ARCTIC MEDICINE

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NUTRITION AND IRON DEFICIENCY STATES AMONG WOMEN AND CHILDREN OF REPUBLIC OF SAKHA (YAKUTIA)

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ABSTRACT

Actual nutrition of pregnant women was studied on a basis of epidemiological research. It is established that rations of a majority of the pregnant women are profoundly deficient in an energy value and all nutrients. Parameters of «red blood» (RBC, HBG, Ht, MCH, MCHC, MCV, RDW and PLT) and iron metabolism (serum iron, ferritin and transferrin) of the pregnant women, puerperas and newborns were studied. A high frequency of iron deficiency states among the pregnant women, puerperas and their newborns is determined. Iron deficiency anemia is diagnosed among 26.8% of expectant mothers in the first trimester, 61.7% in the second one and 70% in the third one of pregnancy, 62.9% in a puerperium and 47.3% of the newborns in an early postnatal period. The latent iron deficiency was discovered among 87.4% of women in the first trimester, in 29.8% in the third one of the pregnancy and among 77.9% of the newborns in the early postnatal period. It is proved that the iron deficiency negatively affects a course of the pregnancy, childbirth, a condition of a fetus and newborn. A conducted canonical correlation analysis revealed a significant interrelation between the blood parameters in the first and second trimesters with a protein content (Canonical R = 0.46, χ^2 = 32.29, p <0.04) and minerals (iron, sodium, potassium, calcium, magnesium and phosphorus) (Canonical R = 0.45, χ^2 = 35.63, p <0.05) in the mother's ration.

Keywords: pregnant women, puerperas, newborn children, actual nutrition, micronutrients, red blood parameters, serum ferritin, iron deficiency states (IDS), iron deficiency anemia (IDA).

Introduction

Until now, a problem of the micronutrient deficiency has not been resolved. 2 billion people suffer from microelement insufficiency, and a maximum risk group consist of the pregnant women and children under 5 years of age [5]. The iron deficiency occupies one of leading places in prevalence in all countries of the world. According to data of the World Health Organization (WHO), published in 2008, 42% of the pregnant women, 30% of the reproductive age women in the nonpregnant state, 47% of the children under 5 and 12.7% of men suffer from the anemia, in half of cases associated with the iron deficiency [6, 8] . According to N.J. Kassebaum et al. (2014), the prevalence of the anemia in the 187 studied countries was 32.9%. A decrease of the prevalence was noted among all age and gender groups, with an exception of the children under 5 years of age, among whom this disease was detected more often in 2010 compared with 1999 [7]. The frequency of occurrence of the iron deficiency in the world is inhomogeneous and primarily depends on socioeconomic reasons. In materials of the Fourth Report of the World Nutrition Situation of the United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition and the International Food Policy Research Institute it was noted that in the countries with a low socioeconomic level among the children with the various deficient states, the iron deficiency (ID) is the most frequent micronutrient deficiency. In the industrialized countries, despite the fact that the deficiency states in the recent years began to occur much less frequently, the iron deficiency anemia (IDA) remains the most common form of the anemia among the young children [9, 10].

The youngest children, adolescents and pregnant women are the most "vulnerable" to developing the IDS. Thus, in Russia, according to various authors, the IDA frequency varies from 6% to 40% among the children [1, 2, 3] and from 15% to 56% among the pregnant women [4].

In this regard, rational provision of the women and children with the essential micronutrients, including the iron, acquires particular relevance under the conditions of the Far North, where there are many families with low social status, and a population nutritional structure has its own national characteristics. In the Republic of Sakha (Yakutia), the IDA prevalence among the women of reproductive age and infants does not decrease, the parameters of maternal and infant mortality remain high. Therefore, a **purpose** of this study is to assess the

Table 1

Types and volume of studies

Type of research	Pregnant woman				Puer-pera	New-born	Total
	Trimesters of pregnancy			Before childbirth			
	I	II	III				
Blood test							
RBC, × 10^{12}/л	138	125	118	92	118	118	709
HGB, г/л	138	125	118	92	118	118	709
Ht,%	138	125	118	92	118	118	709
MCV, фл	138	125	118	92	118	118	709
MCH, пг	138	125	118	92	118	118	709
MCHC, г/л	138	125	118	92	118	118	709
RDW, %	138	125	118	92			
Serum iron, mmol/L			42			42	84
Serum ferritin, ng/mL	86		86			86	258
Serum transferrin, g/L			42			42	84
Study of energy and nutrients in pregnant women							
Energy, kcal	122	Iron,mg/d				122	
Carbohydrates, g/d	122	Calcium, mg/d				122	
Proteins, g/d	122	Phosphorus, mg/d				122	
Lipids, g/d	122	Potassium, mg/d				122	
Ethanol, g/d	122	Magnesium, mg/d				122	
Vitamin C, mg/d	122	Mono- and disaccharides, g/d				122	
Vitamin B1, mg/d	122	Starch, g/d				122	
Vitamin B2, mg/d	122	Dietary fiber, g/d				122	
Vitamin PP, mg/d	122	Sodium, mg/d				122	
Retinol, retinol equivalent	122	Vitamin A, mg/d				122	
		Beta-carotene, mg/d				122	

prevalence of the iron deficiency states (IDS) and iron deficiency anemias (IDA) among the pregnant women, puerperas and newborn babies of the Republic of Sakha (Yakutia) in conjunction with the actual nutrition of the pregnant women.

Materials and methods of research

Within the framework of this study, 138 pregnant women (the average age is 27.6 ± 0.41 years), 118 puerperas and their newborn babies were complexly examined. The groups of the women were formed by simple randomization from among the women who had consulted a maternity welfare clinic in connection with the real pregnancy. All women and children were examined according to one protocol. A total volume of the conducted studies is presented in Table 1.

The study of composition of the peripheral red blood was carried out in the Laboratory of the Republican Hospital No. 1 of the National Center of Medicine of the Ministry of Health of the Republic of Sakha (Yakutia) (MH RS (Y)) on a hematological analyzer Coulter counter (Switzerland). An anemia severity estimate was conducted according to the level of hemoglobin: a light degree - HBG 112-90 g/L, the medium one - HBG 90-70 g/L, the heavy one - HBG is below 70 g/L (Shekhtman M.M., 1999). In the newborns on the first day after the birth, a lower limit of the hemoglobin level in the blood, according to WHO recommendations, is considered the level of 194 g/L (Johnson T.R., 1982).

A determination of the serum iron, ferritin and transferrin in the pregnant women and their newborns was carried out in the Laboratory of Membranology of the Research Center for Children's Health, Moscow. *The serum iron concentration* was determined using a Synchron cx diagnostic system (Beckman). To assess the iron content in a depot of the women and children, the *serum ferritin content* was determined by the method of a solid-phase enzyme-linked immunosorbent assay using reagents and commercial kits (EIA-ferritin) from the "Alcor Bio" company, Russia. *The serum transferrin* was determined by the method of immunoprecipitation on a Konelab analyzer from the Thermo Electron Corporation.

The estimation of the actual nutrition, calculation of a food set and chemical composition of the rations, energy value and nutrients were carried out on the basis of a questionnaire of the pregnant women in the second half of the pregnancy. The questionnaire was developed by the Federal Research Center of Nutrition, Biotechnology and Food Safety (Moscow) and it was adapted in accordance with the regional characteristics of food traditions of the population in the North.

Table 2

Average daily consumption of certain food groups

Food products	Recommended amount, g/d	Actual consumption,		
		M	m	s
Meat and meat products	180	156,0	9,8	108,9
Fish and fish products	100	34,5	7,0	77,7
Milk and milk products	250	435,6	39,1	431,4
Butter	20	15,5	1,8	20,3
Cooking fat and vegetable oil	25	15,6	0,9	10,9
Bread and bakery products, macaroni products	100	185,1	10,2	113,4
Potatoes	300	164,8	12,3	136,1
Vegetables (except potatoes)	500	127,5	9,1	100,7
Fruits and berries	250	143,5	14,15	156,3
Sugar and confectionery	50	77,7	6,4	71,1
Eggs	47	30,2	4,1	45,2

Results of study and discussion of them

It is discovered that the rations of the majority of the pregnant women are profoundly deficient in the energy value and all nutrients. Consumption of products containing the animal protein (meat, fish, eggs), vegetables, fruits and berries was significantly below the

Table 3

Average daily intake of essential vitamins and iron

Vitamins and minerals	Recommended amounts	Actual consumption		
		M	m	s
A, mg	1,5	0,8	0,2	2,1
B1, mg	1,7	0,9	0,03	0,4
B2, mg	1,8	1,3	0,1	0,8
PP, mg	19	13,1	0,5	5,7
C, mg	90–100	63,3	4,5	49,4
Beta-carotene, mg	3,5	1,9	0,2	1,9
Retinol, Retinol Equivalents (RE)	1200–1400	1087,6	193,6	2137,9
Iron, mg	38	14,7	0,5	5,4

Table 4

Dynamics of hemoglobin parameters (HBG) of blood in different periods of pregnancy

Observation period	n	Hemoglobin, g/L						Reference values
		M	s	m	Min	Max	95% Confidence Interval (CI)	
1 trimester	138	121,3	12,4	1,1	81	147	119,2–123,4	120–145
2 trimester	125	114,7	10,1	0,9	86	144	112,9–116,5	115–130
3 trimester	118	111,8	9,9	0,9	85	133	109,9–113,6	112–130
Before childbirth	118	111,6	9,9	1,0	82	128	109,6–113,7	112–130

ANOVA: Fridman χ^2=73,37, p<0,00000.

Table 5

Parameters of red blood in puerperas

Parameter	n	M	s	m	Min	Max	95% CI	Reference values
RBC, $\times 10^{12}$/л	118	3,7	0,5	0,05	2,0	5,1	3,6–3,8	3,5–4,5
HGB, г/л	118	113,8	15,6	1,4	73	156	110,9–116,7	115–130
Ht, %	118	32,3	3,7	0,4	20,8	40,2	31,5–33,0	36–42
MCV, фл	118	91,4	5,9	0,7	76,3	101,3	90,1–92,7	80–95
MCH, пг	118	30,7	2,4	0,3	20,6	35,6	30,1–31,2	24,5–39,2
MCHC, г/л	118	33,5	2,1	0,2	29,2	39,3	32,9–33,9	30–36
PLT, $\times 10^9$/л	118	246,7	69,6	7,8	139	467	231,1–262,3	140–400

Table 6

Parameters of red blood in newborn children

Parameter	n	M	s	m	Min	Max	95% CI	Reference values
RBC, $\times 10^{12}$/л	118	5,0	0,8	0,1	3,0	6,7	4,9–5,1	5,3–5,9
HGB, г/л	118	186,9	26,5	2,5	97	256	181,9–191,9	194–208
Ht, %	118	49,3	7,9	0,9	29,1	69,5	47,4–51,3	56–58
MCV, фл	118	108,5	6,3	0,8	81,4	124,6	106,9–110,1	108–110
MCH, пг	118	36,5	2,5	0,3	26,7	44,6	35,8–37,1	35–37
MCHC, г/л	118	33,8	2,1	0,3	30,4	44,3	33,2–34,3	33–36
PLT, $\times 10^9$/л	118	284,9	79,1	9,7	70	492	265,4–304,3	273

Table 7

Content of ferritin in serum at different times of observation

Observation time	n	M	s	m	Min	Max	95% CI	Reference values, ng/mL
10-12 weeks of gestation	138	29,0	27,2	2,3	1,0	144,3	24,4–33,7	55–90
34–36 weeks of gestation	118	13,7	12,4	1,3	0,9	71,3	11,0–16,4	10–16
Umbilical blood	118	153,0	100,4	10,8	13,9	532,5	131,5–174,5	200–400

Table 8

Content of transferrin in serum at different times of observation

Observation time	n	M	s	m	Min	Max	95% CI	Reference values, ng/mL
34–36 weeks of gestation	118	4,9	1,39	0,22	2,3	7,6	4,5–5,4	3,05
Umbilical blood	118	2,2	0,51	0,08	1,3	3,2	2,0–2,3	1,3–2,75

recommended values (Table 2). The insufficient provision of macronutrients (the proteins, fats and carbohydrates) was discovered in 80% of the pregnant women; minerals - in 90%; vitamins - in 75%, iron - in 100%. It was found that, in relation to a norm for the pregnant women, the consumption of the proteins was 75%, fats – 96%, carbohydrates – 68%, the vitamin B_1 –55%, vitamin B_2 – 72%, vitamin PP – 72%, vitamin C – 63%, vitamin A (retinol) – 77%, magnesium – 60%, phosphorus – 88%, potassium – 83%, calcium – 59% and magnesium – 60% (Table 3). All examined women consumed the iron 3 times less than the recommended norm.

Clinical manifestations of the iron deficiency in the IDA form up to 13 weeks of pregnancy were diagnosed in a third of the examined pregnant women, in the period of 14-26 weeks – in more than 70%, in the third trimester - in 77.5% (Cochran Q-Test=89.75; p<0.000000).

All examined women, according to the standard of management of the pregnant women in the Republic of Sakha (Yakutia), were prescribed iron preparations (Sorbifer Durules). Despite this, the decrease of the hemoglobin content in the peripheral blood was noted during the pregnancy (ANOVA Fridman χ^2 = 73.37, p<0.00000) (Table 5). The hemoglobin level below the norm was registered in 26.8% in the first trimester; in 61.7% in the second one; in 70.0% of the women and more in the third one and before the childbirth (Table 4).

A similar pattern was revealed for the parameters of hematocrit, mean erythrocyte volume and mean corpuscular hemoglobin concentration. A number of erythrocytes below the norm was noticed in 17.4% of the women in the first trimester, 54.4% in the second one, 61.5% in the third one and 64.1% before the childbirth. The hematocrit parameters below the norm were observed in 78.9% of the women in the first trimester, in 34.4% in the second one, in 41.9% in the third one and in 42.4% before the childbirth. The MCV values below the norm were observed in 15.2% of the women in the first trimester, in 12.0% in the second one, in 17.1% in the third one and in 19.6% before the childbirth. The MCHC parameters during the corresponding observation periods were registered at the below normal level in 4.4%, 2.4%, 0.9% and 1.1% of the women. The MCH level below the norm was in 3.6% in the first trimester and 2.4% in the second one. Anisocytosis (RDW) is diagnosed above the norm in 59.4% of the women in the first trimester, in 64.0% in the second one, in 73.7% in the third one and 76.3% before the childbirth.

The parameters of the red blood of the puerperas are presented in Table 5. The number of erythrocytes below the normal values was observed in 47.9% of the puerperas, the low hemoglobin content in 62.9%, the hematocrit in 84.9%, the MCH in 1.3%, the MCHC in 2.5%, the PLT in 1.3% of the women after the childbirth.

As for the newborns (Table 6), 56.6% had the number of the erythrocytes below the norm, 47.3% had the low content of the hemoglobin, in 65.7% - the hematocrit, in 40.9% - the MCV, 24.2% - the MCH, 95.4% - the MCHC and 4.6% - the PLT.

Thus, in the first trimester the average number of erythrocytes, the content of the hemoglobin and hematocrit corresponded to the norm. From the second trimester until the childbirth time, the above listed indicators decreased. For example, the decrease of the erythrocytes in the first trimester was in 17.4% of the women, in the second one - in 54.4%, in the third one - in 61.5% and before the childbirth - in 64.1%. The corresponding pattern is noted for the hemoglobin and hematocrit. At the same time, the frequency of detection of the anisocytosis in the peripheral blood increased with a rise of the pregnancy period (from the first trimester until the childbirth).

The parameter of the serum iron below the norm was in 21.7% of the women at 34-36 weeks of the pregnancy and in 4.9% in the newborns. The level of the serum ferritin below the norm was diagnosed in 87.4% of the women in the first trimester, in 29.8% in the third one and in 77.9% of the newborns (Table 7).

The values of the serum transferrin were higher than the reference ones in 66.7% of the pregnant women in the third trimester (Table 8).

Thus, the latent iron deficiency (according to the ferritin level) was detected in 87.4% of the women in the first trimester, in 29.8% in the third one of the pregnancy and in 77.9% of the newborns in the early postnatal period, which indicates the very high frequency of the iron deficiency states of the mother and child in the Republic of Sakha (Yakutia).

Conclusion

The decrease of the red blood parameters prognostically adversely affects the course of pregnancy, childbirth, the condition of the fetus and newborn. It is found that 47.3% of the newborns in the early postnatal period have the iron deficiency (according to the hemoglobin level). The latent iron deficiency (according to the serum ferritin level) was diagnosed in 87.4% of the women in the first trimester, in 29.8% in the third one of the pregnancy and in 77.9% of the newborns in the early postnatal period. The conducted canonical correlation analysis shows the interrelation of the parameters of the composition of the peripheral red blood with the provision of the mother's ration with the proteins (Canonical R = 0.46, χ^2 = 32.29, p <0.04), mineral substances (iron, sodium, potassium, calcium, magnesium and phosphorus) (Canonical R = 0.45, χ^2 = 35.63, p <0.05). The strongest contribution to the correlation coefficient is made from the composition of the peripheral red blood - the Ht in the I and II trimesters, and from the micronutrients in order of importance it is made by potassium (R = 0.68, p <0.05), iron (R = 0.38, p <0.05), phosphorus (R = 0.32, p<0.05), calcium (R = 0.27, p <0.05) and sodium (R = 0.23, p <0.05). The contribution of magnesium (R = 0.03, p <0.05) to the correlation coefficient with Ht turned out to be less than the ones of all indicated microelements. The conducted canonical correlation

analysis revealed the relation close to the statistically significant one between the hemoglobin (HGB) in the puerperas and newborn children and the energy value of the ration of the pregnant woman, the group B vitamins (B1, B2) (Canonical R = 0.87, χ^2 = 37.92, p <0.09). The significant positive relation between the HGB (R = 0.60, p <0.05) and the energy value of the ration (R = 0.56, p <0.05) and vitamins B_2 (R = 0.68, p <0.05) and B_1 (R = 0.35, p <0.05). So, it is determined the statistically significant canonical correlation of the MCHC in the first and second trimesters with the proteins, the Ht in the first and second ones with the minerals (iron, sodium, potassium, calcium, magnesium and phosphorus), the HGB of the puerpera and newborn with the energy value of the ration of the pregnant woman and group B vitamins. The results of the conducted logistic regression analysis allow determining that the state of the newborn is most closely related to the provision of the mother's ration with the beta-carotene (B=1.015, p<0.05), the hemoglobin level of the woman in the first trimester (B=-0.573, p<0.018) and before the childbirth (B=0.423, p<0.014).

Thus, knowledge of the statistically significant relations of the nutrition parameters of the pregnant woman with disorders of the pregnancy period, complications of the childbirth and fetal pathologies and the health of the newborn is recommended for the correction of the ration of the mother and child nutrition in order to prevent the IDS and IDA.

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