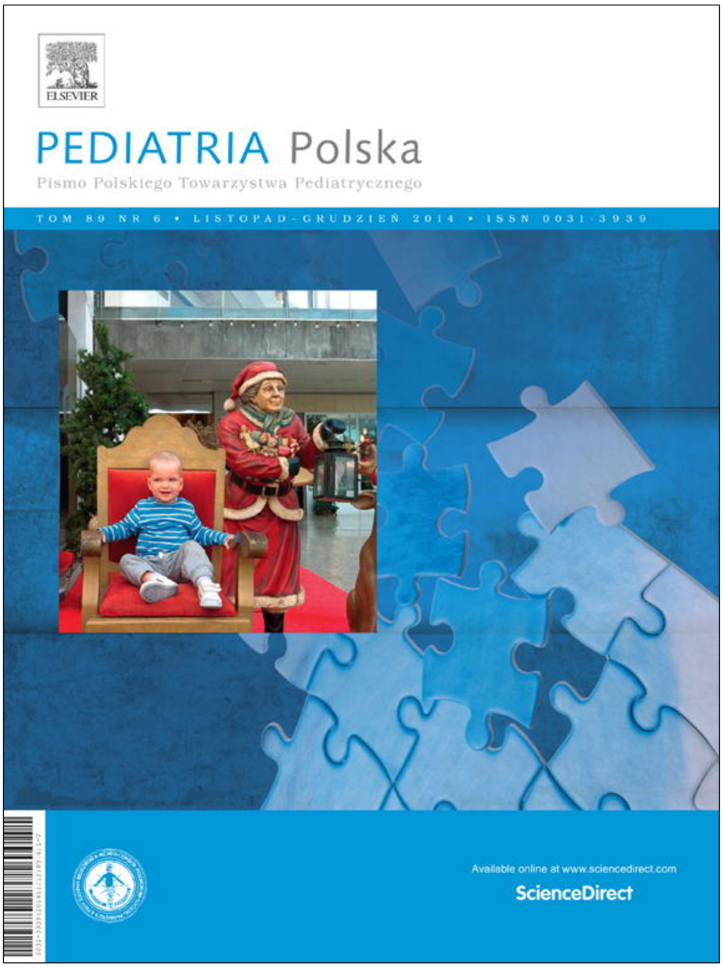
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Dietary habits and nutritional status of children from Ukraine during the first 3 years of life

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ABSTRACT

Aim: The aim of our study was to assess the nutritional status and eating behavior of young children and identify the prevalence of macro- and micronutrient diet deficiencies in Ukraine. **Materials and methods:** Three hundred and fifty children aged from 9 months to 3 years from central, eastern and western regions of Ukraine were involved in the cross-sectional study. Basic child's data were collected, health status was assessed by a physician, and parents used a 3-day food diary and a food questionnaire for self-completion. Data from the diaries and questionnaires were analyzed with DietPlan 6 software. **Results:** The diet composition was mostly adequate for age. Overall average provision with energy (1165.67 [29.67–4951.33] kcal/day), protein (40.53 [0.63–230.37] g/day) and carbohydrates (153.63 [3.53–708.7] g/day) exceeded the corresponding standards. The diet of the majority of children did not comply with the recommended intake of zinc (91%), iron (68%), calcium (61%), iodine (49%), vitamins A (99%), D (97%), B_6 (89%), B_{12} (71%), E (70%) and B_1 (61%). Excessive weight was significantly associated with higher levels of energy, protein, carbohydrates and fat consumption. Overweight was reliably correlated with a higher diet's energy and carbohydrates content. **Conclusions:** The contemporary diet of young children in Ukraine, like in many other developed countries, is generally unbalanced, containing an excess of energy and protein as well as inadequate amount of many minerals and vitamins.

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Introduction

Nutrition is one of the most important factors that determine the relationship of people with the environment and is crucial for health, efficiency, and resistance to negative surrounding impacts. Of particular importance for the health of a child is a full and regular supply with all the necessary macro- and micronutrients, vitamins and minerals [1–4].

The younger the child, the more important is adequate, balanced food for child's further development and health, especially for the first 3 years of life. At this phase of human ontogeny which is characterized by rapid growth and development, adequate nutrition needs and balanced intake of nutrients and energy is a key factor in the full realization of genetic potential, ensuring optimal mental development, formation of immune competence and long-term health. Respectively, inadequate or poor nutrition during the first years of life may lead to significant negative consequences for health, including delayed psychomotor and mental development, behavioral problems, lack of social skills, disorders of attention, learning problems, *etc.* [5].

Adequate provision of basic nutritional needs of a child who is growing and rapidly developing is an important medical and social task for Pediatrics and Family Medicine. However, immaturity of the digestive system, neuromuscular coordination and immunological functions in a young child limit the spectrum of foods, determines its specificity to this particular age period and increases the risk of diet-related disorders and various allergic reactions. It has been proven today that features of early life nutrition not only play an important role in the formation of optimal physical health and intellectual development of a child, but may even determine a substantially higher risk of chronic disease in adulthood [6–9].

The nutrition of young children in Ukraine received considerable attention at the national level. In particular, the main regulations and recommendations are presented in the Laws of Ukraine ''On the baby nutrition'' [10], ''Child protection'' [11], ''On the safety and quality of food'' [12], ''On milk and dairy products'' [13] and others. The national clinical guideline on medical care for a healthy child under 3 years highlighted the features of nutrition of infants during the first year of life, but the current recommendations on feeding for children aged 2–3 years are quite general and incomplete [14].

The prevalence of alimentary-dependent diseases in the pediatric population in Ukraine is rather large, but additional epidemiological studies are needed to clarify remaining important questions [15].

The most urgent problems related to nutrition of children in Ukraine as follows:

- Potentially high prevalence of iron deficiency; estimated prevalence of iron deficiency in pediatric population in our country is approximately 40–50% [15].
- High prevalence of iodine deficiency: incidence of iodine deficiency diseases is about 35% [16].
- Significant lack of vitamin C – 80–90%, and group B vitamins (B_1, B_2, B_6, folic acid – 40–80%) in children's diet [15].

Alimentary-dependent diseases are currently called ''epidemics'' of civilization, as evidenced by an increase in of their frequency and severity as well as by many long-term adverse health effects [5–9].

About 35% of diseases in children aged less than 5 years are associated with certain nutritional disorders. WHO estimated that globally in 2012, 162 million children under five were stunted and 51 million had a low weight-for-height ratio, mainly as a consequence of improper feeding or recurrent infections, while 44 million were overweight or obese. Few children receive nutritionally adequate and safe complementary foods. In many countries only a third of breastfed infants aged of 6–23 months receive complementary feeding which is appropriate to their age criteria of dietary diversity and feeding frequency [17].

According to a national population-based study in the U.S. that evaluated feeding habits of children during the first 4 years of life in 2008 comparing to 2002 the proportion of infants who were breastfed at 8 and 12 months as well as the average age of children at the time of solid food introduction increased. However, the level of unmodified cow's milk consumption during the first year of life (17% in 2008 *vs.* 20% in 2002) and skim milk intake in the second year of life (20–30% *vs.* 20–40% respectively) did not change [18]. Consumption of fruits and vegetables by all children aged 6 months – 4 years remained insufficient also. Specifically, 30% of them did not eat any vegetables and 25% – any fruits on the survey day [19]. At the same time, fried potato was the favorite vegetable dish in children older than 2 years. The diet of many children aged 1–3 years did not contain enough vitamin E, potassium and dietary fiber, but too much sodium, and some of them did not consume enough iron and zinc [18]. The ratio between separate nutrients was broken, in particular, the diet proportion of fat did not provide 30–40% of energy needs, primarily due to excessive protein intake [20]. In children older 12 months the diet diversity was becoming narrower with a negative tendency to increase the proportion of nutritionally inadequate snacks, sweets, sugary and carbonated beverages.

The study conducted in 2012 in Russia also found a high prevalence of various nutritional violations leading to the emergence of various deficient conditions in children aged of 13–36 months [21].

Taking into account the importance of balanced nutrition in early childhood, its impact on the subsequent formation of the body tissues and maintaining health, epidemiological observational studies for comprehensive assessment of nutrition in young children are of paramount importance. Nowadays in Ukraine we are limited with scientific data about nutritional status of young children, prevalence of eating behavior disorders and deficits in basic macro- and micronutrients in children's diet.

Aim of the study

The aim of our study was to assess the nutritional status and eating behavior of young children and identify the prevalence of macro- and micronutrient diet deficiencies in Ukraine.

Materials and methods

Three hundred and fifty children aged from 9 months to 3 years from central, eastern and western regions of Ukraine were involved in the cross-sectional study.

Inclusion criteria were:

- Age from 9 to 36 months.
- The birth weight is 2500–4500 g and the 1st and 5th minute Apgar scores ≥ 7.
- The mother and father of the child (or legal representative) agree on participation of their child in the study and are able to give informed consent.
- Mother and father agreed to follow all the requirements of the study protocol.

Exclusion criteria were:

- The need to follow a special elimination diet for significant food allergies, metabolic disorders (including hereditary diseases).
- Children with severe underlying chronic conditions that can affect their appetite and digestive function (neurological diseases, celiac disease, Crohn's disease, *etc.*).
- Any other reason that violates the usual mode of child's nutrition and appetite (*e.g.*, severe acute infectious disease) and which cannot be eliminated for the forthcoming 2 weeks (*e.g.*, admission to kindergarten).

Main study outcomes

- Prevalence of normal, high and low consumption of basic macro- and micronutrients.
- Prevalence of improper eating behavior.
- Anthropometric growth indicators evaluated according to the standards of WHO (2006) – weight, height (or body length), and body mass index (BMI).

During the first visit basic child's data were collected, health status was assessed by a physician and parents were given a food diary and a food questionnaire for self-completion. The parents were asked to fill in the diary for 3 days (2 regular week days and 1 day – during weekend) and the questionnaire of eating behavior before the second visit. At the second visit (in 8–10 days after the first one) a doctor checked the filled food diary and eating behavior questionnaire (the presence of a child was not required). At the final, third visit (in 4–5 weeks) the parents were informed about the results of the data analysis and were given advice on the nutrition of their child.

Special attention was paid to the presence of infectious and allergic diseases on the basis of physical examination and medical history data of a child.

Data from the diaries and questionnaires were analyzed with DietPlan 6 software (Forestfield Software Ltd., UK). The software allowed calculating the daily consumption of all major nutrients, taking into account age, sex, physical activity and other characteristics of the child as well as the reference values of caloric and nutrient intake and foods recommended by the Committee of Medical Aspects of Food Policy (1991) and adapted to the standards of Ukraine. The following indicators were calculated and included into analysis: daily caloric intake, the amount of consumed protein, fat, carbohydrates, macronutrients (calcium, phosphorus, potassium, sodium, chloride and magnesium), essential micronutrients (iron, zinc, iodine, fluorine, copper, selenium, chromium, molybdenum, cobalt and manganese) and vitamins. The social status of children was not taken into account.

From 105 children, involved in the laboratory part of the study, blood was taken to determine ferritin, erythrocytes, hemoglobin and hematocrit levels.

Statistical analysis

Standard methods of descriptive, categorical and correlation (nonparametric Spearman, Kendall Tau and Gamma coefficients) analyses were used with the calculation of 95% confidence intervals (CIs) as appropriate. If normally distributed continuous data are presented as average $\pm$ standard deviation (SD), if not – as median [minimum–maximum]. The statistical analysis was performed with Statistica 8 software (StatSoft Inc., 2008; USA).

Calculation of the sample size

Assuming that the incidence of nutritional disorders is around 50%, to achieve the accuracy of variable estimation $\pm$ 5.5% (two-sided 95% CI should not exceed 5.5% to each direction from a point value), the sample size of 317 children would be sufficient to perform the tasks of the study protocol. Taking into account the possibility of patient or data loss of about 10–15% it was planned to enroll 350 children into the main study group. The data of all 350 children were used in the final analysis.

To reach the power of at least 80% with α-error of 0.05 the sample size for the laboratory part of the study was calculated based on the reference laboratory values for all the parameters and estimated minimal group values difference of 13.0 mcg/l for ferritin and 3.0 g/l for hemoglobin. To meet such estimations, the sample should include at least 92 persons. Taking into account the possibility that about 5% of the data could be lost, we included into the study 105 children randomly selected from the main study group.

Results

At the time of enrollment into the study 12 (19.05%) infants, 18 (11.69%) children of the second and 2 (1.5%) children in the third year of life were breastfed. Thirty-five (55.56%), 63 (40.91%) and 24 (18.05%) children respectively in the three age groups were fed with infant (special) formula (Fig. 1).

The diet composition was mostly adequate for age at the time of enrollment into the study (Tab. I). Thirty-two (9.14%) babies were breastfed and 122 (34.86%) children received infant formula. Two hundred and fifty-seven (78.83%) children consumed infant cereals, 315 (93.47%) – beef, 191 (60.06%) – pork, 315 (91.3%) – poultry, 301 (87.76%) – fish, 314 (91.81%) – eggs, 322 (94.15%) – cheese, 342 (99.71%) – fruit and 343 (99.71%) – vegetables. However, the consumption of unmodified cow's milk ranged from 60% in infants to 8% of children in the third year of life. The proportions of children

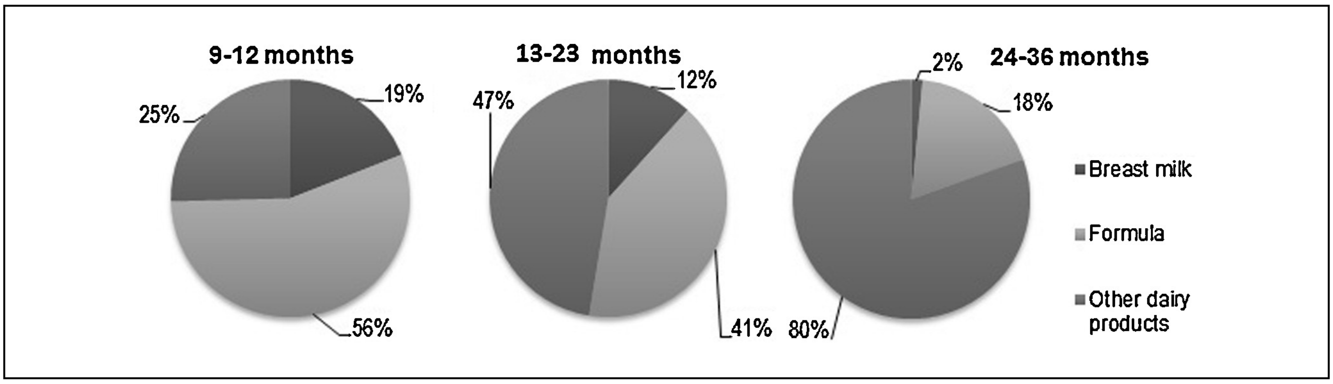

Fig. 1 – Comparative frequency of breast milk, formula and other dairy products (cow's milk, yogurt) feeding at the time of enrollment into the study depending on the children's age

who ate sweets or candy (48%), chocolate (33%), nuts (72%), as well as hot dogs and sausages (34%) were also significant (Tab. I).

The average frequency of weekly formula consumption decreased with age, while the number of cow's milk intakes increased. Infant cereals, vegetables and fruits remained most commonly used food to all ages. The daily diet of the majority of children contained these products. Older children consumed more meat of all kinds, and the corresponding positive trend was particularly evident for pork. The amount of fish intake per week remained mostly unchanged. A similar conclusion could be drawn regarding the consumption of eggs and cheese. The frequency of use of "adult" products (ketchup, sauces, mayonnaise, *etc.*) increased with age.

According to history data 59 (93.65%) infants, 149 (93.65%) children of the second and 125 (93.98%) children in the third year of life were breastfed at the study point or in the past. The average duration of breastfeeding was 10.5 (1–32) months, and the average age of children at the time of the introduction of infant formula and first complementary food was 6 (0–20) months and 6 (1–18) months respectively.

Vegetables and fruits were often given as the first complementary foods, and the average age of children at the time of the introduction of every new food was generally consistent with the recommendations.

The overall average provision with energy (1165.67 [29.67–4951.33] kcal/day), protein (40.53 [0.63–230.37] g/day) and carbohydrates (153.63 [3.53–708.7] g/day) exceeded the corresponding modern standards, although significant individual variations were observed, especially in terms of energy and protein consumption. The excess of proteins was especially significant (Fig. 2). However, the average level of consumption was lower than the national requirements (53 g/day). Thirty-six percentage of children consumed protein at the level of 25–40 g/day, and 31% – 40–53 g/day (Fig. 3).

Only fat consumption (33.61 [15.64–68.62]% of the total calories intake) was appropriate to children's needs providing about 33% of daily energy (Fig. 2). The average intake of saturated fat (3.65 [0–43.64]%) and cholesterol (106.4 [2.2–637.8] mg) was also appropriate. However, the average provision with polyunsaturated fats was insufficient (3.59 [0.087–19.34]%).

Compared to infants, children aged of 13–36 months consumed more energy, protein and carbohydrates but less saturated, polyunsaturated fat, and cholesterol (Tab. II). At the same time the features of provision with energy and basic nutrients described previously became more prominent with increasing age.

Note: Dashed lines indicate the desired level of energy and nutrients consumption according to the recommendations of the WHO [22–25], the European Union [26–28] and the United States [29] (2010–2012). The fine dotted lines represent the level corresponding to the national guidelines (1999) [30]. The national regulation regarding desired percentage of fat intake is absent.

According to calculations, the diet of the majority of children involved in the study did not comply with the recommended intake of zinc (91%), iron (68%), calcium (61%), iodine (49%), vitamins A (99%), D (97%), B_6 (89%), B_{12} (71%), E (70%) and B_1 (61%) (Figs. 4–6).

The exact content of the basic minerals and vitamins in the daily diet depending on the age of the children is presented in Table III.

Frequent intake of sweets and chocolates appeared to be one of the most inadequate in terms of nutrition quality and was associated with diet deficiency in zinc ($R = 0.14$; $p < 0.05$), calcium ($R = 0.12$; $p < 0.05$), vitamins E ($R = 0.23$; $p < 0.05$), D ($R = 0.12$; $p < 0.05$), C ($R = 0.11$; $p < 0.05$), B_6 ($R = 0.16$; $p < 0.05$), and B_{12} ($R = 0.22$; $p < 0.05$). Deficiencies of zinc ($R = 0.12$; $p < 0.05$), calcium ($R = 0.16$; $p < 0.05$), vitamins E ($R = 0.19$; $p < 0.05$), D ($R = 0.14$; $p < 0.05$), B_1 ($R = 0.11$; $p < 0.05$) and B_6 ($R = 0.22$; $p < 0.05$) were associated with increased meat intake. More frequent consumption of unmodified cow's milk was correlated with diet deficiencies in vitamins E ($R = 0.17$; $p < 0.05$), D ($R = 0.11$; $p < 0.05$) and C ($R = 0.17$; $p < 0.05$).

At the same time increased weekly consumption of infant formula and infant cereals most significantly reduced the likelihood of a nutritional deficiency of calcium ($R = -0.17$ and $R = -0.13$ for formulas and cereals respectively; $p < 0.05$), iodine ($R = -0.16$ and $R = -0.13$ respectively; $p < 0.05$), and vitamins E ($R = -0.39$ and $R = -0.21$ respectively; $p < 0.05$), D ($R = -0.23$ and $R = -0.17$ respectively; $p < 0.05$). B_1 ($R = -0.17$ and $R = -0.13$ respectively; $p < 0.05$), B_2 ($R = -0.12$ and

Table I – Consumption of certain food depending on children's age

Children's age	Foodstuff					
	Milk formula	Cow's milk	Infant cereals	Beef	Pork	Poultry
9–12 months	33 (56.9) (*n* = 58)	35 (60.34) (*n* = 58)	52 (88.14) (*n* = 59)	50 (86.21) (*n* = 58)	14 (26.92) (*n* = 52)	54 (87.1) (*n* = 62)
13–24 months	56 (39.72) (*n* = 141)	111 (77.62) (*n* = 143)	126 (86.3) (*n* = 146)	139 (93.92) (*n* = 148)	78 (56.12) (*n* = 139)	133 (88.08) (*n* = 151)
25–36 months	16 (13.79) (*n* = 116)	115 (88.46) (*n* = 130)	79 (65.29) (*n* = 121)	126 (96.18) (*n* = 131)	99 (77.95) (*n* = 127)	128 (96.97) (*n* = 132)
Totally	105 (33.33) (*n* = 315)	261 (78.85) (*n* = 331)	257 (78.83) (*n* = 326)	315 (93.47) (*n* = 337)	191 (60.06) (*n* = 318)	315 (91.3) (*n* = 345)

Children's age	Foodstuff					
	Fish	Eggs	Cheese	Fruits	Fruit juice	Vegetables (except of potato)
9–12 months	40 (66.67) (*n* = 60)	47 (77.05) (*n* = 61)	49 (80.33) (*n* = 61)	62 (100) (*n* = 62)	43 (74.14) (*n* = 58)	62 (100) (*n* = 62)
13–24 months	134 (89.33) (*n* = 150)	139 (92.67) (*n* = 150)	145 (95.39) (*n* = 152)	149 (99.33) (*n* = 150)	133 (86.36) (*n* = 154)	152 (100) (*n* = 152)
25–36 months	127 (95.49) (*n* = 133)	128 (97.71) (*n* = 131)	128 (99.22) (*n* = 129)	131 (100) (*n* = 131)	128 (97.71) (*n* = 131)	129 (99.23) (*n* = 130)
Totally	301 (87.76) (*n* = 343)	314 (91.81) (*n* = 342)	322 (94.15) (*n* = 342)	342 (99.71) (*n* = 343)	304 (88.63) (*n* = 343)	343 (99.71) (*n* = 344)

Children's age	Foodstuff				
	Sweets/candies	Baking/cookies	Chips	Mushrooms	Nuts
9–12 months	8 (14.55) (*n* = 55)	48 (82.76) (*n* = 58)	0 (0) (*n* = 56)	0 (0) (*n* = 60)	4 (6.56) (*n* = 61)
13–24 months	45 (31.03) (*n* = 145)	137 (91.45) (*n* = 152)	0 (0) (*n* = 148)	2 (1.34) (*n* = 149)	142 (28.38) (*n* = 148)
25–36 months	106 (80.3) (*n* = 132)	130 (99.22) (*n* = 130)	1 (0.78) (*n* = 129)	10 (7.69) (*n* = 130)	100 (75.76) (*n* = 132)
Totally	159 (47.89) (*n* = 332)	315 (92.65) (*n* = 340)	1 (0.3) (*n* = 333)	12 (3.54) (*n* = 339)	246 (72.14) (*n* = 341)

Children's age	Foodstuff				
	Ketchup	Mayonnaise	Other sauces	Semi-finished products	Chocolate
9–12 months	0 (0) (*n* = 59)	0 (0) (*n* = 60)	0 (0) (*n* = 60)	0 (0) (*n* = 57)	3 (5.0) (*n* = 60)
13–24 months	1 (0.68) (*n* = 148)	3 (2.03) (*n* = 148)	1 (0.68) (*n* = 148)	3 (2.01) (*n* = 149)	28 (19.05) (*n* = 147)
25–36 months	12 (9.23) (*n* = 130)	11 (8.46) (*n* = 130)	8 (6.11) (*n* = 131)	14 (10.85) (*n* = 129)	80 (60.15) (*n* = 133)
Totally	13 (3.86) (*n* = 337)	14 (4.14) (*n* = 338)	9 (2.65) (*n* = 339)	17 (5.07) (*n* = 335)	111 (32.65) (*n* = 340)

Children's age	Foodstuff				
	Sweet beverages	Popcorn	Smoked sausages	Sausages	Seafood
9–12 months	1 (1.69) (*n* = 59)	0 (0) (*n* = 59)	1 (1.69) (*n* = 59)	4 (6.9) (*n* = 58)	3 (5.08) (*n* = 59)
13–24 months	1 (0.67) (*n* = 149)	2 (1.34) (*n* = 149)	12 (8.16) (*n* = 147)	36 (24.0) (*n* = 150)	19 (12.75) (*n* = 149)
25–36 months	9 (6.98) (*n* = 129)	6 (4.62) (*n* = 130)	38 (29.23) (*n* = 130)	74 (56.92) (*n* = 130)	47 (36.15) (*n* = 130)
Totally	11 (3.26) (*n* = 337)	8 (2.37) (*n* = 338)	51 (15.18) (*n* = 336)	114 (33.73) (*n* = 338)	69 (20.41) (*n* = 338)

Note: The absolute number of children is indicated, in parentheses – percentages for each age group. The text is *italics* shows the number of children in each subgroup used for analysis.

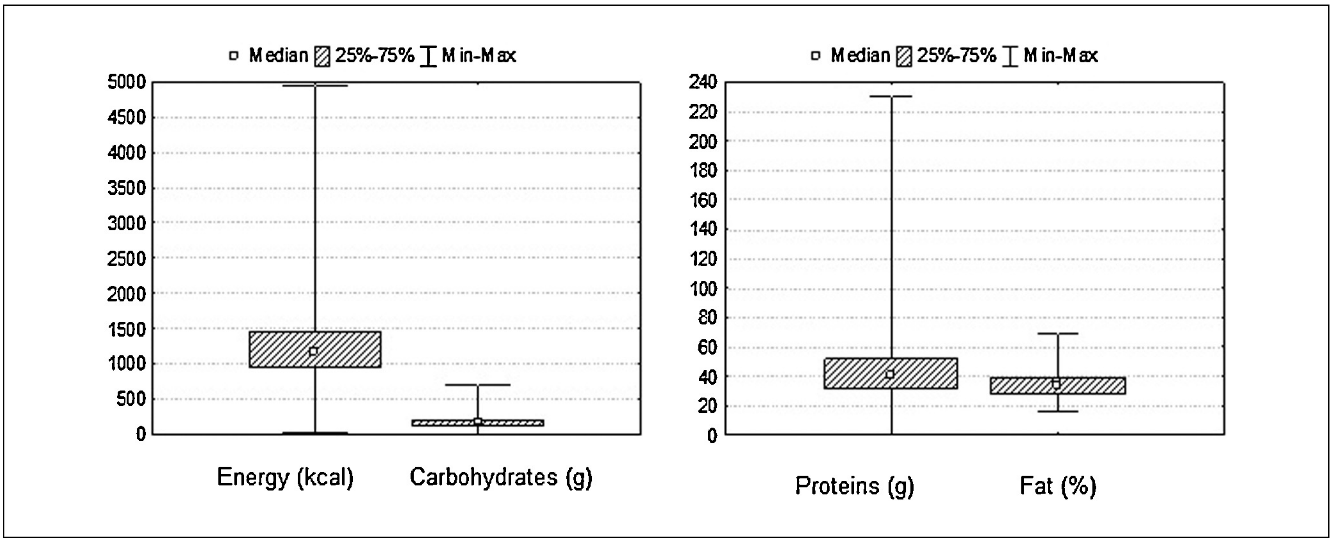

Fig. 2 – Provision with energy and basic nutrients

$R = -0.12$ respectively; $p < 0.05$), B_6 ($R = -0.23$ and $R = -0.13$ respectively; $p < 0.05$), C ($R = -0$ 21; $p < 0.05$ for formulas) and folates ($R = -0.12$; $p < 0.05$ for formulas). Being breastfed was significantly associated with phosphorus deficiency only, but this relationship was rather weak ($R = 0.12$; $p < 0.05$).

The significant positive correlation between the absolute majorities of established deficits suggested the complex nature of the origin of microelements and vitamins food deficiency as a consequence of an inadequately balanced diet (Tab. IV).

The correlation analysis also helped to detect the presence of associations between nutritional deficiency of several micronutrients and vitamins and an increase in allergic and infectious diseases of children involved in the study (Tab. V).

A lower intake of iron ($\tau = -0.15$; $p < 0.05$) as well as calcium and phosphorus ($\tau = -0.14$ for both indicators; $p < 0.05$) significantly correlated with development of iron deficiency anemia. A similar association existed between iron deficiency anemia and an inadequate amount of vitamin B_{12} ($\tau = 0.21$; $p < 0.05$), folate ($\tau = 0.16$; $p < 0.05$), phosphorus ($\tau = 0.19$; $p < 0.05$) and iodine ($\tau = 0.14$; $p < 0.05$)

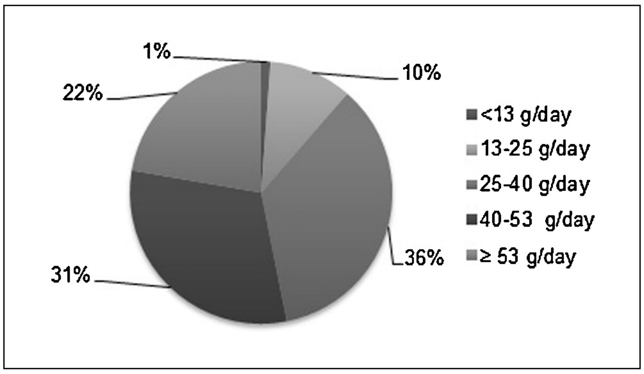

Fig. 3 – Distribution of children according to the average daily protein intake

in children's diet. The nutritional deficiency of vitamin E ($\tau = 0.21$; $p < 0.05$) was significantly associated with the formation of latent iron deficiency defined as a low content of ferritin in children's blood.

We have not established underweight exceeding 2 SD for age in any child. In 16 children (4.57%) a deficit of longitudinal growth (body length) for age was found. Too small (more than 2 SD) BMI for age was found in 17 (5.09%) children.

However, in 256 (73.14%) children weight for age exceeded the average population standard. In about a quarter of them (58–22.66%) BMI was also high (more than 2 SD) that indicated the presence of overweight in 16.57% of all children (95% CI: 13.04–20.83%). Overall BMI was elevated in 62 children (17.71%).

Growth deficiency of more than 2 SD for at least one anthropometric indices was found in 2 (3.17%) infants (95% CI: 0.87–10.86%), 11 (7.14%) children of 2 years of life (95% CI: 4.03–12.34%) and 20 (15.04%) children in the third year of life (95% CI: 9.95–22.09%) ($p = 0.013$). Instead, at least one excessive anthropometric index was found in 31 (49.21%) infants (95% CI: 37.27–61.24%), 65 (42.21%) children of 2 years of life (95% CI: 34.69–50.1%) and 64 (48.12%) children in the third year of life (95% CI: 39.8–56.54%). The presence of two anthropometric measurements exceeding average values was found respectively in 24 (38.1%; 95% CI: 27.12–50.44%), 50 (32.47%; 95% CI: 25.58–40.21%) and 27 (20.3%; 95% CI: 14.34–27.93%) children ($p = 0.031$).

Excessive height/body length was significantly associated with higher levels of energy ($R = 0.17$; $p < 0.05$), protein ($R = 0.14$; $p < 0.05$), carbohydrates ($R = 0.15$; $p < 0.05$) and fat ($R = 0.13$; $p < 0.05$) consumption. Overweight and a combination of several extreme anthropometric measurements were significantly correlated with a higher diet energy ($R = 0.12$ and $R = 0.14$ respectively; $p < 0.05$) and carbohydrates content ($R = 0.13$ and $R = 0.13$ respectively; $p < 0.05$). However, feeding habits did not affect the occurrence of any shortage of physical development of children involved into the study.

Table II – Age-dependent provision with energy and key nutrients[a]

Nutrient	Age group 9–12 months (n = 63)	Age group 13–36 months (n = 287)
Energy (kcal)	936.0 (109.00–2032.33)	1203.83 (29.67–4951.33)
Protein (g)	30.63 (4.13–83.60)	42.68 (0.63–230.37)
Lipids (%)[b]	34.39 (15.64–54.017)	33.41 (15.94–68.62)
Saturated fat (%)[c]	14.11 (0.00–43.64)	2.92 (0.00–38.95)
Cholesterol (mg)	136.0 (7.70–637.8)	95.85 (2.20–561.50)
Polyunsaturated fat (%)[c]	4.43 (0.087–12.45)	3.39 (0.12–19.35)
Carbohydrates (g)	113.68 (18.93–340.93)	161.1 (3.53–708.70)

[a] Median is presented, in brackets – the minimal and maximal values.
[b] Proportion of calories consumed from fat.
[c] Proportion of total fat in the diet.

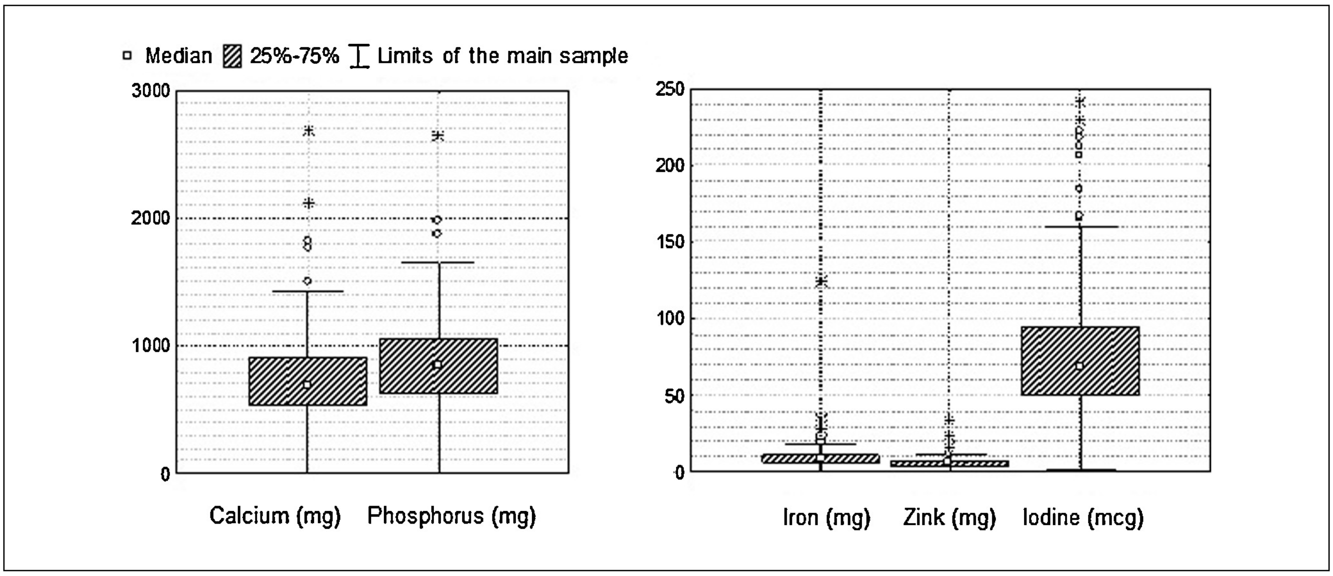

Fig. 4 – Nutritional provision with basic micronutrients. *Note*: Dashed lines indicate the desired level of consumption in accordance with national and international guidelines.

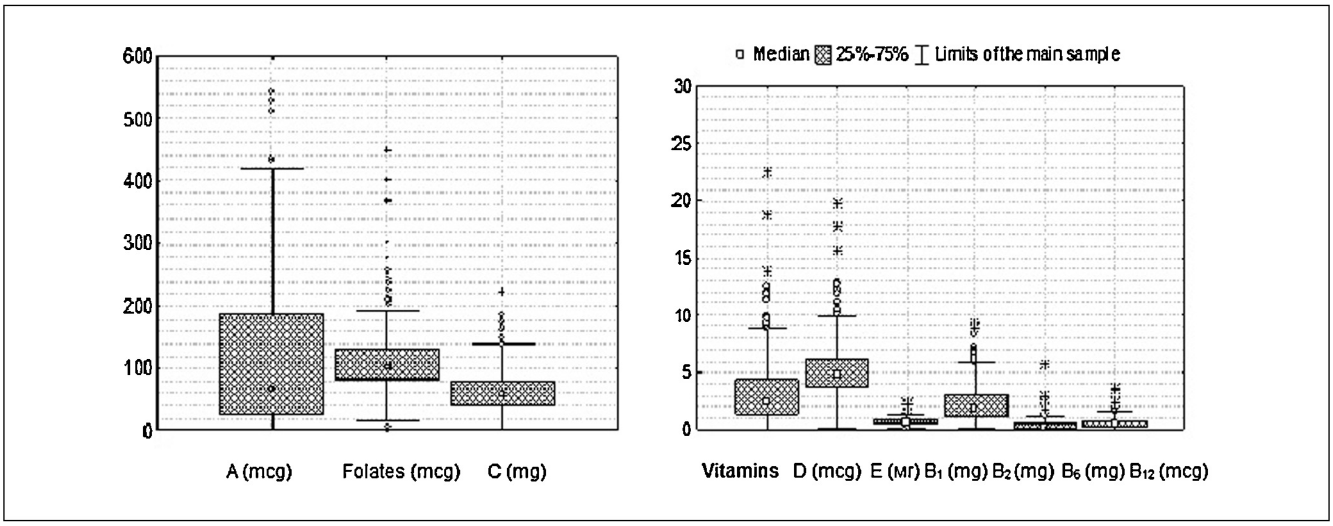

Fig. 5 – Nutritional provision with vitamins. *Note*: Dashed lines indicated the desired level of consumption in accordance with national and international guidelines

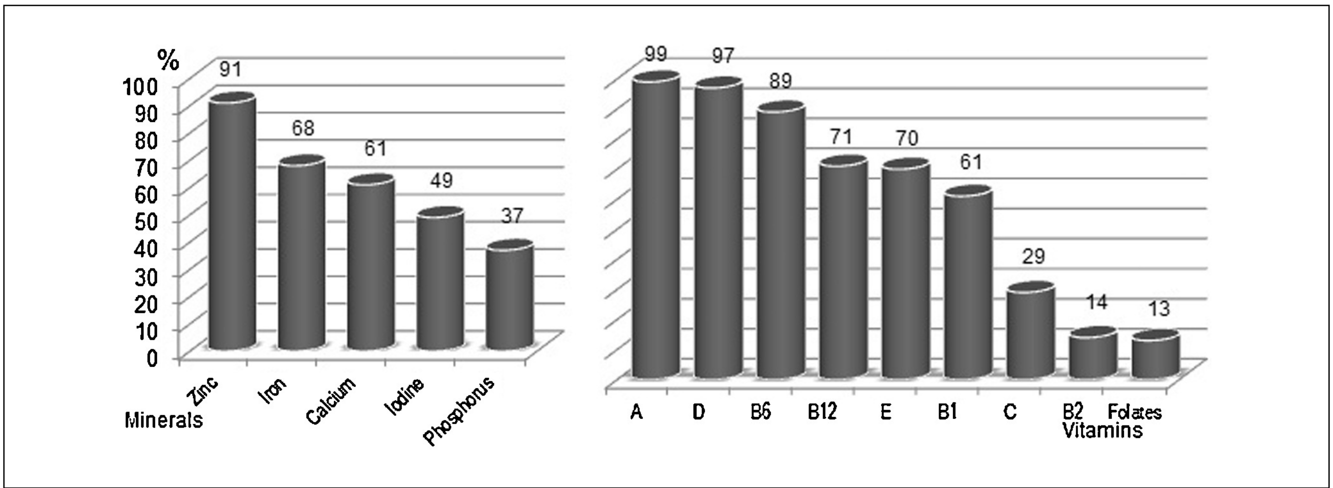

Fig. 6 – Percentage of children with a food deficiency of basic minerals and vitamins, determined in accordance with international and national recommendations

The prevalence of iron deficiency anemia was 4.8% (95% CI: 2.07–10.76%), the prevalence of latent iron deficiency defined as ferritin in the blood content of less than 20 ng/ml – 47.12% (95% CI: 37.8–56.64%), and the frequency of inadequate iron intake – 68.29% (95% CI: 63.23–72.94%). Children who eat more special formula food or infant food had reliably lower risk of latent iron deficiency formation ($R = -0.22$; $p < 0.05$) whereas longer breastfeeding was significantly associated with such a risk ($R = 0.2$; $p < 0.05$).

Additional non-parametric analysis revealed that the negative correlation between the formula consumption and latent iron deficiency development could be even more prominent if measured with a correlation coefficient γ ($\gamma = -0.34$; $p < 0.05$) which is preferable to Spearman R or Kendall Tau when the data contain many tied observations. Lager weekly baby cereal amount in the child's diet did not correlate with the risk of latent iron deficiency, but was significantly associated with the development of iron deficiency anemia ($\gamma = -0.52$; $p < 0.05$).

Discussion

Implementation of modern principles of nutrition of young children first of all means to ensure adequate rates of "healthy growth", not only to avoid wasting and stunting because of nutritional deficiency, but also to prevent excessive weight gain due to unbalanced nutrition. Only under such conditions it is possible to avoid undesirable long-term effects of inadequate nutrition for the young child her future health and development [8]. Dietary habits which are formed at this age under the influence of parents' example are of key importance to ensure a healthy diet in subsequent periods of life.

Table III – Age-dependent provision with minerals and vitamins

Micronutrient	Age group	
	9–12 months ($n = 63$)	13–36 months ($n = 287$)
Calcium (mg)	609.33 (66.33–1421.33)	709.33 (8.67–2689.33)
Phosphorus (mg)	605.0 (177.33–1630.67)	898.17 (8.00–3639.67)
Iron (mg)	7.33 (0.58–19.44)	8.25 (0.13–35.73)
Iodine (mcg)	77.48 (11.43–230.23)	67.05 (1.13–366.3)
Zinc (mg)	4.78 (0.41–12.24)	5.34 (0.05–33.77)
Vitamin A (mcg)	149.0 (0.33–544.33)	53.33 (0.33–529.67)
Folates (mcg)	92.33 (9.00–256.0)	104.17 (2.00–450.0)
Vitamin C (mg)	71.0 (2.00–187.33)	56.0 (0.00–226.0)
Vitamin D (mcg)	3.79 (0.0067–22.5)	2.31 (0.017–18.74)
Vitamin E (mg)	5.83 (0.53–19.71)	4.63 (0.04–17.803)
Vitamin B_1 (mg)	0.59 (0.08–1.83)	0.703 (0.017–2.48)
Vitamin B_2 (mg)	1.52 (0.11–8.22)	1.85 (0.01–9.24)
Vitamin B_6 (mg)	0.22 (0.0067–5.76)	0.33 (0.00–2.92)
Vitamin B_{12} (mcg)	0.47 (0.00–3.5)	0.37 (0.00–2.5)

Note: The median is indicated, in brackets – the minimal and maximal values.

Table IV – Correlation coefficients between the established deficiencies of minerals and vitamins in the daily diet of infants

Nutritional deficiency	Zinc	Vitamin B_1	Vitamin B_2	Vitamin B_6	Vitamin C	Calcium	Phosphorus
Zinc	–	0.39*	0.13*	0.37*	0.13*	0.37*	0.22*
Vitamin B_1	0.39*	–	0.31*	0.24*	0.27*	0.43*	0.33*
Vitamin B_2	0.13*	0.31*	–	0.09	0.29*	0.32*	0.33*
Vitamin B_6	0.37*	0.24*	0.09	–	0.18*	0.22*	0.05
Vitamin C	0.13*	0.27*	0.29*	0.18*	–	0.18*	0.04
Calcium	0.37*	0.43*	0.32*	0.22*	0.18*	–	0.46*
Phosphorus	0.22*	0.33*	0.33*	0.05	0.04	0.46*	–
Iron	0.39*	0.43*	0.26*	0.20*	0.28*	0.38*	0.25*
Iodine	0.21*	0.37*	0.34*	0.21*	0.25*	0.45*	0.26*
Vitamin A	0.15*	0.12	0.04	0.11	0.07	0.13	0.08
Vitamin D	0.39*	0.20*	0.06	0.15*	0.10	0.20*	0.01
Vitamin E	0.26*	0.42*	0.23*	0.32*	0.33*	0.32*	0.08
Vitamin B_{12}	0.20*	0.16*	0.19*	0.26*	0.19*	0.16*	0.06
Folates	0.12*	0.32*	0.39*	0.11*	0.33*	0.23*	0.31*

Nutritional deficiency	Iron	Iodine	Vitamin A	Vitamin D	Vitamin E	Vitamin B_{12}	Folates
Zinc	0.39*	0.21*	0.15*	0.39*	0.26*	0.20*	0.12*
Vitamin B_1	0.43*	0.37*	0.12	0.20*	0.42*	0.16*	0.32*
Vitamin B_2	0.26*	0.34*	0.04	0.06	0.23*	0.19*	0.39*
Vitamin B_6	0.20*	0.21*	0.11	0.15*	0.32*	0.26*	0.11*
Vitamin C	0.28*	0.25*	0.07	0.10	0.33*	0.19*	0.33*
Calcium	0.38*	0.45*	0.13	0.20*	0.32*	0.16*	0.23*
Phosphorus	0.25*	0.26*	0.08	0.01	0.08	0.06	0.31*
Iron	–	0.23*	–0.06	0.20*	0.48*	0.19*	0.25*
Iodine	0.23*	–	0.09	0.12*	0.40*	0.07	0.24*
Vitamin A	–0.06	0.09	–	–0.02	0.15*	0.12	0.04
Vitamin D	0.20*	0.12*	–0.02	–	0.21*	–0.01	0.06
Vitamin E	0.48*	0.40	0.15	0.21	–	0.20*	0.26*
Vitamin B_{12}	0.19*	0.07	0.12	–0.01	0.20	–	0.18*
Folates	0.25*	0.24*	0.04	0.06	0.26*	0.18*	–

Spearman rank correlation coefficients (R) are presented
* $p < 0.05$.

The results of the qualitative and quantitative evaluation of young children typical diet in different countries have shown that it usually does not provide requirements for iron and vitamin D, but leads to excessive consumption of energy, protein and sodium [31, 32]. Thus, the level of protein consumption in children aged 13–18 months exceeds the recommended one by 254% in France, 150% – in Italy, 186% – in Luxembourg [33]. The average protein intake in European countries is 40 g/day at the age of 2 years and 60 g/day at the age of 3 years (about 3 g/kg/day), which determines the consumption of more than 16% of energy from protein [33]. It is believed that increased protein intake in Europe is primarily associated with the use unmodified cow's milk, containing 3.2–3.3 g protein per 100 ml [34].

Available data suggest that young children, especially in Europe, also consume more fat than it is recommended than, especially at the expense of saturated fatty acids [33]. At the same time, iron intake at the age of 1–3 years is about 60% of the requirements in the UK [35], 80% – in France, [36], and 65% – in Germany [37] and 85% – in the

Table V – Association between nutritional deficiency of minerals and vitamins and selected children's morbidity

Morbidity	Nutritional deficit	Spearman's rank correlation coefficient (R)	$p(R)$	Correlation coefficient γ	$p(\gamma)$
Respiratory infections*	Vitamin D	0.14	0.009	0.74	0.0003
	Zinc	0.14	0.008	0.44	0.0002
	Vitamin B_6	–	–	0.28	0.008
	Vitamin C	–	–	0.19	0.008
Intestinal infections*	Iron	0.14	0.01	0.53	0.00015
	Vitamin B_1	0.11	0.03	0.39	0.002
	Zinc	–	–	0.58	0.04
	Vitamin B_6	–	–	0.65	0.015
Allergic diseases	Vitamin B_6	–	–	0.26	0.04

* Total number of episodes of particular infection in medical history.

Netherlands [38]. A similar situation exists with regard to the consumption of vitamin D [39, 40].

Similarly we found that contemporary diet of young children in Ukraine was even more unbalanced, containing an excess of energy and protein with a wider spectrum of inadequate amount of many minerals and vitamins.

We obtained some additional evidence of significant association between increased energy and some macronutrient intake and excessive child's physical growth. We proved an existence of reliable association between the level of dietary iron intake which was inadequate in 68.29% (95% CI: 63.23–72.94%) cases and iron deficiency anemia development. The prevalence of iron deficiency anemia in our patients was 4.8% (95% CI: 2.07–10.76%) with prevalence of latent iron deficiency of 47.12% (95% CI: 37.8–56.64%). Both these numbers were higher than the corresponding values in the USA toddlers' population (2.1% (95% CI: 1.5–2.7%) and 9.2 (95% CI: 7.9–10.5% respectively) [41]. At the same time our estimation of latent iron deficiency was screening and imprecise and could overestimate the true level of the problem.

Thus, in spite of complying with basic nutritional needs of young children in developed countries, there is a problem of food imbalances associated with deficient dietary intake and inadequate food preferences formed during a child's early years. The ingredients of recommended and available food do not meet the all specific needs of young children. Therefore, additional enrichment or the use of special foods is considered as effective strategies to optimize nutrition of this children's group [42].

Conclusions

The contemporary diet of young children in Ukraine, similarly to many other developed countries is generally unbalanced, containing an excess of energy and protein as well as inadequate amount of many minerals and vitamins. Important consequences of inadequate nutrition may impair physical development (especially overweight) and may increase infectious morbidity. The nutritional deficit of zinc, iron, calcium and vitamins A, D, E, B_6, B_{12}, B_1 was most significant. Statistically significant association was found between the established nutritional deficiency, iron deficiency anemia and infectious morbidity. The consumption of infant or special formulas instead of unmodified cow's milk may increase the intake of important nutrients (calcium, iron, iodine, vitamins E, D and folates).

Authors' contributions/Wkład autorów

SN – study design, data interpretation, acceptance of final manuscript version. OI – data collection. DD – statistical analysis, literature search.

Conflict of interest/Konflikt interesu

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None declared.

Ethics/Etyka

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; EU Directive 2010/63/EU for animal experiments; Uniform Requirements for manuscripts submitted to Biomedical journals.

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