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ORIGINAL ARTICLE

ASSESSMENT OF THE NUTRITIONAL VALUE OF DAILY FOOD RATIONS OF CHILDREN AGED 1-4 YEARS

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ABSTRACT

Background. An adequately balanced daily food rations (DFR) providing the organism with a sufficient amount of energy and nutrients, including minerals, is particularly important in infanthood and early childhood due to the child's intensive physical, intellectual and motoric development.

Objective. The aim of this study was to evaluation the supply of energy, nutrients and vitamins in daily food rations of children fed at home and in nursery schools.

Material and Methods. 75 children aged 1-4 years were the research subjects. They were divided into three age subgroups: 12-24-month-olds, 25-36-month-olds and 37-48-month-olds. The daily consumption of energy and vitamins was assessed by means of a 7-day 24-hour nutritional interview made with current note taking and by means of a computer database (Dietetyk 2). Significant differences in the content of energy, nutrients and vitamins in the DFR were investigated using the two-way analysis of variance (Statistica 10.0) at significance level $p \leq 0.05$.

Results. Neither the children's sex nor age had influence on the intake of energy and macronutrients. Apart from the amount of energy (68-101.8% RDA) and proteins (183-288% RDA) these values were generally normal, but they had influence on the content of vitamins in the DFR. The DFR was characterised by generally excessive content of vitamins A, B_2, B_6 and B_{12}. However, in comparison with the RDA the intake was significantly higher in the DFR of the youngest children (12-24 months old). In the group aged 37-48 months there were significantly higher values in the intake of vitamins B_2 (317% vs 137% RDA) and B_6 (334% vs 147% RDA). On the other hand, in comparison with the RDA, the DFR provided too small amounts of vitamins D, E, folates and vitamin C. The DFR of the youngest children (12-24 months old) contained significantly greater amounts of vitamins: D (41.3% vs 16.2% RDA), E (83.6% vs 63.5% RDA) and C (102.0% vs 48.6% RDA), as compared with the children aged 37-48 months. Only the content of vitamins B_1 and PP in the children's DFR was similar or slightly greater than the RDA.

Conclusions. The intake of energy in the DFR of the children aged 1-4 years was generally comparable, but in the children aged 37-48 months it did not satisfy the daily demand. In all the age groups under study the supply of macronutrients satisfied about 100% of the demand, whereas the supply of protein and sucrose was excessive. The children aged 12-24 months consumed more vitamins D, E, B_2, PP, B_6, B_{12}, C than the children aged 37-48 months. The supply of vitamins D, E, C and folates was too low, whereas the consumption of vitamins: B_2, B_6 and B_{12} exceeded the recommended daily intake.

Key words: *nutrition, children, vitamins, intake*

STRESZCZENIE

Wprowadzenie. Odpowiednio zbilansowana całodzienna racja pokarmowa (CRP), dostarczająca organizmowi odpowiedniej ilości energii i składników odżywczych, w tym składników mineralnych jest niezwykle ważna w okresie niemowlęcym i wczesnodziecięcym, ze względu na intensywny rozwój fizyczny, umysłowy i motoryczny dziecka.

Cel. Celem niniejszej pracy była ocena podaży energii, składników odżywczych i witamin w całodziennych racjach pokarmowych dzieci żywionych w warunkach domowych i przedszkolnych.

Materiał i metody. Badaniem objęto 75 dzieci w wielu 1-4 lata, które podzielono na trzy podgrupy wiekowe: 12-24 m-ce, 25-36 m-cy oraz 37-48 m-cy. Ocenę dziennego spożycia energii i witamin przeprowadzono za pomocą 7-dniowego 24 godzinnego wywiadu żywieniowego sporządzanego metodą bieżącego notowania oraz komputerowej bazy danych (Dietetyk 2). Różnice istotne statystycznie w zawartości energii, składników odżywczych oraz witamin w CRP zbadano za pomocą dwuczynnikowej analizy wariancji (Statistica 10.0) na poziomie istotności $p \leq 0.05$.

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Wyniki Zarówno płeć jak i wiek dzieci nie miały wpływu na wielkość pobrania energii i makroskładników, która z wyjątkiem energii (68% - 101,8 % RDA) i białka (183 – 288% RDA) była ogólnie prawidłowa ale miały wpływ na zawartość witamin w CRP. CRP charakteryzowało się ogólnie zbyt wysoką zawartością witaminy A, B_2, B_6 i B_{12}, przy czym istotnie wyższe pobranie w stosunku do RDA zanotowano w CRP dzieci najmłodszych (12- 24 mce), w stosunku do grupy w wieku 37-48 mcy w przypadku witaminy B_2 (317% vs. 137% RDA) i B_6 (334% vs. 147% RDA). Z kolei CRP dostarczyły zbyt małe w stosunku do RDA ilości witamin D, E, folianów oraz witaminy C. Stwierdzono, że CRP dzieci najmłodszych (12-24 mce) zawierały znacząco wyższe ilości witamin: D (41,3% vs.16,2% RDA), E (83,6% vs. 63,5% RDA) i C (102,0% vs. 48,6% RDA) w stosunku do dzieci w wieku (37- 48 mcy). Zbliżone lub nieco wyższe w stosunku do RDA zawartości witamin w CRP dzieci zanotowano tylko dla witaminy B_1 i PP.
Wnioski. Ilość pobranej energii w CRP dzieci w wieku 1-4 lat była ogólnie porównywalna, przy czym u dzieci w wieku 37-48 mcy nie pokryła dziennego zapotrzebowania. Podaż makroskładników odżywczych we wszystkich badanych grupach pokrywała zapotrzebowanie w około 100%, a w przypadku białka i sacharozy w nadmiarze. Dzieci w wieku 12-24 mcy spożywały więcej witamin D, E, B_2, PP, B_6, B_{12}, C w porównaniu z dziećmi w wieku 37-48 mcy. Podaż witamin D, E, C i folianów była zbyt niska w stosunku do norm, a spożycie witamin: B_2, B_6 i B_{12} pokrywało zalecane dzienne spożycie w nadmiarze.

Słowa kluczowe: *żywienie, dzieci, witaminy, spożycie*

INTRODUCTION

The first three years in a child's life is a period of particularly intensive physical, intellectual and motoric development. During this period the manner of children's nutrition changes from the one that is typical of infanthood to the manner of nutrition which is typical of adults although a three-year-old child has different demand for nutrients than an adult [10]. An inadequate amount of nutrients may permanently change metabolism and the course of physiological processes and in consequence, it may increase the child's predisposition to obesity at a later period in life. Apart from basic nutrients, such as proteins, fats and carbohydrates, it is also vitamins and minerals that are particularly important for the child's development [11, 20, 29]. The demand for individual components changes depending on one's age, growth rate, body build and physical activity. It is very important to maintain adequate proportions between nutrients, to consume products from all groups, to diversify meals and to serve products free from microorganisms and contaminations regularly, at specific times of the day. Apart from parents and legal guardians, public day-care centres for children play an important role in developing adequate feeding habits. In Poland about 70% of children aged 3-6 years attend nursery schools [22]. Appropriate nutrition is an important aspect of children's stay in nursery schools, because they spend most of the day there and the meals they receive are the basis of all-day nutrition. Therefore, it is important that meals served both at home and in nursery schools provide the amounts of energy and nutrients which are adequate to children's age [7].

Data on the nutritional value of daily food rations (DFR) of children aged 1-4 years are incomplete [5]. In view of the important role of public institutions and parents in developing feeding habits the aim of this study was an assessment of the supply of energy, macronutrients and vitamins in DFRs of children aged 1-4 years fed at home and in nursery schools. The aim of the study was to determine the influence of sex and age on the intake of energy, macronutrients and vitamins in the daily food rations of children aged 1-4 years with reference to the recommended daily allowance (RDA) for a particular age group.

Population under study

The Bioethical Commission, Medical University of Poznań gave the permission for the study (No. 871/10). The study was conducted in 75 children aged 1-4 years living in Poznan and the surrounding area. The population was divided into three age subgroups: 12-24-month-olds (27 children), 25-36-month-olds (19 children) and 37-48-month-olds (29 children). The first two subgroups consisted of children staying at home with their parents or legal guardians. Children attending to several nursery schools in Poznan were recruited to the subgroup aged 37-48 months. The children's age was the criterion for inclusion into the group under study (12-48 months), whereas the exclusion criterion was the children's illnesses, which caused the need to apply a different nutrition than oral nutrition. The study was conducted in April 2014.

MATERIAL AND METHODS

Anthropometric test

Anthropometric measurements were made according to the generally accepted methodology, in the morning, without outerwear and shoes. The height and body weight were measured on medical scales with an accuracy of 0.10 cm (body height) and 0.10 kg

(body weight). The anthropometric data gathered in the research were used to calculate the body mass index (BMI) values (kg/m2) . Then they were standardised with reference to the WHO growth charts. For each child a standardised body mass index z-score and percentile values of the body weight, body height and body mass index were calculated.

Assessment of energy intake and consumption of nutrients

The assessment of the children's nutrition was based on 24h - records of the 75 children's menus, which their guardians made by means of current note taking for seven consecutive days. The data on the amount of consumed portions were obtained by weighing ready meals and leavings. The data gathered in this way were used to estimate the daily food ration (DFR) and its energetic and nutritional value was calculated by means of the '*Dieteyk 2*' nutritional computer program. The calculations allowed for culinary and technological losses. An equal loss of 10% was assumed for the energetic value, total protein, fats, carbohydrates and vitamins B_6, B_{12} and D. Due to the diversified sensitivity of other vitamins to factors observed in the culinary processing of food the content of vitamin A was reduced by 20%, riboflavin and niacin – by 25%, vitamin E – by 30%, folates – by 40%, vitamin C – by 55% [16]. The values of consumption which differed by ± 10% from the standard values were regarded as adequate.

Statistical analysis

This study assumed a 15% standard error in the estimation of the values of the nutritional indexes under investigation and the minimum size of the population subgroup calculated for the error was 16 people. The results were analysed statistically. The arithmetic mean and standard deviation were calculated. The two-way analysis of variance was used to investigate significant differences in the content of energy, nutrients and vitamins in the DFR, where the significance level was $p \leq 0.05$. *Pearson's* test was used to calculate the correlation coefficients for the dependences between the body weight, body height and individual components of the DFR. Microsoft Excel ver 2007 and Statistica 10.0 Pl programs were used for statistical analysis, where the significance level was $p \leq 0.05$.

RESULTS

Table 1 shows the characteristics of the group of children under study. Each child's state of nutrition was assessed by means of sex-and-age-independent body mass index z-score. 57.3% of the children were in a normal state of nutrition and their BMI z-score ranged from -1.0 to +1.0. Low body weight (BMI z-score between -2.0 and-1.0) was observed in 17.3% of the children, whereas very low body weight (BMI z-score <-2.0) was observed in 4.0% of the children. Overweight and obesity was observed in 20.0% and 1.3% of the children, respectively. The children aged 37-48 months were characterised by much lower WA (weight-for-age) and LA (length/height-for-age) than the younger children. Tables 2 and 3 show the results. The energy intake was comparable in all the age groups, but in the group of 37-48-month-olds it was about 30% lower than the RDA. In all the groups under investigation the consumption of fat and carbohydrates in the DFR was similar and covered about 100% of the demand. Neither the children's age nor sex (independent of each other) had significant influence on the intake of energy and macronutrients. As was observed, both the boys' and girls' DFR was characterised by an excessive supply of protein – at least 83% more than the RDA. The analysis of variance did not reveal an interaction between the investigated factors in their effect on the consumption of macronutrients.

Table 1. The characteristics of the children group under study

	12-24 months			25-36 months			37-48 months		
	Total	girls	boys	total	girls	boys	total	girls	boys
n	27	9	18	19	12	7	29	18	11
body weight [kg]*	12.1±2.0[a]	11.2±1.4	12.5±2.1	14.0±1.8[b]	14.3±1.5	13.5±2.3	15.2±2.2[c]	14.8±2.3	15.9±2.0
height [cm]*	85.6±3.9[a]	84.6±4.5	86.2±3.5	94.4±4.0[b]	94.4±3.2	94.5±5.4	98.7±4.3[c]	98.9±3.2	98.3±5.3
LA	1.3±1.2[b]	1.6±1.4	1.1±1.0	1.3±1.0[a]	1.3±0.9	1.3±1.2	0.0±0.8[a]	0.1±0.8	-0.1±0.9
WA*	0.9±0.8[b]	1.0±0.7	0.9±0.9	1.0±1.0[b]	1.2±0.8	0.6±0.9	0.1±1.0[a]	-0.1±1.0	0.4±0.9
BMI	16.4±2.6	15.7±2.0	16.8±2.8	15.6±1.2	15.8±1.3	15.3±0.9	15.6±1.8	15.1±2.0	15.1±2.0
BMI z-score*	0.1±1.6	-0.3±1,7	0.3±1.6	0.0±1.1	0.3±1.1	-0.6±0.9	0.0±1.4	-0.3±1.6	0.7±0.9

*[(a,b,c)]statistically significant differences between age groups ($p < 0.01$)

BMI z-score* - body mass index-for-age; LA- length/height-for-age; WA - weight-for-age

Table 2. The influence of investigated factors on the intake of energy and selected nutrients in the daily food rations of children aged 1-4 years

Experimental factor		Energy (kcal)	Protein (g)	Fat (g)	Cholesterol (mg)	Carbohydrates (g)	Sucrose (g)
Sex (A)							
Boys A_1	mean ±SD	1008.78±236.09	41.68±13.42	39.57±12.88	170.97±98.03	130.09±27.47	25.64±10.10
	% RDA	90.4	269	101.8	-	100.1	-
Girls A_2	mean ±SD	967.90±242.10	37.62±10.86	36.45±11.4993.8	164.36±58.67	131.50±34.03	27.91±13.52
	% RDA	87.7	229		-	101.2	-
Age (B)							
12-24 months B_1	mean ±SD	1017.74±219.42	40.37±11.40	38.34±11.32	178.23±109.06	137.21±26.31	26.01±8.67
	% RDA	101.8	288	86.3	-	105.6	-
25-36 months B_2	mean ±SD	1009.87±213.72	40.23±10.48	38.55±13.25	162.41±4±9.44	135.12±30.49	30.85±11.62
	% RDA	101.0	287	86,7	-	103.9	-
37-48 months B_3	mean ±SD	951.74±266.89	38.62±14.02	37.34±12.66	161.96±66.28	123.37±33.56	25.21±14.06
	% RDA	67.9	183	112.1	-	94.9	-
Interaction of factors (AxB)							
A_1B_1	mean ±SD	1061.85±206.71	43.89±11.35	40.60±10.51	186.79±121.33	139.81±26.69	27.29±8.16
	% RDA	106.2	313	91.4	-	107.5	-
A_2B_1	mean ±SD	916.91±229.49	32.32±6.77	33.19±12.23	158.67±78.49	131.27±26.43	23.08±9.75
	% RDA	91.7	230	90.5	-	101.0	-
A_1B_2	mean ±SD	967.83±265.73	44.98±14.38	39.35±18.93	152.89±48.25	115.46±16.91	26.30±13.04
	% RDA	96.8	321	74.9	-	88.8	-
A_2B_2	mean ±SD	1035.09±187.12	37.38±6.65	38.07±9.64	168.12±51.81	146.92±31.27	33.58±10.41
	% RDA	103.5	267	85.7	-	113.0	-
A_1B_3	mean ±SD	953.90±264.86	36.68±15.42	38.20±13.51	157.83±81.96	123.92±29.70	22.87±11.32
	% RDA	68.1	175	114.6	-	95.3	-
A_2B_3	mean ±SD	950.42±275.77	39.81±13.41	36.81±12.48	164.48±57.16	123.02±36.55	26.64±15.63
	% RDA	67.9	190	110.4	-	94.6	-

SFA - saturated fatty acids; MFA - monounsaturated fatty acids, PFA - polyunsaturated fatty acids; - no data available in reference publications; for energy EER (estimated energy requirement) is given; for fat RI (reference intake) is given

The consumption of vitamins in the children's DFR was diversified, depending on the vitamin type, child's age and sex. It was adequate, too high or too low in comparison with the recommended amounts. In general the DFR was characterised by too high content of vitamin A (134-181% RDA), B_2 (137-317% RDA), B_6 (147-334% RDA) and B_{12} (172-496% RDA). In comparison with the RDA the intake was significantly greater in the DFR of the youngest children (12-24-month-olds). As far as the children aged 37-48 months are concerned, the intake of vitamins B_2 (317% vs 137% RDA) and B_6 (334% vs 147% RDA) was too high. On the other hand, in comparison with the RDA, the DFR provided too small amounts of vitamins D (16.2-41.3%), E (63.5-83,6%), folates (35.5-67.2%) and vitamin C (48.6-102.0%). The youngest children's (12-24-month-olds) DFRs were found to contain significantly greater amounts of vitamins D (41.3% vs 16.2% RDA), E (83.6% vs 63.5% AI) and C (102.0% vs 48.6% RDA), as compared with the DFRs of the children aged 37-48 months. In comparison with the RDA, the children's DFR provided similar or slightly greater amounts of only vitamins B_1 (79.0-133%) and PP (75.4-143.3%).

The analysis of variance revealed the occurrence of interactions between the investigated factors in their effect on the children's consumption of vitamins D, B_6 and C and folates. As was observed, both the boys and girls in the youngest group consumed much more vitamin D than the boys aged 25-36 months and the boys and girls aged 37-48 months. The youngest boys' DFR was characterised by a higher content of vitamin B_6 than the oldest boys' and girls' DFR. The content was about 98% and 81% greater, respectively. The analysis of interactions between the sex and age revealed that the consumption of folates and vitamin C by the 12-24-month-old girls was significantly greater than the consumption by 25-36-month-old boys and 37-48-month-old children. The difference was about 101% and 68%, respectively; for folates - 209% and 170%, respectively.

Table 3. The influence of investistigated factors on the intake of vitamins in the daily food rations of children aged 1-4 years

Experimental factor		Vitamin A (µg)	Vitamin D (µg)	Vitamin E (mg)	Vitamin B_1 (mg)	Vitamin B_2 (mg)	Vitamin PP (mg eq.)	Vitamin B_6 (mg)	Folates (µg)	Vitamin B_{12} (µg)	Vitamin C (mg)
Sex											
Boys A_1	mean ±SD	630.99±344.27	3.83±3.29	4.16±1.66	0.56±0.33	1.34±1.27	7.64±4.19	1.32±0.80	79.20±30.08	2.94±2.02	27.91±16.07
	% RDA	143.3	25.5	69.4	109.3	240.2	115.3	239.8	45.6	291.1	58.8
Girls A_2	mean ±SD	686.5±482.79	3.59±2.82	4.25±2.39	0.59±0.28	1.08±0.57	6.63±2.48	1.20±0.65	93.10±43.14	3.31±4.69	34.03±20.41
	% RDA	176.1	24.0	70.9	118.1	219.5	101.5	248.0	62.5	348.1	92.6
Age											
12-24 months B_1	mean ±SD	727.88±383.25	6.20±2.95^b	5.02±1.51^b	0.63±0.26	1.59±1.45^b	8.60±3.94^b	1.67±0.94^b	100.73±40.26	3.54±2.27^b	40.80±22.33^b
	% RDA	181	41.3	83.6	126	317	143.3	334	67.2	393	102.0
25-36 months B_2	mean ±SD	674.21±519.59	3.13±2.41^{ab}	4.07±3.27^{ab}	0.67±0.47	1.32±0.67^{ab}	6.57±2.94^{ab}	1.27±0.59^{ab}	89.97±47.91	4.47±6.71^{ab}	29.89±18.65^{ab}
	% RDA	168	20.9	67.9	133	263	109.5	253	60.0	496	74.7
37-48 months B_3	mean ±SD	606.87±366.38	2.43±2.15^a	3.81±1.35^a	0.47±0.15	0.82±0.32^a	6.03±2.42^a	0.88±0.24^a	70.93±21.47	2.07±0.93^a	24.30±10.41^a
	% RDA	134	16.2	63.5	79	137	75.4	147	35.5	172	48.6
Interaction of factors (AxB)											
A_1B_1	mean ±SD	703.31±395.71	5.90±3.36^b	5.03±1.79	0.60±0.25	1.76±1.69	9.10±4.38	1.68±0.94^b	92.48±32.63^{ab}	3.75±2.51	35.81±18.01^{ab}
	% RDA	175	39.4	83.9	119	352	151.0	335	61.7	414	89.5
A_2B_1	mean ±SD	784.03±376.58	6.87±1.69^b	4.99±0.57	0.71±0.28	1.19±0.54	7.26±2.15	1.65±1.03^{ab}	119.57±51.84^b	3.12±1.70	52.22±28.26^b
	% RDA	196	45.8	83.1	142	238	121.0	330	79.7	346	130.0
A_1B_2	mean ±SD	486.97±168.32	1.89±1.19^a	2.49±0.45	0.66±0.66	1.18±0.57	7.47±4.53	1.22±0.64^{ab}	59.35±12.81^a	2.72±1.00	16.85±7.92^a
	% RDA	121	12.6	41.6	132	235	124.5	243	39.6	301	42.1
A_2B_2	mean ±SD	786.5±629.93	3.88±2.69^{ab}	5.02±3.88	0.67±0.36	1.40±0.74	6.03±1.47	1.30±0.59^{ab}	108.34±52.29^{ab}	5.53±8.43	37.72±19.07^{ab}
	% RDA	196	25.8	83.6	134	279	100.5	259	72.2	614	94.3
A_1B_3	mean ±SD	604.34±329.57	1.87±1.90^a	3.81±0.98	0.46±0.16	0.80±0.37	5.60±3.01	0.85±0.29^a	70.69±24.87^a	1.90±0.95	22.45±10.10^a
	% RDA	134	12.5	63.6	77	133	70.0	142	35.4	158	44.9
A_2B_3	mean ±SD	610.34±435.88	3.21±2.36^a	3.81±1.82	0.47±0.14	0.85±0.25	6.61±1.20	0.93±0.15^a	71.25±17.36^a	2.30±0.90	26.84±10.96^a
	% RDA	136	21.4	63.5	78	142	82.7	155	35.6	192	53.7

$p<0.05$ for vitamin E % AI (adequate intake) is given

DISCUSSION

Energy is necessary to regulate biochemical processes in the organism, sustain physiological functions, the organism structure, growth and all physical activity [10]. The daily demand for energy is 1000 kcal in children aged 1-3 years and 1400 kcal in children aged 4 years. This study proved that the energy intake in the DFR was generally adequate in the children aged 1-3 years, but it was lower in the children aged 4 years. It was caused by the fact that the pre-school children ate only a portion servings. This can be explained by other dietary preferences or the stress of separation from their parents. The study by *Weker* et al. [35] revealed that the energetic value of the DFR consumed by children in Warsaw crèches was 20% greater than the recommended value. *Trafalska* et al. [23] observed that the energy content differed in individual decades and it ranged from 442.8 kcal per day to 1507.0 kcal per day. *Smorczewska-Czupryńska* et al. [27] assessed nutrition in crèches in Białystok and they found that the energy intake was about 100 kcal greater than the recommended value. On the other hand, *Sadowska* and *Krzymuska* [25] proved that the energetic value of the meals consumed in nursery schools in Szczecin was 10% greater than the allowance. In the study by *Czerwonogrodzka-Senczyna* et al. [2] the researchers observed that the average supply of energy in the DFR of children aged 1-3 years with simple obesity was high and amounted to 156% of the allowance.

Adequate consumption of protein according to the demand is of primary importance to human health. Proteins are necessary for the growth of young organisms, but their excess in the DFR burdens the kidneys and liver and it may cause metabolic disorders and atherosclerotic processes in adulthood [28]. Excessive supply of protein is commonly observed in children. The average daily content of protein in the DFR of the children aged 1-4 years in this study was 39 g. It was much greater than the recommended allowance (RDA), i.e. 14 g per day and 21 g per day for children aged 1-3 years and 4 years, respectively. Similarly, *Trafalska* et al. [25] analysed the nutritional value of the DFR of crèche children and they observed that the content of protein in the DFR was too high (32.8 g per day) and it concerned 65% of DFRs in the crèches under study.

The amount of energy from fat in the DFR of children aged 1-3 years assumed to be 40% and 30% for 4-year-olds [10]. Children's and young people's excessive consumption of energetic nutrients, especially animal fats and refined carbohydrates increases the total caloricity of food and contributes to overweight and obesity by increasing the number of fat cells which are metabolically active during the whole human life [10]. The amount of fat in the children's DFRs was generally adequate and it ranged from about 33.9% to 35.3% of the energy intake. *Trafalska* et al. [23] observed that the content of fat in the food rations of children aged 13-36 months was 30 g per day and it amounted to about 31.1% of total energy. In the study by *Smorczewska-Czupryńska* et al. [27] 92% of the demand for fat was satisfied. The highest coverage of the allowance, i.e. 180% in the food rations in nursery schools was proved by *Dymkowska-Malesa* and *Szparaga* [3].

Carbohydrates should provide 55-60% of energy in a child's DFR. They are necessary elements of a child's DFR, because they are the basic energetic material in the human organism. Too small supply of carbohydrates has negative influence on metabolic processes in the system and causes disorders in fat and protein metabolism. This study proved that the total share of carbohydrates in the DFR was adequate. However, their structure was inadequate due to the high share of sucrose, i.e. about 20% of total energy. Similarly, *Hamułka* et al. [8, 9] observed that there was too high supply of sucrose in the DFR of children aged 1-6 years. *Trafalska* et al. [23] observed that the supply of carbohydrates was slightly lower than the recommended allowance (i.e. 130 g) and it amounted to 120.8 g. On the other hand, *Weker* et al. [35] proved that crèche children's food rations provided 142.4 g of carbohydrates.

This study proved that neither the children's sex nor age had influence on the consumption of macronutrients in the DFR, but they influenced the consumption of vitamins. The children aged 12-24 months were observed to take much more vitamins in their total DFR than the children aged 37-48 months. It was caused by the fact that the younger children's menu included products for special nutritional purposes, such as modified milk or cereals enriched with some vitamins. The share of these products in the children's DFR decreased as they grew older in favour of the products typical of adults' food rations.

Both the excess and deficit of vitamin A contributes to many irregularities: liver function disorders, loss of appetite, growth restriction or visual problems. The DFRs of the children aged 1-4 years were generally characterised by excessive supply of vitamin A (134-181% RDA). *Dymkowska-Malesa* and *Szparaga* [3] analysed the supply of vitamins in a nursery school in Koszalin and they also found that the intake of vitamin A exceeded the recommended allowance by 76% on average. Excessive consumption of vitamin A in nursery school children's food rations was also observed in the studies by *Orkusz* and *Włodarczyk* [21], *Sadowska* et al. [26] and *Grajeta* et al. [7]. Like in this study, *Trafalska* [24] proved that the supply of vitamin A considerably exceeded the recommended values in 30 crèches in Łódź.

Vitamin D is one of more significant factors which are necessary for normal absorption of calcium from the alimentary tract. The absorption of calcium ranges from 10% to 80%, depending on the supply of vitamin D in the organism. Disruption of calcium homeostasis caused by deficient vitamin D may cause disorders of calcium and phosphate metabolism and in consequence, it may cause bone diseases [11, 14, 19]. The supply of vitamin D in the DFRs of the children aged 1-4 years was too low and it amounted only to 1-41% of the RDA. In the studies by *Dymkowska-Malesa and Szparaga* [3] and *Sochacka-Tatara* et al. [28] the content of vitamin D in food rations was also low (11.2% RDA).

A DFR with a low content of vitamin E is particularly unfavourable to the development of children, especially neonates, because it may cause anaemia, visual disorders (retinopathy, fibroplasia), bronchopulmonary dysplasia and sudden death [4]. The deficiency of vitamins E and C in the organism causes reduced immunity to infections, which can be observed in impaired phagocyte activity [13]. The consumption of vitamin E by the population of children aged 1-4 years under study did not satisfy the recommended demand of 6 mg per day. The studies by *Sadowska* et al. [26] and *Grajeta* et al. [7] revealed that the supply of this vitamin was adequate or even slightly higher and it amounted to 125% and 120% of the AI, respectively.

B vitamins are necessary for optimal functioning of the central nervous system, because they have accessory functions in the production of neurotransmitters. The analysis of the DFR of the children aged 1-4 years revealed that the content of B vitamins, especially vitamins B_2, B_6, B_{12}, considerably exceeded the recommended daily allowance of food, except folates (vitamin B_9). *Dymkowska-Malesa* and *Szparaga* [3], *Sadowska* et al. [26] and *Kucharska* et al. [15] obtained similar results in their analyses of food rations in nursery schools. In our research only the consumption of vitamin B_1 in the group of three-year-olds was similar to the recommended value and it amounted to about 93.2%. *Sochacka-Tatara* et al. [28] also observed that on average the supply of vitamin B_1 satisfied 91% of the demand and simultaneously, there was excessive supply of vitamin B_{12}. *Leszczyńska* et al. [18] found that meals in nursery schools sufficiently satisfied the demand for thiamine and riboflavin. *Górnicka* et al. [6] found in their study that the consumption of folates, which are responsible for normal development of the nervous system and haematopoietic processes, was too low. The authors proved that only 2 out of 5 nursery schools satisfied the daily demand for folates.

Vitamin C participates in the production of immunoglobulins and increases immunity to some viral and bacterial diseases [17]. Apart from that, it increases the absorption of calcium and iron, which is necessary for the production of red blood cells. In this research the demand for vitamin C was fully satisfied only in the youngest group of children. There was a low supply of the vitamin observed in the other children's DFRs, i.e. about 60% of the RDA. Insufficient consumption of this vitamin was also noted in the studies by *Orkusz* and *Włodarczyk* [21]. *Sadowska* and *Krzymuska* [25] observed that the low consumption of vitamin C was caused by the fact that children were reluctant to eat vegetables. *Leszczyńska* et al. [18] reported that the content of vitamin C in food rations in nursery schools depended on the season of the year. In spring 50% of the demand for vitamin C was satisfied, in autumn and winter – 44%, whereas it was the lowest in summer – 35%. *Trafalska* et al. [23] analysed the nutritional value of crèche children's food rations and they proved that nearly 100% of the demand for vitamin C was satisfied. On the contrary, *Dymkowska-Malesa* and *Szparaga* [3] proved a relatively high content of vitamin C, i.e. 120.6 mg per day. In the study by *Sochacka-Tatara* et al. [28] the consumption of vitamin C exceeded the recommended allowance twice. The demand was satisfied in a slightly lower degree (177% RDA) in the study by *Grajeta* et al. [7]. *Weker* et al. [30, 31] analysed the manner of nutrition of 400 children aged 13-36 months and they observed that both the supply of vitamin C and B vitamins exceeded the recommended allowance. The authors suggested that it was caused by the high share of enriched food in the children's DFR (60% of the children), including food products for special nutritional purposes for infants and small children.

CONCLUSIONS

1. The intake of energy in the DFRs of the children aged 1-4 years was generally comparable, but it did not satisfy the daily demand in the children aged 37-48 months.
2. In all the age groups under study the supply of macronutrients satisfied about 100% of the demand, whereas the supply of protein and sucrose was excessive.
3. The DFRs of the children aged 12-24 months contained more vitamins D, E, B_2, PP, B_6, B_{12}, C than the DFRs of the children aged 37-48 months. The supply of vitamins D, E, C and folates in the DFRs was too low, whereas the supply of vitamins B_2, B_6 and B_{12} was too high in comparison with recommended allowances.
4. About 42.7% of the children under study were characterised by an abnormal state of nutrition.
5. An inadequately balanced DFR needs to be corrected by educating parents or guardians in appropriate nutrition.

Conflict of interest

The authors declare no conflict of interest.

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