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Assessment of actual nutrition in the first trimester of pregnancy as a premorbid indicator

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AIM: The aim of this study was to assess the actual nutrition of pregnant women in the first trimester as the basis for a personalized approach to pregnancy management.

MATERIALS AND METHODS: The actual nutrition during pregnancy was studied by analyzing the frequency of food consumption using the food weighing method, and the average daily indicators were calculated based on data for a period of one week. In total, 417 women were surveyed. The diet was characterized to identify deficiencies of the vitamins and minerals most significant for the reproductive system using the Individual Diet (My Body 3.0 version) software. Descriptive statistics methods were used to quantify the results. In the course of the work carried out, descriptive statistics methods were used.

RESULTS: The energy value of the daily diet of pregnant women averaged 2294.3 ± 487.21 kcal, which is within normal values (2070.0–3507.5 kcal / day), a surplus being observed in almost a third of the respondents (n = 118, 28.3%). The analysis of the diet showed that most of the patients had a deficiency in vitamins, macro- and microelements most significant for the reproductive system. On average, pregnant women consumed 155.0 ± 0.52 µg / day of folic acid with food, no woman receiving enough folic acid to prevent congenital malformations of the fetus. The average dietary intake of iodine was 70 µg / day. Thus, focusing on the recommendations for pregnant women, a diet deficient in iodine was observed in 90% of the respondents, and only five women (1.2%) consumed a sufficient amount of iodine-containing products. It was found that pregnant women consumed 5.9 ± 2.10 mg / day of zinc, with the recommended intake level of more than 12.5 mg / day not recorded in any woman. Iron deficiency was found in 289 respondents (69%). According to the survey results, more than half of the respondents (n = 269, 64.5%) had insufficient selenium intake. Calcium deficiency was registered in half of pregnant women (n = 210, 50.0%). Only every tenth woman (n = 48, 10.0%) consumed a sufficient amount of calcium containing food. Poor magnesium consumption was rarer and was found in only one third of the respondents (n = 135, 32.0%).

CONCLUSIONS: The data obtained indicate the need to study the individual level of actually consumed vitamins and nutrients, which may be the basis for personalized selection of drugs and efficient microelement dosing strategy.

Keywords: pregnancy; eating behavior; vitamin deficiency; trace elements.

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Оценка фактического питания в первом триместре беременности как показатель формирования преморбидного фона

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Цель — оценить фактическое питание беременных в I триместре как основу персонифицированного подхода к ведению беременности.

Материалы и методы. Фактическое питание во время беременности изучали, анализируя частоту потребления пищи с помощью весового метода, рассчитывали среднесуточные показатели на основе данных за период, равный одной неделе. Анкетирование прошли 417 женщин. Характеристику рациона проводили по выявлению дефицитов наиболее значимых для репродуктивной системы витаминов и минералов с использованием программного комплекса «Индивидуальная диета» (версия My Body 3.0). В ходе работы были применены методы описательной статистики.

Результаты. Энергетическая ценность суточного рациона беременных в среднем составила 2294,3 ± 487,21 ккал, что укладывается в нормальные значения (2070,0–3507,5 ккал/сут), вместе с тем профицит наблюдался почти у трети респонденток (118 человек; 28,3 %). При анализе рациона беременных оказалось, что у большинства из них есть дефицит по содержанию наиболее значимых для репродуктивной системы витаминов, макро- и микроэлементов. В среднем беременные потребляли с продуктами питания 155,0 ± 0,52 мкг/сут фолиевой кислоты, ни одна женщина не получала достаточного для профилактики врожденных пороков развития плода количества фолиевой кислоты. Средний уровень потребления с пищей йода беременными составил 70 мкг/сут. Таким образом, ориентируясь на рекомендации для беременных, дефицитный по содержанию йода рацион наблюдался у 90 % респонденток, и только пять женщин (1,2 %) потребляли достаточное количество йодсодержащих продуктов. В среднем беременные потребляли 5,9 ± 2,10 мг/сут цинка, и рекомендуемого уровня потребления более 12,5 мг/сут не было зафиксировано ни у одной женщины. Дефицит железа выявлен у 289 женщин (69 %). Более половины респонденток (269 человек; 64,5 %) недостаточно потребляли селен. Дефицит кальция зарегистрирован у половины беременных (210 человек; 50,0 %). Достаточное количество кальцийсодержащих продуктов употребляла только каждая десятая женщина (48 человек; 10,0 %). Дефицит потребления с продуктами питания магния встречался реже и был выявлен только у трети респонденток (135 человек; 32,0 %).

Заключение. Полученные нами данные свидетельствуют о необходимости изучения индивидуального уровня фактически потребляемых витаминов и нутриентов, что является основой персонифицированного подбора препаратов и доз необходимых элементов.

Ключевые слова: беременность; пищевое поведение; дефицит витаминов; микроэлементы.

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BACKGROUND

Problems associated with the protection of the health of mothers and children are extremely complex and diverse. Their solutions must naturally be comprehensive and include measures that can improve medical prevention activities and social and organizational ones. However, the predictors of the development of gestational disorders and the optimal ways of leveling them have yet to be identified.

Russian and international scientists have discussed the role of deficiency states of the body of a pregnant woman as a premorbid background for the formation of obstetric complications because of their influence on metabolic processes, enzyme systems of the body, and chromosomal structure [1, 2]. A diet high in energy value is often characterized by an insufficient intake of essential trace elements and vitamins; as such, the risk of adverse pregnancy outcomes increases. Moreover, the state of macroorganisms in the pregravid period is essential. Further studies should address the issue of nutritional support because nutrition is one of the controllable factors that can be implemented by patients themselves. Therefore, the eating behavior of women with adverse pregnancy outcomes should be analyzed. This analysis is also one of the promising aspects in a complex of measures during preconception and will prevent the development of complications in these patients in the future.

This study aimed to evaluate the actual nutrition of pregnant women in the first trimester as a basis for developing a personalized approach of pregnancy management.

MATERIALS AND METHODS

An observational descriptive study was conducted in August–October, which is the most optimal time for the consumption of seasonal vegetables and fruits. Empirical information on the actual nutrition of pregnant women was collected by analyzing the questionnaires of 417 Perm women who were at the term of 11 weeks to 13 weeks and 6 days of gestation and applied to the Center for Family Protection and Reproduction of the Academician E.A. Wagner Perm State Medical University (Center). The general population in the sample formation included all the women registered for pregnancy in Perm during the year (i.e., 11,806 people in 2018).

All the respondents who participated in this study were asked to sign an informed consent. Their actual nutrition was examined with the questionnaire-weight method of analysis of the frequency of food intake. The average daily indicators were calculated on the basis of their data for 1 week. The obtained indicators were then compared with the norms of the physiological requirements for energy and nutrients of various groups of the population of the Russian Federation [3]. Diet was characterized using Individual Diet, My Body 3.0 version (Certificate of State Registration of Computer Programs No. 2009615061 dated 09/16/2009) to identify the most significant vitamin and mineral deficiencies in the reproductive system. This version includes information on the databases of products and diets approved by the Institute of Nutrition of the Russian Academy of Medical Sciences. With this program, the quantitative levels of cholesterol, fiber, vitamins (A, C, D, E, B_1, B_2, B_3, B_5, B_6, B_9, and B_{12}), and minerals (Ca, Fe, I, F, K, Mg, Na, Se, and Zn) in the diet can be determined.

The physical activity of the female patients was assessed by analyzing their responses about the frequency and intensity of the physical activities performed. Average level physical activities included the following: brisk walking, going downstairs or downhill, quiet cycling (8–10 km/h), yoga, aqua-aerobics, active housework (washing the floor, rearranging, and carrying things), dancing, active play with a child, active walk with a stroller, and other activities of a similar intensity. High level physical activities were as follows: running, brisk climbing uphill or upstairs, brisk cycling, professional dancing, competitive professional sports, and other activities of similar intensity.

In this work, descriptive statistics was used: mean (M), standard deviation (δ), 95% confidence interval, median, lower and upper quartiles (or 25% and 75% percentiles), absolute values of the desired attribute (deficit condition), and their corresponding percentage in the structure of the entire population (all pregnant women).

At the time of the study, some of the patients were taking vitamin and mineral complexes (332 people, 79.6%): multivitamin complexes in 43.4% of cases (144 women), including preparations containing folic acid and iodine in 17.2% (57 people), folic acid alone in 27.7% (92 people), or iodine preparations in 11.7% (39 people). Only 1.2% of cases (5 women) received pregravid preparation with vitamin supplements for at least 3 months. Our data were below the all-Russian indicator. According to Russian literature, 4% of Russian women receive full-fledged preconception preparations [4].

RESULTS

Smoking is a proven risk factor of obstetric complications [5, 6]. As such, nutritional status should be adjusted to alleviate its negative effects on the body. Of the 60 (14.3%) people who noted a history of smoking and/or currently smoking, 32 (53.3%) continued to smoke during pregnancy, including 8 people who smoked one pack or more per day. Furthermore, 28 (46.7%) patients quitted smoking only when they knew about their pregnancy, but the first weeks of embryo development proceeded with nicotine intoxication. Among all the women who participated in the study, the prevalence of second-hand smoking was high. In particular, spouses, parents, and colleagues of 20.7%, 25.3%, and 20.1% of pregnant women were smokers, respectively.

The structure of somatic pathology affecting the quality of food consumption and associated with the observance of a special dietary regime included diabetes mellitus; in particular, 17 (4%) patients had gestational diabetes, 3 (0.7%) patients had gastrointestinal tract diseases with malabsorption syndrome, and 4 (0.9%) patients had epilepsy with the need for constant intake of valproic acid. In 28 (6.7%) patients, gastritis was indicated as an extragenital pathology, but all of them noted that the last exacerbation was more than 5 years ago. The patients with somatic pathology were also included in this research because of the study design, but vegetarians, vegans, or other nontraditional diet representatives were excluded.

The average energy value of the daily diet of pregnant women was 2294.3 ± 487.21 kcal, which is within normal limits (2070–3507.5 kcal/day). Conversely, a surplus was observed in almost one-third of the respondents (118 people, 28.3%). The consumption values of basic nutrients, energy, minerals, and vitamins in the daily ratio of the respondents are presented in Table 1.

Excessive caloric value in the absence of physical activity is a proven risk factor of the development of obesity and obstetric complications, such as gestational diabetes mellitus, pre-eclampsia (PE), and stillbirth [6, 7]. In physical activity assessment, the activities of 112 (26.8%), 49 (11.7%), and 256 (61.4%) pregnant women at least twice a week were average, high, and low, respectively.

Nutritional status assessment revealed that the average of the total proteins in the daily diet was 16.9 ± 2.52 g (the standard rate of consumption = 10–35 g/day). The average daily content of the consumption of fats in the diet was in the upper limit of the norm, i.e., 35.1 ± 4.0 g/day with the norm of 20–35 g/day (131.4% ± 15.7% of the norm of physiological need). The consumption of total fats corresponding to the physiological norm was noted in 67.6% of pregnant women. The nutrition of pregnant women was also characterized by the excessive consumption of fats, which were rich in saturated fatty acids and exceeding the normal physiological requirement by 17% to 50%. This finding was due to the high content of fat sources, such as sausages, mayonnaise, deep-fried dishes, and fried potatoes, in the diet. The consumption of polyunsaturated fatty acids was within the physiological norm (5%–14% of the caloric content of the diet) in all pregnant women; the average value for the sample was 20.0 g (6.7%–8.5% of the caloric content). Only 7 patients (1.7%) additionally consumed preparations containing omega-3 fatty acids (dosage of 200–600 mg). The contribution of fats to the caloric content of the diet exceeded the normalized level, i.e., 35.4%–38.0% of the energy value of the diet at the recommended level of 30%. The average carbohydrate content in the daily diet was 49.4 ± 4.73 g, which is within the recommended physiological norm. The level of carbohydrate consumption corresponding to the normative values was found in 70.9% of the respondents. The value of insufficient consumption of dietary fiber is 13.3 ± 7.02 g/day, whereas the normal rate is 20 g/day. In 72.2% of women, the total protein level in the daily diet was normal (Table 1). The analysis of the ratios of proteins, fats, and carbohydrates showed an imbalance of macronutrients at a food ratio of 1:1.35:4.28 (with the recommended ratio of 1:1.1:4.8).

According to the clinical protocol “Normal pregnancy,” during pregnancy, folic acid and iodine supplements are necessary [8], but a deficiency of other vitamins and minerals can also be a risk factor of gestational complications and adverse perinatal outcomes.

B_9, B_{12}, and B_6 are the most important B vitamins of the reproductive system. Vitamin B_9 (folic acid) is associated primarily with the prevention of congenital malformations of the fetus. The analysis of the diet of pregnant women revealed that pregnant women consumed an average of 155.0 ± 0.52 μg of folic acid per day with food (Table 2), that is, the women did not receive enough folic acid to prevent congenital malformations of the fetus. This observation confirmed the need for the mandatory supplementation of vitamin B_9 during pregnancy. The dose of folic acid recommended for daily intake by a pregnant woman is 400–800 μg/day because these doses maintain a sufficient

Table 1. Energy value of the actual nutrition of pregnant women

Nutrients	M ± SD	Normal values
Energy value, kcal	2294.3 ± 487.21	2070–3507.5
Proteins, g	16.9 ± 2.52	10–35
Total fat, g	35.1 ± 4.0	20–35
Proportion of saturated fat, %	12.8 ± 2.11	<10
Carbohydrates, g	49.4 ± 4.73	45–65
Fiber, g	13.3 ± 7.02	20

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Table 2. Qualitative composition of the actual nutrition of pregnant women

Nutrient	Average daily consumption normal rate for the female population + increase for pregnant women	Median	Mean value, M	Standard deviation, δ	Highest value	Lowest value	95% confidence interval	Deficiency according to the norms for non-pregnant women, pers. (%)	Deficiency according to the norms for pregnant women, pers. (%)	Normal rate for pregnant women, pers. (%)	Surplus according to the norms for pregnant women, pers. (%)
A, mg	600–1500 μg retinoid equivalent/day + 100	1200	991.369305	51.0926715	1700	820	45.0145493	139 (33.3%)	153 (36.7%)	237 (56.8%)	27 (6.5%)
B_6, mg	1.1–2.6 mg/day	1.19	1.254304556	0.496933277	3.39	0.247	0.047030126	170 (40.8%)		243 (58.2%)	4 (0.9%)
B_{12}, mg	1.4–3.0 μg/day	1.95	1.95	0.699160451	3.31	0.39	0.374321412	100 (23.9%)		207 (49.6%)	110 (26.4%)
C, mg	35–110 mg/day + 10	87.8	53.06688995	35.54589987	206	2.78	10.84572297	147 (35%)	218 (52.3%)	307 (73.6%)	108 (25.9%)
D, μg	2.5–13.5 μg/day	2.7	2.152685851	2.052413209	10.3	0.04	0.316733503	310 (74.3%)		107 (25.6%)	0
E, mg	7–25 mg tocopherol equivalent/day + 2	6.44	7.757242206	4.557895284	28.9	1.26	5.969946624	240 (57.5%)	300 (71.9%)	111 (26.6%)	6 (1.4%)
Calcium, mg	500–1200 mg/day + 300	496	538.92494	216.8923424	1388.2	146	20.81802931	210 (50%)	369 (88%)	48 (10%)	0
Iron, mg	15–20 mg/day + 15	12.6	13.2423741	4.509276809	27.1	3.23	0.431909322	289 (69%)	405 (97%)	4 (0.95%)	8 (1.9%)
Potassium, mg	1000–4000 mg/day	1661.1	1728.289209	680.8074989	5726	546.4	65.34308138	49 (11.8%)		49 (11.8%)	319 (76.5%)
Magnesium, mg	200–500 mg/day	231.1	237.7395683	86.10855367	671.6	83.1	50.19746116	135 (32%)		279 66.9%	3 (0.7%)
Sodium, mg	1300–1600 mg/day	1717.2	1751.501439	499.5858591	2740.2	527.3	77.4269444	69 (16.5%)		91 (21.8%)	257 (61.6%)
Phosphorus, mg	550–1400 mg/day + 200	816.9	882.0016787	283.3915445	1620.3	261.5	29.17787418	40 (9.6%)	157 (37.6%)	259 (62.1%)	1 (0.2%)
Zinc, mg	9.5–15.0 mg/day + 3	5.84	5.913381295	2.152028173	11.5	1.55	0.206356676	269 (64.5%)	400 (96%)	17	0
Selenium, μg	30–75 μg/day + 10	24.7	29.11136691	17.23802717	86	2.07	3.589646362	269 (64.5%)	323 (77.4%)	92 (22%)	2 (0.4%)
Iodine, μg	130–200 μg/day + 70	63.7	70.51294964	40.88425406	213.4	12.6	6.900951162	376 (90.2%)	412 (98.8%)	5 (1.2%)	0

concentration of folate in erythrocytes in pregnant women (906 nmol/L) [3, 8].

Our data showed that 337 (80.8%) patients took medications containing vitamin B_9: 190 (56.4%) people, 400–800 μg/day (recommended dose); 97 (28.8%) people, 1000 μg/day; 1 (0.3%) patient, 2000 μg/day; 14 (4.1%) women, 5000 μg/day; 1 (0.3%) pregnant woman, 5400 μg/day; and 10 (10.1%) women, less than 400 μg/day. Furthermore, 2 women had multivitamins not adapted for pregnant women (50 and 70 μg of folic acid per day).

Some pregnant women took several types of multivitamins at the same time, thereby inducing folic acid hyperdose, i.e., more than 5000 μg/day (15 people, 4.4%). According to the clinical protocol pregravid preparation 2.0 [4], the dose of folic acid during the preconception period and in the first trimester of pregnancy should be selected on the basis of the degree of risk of folate-dependent fetal malformations [9, 10]. The recommended daily doses of folate are 400 μg/day in the low-risk group, up to 1000 μg/day in the moderate risk group, and up to 4000–5000 μg/day in the high risk group.

Our results revealed that 51 (12.2%) patients had a high risk of folate-dependent congenital malformations: a BMI of 30 kg/m^2 or higher was found in 26 (6.25%) patients, including 2 women (0.5%) with class III obesity (BMI > 40 kg/m^2); 1 patient with a birth in a family of children with congenital malformations (neural tube defect), 17 patients with diabetes mellitus, 3 people with gastrointestinal tract diseases with malabsorption syndrome, and 4 people with epilepsy (with valproic acid intake). Folic acid in the required dose of 5000 μg/day was received by 1 patient with a burdened family history of birth of children with a neural tube defect. Notably, the intake of high doses of folic acid (≥4000 μg/day) can reduce the risk of congenital malformations in the fetus and neutralize the negative effects of homocysteine on endothelial function [11]. In our study, none of the smoking patients received the required dose of folic acid.

Folic acid synergists, including vitamin B_{12}, enhance the positive effect of folic acid on hyperhomocysteinemia. In our study, 100 (23.9%) women revealed vitamin B_{12} intake deficiency, 170 (40.8%) patients had insufficient vitamin B_6 intake, and 145 (34.8%) patients had combined Mg and B_6 deficiency.

The city of Perm is an iodine-deficient region, where the severity of the goiter endemic increases because of climatogeographic, socio-economic, and ecological aspects. In this study, the average dietary iodine intake of pregnant women was 70 μg/day (Table 2). However, this study did not verify if iodized salt was used in food, so our assumption was that only fortified salt was consumed. The minimum value was 12.6 μg/day, and the maximum level of average daily consumption with food was 213.4 μg/day. The normal consumption rates in Russia correspond to international ones, i.e., 130–200 μg/day for women of reproductive age and 200–270 μg/day during pregnancy. Thus, based on the recommendations for pregnant women, 90% of the respondents had an iodine-deficient diet, and only 5 (1.2%) women consumed a sufficient number of iodine-containing products. Only half of the respondents (212 people, 50.8%) took iodine preparations: 13 (6.1%) patients, 100 mg; 70 (33%) patients, 150 mg; 106 (50%) patients, 200 mg; and 12 (5.7%) patients, 250 mg. Thus, only one-third of the pregnant women (123 people, 29.5%) received a sufficient amount of iodine for the prevention of obstetric and perinatal complications.

The capital of the Perm Territory, i.e., the city of Perm, belongs to the cities with climatic conditions characterized by low solar radiation levels. The number of sunny days per year is about 145, which is fewer than that in other regions, such as Chita, with 284 sunny days. According to our data, the average level of vitamin D_3 intake among pregnant women was 2.2 ± 2.2 μg/day, which is lower than the recommended dose (2.5–13.5 μg/day). Furthermore, 310 (74.3%) patients did not receive vitamin D_3 with food, so the highest and lowest values were 27.7 and 0.016 μg/day, respectively. However, the dosage of mandatory vitamin D_3 supplementation during pregnancy has yet to be standardized. In the clinical guidelines Normal Pregnancy of the Ministry of Health of the Russian Federation (2020), pregnant women at a high risk of D_3 hypovitaminosis are recommended to take oral vitamin D_3 throughout pregnancy in a prophylactic dose of 10 μg (400 IU) per day. However, this document does not provide information on the need to correct the deficit. International studies have demonstrated that a dosage of 400–600 IU/day does not compensate for the increasing body demands in each trimester, which is especially important in case of an initial deficit [12]. Our data revealed that only 63 (15.1%) people received vitamin D_3 with multivitamin preparations at a dosage of 100–600 U/day. When inadequate doses of vitamin D_3 are administered and when high treatment doses are prolonged, acute or chronic poisoning may develop [13]. Our results indicated that no patients consumed excessive amounts of D_3 with food. As such, only prophylactic doses could be prescribed to the population. Therefore, vitamin D_3 deficiency should be confirmed through laboratory examinations to resolve the issue on the use of therapeutic dosages.

Insufficient calcium (Ca) intake with food is associated primarily with an increased risk of developing PE. Ca supplementation in the second half of pregnancy reduces the serious consequences of PE and is recommended by the World Health Organization (WHO) for women with low dietary Ca intake. A cohort study (60,027 female patients) by Norwegian scientists revealed that low calcium intake in the gestational period is related to the development of arterial hypertension within 10 years after pregnancy [22].

For normal Ca uptake, a sufficient intake of D_3 is necessary. For the inclusion of Ca into bone tissues, P, Mg, Zn, Mn, Cu, K, C, and B_9, in addition to D_3, are required. During pregnancy, calcium metabolism is negatively affected by a diet rich in sugars, grains, and other carbohydrates. As such, the strength of the bones weakens because sugar promotes the excretion of Ca from the body by lowering the blood pH. In prescribing calcium-containing drugs, a single dose should not exceed 600 mg of elemental Ca. At higher doses, Ca absorption decreases. With normal renal function, an intake of up to 2500 mg of Ca does not generally cause hypercalcemia or lithogenesis. With a low level of Ca consumption, especially in the presence of Mg deficiency, the risk of Ca salt deposition in hypomagnesium tissues sharply increases (e.g., placental calcification, atherosclerotic plaque calcification, kidney stone crystallization, and salt accumulation in the joints). In taking Ca preparations without meals or on an empty stomach, the risk of calcification increases [22].

Our data showed that 210 (50%) pregnant women had Ca deficiency. If the recommended intake rates for pregnant women (800–1200 mg/day) were considered, then almost 90% of the population (369 [88%] people) received less Ca than the needed amount in their diet. A sufficient number of calcium-containing products were consumed only by 48 (10%) people. These results were correlated with the recommendations by the Russian clinical protocols Hypertensive Conditions during pregnancy [23], Normal pregnancy [7], and the WHO recommendations on the provision of antenatal care as a means of forming a positive pregnancy experience [24]. Thus, the prophylactic administration of Ca preparations to all pregnant women should be further explored.

The deficit in the consumption of Mg with food was rarer and detected only in one-third of the respondents (135 [32%] people) at the recommended rate of 200–500 mg/day, and the average value was 237.74 ± 86.1. The normal consumption rate of this macronutrient was found in 279 women (66.9%).

The data on vitamins C, A, and E were compared with the recommendations for women of reproductive age and with different indicators for pregnant women. According to the recommendations for pregnant women, our results revealed a deficiency in dietary intake of vitamins C, A, and E in 35%, 33.3%, and 57.5% of the respondents, respectively.

A surplus of vitamin A intake with nutrition was detected in 40 (9.6%) people, and the highest value was 1700 µg/day.

Pregnant women consumed an average of 5.9 ± 2.1 mg/day of zinc (Zn), with the highest and lowest values of 11.5 and 1.55 mg/day, respectively (Table 2). In calculating the frequency of deficiency states, if an indicator of 9.5 mg/day (the lower limit of the norm for women of reproductive age) was used, our results showed that 377 respondents (80%) received less zinc than that obtained from food. If the recommended norm for pregnant women (12.5 mg/day) was considered, then almost all women (96%, 400 people) in Russia had Zn deficiency. However, the recommended intake level of more than 12.5 mg/day was not detected. Our results of the assessment on the frequency of zinc deficiency states were consistent with the data of international studies. According to international studies, more than 80% of pregnant women in the world do not receive sufficient amounts of Zn, but they consume an average of 9.6 mg of Zn per day, which is almost two times higher than our results [14].

The risk factors of zinc deficiency include long-term and excessive use of alcohol-containing products; diabetes mellitus; bowel diseases, such as malabsorption syndrome and inflammatory bowel diseases; rheumatoid arthritis; eating disorders; chronic kidney diseases; sickle-cell anemia; and strict veganism; in this case, the need for Zn increases by 50% because the main food of vegetarians contains grains and legumes, and the high level of phytic acid in these products reduces Zn absorption [15].

The competitive relationship of Zn with other elements is essential. Zn levels in the body of a pregnant woman and a fetus decrease possibly because of the excessive intake of copper (Cu), cadmium (Cd), and lead (Pb), which are important for megacity residents and smokers, including second-hand smokers. The survey revealed that 13% of women continued to smoke despite the onset of pregnancy. Tobacco smoke contains high Cd concentrations. The serum Cd level of women who quit smoking remains high during the subsequent year [16]. Cd and Zn are in a competitive relationship; as such, Zn deficiency is found in smokers [17]. Thus, the intake of this trace element into the body is lower than the amount consumed with food because of a decrease in Zn absorption in women who smoke.

According to the average daily consumption rates of the women of reproductive age (15–20 mg/day), iron 9 (Fe) deficiency was found in 289 (69%) people. On the basis of the recommendations for pregnant women (30–35 mg/day), our results revealed Fe deficiency in almost all the respondents (405 [97%] people). The obtained data on the prevalence of dietary Fe deficiency are consistent with the WHO recommendations on providing supplements with prophylactic doses of ferrous preparations to all women during pregnancy and at the pregravid stage [18]. According to Russian regulatory documents, Fe preparations are advisable in a therapeutic dose (120 mg/day) when anemia is detected. An increase in the daily dose of more than 200 mg significantly increases the frequency and severity of adverse reactions, including dyspeptic disorders, ulceration of the oral cavity, esophagus, severe skin complications, and even anaphylactic shock, especially when ferrous sulfate is taken

[19, 20]. In our study, Fe consumption surplus was detected in 8 patients (1.9%).

Our data showed that 27 (6.5%) people took therapeutic dosages of Fe preparations in the first trimester, and all of them had laboratory-confirmed iron deficiency anemia. Furthermore, 17 (4.1%) people had Fe and Ca preparations at the same time, and only two of the cases included remarks about the need to take these drugs in different periods.

According to the results of our study, more than half of the respondents (269 [64.5%] people) received insufficient amounts of selenium (Se) with food (Table 2). If the recommended consumption level for pregnant women (40–85 μg/day) was considered, then the deficit was even more common and detected in 323 (77.4%) women. Furthermore, 92 (22%) patients consumed sufficient Se-rich foods. The comparison of the obtained results and the data of European colleagues revealed that despite the designation of the global deficit of Se consumed with food in countries in Western Europe, the median exceeds our data almost twice (49 and 27.4 μg/day, respectively) [21].

DISCUSSION

Regulatory guidelines indicate that the need for energy and nutrients depends on physical activity, which is characterized by the coefficient of physical activity equal to the ratio of energy expenditure for performing a specific work to the value of basal metabolism. Daily energy consumption is determined by energy consumption for specific activities and the amount of basal metabolism, which depends on a number of factors, primarily including age, body weight, and gender. The basal metabolic rate of women is 15% lower than that of men. During pregnancy and breastfeeding, energy requirements increase by an average of 15% and 25%, respectively. The physiological energy need of women is 1800–3050 kcal/day, but it is 2070–3507.5 kcal/day during pregnancy [3]. Our study showed that almost one-third (28.3%) of the patients had a surplus in energy consumption, which is a known risk factor of the development of obesity and associated pregnancy complications, such as PE and stillbirth [2, 25]. Moreover, more than half of the respondents (61.9%) had low physical activity, which aggravated the situation. Although most women had diets containing a low amount of fats and carbohydrates, one-third of them had these nutritional components that still exceeded the upper limits of the norm (32.4% and 29.1%, respectively), which determined the risk of obesity and its complications.

Regulatory guidelines [8] established a mandatory supplement of iodine and folic acid preparations during pregnancy. However, only 17.2% of women received this necessary combination of drugs, which can be regarded as a negative characteristic of antenatal monitoring.

Despite the state of knowledge of iodine deficiency, this issue remains relevant. Goiter, hypothyroidism, cretinoid idiocy, and impaired cognitive development of the newborn are potential consequences of iodine deficiency [26, 27]. The use of iodized salt is an effective and sustainable way to ensure adequate iodine intake; however, only 70% of the world's population currently consumes iodized salt because many countries do not have a national iodine supplementation program [27]. Until September 2018, GOST was in force in the Russian Federation; as such, edible salt was enriched with potassium iodide only. However, iodine in this type of salt remains for 3–4 months and disappears when it is heated to 30°C. In 2018, a new GOST for salt was implemented; thus, salt was enriched with potassium iodate only (GOST R 51574-2018) [28]. However, no norms on iodine levels in the new standard have been established. According to the previous version of this document (GOST R 51574-2000), the mass fraction of iodine should be 40 ± 15 mg per 1 kg of salt. This requirement has been fulfilled, and according to the statistics of Rospotrebnadzor for 9 months in 2019, only 0.77% of all the tested iodized salt samples did not meet the standards. Even if iodine in salt is sufficient, its level inevitably decreases during storage. When the required storage conditions (e.g., dark and dry place and lack of exposure of salt to direct sunlight) are not met, iodine in salt may be below normal levels even before the expiration date. At home, following these storage rules is difficult because some of the salt is stored in a constantly used open salt shaker, and packaging is usually kept open. Currently, in Russia, a draft of the Federal Law on the Prevention of Diseases Caused by Iodine Deficiency, which has been submitted for consideration, specifies the mandatory fortification of edible salt with iodine and the production of bakery products with iodine-fortified salt. The development of this law indicated the significance and widespread prevalence of iodine deficiency states on the territory of the Russian Federation at the state level [29]. However, to date, the law has not been submitted for consideration to the State Duma of the Russian Federation.

Another essential component of a nutritious diet is an adequate amount of vitamin D_3. However, studies have yet to verify the need for its mandatory supplementation during pregnancy. In 2016, F. Aghajafari et al. (in an international study in Canada and the USA) [30] assessed the D-status of pregnant women by analyzing their eating behavior and post-supplementation. They found that 20% of their respondents have a laboratory-confirmed deficiency (according to the definition of the Canada Endocrine and Osteoporosis Society, the recommended level is ≥75 nmol/L) even if an adequate dose of D_3 of 6000 IU/day or higher is administered. Similar data are presented in studies conducted in various regions of the Russian Federation. For example, in the northwest region of the Russian Federation, the consumption of 25(OH)D is insufficient in 82.7% of patients aged 18–70 years [31]. Similar results were obtained in residents of southern regions. For instance, in the Rostov region, a diet deficient in D_3 level is noted in 82.1% of the people examined [31]. In the Chuvash Republic, the optimal consumption of 25(OH)D is detected only in 6.4% of young women and men aged 18–27 years [32].

The normal rates of consumption of retinoids remain controversial. Vitamin A is essential for growth and reproduction, differentiation of epithelial and bone tissues, and maintenance of immunity and vision. However, in current regulatory guidelines, a discrepancy in the recommended consumption rates is found. According to the norms of physiological needs for energy and nutrients for various groups of the population of the Russian Federation, the physiological need is 600–1500 μg retinoid equivalent per day. During pregnancy, this requirement increases by 100 μg per day. The average consumption in different countries is 530–2000 μg retinoid equivalent per day; in the Russian Federation, it is 500–620 μg retinoid equivalent per day [3]. Nevertheless, according to Normal pregnancy, the recommended dose of vitamin A intake should not exceed 700 μg/day because excessive amounts during pregnancy are associated with the risk of fetopathy and embryopathy [8]. This recommendation at a C level of persuasion is based on the publication of British scientists, namely, H.M. Dolk et al. (1999), who concluded that the potential toxicity of a dose of retinoids above 700 μg per day is based on a probabilistic analysis of safe vitamin A intake during pregnancy in animal models [33]. However, they believed that further research is required to rank the consumption rates better in terms of the potential risk of fetopathy and embryopathy. Our research was based on the proposed vitamin A consumption standards, which are regulated in the guidelines "norms of physiological requirements for energy and nutrients for various groups of the population of the Russian Federation."

Obesity and its related nutritional deficiencies should be further explored to determine the causes of the formation of a premorbid background during pregnancy. Studies have shown that low Zn consumption and a decrease in its level in the blood serum are correlated with an increase in the prevalence of obesity and diabetes mellitus [2, 34, 35]. In our study, we did not reveal a strong correlation between dietary Zn deficiency and obesity (Figure) probably because of the stimulation of zinc-dependent processes of insulin resistance and obesity, which lead to impaired Zn metabolism. Even with normal Zn consumption with food, the degree of expression of zinc-containing transport proteins is not affected, so the therapeutic doses of Zn should be prescribed. We believe that the effect on the regulation of Zn homeostasis should be considered as a possible therapeutic target in the presence of obesity and associated obstetric complications, such as gestational diabetes mellitus, PE, and stillbirth. As such, this issue should be further studied.

Fe is another essential nutrient for pregnant women. Although Fe has essential properties, it elicits potential toxic effects, which manifest mainly in the free form of Fe that is not bound to ligands. Free Fe ions are reactogenic and aggressive toward cell membranes and cell organelles (primarily mitochondrial membranes). Moreover, an excess of Fe in certain tissues promotes the development of an infectious process, the proliferation of tumor cells, cardiomyopathy, arthropathy, and the occurrence of endocrine and neurodegenerative disorders [36]. Excessive and deficient supplies of Fe during pregnancy affect placental function. The processes characterized by the escalation of pro-oxidant processes have been described, and they contribute to the development of placental insufficiency [37]. For optimal Fe absorption, the normal secretion of gastric juice and the intake of food rich in vitamin C are required. The intake of some medicines in conjunction with ferrous preparations can alter Fe absorption. For example, a decrease in gastric acidity with prolonged use of antacids, which are often used during pregnancy, can reduce the ability to absorb Fe. The long-term use of aspirin, even in small doses, can induce the loss of Fe, causing "silent" gastric bleeding. Other studies have also demonstrated a decrease in the uptake of some trace elements, such as Zn, when an excess amount of Fe is consumed, and the combined intake of Fe and Ca leads to a decrease in Ca absorption [12]. The effects of Fe are potentiated with its deficiency in anemia, hypovitaminosis B_6, and hemochromatosis (due to increased erythropoiesis). Furthermore, similar to other organic acids, ascorbic acid reduces Fe in chelate complexes, thereby increasing the bioavailability of Fe.

Studies have yet to address the problems associated with Se deficiency. International studies have demonstrated that dietary Se consumption ranges from 7 μg/day to 4990 μg/day and from deficient to toxic doses [21]. A number of countries,

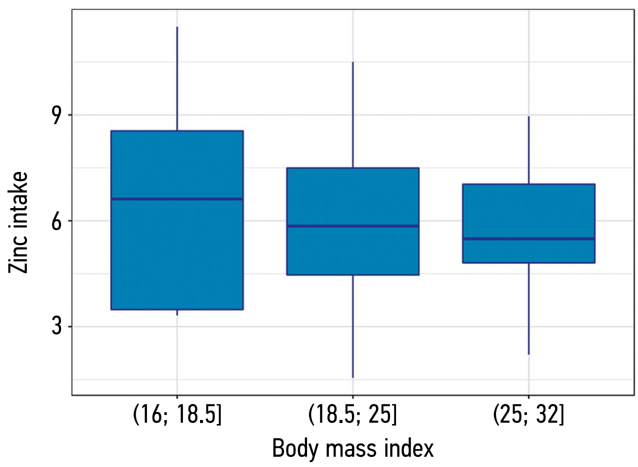

Figure. Relationship between zinc deficiency and body mass index in pregnant women such as New Zealand and Australia, have considered the adverse effects of Se deficiency on the body, primarily of fertile people, indicating the importance of adequate consumption of this trace element at the state level; they have also discussed the need for food fortification [38]. Food fortification is associated not only with the role of Se in the body as the most important antioxidant element but also with the direct involvement of selenoproteins in the metabolism and production of thyroid hormones [39]. In particular, Selenopop participates in the production of the active thyroid hormone T_3 (triiodothyronine) from the inactive form T_4 (thyroxine) [40]. Selenium is also an important cofactor of glutathione peroxidase, a powerful antioxidant that protects thyroid cells from damage caused by the overproduction of hydrogen peroxide during thyroid hormone synthesis [41]. For the first time, in Perm Territory, the consumption of Se with food was studied in a population of pregnant women. Our results suggested that the compensation of this trace element, especially in iodine-deficient regions, such as Perm, is a promising direction in the search for additional opportunities that could prevent not only selenium-associated complications but also thyroid pathology, which is important during gestation.

CONCLUSIONS

The majority of women (256 people, 61.5%) do not perform physical exercises, even simple ones, at the beginning of pregnancy, and their daily activity is minimal. This finding indicates an unfavorable prognosis of the development of metabolic disorders at later stages.

Nutritional composition should be assessed so that nutrient sources can be adequately provided to support the vital functions of pregnant women and their fetus. Our data suggest that the individual levels of consumed vitamins and nutrients should be explored because they are fundamental for a personalized approach of pregnancy management. Even though the entire territory of Russia is considered an iodine-deficient region, the relationship of congenital malformations with a deficiency of folic acid and other elements and vitamins does not compel patients and doctors to take preventive measures.

The comprehensive assessment of physical activity and nutritional composition should serve as a basis for establishing an individual plan for the consumption of vitamins, macroelements, and microelements at the stage of pregravid preparation and pregnancy. With the current epidemiological situation, programs that enable patients to examine their physical activity and actual nutrition independently should be developed. Furthermore, relevant information should be submitted to an obstetrician–gynecologist, and personal pregravid training and pregnancy programs should be created within remote consultations. Therefore, the proposed and tested approach is economically feasible because it avoids a large number of evaluations, including laboratory tests of blood samples, which are needed to examine the levels of vitamins and elements in the body.

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