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## Nutritional deficiencies in the diets of preschool children

## Niedobory żywieniowe w dietach dzieci przedszkolnych

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### Summary

**Introduction.** During childhood, the body needs a diversity of vitamins and minerals in appropriate amounts to ensure optimal growth, proper physical and cognitive development, and appropriate physical fitness.

**Aim.** The objective of the paper was to evaluate the energy value and the content of basic nutrients in habitual diets of four-year-old children in terms of the adequateness of their intake with reference to current nutritional standards and to analyse the prevalence of mineral and vitamin deficiencies risk.

**Material and methods.** The study was carried out in 2005 across the Polish-nationwide group of 396 children aged 4, randomly selected from the PESEL – birth register, proportionally from urban and rural areas.

The analysis of the habitual nutrition was carried out on the basis of the record of all products, meals and drinks consumed by children over 7 days. The energy and nutritional values of diets were calculated using DIETA 4.0 computer software. To assess the prevalence of deficient diets with reference to 2008 Nutritional Standards, a probability evaluation method was applied and carried out in accordance, with US IOM recommendations.

**Results.** It was found that every 4<sup>th</sup> child aged four years had underweight reflecting prolonged energy malnutrition, and every 5<sup>th</sup> child had increased body mass in the form of overweight or obesity (evaluated according to BMI and Cole at al. classification 2000, 2003). Frequent vitamin D, potassium, calcium and iron deficiencies in 50% to 90% of children, and vitamin E and C and foliate deficiencies in less than 25% of children were observed.

**Conclusions.** The results of the Polish-nationwide study of 4 years old indicate an urgent need for education aimed at increasing the consumption by children of these nutrients that are highly deficient in diets. Particular attention should be paid to calcium and vitamin D as key nutrients for the development and promotion of health across this group of children.

Key words: nutrients, children, minerals and vitamins deficiencies, underweight

### Streszczenie

**Wstęp.** W okresie dzieciństwa organizm potrzebuje różnorodnych witamin i składników mineralnych w odpowiedniej ilości, aby zapewnić optymalny wzrost, prawidłowe tempo rozwoju fizycznego i umysłowego oraz odpowiednią sprawność fizyczną.

**Cel.** Celem pracy była ocena wartości energetycznej i zawartości podstawowych składników odżywczych w zwyczajowych dietach dzieci czteroletnich, pod względem adekwatności ich spożycia w relacji do znowelizowanych norm żywienia oraz analiza częstości występowania ryzyka niedoborów składników mineralnych i witamin.

**Materiał i metody.** Badanie przeprowadzono w roku 2005, w ogólnopolskiej grupie 396 dzieci w wieku 4 lat, wylosowanych z rejestru urodzeń PESEL.

Analizę zwyczajowego sposobu żywienia przeprowadzono na podstawie zapisu wszystkich produktów, potraw i napojów spożywanych przez dzieci w czasie 7 dni. Wartość energetyczną i odżywczą diet wyliczono za pomocą programu komputerowego DIETA 4,0. Do oceny częstości występowania diet niedoborowych w stosunku do Norm Żywienia z roku 2008, wykorzystano metodę oceny prawdopodobieństwa, przeprowadzoną zgodnie z rekomendacjami IOM USA.

**Wyniki.** Stwierdzono, że co czwarte czteroletnie dziecko wykazało niedoborową masę ciała świadczącą o przewlekłym niedożywieniu energetycznym, a co piąte dziecko miało zwiększoną masę ciała w postaci nadwagi lub otyłości (ocenione wg wskaźnika BMI i klasyfikacji Cole i wsp. 2000, 2003). Stwierdzono częste niedobory dotyczące 50% lub większego odsetka dzieci w wypadku witaminy D, potasu, wapnia i żelaza oraz niedobory dotyczące mniej niż 25% dzieci w wypadku witaminy E, i C oraz folianów.

**Wnioski.** Wyniki ogólnopolskiego badania sygnalizują pilną potrzebę edukacji zmierzającej do wzrostu spożycia przez dzieci składników o bardzo wysokich niedoborach w dietach. Szczególnie należy zwrócić uwagę na wapń i witaminę D, jako kluczowe składniki dla rozwoju i zachowania zdrowia tej grupy dzieci.

Słowa kluczowe: wartość odżywcza, dzieci, niedobory, niedowaga

## INTRODUCTION

Proper nutrition in early childhood is of particular importance, because the body needs a diversity of vitamins and minerals in appropriate amounts over these periods to ensure optimal growth, proper physical and cognitive development and appropriate physical fitness (1, 2). Over the recent years more and more has been known about the importance of early nutrition programming which allows to maintain low cardiovascular disease risk profile in middle age (3). To educate or conduct intervention programs among small children, nutrient deficiencies or excesses occurring in usual diets of children should be well understood. Paradoxically, we don't know much about early nutrition, and existing publications draw attention to some nutrition problems among children. The excessive sugar intake (sucrose) is the most frequently mentioned as an obesity risk factor and indicator of the children poor diet (4-6). Intervention programs are also undertaken to counteract high sucrose intake by children aged 13 months through 9 years, as a cardiovascular disease risk factor (7).

Knowledge about early nutrition and the most frequent problems is indispensable to undertake education among parents or persons responsible for nutrition of preschoolers.

## AIM

The objective of the paper was to evaluate the energy value and the content of basic nutrients in habitual diets of four-year-old children in terms of the adequateness of their intake with reference to current nutritional standards and to analyse the prevalence of the mineral and vitamin deficiencies risk.

## MATERIAL AND METHODS

Four-year-old children aged 4, were randomly selected from the PESEL – birth register and the whole country territory, proportionally from urban and rural areas, and attending and not attending preschools (2005). After questionnaire verification, 396 children were included in further analyses.

The habitual nutrition among four-year-old children was examined using a method of recording food intake over the 7-day period. In total, 2772 daily menus were examined. The field study was conducted by interviewers trained by the Department of Nutritional Epidemiology and Dietary Standards of the National Food and Nutrition Institute. Interviewers informed parents and carers at preschools of the manner of recording food consumed by children. Next, after all the recordings were completed, the questionnaires were reviewed and filled up, if necessary, by interviewers, and then by nutritionists from the National Food and Nutrition Institute. The energy and nutritional values calculated on the basis of recordings were analysed with reference to current human nutritional standards of 2008 (8) using DIETA 4.0 computer software for this purpose, developed at the Department of Nutritional Epidemiology of the National Food and Nutrition Institute.

To evaluate the prevalence of insufficient nutrient intake among children, a probability method was applied to evaluate deficiencies of all nutrients, that was proposed by IOM [Institute of Medicine (U.S.A.)], except for iron (the evaluation of insufficient intake is performed by comparing distributions of intake and distributions of reference intake for this nutrient due to skewed distributions of intake and requirement) (9, 10). In the statistical analysis intraindividual variability (day-to-day) was used to eliminate randomness from nutrition. DIETA 4.0 software enabled to estimate on the basis of usual distributions of nutrients intake the proportion of children, whose usual intake was below the specified reference value appropriate for each nutrient and appropriate standard level.

## RESULTS

### Energy and basic nutrients intake

The average energy value of diets among children aged 4 covered by the study was relatively high and equal to  $1904 \pm 488$  kcal (tab. 1), exceeding by approximately 500 kcal the recommended values according to the estimated energy requirement (EER) depending on age, body weight, gender and physical activity. When evaluating the prevalence of insufficient energy intake using the probability method on the basis of 7-day recordings of intake it was found that the energy content was insufficient in diets of only 13% of children (tab.1). Due to the differences in body weight and physical activity levels among children, and also in view of the fact that energy intake and requirement are correlated, it is difficult to evaluate the appropriateness of energy intake versus EER, even with 7-day recordings of intake at disposal. Therefore, the evaluation of the appropriateness of energy delivered versus the requirement and versus standards for BMI (11) was performed. Across the analysed group of children, 25.2% had underweight, (criterion recommended by IOTF according to BMI classification, developed by Cole at al. (12, 13), (fig. 1) which indicated the usual insufficient energy intake in the diets of approximately 1/4 of studied children. At the same time, overweight was observed in 12.1% of children, and obesity in 8.1 % of children (fig. 1), which in turn allows to conclude that the energy intake as a part of the diet was too high compared with the requirement in 1/5<sup>th</sup> of children.

Four-year-old children covered by the study consumed large amounts of protein in their habitual diets at an average level of  $62.5 \pm 16.1$  g, which gives 3.4 g per 1 kilogram of body mass. No dietary protein deficiency was revealed among children after the probability method was applied to evaluate the occurrence of deficiencies with reference to EAR value. The average total fat intake is also high with  $68.0 \pm 19.3$  g across children. However, the evaluation of deficiency occurrence using the probability method showed that around 1/5<sup>th</sup> of children consumed fat in less than recommended amounts.

Table 1. Energy and nutrient mean intakes (SD), by 4 years old children, from 7 days records and percentage of children below standards. National sample, N = 396, 2005 y (data from food without supplements).

Nutrients	X (SD)	Percentage of children below the standards calculated by the probability method (only from food)
Energy (kcal)	1904 (488)	13.0
Protein (g)	62.5 (16.1)	0.0
Protein in g per kg body mass (g/kg m.c.)	3.37 (1.00)	–
Fats (g)	68.0 (19.3)	24.6
Carbohydrates (g)	273.6 (73.1)	0.02**
SFA*(g)	26.9 (8.4)	–
MUFA*(g)	27.0 (8.0)	–
PUFA*(g)	9.2 (3.6)	–
Long-chain polyunsaturated fatty acids	0,108 (0.144)	87.5
Linolenic acid C <sub>18:3</sub> (g)	1.5 (0,6)	81.9
Ratio of PUFA: SFA		0.34
Cholesterol (mg)	246.8 (85.3)	–
Sugar (g)	84.2 (29.2)	–
Fiber (g)	14.8 (4.4)	–

\*SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids

\*\*for the carbohydrate level necessary to ensure proper functioning of the brain

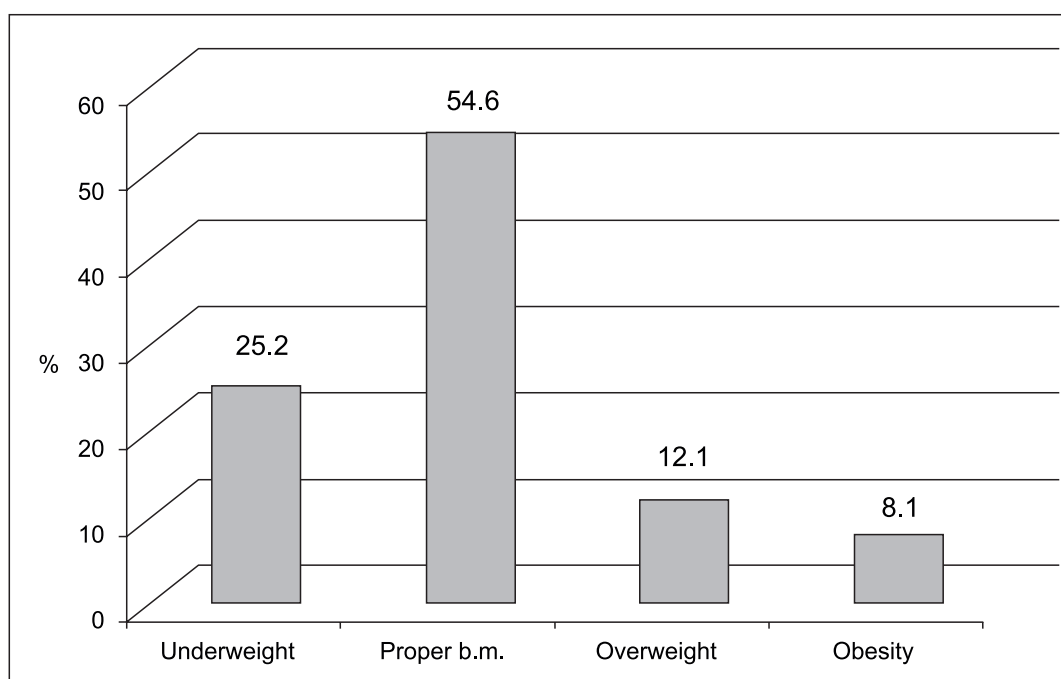


Fig. 1. Percentage of children under the age of 4 years in clusters of BMI classification (according to the criterion Cole and co. 2000, 2003).

In particular, unfavourably low consumption of long chain polyunsaturated acids (EPA and DHA) was found in 87.5% of children, and omega-3 linolenic acids in 81.9% of children.

Carbohydrate intake oscillated within the recommended intake, and was equal to  $273.6 \pm 73.1$  g. No deficiencies of available carbohydrates indispensable to ensure proper brain function versus EAR were observed after the evaluation using the probability method was applied.

The structure of energy from basic nutrients in children's diets (tab. 2) was close to the recommended one. However, there was higher than recommended energy contribution of 10% from saturated fat acids, and large energy contribution from sugar of 17.6%. There was also high consumption of saturated fats and sugar among children and low fibre content. As results from (tab. 3), 9.3% of children consumed insufficient amounts of fibre, but there was high percentages of children with a high intake of total fat, saturated fat, sugar and cholesterol.

Table 2. The contribution of energy from the basic nutrients in the diets of 4 years old children, national sample, 2005 y.

Contribution of energy from:	%
	X (SD)
Protein	13.3 (1.5)
Fats	31.5 (3.5)
Total carbohydrates	55.2 (3.8)
SFA	12.7 (2.1)
MUFA	12.7 (1,8)
PUFA	4.3 (1.1)
Sugar (saccharose)	17.6 (3.6)

Table 3. Percentage of children 4 years old who consume diets high in total fat amount, saturated fatty acids, sugar, cholesterol and too low and high amounts of fiber. National sample, 2005 y.

Level of nutrients	% of children
<b>Percentage of children with:</b>	
Low fat intake < 25% energy	1.8
The fat intake of 25-30% of energy	25.0
High intake of fat > 30% energy	73.2
<b>Percentage of children consuming in diets:</b>	
SFA > 10% energy	91.4
Sugar > 10 % energy	98.4
Cholesterol > 300 mg	25.0
Fiber > 19 g	15.9
Fiber < 9.5 g	9.3

### Vitamin and mineral intake

The average content (taking into account only food) of minerals: calcium, phosphorus, magnesium, zinc and iron in diets was a little or much higher versus the recommended intake (except for potassium of which the consumption was lower than 3100 mg recommended by the standard at AI level).

However, the average content of sodium in diets of four-year-old children covered by the study was very high (tab. 4), and exceeded almost threefold the recommended values (1000 mg/day for sodium) and almost two-fold the recommended UL level of 1500 mg/day of sodium for this age group. Only 10% of children consumed salt in the recommended amounts of 5.0 g/day.

The average content of selected vitamins: A, E, B<sub>1</sub>, B<sub>2</sub>, PP, B<sub>6</sub>, C, foliates and vitamin B<sub>12</sub> was also higher than the recommended intake for these vitamins, except for vitamin D of which the intake was two-fold lower versus the recommended AI level of 5 µg (tab. 4).

The average intake and direct reference to standards does not allow to conclude about the proportion of children with insufficient intake of minerals and vitamins. Even with quite high average of the nutrient intake, deficiencies may also occur in considerable parts of groups under evaluation, which was found for many components.

Table 4. Minerals and vitamins mean intakes (SD), by 4 years old children, from 7 days records (from foods without supplements). National sample, 2005 y.

Nutrients	X (SD)
Sodium (mg)	2816.6 (693.0)
Potassium (mg)	2667.2 (687.2)
Calcium (mg)	743.1 (253.1)
Phosphorus (mg)	1064.8 (284.2)
Magnesium (mg)	234.6 (59.8)
Zinc (mg)	7.5 (2.0)
Iron (mg)	8.9 (2.5)
Vitamin A (µg)	1244 (732)
Vitamin E (mg)	8.11 (3.18)
Vitamin B <sub>1</sub> (mg)	0.984 (0.275)
Vitamin B <sub>2</sub> (mg)	1.724 (0.516)
Vitamin PP (mg)	11.73 (3.47)
Vitamin B <sub>6</sub> (mg)	1.55 (0.42)
Vitamin C (mg)	83.9 (43.5)
Folate (µg)	204.91 (58.15)
Vitamin B <sub>12</sub> (µg)	3.53 (1.71)
Vitamin D (µg)	2.58 (1.60)

Distributions of usual intake of nutrients from food were compared to reference intake values using the currently recommended probability method. The percentages of children with insufficient intake (fig. 2) were particularly high as regards vitamin D – in 94.3% of children, potassium – in 76.1%, calcium in 47.4%, iron – in 46.2%, vitamin E – in 25.5%, foliates – in 22.8%, and vitamin C – in 12.8%. The prevalence of deficiencies of the remaining nutrients was lower than 2% among children covered by the study.

### DISCUSSION

In this study, insufficient energy content in usual diets was observed in every 8<sup>th</sup> child aged four, and underweight evaluated on the basis of BMI occurred in even higher portion, i.e. in every 4<sup>th</sup> child.

At the same time, more than 73% of children consumed high fat diets, and over 98% consumed diets high in sugars. Over 91% of children consumed saturated fats in the amount higher by 10% than recommended reference intake values. In view of the above results, it seems to be necessary to make efforts to change the structure of fats consumed by children, ensuring higher share of vegetable oils and products that will ensure higher intake of linolenic acid, and sea fish to provide DHA and EPA acids. High percentages of children (25%) with insufficient vitamin E intake indicate low oil consumption. Across the group of children covered by the study, low consumption of omega-3 fatty acids was revealed: alpha-linolenic in more than 81% of children, and DHA and EPA in more than 87% of children. Polyunsaturated fatty acids are important structural components of the central nervous system.

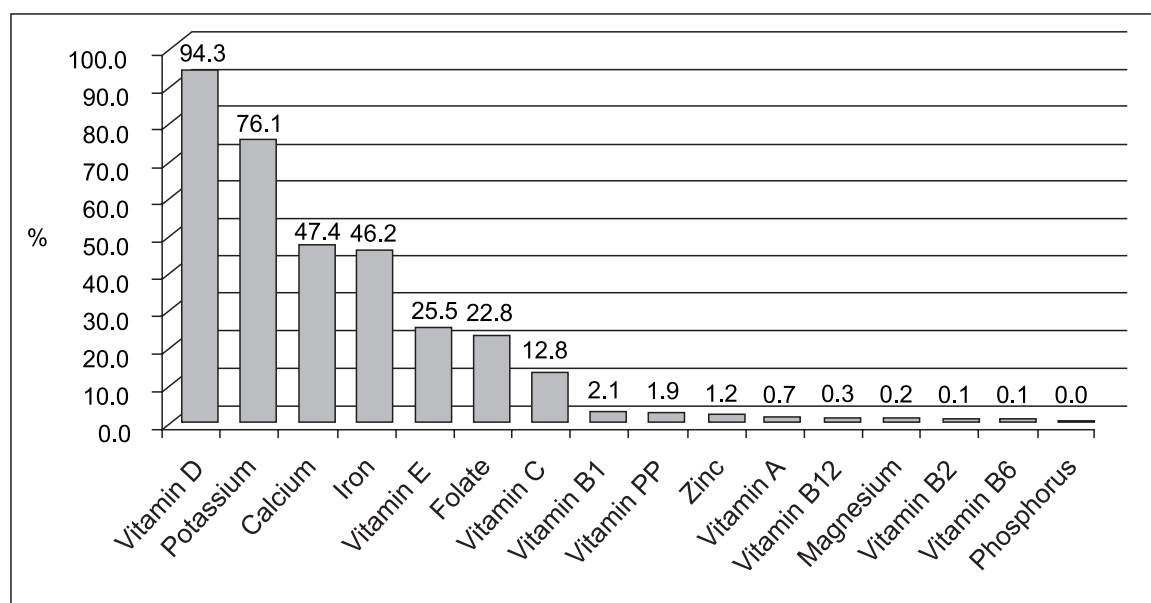


Fig. 2. Percentage of 4 years old children, with inadequate intakes of vitamins and minerals as calculated by the probability method (from diet only). National sample, N = 396, 2005 y.

They constitute approximately 1/5<sup>th</sup> of all fatty acids of the cerebral cortex, therefore the quality of fats in children's diet is of extreme importance. Besides, they are essential for building cell membranes, proper function of retina and many enzymes, for active transport, and many other metabolic processes (2). Interventional studies have shown favourable effects of giving n-3 long chain polyunsaturated fatty acids on cardiovascular disease risk factors, such as high triglyceride level in blood serum, platelet aggregation, and increased arterial pressure.

Insufficient fibre consumption found in every 10<sup>th</sup> child indicates the low intake of vegetables, fruit, whole-meal bread, pasta and groats, as well as leguminous plants in diets. High prevalence of deficiencies of analysed vitamins and minerals indicates low consumption of these valuable products.

There is a general consensus among nutritionists that the total energy value is positively correlated with its total nutritional value (4). Therefore, the energy intake seems to be predictive of vitamin and mineral intake. However, it was also revealed that the risk of low intake of valuable nutrients is the largest in diets with high percentage of energy from sugar and low energy content at the same time. As it was noted, the increase in the added sugar consumption (expressed as a percentage of energy or total sugars e.g. in consumption quartiles) among the youngest children has a negative impact on the consumption of other nutrients, which was found in several studies (5, 6, 14). The inverse relationship between the sugar intake and micronutrient content in diets was demonstrated, in particular such as folic acid, vitamin C, calcium, iron, vitamin D. In Bogalusa Heart Study (15) the increase in the total sugar intake was associated with the decrease in the intake of proteins, fats, saturated fats, starch, sodium,

vitamins B<sub>6</sub>, E, thiamine, niacin, iron and zinc. Sweetened products such as sweetened soft drinks, sweets, cakes and pastries may have a negative impact, particularly on the intake of calcium, iron and folic acid (16). The above findings indicate that the diets because of the interrelation between nutrients contained in them, should be evaluated as whole. In the intervention program among children aged 1-9 as a part of Turku Coronary Risk Factor Project (7), high sucrose consumption was observed (above the recommended 10% of energy) among children aged 2 already. On the other hand, children's diets with low or medium sucrose intake contained more protein, better quality fats, larger amounts of vitamin E, niacin, calcium, iron, zinc and fibre compared with children with a high intake of this component. Prolonged low sucrose consumption was associated not only with better nutritional value of consumed diets, but also with better development compared to groups with high sucrose intake.

It is not wrong to say that the youngest children consuming food rich in fats, sugar and salt will be at risk of insufficient consumption of valuable nutrients, and what is connected with it an increased risk of disease against faulty nutrition. Therefore, should be promoted among children foods high proportion of nutrients to energy, to choose the most valuable, provide variety and it may be the best strategy to improve the overall quality of the diet. Chronic calcium deficiencies were revealed in almost half of the children covered by this study. The picture for vitamin D was considerably worse. As many as 81% of four-year-old children showed chronic vitamin D deficiencies in their diets (even after the supplement consumption is taken into account). This consumption presents less favourably compared with e.g. US children aged 4-8 years (NHANES – National Health and Nutrition Examination

Survey 2005-2006), because considerably lower percentages of children, i.e. 32% and 41%, did not meet the recommended intake for calcium and vitamin D (respectively) applicable in USA, taking into account the total intake from food and supplements (17). One reason for such calcium and vitamin D deficiencies in Polish children's diets is awareness among mothers of young children, because the majority of them have no sufficient knowledge of evaluating nutritional value of products given to children (1). It is confirmed by other studies on Polish-nationwide sample of the Polish children aged 13-36 months (18), which suggested the need for educating mothers and carers of children on the importance of correct nutrition, because insufficient consumption of wholemeal bread, vegetables, milk and fermented milk drinks, and insufficient content of important nutrients such as vitamins D and E as well as iodine and potassium in diets were noticed.

The most frequent deficiencies in diets of all Polish demographic groups are high percentages of diets with calcium and vitamin D deficiency. It is alarming that calcium and vitamin D deficiencies occur very often among small, four-year-old children, as these nutrients are responsible for the condition of the skeletal system, and for building optimal peak bone mass. Therefore, they should be consumed in the amounts recommended by the standards. Calcium deficiency combined with vitamin D deficiency leads to compromising the health and decreased mineral density of bones and teeth, and to rickets or osteoporosis in extreme cases. Calcium and vitamin D deficiencies are associated with the increased risk of calcium and phosphorus balance disorders and various metabolic disorders such as diabetes, metabolic syndrome – obesity, hypertension, impaired glucose metabolism. Calcium and consumption of milk products may influence the energy-to-fat ratio, which indicates that insufficient calcium and milk product consumption increases the risk of positive energy balance (19), and this may affect the risk of developing obesity in children.

Among Polish four-year old children covered by the study, every second child showed dietary iron deficiencies. Among American children aged 4-8, only less than 3% of them consumed insufficient amounts of iron compared to the estimated average requirement, EAR (NHANES 2001-2002) (20). As haemoglobin and myoglobin component, iron prevents anaemia, is essential for oxygen transport, and increases the immunity of the body. Its deficit leads to anaemia, decreased concentration and mental and physical fitness, and cardiac arrhythmias. Due to the fact that iron is involved in multiple roles in the body, iron and foliate deficiencies occurring that often in the analysed group of four-year-old children may pose a risk of iron-deficiency anaemia or a risk of cardiovascular disease in the future. For iron deficiency in Polish children are in part responsible changes in meat consumption structure: exchange of red meats by poultry.

Almost every 4<sup>th</sup> child of the Polish four-year-old children showed also foliate deficiencies, and every 8<sup>th</sup> child had vitamin C deficiencies as regards diets. It compares unfavourably with American children, where the content of foliates and vitamin C was insufficient in less than 3% of children aged 4-8 (20). Folic acid participates in red blood cells production in the bone marrow. There are also reports about the lower coronary disease incidence rate when folic acid is consumed in sufficient amounts. Vitamin C (ascorbic acid) stimulates collagen synthesis, maintains proper condition of the skin and mucous membrane, facilitates wound healing, increases the immunity of cells to infections and damage. Its shortage results in the decreased immunity of the body and susceptibility to diseases of children.

This unfavourable picture in terms of vitamin and mineral intake among Polish four-year-old children is related to the fact that not all preschool pupils eat first breakfast before leaving home, many of them omit, don't eat basic meals replacing them with between meal intake of high calorie food, which is globally allowed, reach in saturated fatty acids, sugar and salt, but tasty, omnipresent, however, having little vitamins, minerals and fibre. It applies both to children who are poor eaters and to children with large appetite.

It was noted that going hungry along with fluid deficit result in apathy and concentration difficulties, but can also increase the irritability (21). Frequent between meal intake of food that is not nutritionally valuable among children leads to the decreased number of meals consumed daily and volume of meals consumed.

In some children poor nutrition may can be related to parents' economic condition, which is indicated by the decreased body weight. We encounter predominantly nutrition errors and lack of basic knowledge among mothers about the proper nutrition, following fashions and trends related to trendy nutrition or errors in preschool nutrition. Mistakes at an early age can have serious consequences, such as growth disorders, decreased muscle strength, development of posture defects, or decreased immunity, which can lead to obesity or malnutrition as a result.

## CONCLUSIONS

Among Polish four-year-old children there is a large group of children (every 4<sup>th</sup> child) with the decreased body mass, which reflects prolonged energy malnutrition. At the same time, every 5<sup>th</sup> child showed increased body weight in the form of overweight or obesity, which indicates the need for education among parents and persons responsible for the nutrition of children on the improvement in the structure of food consumed by children.

High percentages of children (above 80%) with low n-3 fatty acid and fibre consumption were observed with simultaneous high total fat, saturated fatty acid and sugar consumption (above 70% of children), which may result in the risk of abdominal obesity and nutritional diseases in the future.

Frequent vitamin D, potassium, calcium and iron deficiencies in the diets of 50% to 90% children aged four, and vitamin E and C and foliates deficiencies in less than 25% of children were observed.

Conducted analyses of nutrition among four-year-old children suggest the need for education aimed at increas-

ing the intake of highly deficient components in diets by children. Particular attention should be paid to calcium and vitamin D as key nutrients for the development and preservation of health in this group of children. Education should be adapted especially to the age of children covered, but also pre-school carers and parents.

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