1±1,8	28,6±2,0	24,6±1,9	26,8±1,8*	22,1±2,1*	29,6±2,2	23,8±2,1

According to the results of our studies, the iron content in the blood of girls was significantly lower compared to the indicators of women of fertile age (P<0.01). This was especially noticeable on days 1-3 of the menstrual cycle, both in blood serum (136.4±9.3 mcg%) and in erythrocytes (48.3±3.1 mcg%). However, starting from the 7th day of the menstrual cycle, the concentration of iron in the blood begins to increase, respectively: 128.6±11.3 and 51.6±4.8 mcg% (P>0.05), reaching its maximum by the 14th day of the menstrual cycle: 138.0±11.6 and 55.3±4.1 mcg% (P<0.05). Then, starting from the 21st day of the cycle, the iron level begins to decrease (P>0.05). According to the study of iron concentration, this pattern was characteristic of both blood serum (127.3±19.6μg%) and erythrocytes (52.3±4.2μg%).

According to the correlation matrix data, there is a negative correlation between the level of iron in erythrocytes and the amount of cobalt (r=0.41; P<0.05). The detected low negative correlation between iron levels and cobalt concentration apparently indicates a certain antagonism of these MEs.

According to the results of our studies, the level of iodine in the erythrocytes of girls was on average 2.7 times higher compared to the blood serum indicators and fluctuated regularly depending on the day of the menstrual cycle (in blood serum 7.6±0.6 mcg%; and in erythrocytes 22.8±1.7 mcg%;P<0.05). К On days 1-3 of the menstrual cycle, there is a physiological deficiency of iodine in the blood as a whole. However, starting from the 7th day of the cycle, the blood iodine level begins to rise, reaching its maximum during the days of ovulation (blood serum 9.6±0.7 mcg% and erythrocytes 28.6±2.1 mcg%). And in the luteal phase of the ovarian cycle, the iodine concentration reaches its initial level (respectively: 8.3±0.6 and 22.7±2.0). At the same time, we did not reveal the peculiarities of fluctuations in the level of iodine in blood serum or erythrocytes. A positive correlation is observed between iodine and selenium (r=0.48; P<0.05) and copper (r=0.54; P>0.05), which indicates the important role of these MEs in the activity of the thyroid gland. Consequently, the participation of these ME in iodine metabolism is quite evident.

The concentration of manganese in the blood, according to our research, accumulates mainly in erythrocytes. In erythrocytes, the concentration of manganese remained relatively unchanged, while in blood serum, its level changes significantly depending on the day of the menstrual cycle. Thus, at the beginning of the menstrual cycle (1-3 days), the concentration of manganese in blood serum is 11.2±0.9 mcg%, which begins to increase from the 7th day of the cycle (13.3±0.9 mcg%). By the 14th day of the menstrual cycle, the manganese level reaches its maximum values (16.8±1.3 mcg%), then decreases towards the end of the cycle (12.6±1.3 mcg%). The same trend persists in erythrocytes, respectively: 24.3±2.1 mcg%, 24.1±2.1 mcg%, 25.3±5.9 mcg% and 23.4±1.1 mcg% (P<0.05). A positive correlation was noted between manganese concentration and copper levels (r=0.46; P<0.01), and cobalt (r=0.34; P<0.05), which likely indicates synergism of these ME.

According to our research results, girls' blood copper content accumulates mainly in plasma. In our observations, the plasma concentration of copper varies significantly depending on the day of the menstrual cycle. This was especially noticeable on days 1-3 of the menstrual cycle in blood serum (154.8 ±12.4 mcg%). However, starting from the 7th day of the cycle, the concentration of copper in the blood begins to decrease, respectively: 121.0±9.6;109.0±8.6 mcg% and 113.6±10.6 (P>0.05). Thus, at the beginning of the menstrual cycle (1-3 days), the concentration of copper in blood erythrocytes is 120.0±8.6 mcg%, which begins to increase from the 7th day of the cycle (128.3±11.4 mcg%). By the 14th day of the menstrual cycle, the copper level reaches its maximum values (131.4±12.1µg%), then there is a decrease by the end of the cycle (128.0±10.3µg%).

The results of our studies show that the zinc content in the blood of girls is significantly lower compared to the indicators of women of fertile age (P<0.01). This was especially noticeable on days 1-3 of the menstrual cycle, both in blood erythrocytes (623.0±36.2 mcg%) and in plasma (121.0±8.9 mcg%). However, starting from the 7th day of the menstrual cycle, the concentration of zinc in the blood begins to increase, respectively: 646.0±48.3 and 127.4±11.4 mcg% ($P>0.05$), reaching its maximum by the 14th day of the menstrual cycle at 778.0±54.6 and 144.8±9.8 mcg% ($P<0.05$). Thus, at the beginning of the menstrual cycle (1-3 days), the concentration of copper in blood erythrocytes is 120.0±8.6 mcg%, which begins to increase from the 7th day of the cycle (128.3±11.4 mcg%). By the 14th day of the menstrual cycle, the copper level reaches its maximum values (131.4±12.1μg%), then there is a decrease by the end of the cycle (128.0±10.3μg%).

The results of our studies show that the zinc content in the blood of girls is significantly lower compared to the indicators of women of fertile age ($P<0.01$). This was especially noticeable on days 1-3 of the menstrual cycle, both in blood erythrocytes (623.0±36.2 mcg%) and in plasma (121.0±8.9 mcg%). However, starting from the 7th day of the menstrual cycle, the concentration of zinc in the blood begins to increase, respectively: 646.0±48.3 and 127.4±11.4 mcg% ($P>0.05$), reaching its maximum by the 14th day of the menstrual cycle at 778.0±54.6 and 144.8±9.8 mcg% ($P<0.05$). And in the corpus luteum phase, the selenium concentration reaches its initial level (respectively: 12.3±0.9 and 17.6±1.1). At the same time, we did not reveal the peculiarities of selenium fluctuations in blood serum or erythrocytes.

According to our research results, the cobalt level in erythrocytes in girls was 2.2 times higher on average compared to blood serum indicators and fluctuated regularly depending on the day of the menstrual cycle (in blood serum 5.3±0.4 mcg %; and in erythrocytes 17.3±1.3 mcg%;$P<0.05$). However, starting from the 7th day of the cycle, the level of cobalt in the blood begins to rise, reaching its maximum on the days of ovulation (blood serum 6.2±0.6 mcg% and erythrocytes 19.3±1.2 mcg%). And in the lutein phase, the cobalt concentration reaches its initial level (respectively: 6.0±0.56 and 17.2±1.1). At the same time, we did not reveal the peculiarities of fluctuations in the level of cobalt in blood serum or erythrocytes. Thus, studies have shown a significantly lower concentration of a number of essential MEs in practically healthy girls compared to similar indicators in healthy women of fertile age. Depending on the days of the menstrual cycle, the level of essential ME fluctuates regularly. Thus, starting from the 6-7th day of the menstrual cycle, the concentrations of iron, zinc, copper, selenium, and others begin to increase significantly, reaching their maximum by the 14th day of the menstrual cycle ($P<0.05$-0.001). Then, in the second phase of the cycle, the concentration of these MEs tended to decrease significantly ($P<0.05$-0.01). This situation, in our opinion, indicates the participation of these vital MEs in the ovulation process, and possibly the menstrual cycle as a whole. The concentration of toxic ME also had a significantly reduced level in the group of conditionally healthy girls and in comparison with women of fertile age, both in blood serum and in erythrocytes ($P<0.05$ - 0.001).

This was especially noticeable on days 1-3 of the menstrual cycle (Fig. 3.9) in the example of aluminum, both in blood serum (253.0±1.9 mcg%) and in erythrocytes (268.0±33.1 mcg%). However, starting from the 7th day of the menstrual cycle, the concentration of aluminum in the blood begins to increase, respectively: 268.0±18.3 and 236.0±18.6 mcg% ($P>0.05$), and by the 14th day of the menstrual cycle, this indicator decreases to 251.0±19.6 and 230.0±20.8 mcg% ($P<0.05$). Then, starting from the 21st day of the cycle, the aluminum level gradually increases ($P>0.05$). This pattern was characteristic of both blood serum (273.0±26.3 mcg%) and erythrocytes (254.0±22.4 mcg%). According to the results of our studies, the amount of lead in the blood of girls (3.10-rasm) was significantly lower compared to the indicators of women of fertile age ($P<0.01$). On days 1-3 of the menstrual cycle, both in blood serum (30.6±2.8 mcg%) and in erythrocytes (23.1±1.8 mcg%). However, starting from the 7th day of the menstrual cycle, the concentration of lead in the blood begins to decrease, respectively: 28.6±2.0 and 24.6±1.9 mcg% ($P>0.05$), by the 14th day of the menstrual cycle, respectively. 26.8±1.8 and 22.1±2.1 mcg% ($P<0.05$). Then, starting from the 21st day of the cycle, the level of lead begins to increase

(P>0.05). This pattern was characteristic of both blood serum (29.6±2.2μg%) and erythrocytes (23.8± 2.0μg%).

Thus, the concentration of toxic ME in the blood of practically healthy girls was significantly reduced compared to the same indicators of women of fertile age. This situation likely indicates the possibility of gradual accumulation of toxic ME in the human body.

Summarizing the results of studying the blood status of ME in practically healthy girls aged 11-17 and women of fertile age, it can be concluded that the level of ME in the blood of practically healthy girls fluctuates regularly, both in terms of age and the days of the menstrual cycle. This circumstance indicates the undoubted role of these vital ME in the human body, namely in the process of ovulation and the menstrual cycle as a whole.

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