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ANEMIAS AND THEIR RELATIONSHIP WITH NUTRIENT STATUS

O. V. Yermishev[1], A. K. Rudkevych[2], O. V. Hadzhyieva

Vasyl' Stus Donetsk National University
21021, Yunosti, 16, Vinnytsia, Ukraine
[1]ORCID: https://orcid.org/0000-0001-5854-9678
[2]ORCID: https://orcid.org/0000-0001-5859-062X
o.yermishev@donnu.edu.ua, a.kutsevol@donnu.edu.ua

Abstract

Nutritional anemias are among the most common nutrient deficiencies in the world. Anemia syndrome was found in about 2 billion persons, and the annual mortality rate due to anemia nowadays reaches 1 million persons. The main cause for the development of anemia of alimentary origin is the imbalance of the diet by micronutrients, especially supply of iron as well as vitamins B_{12} and B_9. The problem of the abundance of anemia is also characteristic of Ukraine and has its own regional features; this requires research, analysis and identification of the main causes of anemia associated with alimentary status. In order to assess the actual diet and differentiation of anemias by type we used a calculation method realizing a retrospective method of analysis of the frequency of food consumption and biochemical and hematological methods of blood tests. Analysis of the actual diet of the population revealed an imbalance and irrationality of nutrition which created preconditions for the formation of eating disorders associated with the development of anemia of alimentary origin. According to the results of the analysis of the actual diet 77.3 % of persons with iron deficiency anemia were found, folate deficiency anemia was found in 13.6 % of individuals, and

cyanocobalamin deficiency anemia was found in 9.1 % of persons. According to the results of the research some sexual peculiarities of the microelement status for iron were revealed among the examined individuals, in particular, within the female group pre-latent iron deficiency was observed in 13.8 % of persons, and in the male one it was found in 41.7 % of ones; latent deficiency was found in 32.8 % of persons and in 22.9 % of persons, respectively, but iron deficiency anemia was revealed in 19.8 % persons and 2.1 % of persons, respectively. The number of individuals with anemia detected in the biochemical study of serum by iron content confirmed the results of the assessment of the actual diet; these numbers were equal to 32.9 % and 31.1 %, respectively.

Key words: anemia; iron deficiency; nutritional composition; analysis of the frequency of food consumption; method of estimating of the actual diet.

Introduction. Nutritional anemias are among the most common problems related to the nutrient deficiencies in the world. The prevalence of this pathology is not decreasing significantly during the recent years, which determines the need to develop a set of effective measures based on state-of-the-art prevention strategies. Iron deficiency condition (IDC) is the iron deficiency anemia (IDA) and latent iron deficiency (LID) are widespread in all the countries of the world [3, 5, 7]. According to the information of the World Health Organization (WHO), every fourth or fifth inhabitant of the planet suffers from IDC (2019). It is known that in developed countries (USA, Sweden) prevalence of IDC is 12 to 15 %. At the same time, in underdeveloped countries its prevalence is much higher and is up to 80 % and even higher in risk groups (pregnant women, children) [2].

The problem of IDC has not only significant medical but also social sense [3]. People with this pathology show deterioration of health and sharp decrease in working capacity [1]; women are more likely to have various complications during pregnancy and childbirth [6]. At the same time, there are no sufficient number of scientific papers at the popular level on iron deficiency in the adult population of Ukraine [2, 8]. These papers are mainly devoted to identifying the prevalence of IDA in women. Studies aimed at identifying prevalence of IDC among different sex and age groups are of single nature [9].

The role of the alimentary factor in the development of IDC is also studied and described in the literature insufficiently. Studies on the hygienic assessment of food consumption as a risk factor for the development of IDC are not numerous and have very contradictory results [10]. To date, there is virtually no information on a comprehensive study of the peculiarities of nutrition, social and living conditions, and biological factors as risk

factors for the development and prognosis of IDC in the different categories of the population [1].

Until now, the issue of the need for iron fortification of food to prevent iron deficiency among the population is not standardized, and in this regard the hygienic study of actual food consumption by different categories of the population and its impact on the development of IDA is of great scientific and practical importance [10].

The actuality of the work is to identify factors and determine methods for optimizing the nutrition of the population to reduce the prevalence of hypovitaminosis and deficiency of trace elements, which have become widespread. Emphasis should be placed on the areas of primary prevention of micronutrient deficiencies, including those involved in the etiology or pathogenesis of anemia associated with the nutrition.

The aim of the work was to substantiate scientifically a set of measures to improve the system of primary prevention of food-related anemia for the regional level of implementation.

Materials and methods. 144 persons were involved in the study whose sample was representative and stratified by sex and age, including 21 (30 %) men and 123 (70 %) women aged 18 to 59 years (mean age was 29.2 ± 0.84 years).

To assess the actual diet, we used a calculation method using a retrospective protocol of analyzing frequency of food consumption over a two-month period (questionnaire interrogation method using a specially designed questionnaire to be filled out by the respondents themselves included 67 questions. It allows you to determine how often specific product is consumed over a period of time, and amount of food consumed is analyzed along with the frequency of its consumption) [10]. The content of micro- and macronutrients in the diet of the surveyed people was calculated using a database of chemical composition of food.

The study was conducted in two stages with an interval of two months. In the first stage, respondents were surveyed by analyzing the frequency of food consumption and detecting low blood hemoglobin by hematological laboratory tests to determine general nutritional status and identify any respondents with laboratory signs of anemia. During the second stage the individuals selected in the first stage with signs of anemia (by blood hemoglobin level) were re-surveyed and expanded hematological studies to differentiate anemia by type were conducted.

Statistical analysis was performed using the STATISTICA-6 package (critical significance level $p < 0.05$).

Results and discussion. Hygienic characteristics of the actual nutrition of the respondents were carried out taking into account the principles of nutrition, namely,

nutritional provision, balanced diet (balance of energy, basic nutrients, and biologically active substances) as well as diet.

It was found in the analysis of individual estimates of actual nutrition, that adequate energy value of the diet was observed in 77.0 ± 31.8 % of the population, but 6.7 ± 1.1 % of the respondents found to have a reduced energy value of the daily diet with a shortage depth of more than 40 %. Excess energy value of the diet was found in 16.3 ± 31.6 % of the respondents (Table 1).

Table 1 – Determination of the proportion of the population with the consumption of certain nutrients below and above the recommended values (indicating the shortage depth; 2020; %)

Nutrients	Below the recommended values				Above the recommended values, number of individuals, %		Adequate nutrition, number of individuals, %	
	Number of individuals, %		Shortage depth, %					
	I stage of the study	II stage of the study	I stage of the study	II stage of the study	I stage of the study	II stage of the study	I stage of the study	II stage of the study
Energy value 1.3/1.31	6.7	5.1	41.1	31.3	16.3	15.1	77	89
Proteins	11.5	4.9	54.5	23.2	6.2	6.0	82.3	82.3
Proteins of animal origin 1.6	17,7	11.1	74.6	72	14.8	13.9	67.5	63.4
Fats 4/1.63	4.8	1.2	52.3	32.1	58.4	52.2	36.8	32.9
Carbohydrates 2.98/2.98	37.8	12.7	42.9	14.4	7.7	7.2	54.5	50.9
Iron	–	31.1	–	37.9	–	9.6	–	59.3
B_{12} vitamin	–	15.8	–	71.8	–	14.4	–	69.9
Folic acid	–	97.6	–	68.8	–	0	–	2.4
Copper	–	4.8	–	26.8	–	1	–	94.3

The results of the analysis of protein consumption in the diet of the surveyed persons showed a coincidence with the recommended standards in 82.0 ± 31.7 % of the respondents, and insufficient consumption was noted in 11.5 ± 31.4 % of the individuals with a depth of the detected shortage above 50 %. Fats consumption was excessive in 58.0 ± 2.2 % of the population. At the recommended value of 30 to 35 %, the proportion of vegetable fats in the daily diet was 51.1 % at the average.

In terms of carbohydrate content in the daily diet, 54.5 ± 2.2% of the respondents met the recommended consumption standards.

Analysis of gender differences in women's diets revealed consumption of more animal proteins (37.0 g, which averaged 102.8 % of the recommended daily standard) compared to men. The female population also consumed more food groups such as eggs, fruits and confectionery.

Analysis of the structure of nutrition in the daily diet of the population from the standpoint of the food set showed the following results: soft drinks – 33.5 %, vegetables and fruits – 35.1 % in total (21.5 % and 13.6 %, respectively), milk and dairy products – 10.6 %, grain products – 6.3 %, bakery products – 5.3 %, meat and meat products – 4.7 %, grain products – 5.25 %, confectionery – 1,69 %, oils and fats – 1.12 %, and fish and fish products – 0.86 % (Table 2).

Table 2 – Content of the main groups of food products in the daily diet of the population (g/day/person; excluding losses for cleaning and cooking) in comparison with the recommended consumption (order of the Ministry of Health of Ukraine of 2016-08-19 No. 614)

Groups of products	Recommended consumption (per capita)		Actual consumption, g	Excess/ shortage, %
	for a year, kg	for a day, g		
Bread products	96	263	271.2	3.1
Fruits and vegetables	330	904.1	537.2	- 40.8
Sugar and confectionery	24	65.8	78	17.5
Meat and meat products	73	200	154.5	- 22.8
Fish and seafood	22	60.3	20	- 66.8
Milk and dairy products	325	890.4	337,1	- 62.4
Eggs	12.5	34.2	31.3	- 8.5
Oils	12	32.9	35.2	7

Analyzing the data we can conclude that the consumption of the main groups of products by the population of the region is below the recommended standards. The most expressed is the insufficient consumption of such groups of products as milk and dairy products – by 62.4 %, fish and seafood – by 66.8 %, vegetables and fruits – by 40.8 %, and

meat and meat products – by 22.8 %. At the same time, excessive consumption of sugar and confectionery was noted which was as much as 18.5 %.

When analyzing the actual nutrition in the age groups certain features were identified. Thus, in the age group of 18 to 29 years the respondents were consuming more bakery products, cereals, confectionery, meat, fats, and beverages. In the age group of 30 to 39 years higher consumption of vegetables and fish was taking place and the population of 40 years and older consumed more eggs, fruits and dairy products.

Low consumption of major food groups is often due to a lack of essential macronutrients, vitamins and minerals in the diet. Based on the analysis of the diet according to the results of the study one can predict an increase in the number of diseases associated with eating disorders, such as obesity, hypertension, diabetes, anemia, and hypo- and avitaminosis. According to the results of the survey, consultative assistance was provided with the recommendations for further nutrition.

In the second stage of our study, a repeated questionnaire was conducted to analyze the actual diet to identify changes and clarify the indicators of micronutrient status for the differentiation of anemia by types. It was attended by 44 respondents, including 15 (35 %) men and 29 (65 %) women aged 18 to 59 years with anemia identified, which accounted for 32 % of the total number of surveyed people in the first stage of the study.

Repeated analysis of the actual diet of the surveyed people with identified anemia in the first stage of the study revealed qualitative changes in the structure of the diet for the two months. The respondents who had shown reduced macronutrient composition of the diet compared to the recommended standard in the first stage, showed significant improvement in the structure of the diet for all macronutrients during the second stage. In terms of total energy, the number of the individuals with energy deficiency and the depth of energy deficiency in the diet decreased by 1.3 times, for carbohydrates by 2.98 times, and protein by 2.35 times, including animal proteins by 1.6 times. The number of the respondents with a shortage of fat in the diet decreased by 4 times, including shortage depth of 1.63 times. Respondents with excess energy intake and macronutrients did not show significant changes in the tendency to decrease in the direction of the recommended standards.

In general, analysis of the structure of the actual diet revealed significant positive changes in the respondents in the structure and quality of the diet.

In addition, the diet was analyzed for content of iron, B_{12} vitamin, folic acid and copper which were directly related to the etiology of anemia of alimentary origin. According to the results of the analysis of actual nutrition, avitaminosis for folic acid was found in

97.6 % of respondents with a shortage depth of 68.8 %, and in 15.8 % of the population it was found for vitamin B_{12} with a shortage depth of more than 70 %. Analysis of the micronutrient composition of the diet associated with the development of anemia in 31.1 % of the respondents found a deficiency of iron in the diet with a depth of deficiency of about 30 % and that of copper of 4.8 % with a shortage depth of 2.8 %. Also 9.6 % of the respondents were found with excess iron in the diet and 14.4 % with that of B_{12} vitamin.

In the structure of the distribution of anemia associated with nutrition, there was revealed some difference from the literary data. The analysis of the actual diet revealed 77.3 % of persons with iron deficiency anemia which was less than the literature (84.2 %), folate deficiency anemia was found in 13.6 % and 4.2 % individuals, respectively, and cyanocobalamin deficiency anemia was found in 9.1 % and 11.6 % individuals, respectively.

In the age group of 18 to 29 years there is a greater consumption of B_{12} vitamin and copper. In the age group of 30 to 39 years, according to our calculations, there is an increase in iron consumption. According to the results of the research in the second stage of the experiment, there is a general improvement in the nutritional status of the respondents due to the recommendations for dietary and lifestyle changes.

Biochemical blood test evaluated prevalence and structure of diet-related anemias in the population. The following values were taken as criteria for the deviation from the normal values (insufficient provision): hemoglobin (Hb) concentration in adults – 120 g/l (7.5 mmol/l) in women and 130 g/l (8.1 mmol/l) in men; serum iron level less than 12.5μg/l, MCV (mean erythrocyte volume) – 80 to 95 μm^3, reference interval (standard) of MCH in the blood is 27 to 31 pg (picograms), and reference interval for MCHC is 320 to 360 g/l.

Indicators of venous blood serum were as follows: erythrocyte content – 4.78×10^{12}/l (4.36 to 5.07), hemoglobin – 141.0 (129.0 to 150.3) g/l, hematocrit –41.0 (37.8 to 43.4) %, serum iron – 14.6 (10.0 to 20.5) μmol/l (Table 3).

When performing individual assessment in comparison with the reference values reduced content of erythrocytes was observed in 5.5 ± 1.8 % of the subjects, that for hemoglobin was in 12.8 ± 2.6 % of the subjects, and that for serum iron was in 32.9 ± 3.7 % of ones.

The study found prelatent iron deficiency in 22.0 ± 3.2 % of persons, latent iron deficiency in 30.5 ± 3.6 % of them, and iron deficiency anemia was found in 14.0 ± 2.7 % of persons, at that but 33.5 ± 3.7 % of the subjects had reference values of venous blood within the established standards.

Table 3 – Serum parameters in the sample study

Indicators	M	SE	P25	P50	P75
Erythrocytes, 10^{12} per liter	4.73	0.04	4.36	4.78	5.07
Hemoglobin, g/l	139	1.2	129	141	150.25
Hematocrit	40.37	0.32	37.78	41	43.43
MCV (average volume of erythrocytes)	85.56	0.37	82.8	86	88.65
MCH (average level of hemoglobin in erythrocytes, pg)	29.44	0.14	28.68	29.85	30.63
MCHC (concentration of hemoglobin in erythrocytes, g/l)	343.99	0.74	338	344	351
Serum iron, μg/l	15.85	0.63	9.98	14.6	20.5

Gender features of biochemical blood test revealed latent iron deficiency in 32.8 % of females, which almost coincided with the literary data (33.6 %), the number of women with prelatent iron deficiency was 13.8 %, and with anemia – 19.8 %. Specific feature of the male group of the subjects was as follows: prelatent iron deficiency was found in 41.7 % of them, latent iron deficiency was found in 22.9 % of men, and anemia was found but in 2.1 % cases.

It shall be noted that the number of identified individuals with iron deficiency anemia in the biochemical study of the serum coincided with the results derived in the analysis of the actual diet by iron – 31.1 ± 3.2 % and 32.9 ± 3.7 %, respectively.

Thus, the actual prevalence of diet-related anemias (according to research) is lower in iron deficiency (77.3 ± 4.88 %) and B_{12}-deficient (9.1 ± 3.35 %) anemias, but it exceeded the number of cases of folate deficiency anemia (13.6 ± 4.0 %) which were based on the population's requests for medical care.

Conclusion

1. Analysis of the actual nutrition of the population at the first stage of the study revealed that the nutrition of the population was unbalanced and irrational, which created preconditions for the formation of nutrition disorders associated with the development of anemia of alimentary origin.

2. In the second stage of the study the respondents showed significant improvement in nutritional status due to the recommendations for dietary and lifestyle changes.

3. According to the results of our research, prelatent iron deficiency was found in the mixed sex and age group in 22.0 % of the examined persons, latent iron deficiency was found in 30.5 % of cases, iron deficiency anemia was found in 14 % of the individuals, and but 33.5 % of the population had reference venous blood values within the established standards.

Analysis of sexual characteristics revealed in the female group prelatent iron deficiency in 13.8 % of cases, and in the male one in 41.7 % of them, latent deficiency was found in 32.8 % and 22.9 % of cases, respectively, but anemia was found in 19.8 % and 2.1 % of persons, respectively.

4. The number of the persons with anemia in the biochemical study of serum by iron content confirmed the results of the assessment of the actual diet and was 32.9 % and 31.1 %, respectively.

Referenced publications

1. Banjari, I. & Hjartåker, A. (2018). Dietary sources of iron and vitamin B12: Is this the missing link in colorectal carcinogenesis*? Med Hypotheses,* 116, 105–110. doi: 10.1016/j.mehy.2018.05.003.

2. Carla Valeria de Alvareng Antunes, Abrahao Elias Hallack Neto & Cristiano Rodrigo de Alvarenga Nascimento. (2015). Anemia in inflammatory bowel dtsease outpatients: prevalence, risk factors, and etiology. *Biomed Res Int*, *8*(1), 1–7. doi: 10.1155 / 2015/728925.

3. de Batlle, J., Matejcic, M., Chajes, V., Moreno-Macias, H., Amadou, A. & Slimani, A. (2018). Determinants of folate and vitamin B_{12} plasma levels in the French E3N-EPIC cohort. *Eur J Nutr*, *57*(2), 751–760. doi: 10.1007/s00394-016-1365-z.

4. Gille, D & Schmid, A. (2015). Vitamin B_{12} in meat and dairy products. *Nutr Rev*, *73*(2), 106–115. doi: 10.1093/nutrit/nuu011.

5. Ivanov, S. V., Khoroshilov, I. E., Tkachenko, E. I., Sitkin, S. I. & Khrabrova, M. V. (2016). Nutritional factors of anemia in ulcerative colitis patients. *Clinical gastroenterology*, *132*(8), 19–25.

6. Methods of viznachennya warehouse and energetic value of products. https://zakon.rada.gov.ua/laws/show/z0146-00#Text (access: 05.09.2014).

7. Miller, S. D., Cuffari, C., Akhuemonkhan, E., Guerrerio, A. L., Lehmann, H. & Hutfless, S. (2017). Associations between Folate and Vitamin B12 Levels and Inflammatory Bowel Disease: A Meta-Analysis. *Nutrients, 9*(4), 382–389. doi: 10.3390/nu9040382.

8. Ratajczak, A, E., Rychter, A. M., Zawada, A., Dobrowolska, A. & Krela-Kazmierczak I. (2020). Nutrients in the Prevention of Osteoporosis in Patients with Inflammatory Bowel Diseases. *Nutrients, 12*(6), 1702–1710. doi: 10.3390/nu12061702.

9. Robert Oh & David L Brown. (2013). Vitamin B_{12} deficiency. *Am Fam Physician, 67*(5), 979–986. PMID:12643357.

10. Sorvacheva, T. N., Martynchyk, A. N. & Pyreva, E. A. (2014). Comprehensive assessment of the actual nutrition and nutritional status of children and adolescents. Tutorial. Moscow: HBOU DPO RMAPO, 73 c.

11. Stauder, R., Valent, P. & Theurl I. (2018). Anemia at older age: etiologies, clinical implications, and management. *Blood*, *131*(5), 505-514. doi: 10.1182/blood-2017-07-746446.

12. The order about the consolidation of the Norms of physiological needs of the population of Ukraine in the main grub talk and energy. https://zakon.rada.gov.ua/laws/show/z1206-17#Text (access: 03.09.2017).

13. Yakut, M., Ustün, Y., Kabaçam, G. & Soykan, I. (2010). Serum vitamin B_{12} and folate status in patients with inflammatory bowel diseases. *Eur J Intern Med*, *21*(4), 320–223. doi: 10.1016/j.ejim.2010.05.007.