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Analysis of vitamin intake among pupils aged 7–18 living in rural areas of the Podbeskidzie region

Analiza spożycia witamin wśród uczniów w wieku 7–18 lat zamieszkujących tereny wiejskie z regionu Podbeskidzia

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Abstract

Introduction and Objective. Research into the dietary habits of specific groups of children and adolescents is important from the public health perspective due to the possibilities for modifying any existing irregularities. The aim of the study was to assess the intake levels of vitamins in the daily diets of children and adolescents living in rural areas.

Materials and method. The research used a study questionnaire containing questions on food products consumed every day from all 12 food groups, including: sweetened drinks, snacks, ready meals, sweets and fast food, as well as purchases made in the school shop, vitamin supplements and minerals consumption and dietary habits. Weight and height of each student were measured, BMI value calculated. The study participants comprised 332 pupils aged 7–9 years, 376 aged 10–12, 333 aged 13–15, and 139 aged 16–18.

Results. In the study group, insufficient body weight was noted in 4.5% of pupils, excessive weight in 11%, and obesity in 10%. In all the groups of pupils, irrespective of age, the average daily intake of water soluble vitamins (with the exception of folic acid) met the Recommended Dietary Allowance. The average daily intake of vitamin A for all pupils exceeded the RDA. In vitamin D, even the maximum daily intake across all age groups did not meet the AI.

Conclusions. The amount of vitamins in the diet was not in line with recommendations on correct dietary habits and, as such, requires the implementation of educational activities on the correct composition of the diet, in particular the variety of foodstuffs consumed. The daily supply of vitamin D was insufficient, and therefore must be supplemented, in particular during the autumn and winter seasons.

Key words

adolescence, child development, vitamin

Streszczenie

Wprowadzenie i cel pracy. Poznanie nawyków żywieniowych konkretnej grupy dzieci i młodzieży jest ważne z punktu widzenia zdrowia publicznego, ze względu na możliwość zmodyfikowania występujących nieprawidłowości.
Celem badań była ocena spożycia wybranych witamin w codziennej diecie dzieci i młodzieży zamieszkujących tereny wiejskie.

Materiał i metody. Badania przeprowadzono przy użyciu kwestionariusza ankiety. Ankieta zawierała pytania dotyczące produktów spożywczych spożywanych każdego dnia, z uwzględnieniem: słodzonych napoi, przekąsek, słodyczy, produktów typu fast food. U każdego z uczniów wykonywano pomiary masy i wysokości ciała, a następnie obliczano wartość BMI. Analizą objęto 332 uczniów w wieku 7–9 lat, 376 uczniów w wieku 10–12 lat, 333 uczniów w wieku 13–15 lat oraz 139 uczniów w wieku 16–18 lat.

Wyniki. W analizowanej grupie uczniów u 4,5% odnotowano niedobór masy ciała, u 11% nadwagę, a u 10% otyłość. We wszystkich grupach, bez względu na wiek, średniodobowe spożycie witamin rozpuszczalnych w wodzie (z wyjątkiem kwasu foliowego) pokrywało zalecane dzienne spożycie (RDA). Średniodobowe spożycie witaminy A u wszystkich uczniów przekroczyło zalecane dzienne spożycie (RDA). Nawet maksymalne dobowe spożycie witaminy D we wszystkich grupach wiekowych nie pokrywało wystarczającego spożycia.

Wnioski. Niezgodna z wytycznymi racjonalnego odżywiania zawartość witamin w diecie nakazuje wdrożenie działań edukacyjnych dotyczących właściwego komponowania diety, ze szczególnym uwzględnieniem jej różnorodności. Dzienna podaż witaminy D jest niewystarczająca, należy ją więc suplementować, w szczególności w okresie jesienno-zimowym.

Słowa kluczowe

rozwój dziecka, witaminy, nastolatek

Abbreviations

AI – Adequate Intake; **BMI** – Body Mass Index; **COVID-19**; **EAR** – Estimated Average Requirement; **RDA** – Recommended Dietary Allowances; WHO – World Health Organization

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INTRODUCTION

Proper nutrition is one of the most important elements affecting the correct physical and psychological development of children and adolescents. In the early years of schooling, dietary habits are shaped by children's parents. Later, in the teenage years, friends and classmates, to a certain degree influence their nutritional habits, although these are mainly shaped by advertisements for food products on internet websites and on television [1]. To ensure correct development, it is of crucial importance to supply the appropriate amounts of minerals and vitamins. Vitamins are compounds that are essential for the body to function properly, but which (apart from vitamin D) the body is unable to synthesize on its own. Vitamin deficiencies are today a significant public health problem [2–5].

Vitamin A, which is vital for eyesight, affects proper growth and the development of bones. It has anti-oxidant properties and is involved in the synthesis of proteins and in the transformation of fats. Group B vitamins affect the correct functioning of the nervous system, and a deficiency of this vitamin causes growth inhibition, impaired concentration, insomnia, headaches, weakening of the muscles, heart problems, inflammation of the cornea, anxiety, depression and anaemia [6–9].

Vitamin C, a natural anti-oxidant, inhibits the action of free radicals and assists in the absorption of iron and in corticosteroid synthesis. Vitamin E, similarly to vitamin C, is a natural anti-oxidant and affects immunity and the body's reaction to infections. Vitamin D is of exceptional importance in the process of mineralization of the teeth and bones, and a deficiency of this vitamin increases the risk of obesity and cardiovascular diseases. A deficiency of vitamin D during the foetal stage can lead to permanent damage to brain function. Fat-soluble vitamins, unlike water soluble vitamins, can be stored in the body, which may lead to the onset of hypervitaminosis [2, 6, 8, 9].

Research into the dietary habits of specific groups of children and adolescents is important from the perspective of public health due to the possibilities for modifying any existing irregularities. This has a direct effect on minimising the risk of the occurrence of vitamin deficiencies, as well as on reducing the costs related to health policies, both for the individual and for society as a whole [3, 10]. A key challenge is to ensure a sufficient level of vitamins in the diet, while at the same time preventing the upper intake limits from being exceeded [5].

OBJECTIVE

The aim of the study is to assess intake levels of selected vitamins in the daily diets of children and adolescents living in rural areas, and to examination whether the amount of vitamins in a diet of a studied group complies with the recommendations for proper nutrition.

MATERIALS AND METHOD

The study was conducted between the third quarter of 2017 and the first quarter of 2018, among pupils attending one of the schools (primary or secondary) located in a village in the Podbeskidzie region. The village is not a farming community and is the largest village in Poland in terms of population, as well as being in the 566th position in all the districts in Poland in terms of material status.

Body mass and height measurements were taken and BMI values calculated for each pupil. The research used a study questionnaire developed for the purpose of a previous study and published in the monograph *Eating habits and the way of life elements influent on the nutritional status of children and youth living in the rural areas* [11].

The questionnaire contained questions on food products consumed every day from all 12 food groups, including: sweetened drinks, snacks, ready meals, sweets and fast food, as well as purchases made in the school shop, vitamin supplements and minerals consumption and dietary habits. The questionnaire was completed after instructions were given to participants by the researcher. Information meeting were held before the research started, during which the researcher explained how to complete the questionnaire with particular focus on the accuracy of its completion. Each respondent and their parent/guardian had an opportunity to read the questionnaire and ask the researcher questions.

All study participants and their parents were informed of the correct method for measuring the portions of food products consumed. Assessment of the size of portions was performed using terms such as 'glass', 'spoonful' and 'mililitres, and portions were further verified using 'The Album of Photographs of Food Products and Dishes' [12]. The study questionnaire also contained the results of pupils' height and body mass measurements.

Recruitment procedure. Once permission to conduct the study was received from the Bioethics Committee, a series of meetings was held with pupils and their parents in order to obtain their consent for the study to be conducted. The criteria for inclusion in the study was the age of study participants between seven and 18 years old, and that they should attend one of the schools located in the village covered by the study. The exclusion criteria were: special diet applied to children, for instance, in case of being diagnosed with food allergies or chronic illnesses (heart, lung or thyroid disease).

Collection and assessment of the results of body mass and height measurements. Every pupil received a number indicating both their gender and their date of birth, which was necessary for determining their age. Body mass and height measurements were carried out on pupils in their underwear. Each measurement was taken three times, with the average of the three then calculated. The BMI index was then calculated for all pupils, who were then ranked according to WHO reference values, where a value between the 5th and 85th percentile was considered correct [13–15]. The results of the body mass and height measurements were archived using computer software.

Collection and assessment of food intake data. The researcher checked the completeness of the data in the seven-day dietary questionnaires. Any questionnaires that were found to contain inaccuracies were not included in the analysis. Data on the consumption of each food product was entered into the DIETA FAO 5.0 software, which contains data on 1,067 typical food products, allowing the daily intake of vitamins to be determined. The results were then

compared to Polish dietary norms: EAR (Estimated Average Requirement), RDA (Recommended Dietary Allowances) and AI (Adequate Intake) [16, 17]. During the period of the study, none of the study participants took vitamin supplements.

Statistical analysis. Statistical analysis was carried out using PQStat computer software (version 1.6.6), which analysed pupils according to gender and age. Pupils' age was calculated on the basis of their date of birth and the date the anthropometric measurements (body mass and height) were taken, with a division by calendar year [18]. For all the variables analysed (individual vitamins), minimum and maximum values were defined, as well as the average value, the median and the 25th and 75th percentile.

Study group size. The study was conducted on 1,243 pupils, which accounted for over 90% of the pupils. Of all the study participants' questionnaires, 63 were not included, of which 12 were due to participants' health reasons. The study participants encompassed 332 pupils aged 7–9 years old, 376 pupils aged 10–12 years old, 333 pupils aged 13–15 years, and 139 pupils aged 16–18 years old. The division into age groups was consistent with the different norms for daily vitamin requirements.

Ethical approval. The study was approved by the Bielsko-Biala Bioethics Review Board (No: 2017/06/1/4), in accordance with the Helsinki Declaration.

RESULTS

Characteristics of the study group. In the study group, insufficient body weight was noted in 4.5% of pupils, excessive weight in 11%, and obesity in 10%. Correct BMI values were noted in over 74% of the pupils. Among the boys, the number of cases of insufficient body weight decreased with age. Incorrect body mass (both insufficient and excessive weight) was more often noted among the girls (Tab. 1).

Daily vitamin intake. The study analysed 1,180 seven-day dietary records kept by the study participants and their parents. In all the groups of pupils, irrespective of age, the average daily intake of water soluble vitamins (with the exception of folic acid) met the Recommended Dietary Allowance (RDA). The minimum daily intake of folic acid varied in individual age groups and was around 50% of the average daily requirement. The average daily intake of vitamin A for all pupils exceeded the Recommended Dietary Allowance (RDA). The intake of vitamin C varied depending on the group, but most frequently this covered the average requirement for the group (Tab. 2–5).

The amount of vitamin E in the diet varied among the pupils in the study. The average daily intake of vitamin E among the 7–9-year-olds (both boys and girls), as well as among boys aged 13–15 and 16–18, did not meet the adequate intake (AI) (Tab. 2,4,5). In the case of vitamin D, even the maximum daily intake across all age groups did not meet the adequate intake (AI) of 15 µg. The lowest amount of vitamin D was noted in the diet of the youngest age group (7–9- year-olds) (Tab. 2).

There is a statistical dependence regarding the amount of vitamin intake and the BMI values of the studied respondents – BMI increased with the increase in the amount of consumed vitamins. This dependence concerns mainly children aged 7–9 and 10–12 (Tab. 2,3). In the group of students aged 13–15, this relationshipwais observed in the group of girls, while in the group of boys this relationship was not so noticeable (Tab. 4). In the group of those aged 16–18, regardless of the respondents' BMI values, the amount of vitamins ingested depended on the quality of food products consumed (Tab. 5).

DISCUSSION

An insufficient amount of nutrients in the diet can have a negative impact on a person's physical and psychological state. Vitamins are vital for the body to function correctly, in particular fat-soluble vitamins [2, 6]. In the literature, studies onthe amount of vitamins in the diets of healthy children and healthy adolescents living in rural areas are relatively rare, and most often examine the amount of vitamin D in the diet [2, 8, 11, 19, 20].

While analyzing the eating habits of children and teenagers, most researchers examined a group of respondents of a certain age, without a division based on body weight, which could have affected the research results. The strength of the current study is the very accurate analysis taking into account the age, gender and body weight of the subjects. The study shows that the intake of vitamin D in the study groups was at a very low level, meeting, on average, only 4.5–9% of the daily requirement. The average daily intake of vitamin A in the study group, however, was very high, exceeding the recommended dietary allowance (RDA) by 34–85% among the girls, and by 25–75% among the boys. The intake of vitamin E varied and in some groups did not meet 50% of the adequate intake (AI), while in other cases, the maximum daily intake exceeded the AI by 100%.

Research into the intake of vitamin D conducted among pupils of 10 Belgian provinces and the Brussels Capital Region, showed the lowest intake of vitamin in the 7 – 10-year-old age group. At the same time, irrespective of age, the intake was lower among girls than the lowest intake of the vitamin among boys [5]. Physical activity outdoors in the fresh air

Table 1. Division of study group by gender, age and BMI value

BMI	7-9 years		10-12 years		13-15 years		16-18 years		n/%
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
Below 5 percentile	18/1.5%	6/0.5%	-	7/0.6%	6/0.5%	11/0,9%	1/0,1%	4/0,3%	53/4,5%
5-85 percentile	118/10%	109/9.2%	135/11.5%	144/12.2%	122/10.3%	128/10,9%	50/4,3%	73/6,2%	879/74,5%
85-95 percentile	14/1.2%	13/1.1%	20/1.7%	24/2%	27/2.3%	25/2,1%	5/0,4%	2/0,2%	130/11%
Above 95 percentile	14/1.2%	40/3.4%	21/1.8%	25/2.1%	8/0.7%	6/0,5%	-	4/0,3%	118/10%
Total	332/28.1%		376/31.9%		333/28.2%		139/11.8%		1180/100%

Table 2. Daily vitamin intake among children aged 7-9 years considering the statistical significance regarding differences in vitamin intake in the groups according to the BMI value

Gender/age	Analyzed variable	Mean	Median (IQR)	Min.–Max	Reference Values	p-value
Boys 7-9 years	Vitamin A (µg)	879.43	719.34 (544.39 – 1129.92)	425.23 – 1992.81	EAR 350 RDA 500	p < 0.05
	Vitamin D (µg)	2.95	2.77 (2.33-5.57)	0.70-6.08	RDA 15-25	p < 0.05
	Vitamin E (mg)	6.9	6.7 (5.92-8.85)	4.48-10.34	AI 7	p < 0.05
	Vitamin B1 (mg)	1.3	1.29 (1.05-1.6)	0.77-2.15	EAR 0,7 RDA 0,9	p < 0.05
	Vitamin B2 (mg)	1.62	1.42 (1.2-1.99)	0.89-4.57	EAR 0,8 RDA 0,9	p < 0.05
	Vitamin PP (mg)	15.76	14.81 (11.59-20.09)	9.63-25.35	EAR 9 RDA 12	p < 0.05
	Vitamin B6 (mg)	1.67	1.65 (1.43-2.12)	0.8-2.68	EAR 0,8 RDA 1,0	p < 0.05
	Vitamin B12 (µg)	4.22	2.12 (1.61-3.33)	1.09-12.08	EAR 1,5 RDA 1,8	p < 0.05
	Vitamin C (mg)	48.56	45.5 (28.36-54.4)	8.72-139.39	EAR 40 RDA 50	p < 0.05
	Folates (µg)	209.26	171.0 (152.63-257.5)	120.02-638.74	EAR 250 RDA 300	p < 0.05
Girls 7-9 years	Vitamin A (µg)	928.72	781.12 (578.69 – 1316.53)	450.04-2048.65	EAR 350 RDA 500	p < 0.05
	Vitamin D (µg)	3.84	2.83 (2.08 – 3.09)	1.05 – 12.0	RDA 15-25	p < 0.05
	Vitamin E (mg)	6.4	5.76 (4.69 – 7.2)	3.25 – 12.37	AI 7	p = 0.33
	Vitamin B1 (mg)	1.25	1.34 (1.07 – 1.7)	0.69 – 2.18	EAR 0,7 RDA 0,9	p < 0.05
	Vitamin B2 (mg)	1.51	1.45 (1.36-2.03)	0.92-2.32	EAR 0,8 RDA 0,9	p = 0.1
	Vitamin PP (mg)	17.25	17.24 (16.62-17.83)	9.74-29.57	EAR 9 RDA 12	p < 0.05
	Vitamin B6 (mg)	1.78	1.82 (1.6-2.69)	1.00-2.98	EAR 0,8 RDA 1,0	p < 0.05
	Vitamin B12 (µg)	3.15	2.44 (2.04-2.93)	1.09-9.78	EAR 1,5 RDA 1,8	p < 0.05
	Vitamin C (mg)	47.93	43.38 (30.97-73.06)	8.38-89.49	EAR 40 RDA 50	p < 0.05
	Folates (µg)	186.21	179.68 (154.03-244.53)	114.78-300.07	EAR 250 RDA 300	p < 0.05

AI – Adequate Intake; EAR - Estimated Average Requirement; RDA - Recommended Dietary Allowances

is vital to ensuring the appropriate amount of vitamin D in the body. If there is an insufficient supply of vitamin D in the diet, according to Polish recommendations, this should be supplemented in the autumn and winter seasons. According to Polish recommendations, from 2023, the upper limits for daily cholecalciferol intake for vitamin D deficiency prophylaxis in children aged 1–10 years is 50 µg, and for adolescents aged 11–18 years – 100 µg [17]. None of the children in the study were taking any vitamin supplements at the time the research was conducted. This is dangerous as vitamin D is vital in the process of bone mineralization, and a deficiency in the body increases the risk of the development of cancers and autoimmune diseases, and in particular increases the risk of infection with coronaviruses, including COVID-19 [17, 21].

The current study is consistent with the above study on Belgian children and adolescents with regard to the intake of vitamin D. However, the results regarding the levels of vitamin A intake did not confirm the results of the Belgian study, which showed an insufficient intake of this vitamin in all study groups, with the lowest among children aged 7–10 [5].

Vitamin A hypervitaminosis can lead to an increase in body mass, headaches and pains in the limbs, skin diseases and impaired vision [22]. The current study did not analyse the existence of dependencies between vitamin A intake and the occurrence of pain. It was shown, however, that in age groups up until 15 years of age, large amounts of vitamin A were found in the diets of groups with excessive body mass. Among adolescents (aged 16–18), large amounts of vitamin A were found in the diets of those with insufficient body mass.

As indicated in the literature, large amounts of vitamin A (retinol) are found in offal, yellow cheese, butter and margarine [16, 22]. It may be that the large amounts of the

Table 3. Daily vitamin intake among children aged 10-12 years considering the statistical significance regarding differences in vitamin intake in the groups depending on the BMI value

Gender/ae	Analyzed variable	Mean	Median (IQR)	Min.–Max	Reference values	p-value
Boys 10–12 years	Vitamin A (µg)	920.57	833.05 (538.5 – 894.95)	229.02 – 1869.77	EAR 450 RDA 600	p < 0.05
	Vitamin D (µg)	3.3	2.48 (1.84-3.73)	1.3-13.14	RDA 25-50	p < 0.05
	Vitamin E (mg)	6.89	6.73 (5.88-9.15)	3.68-12.25	AI 10	p < 0.05
	Vitamin B1 (mg)	1.46	1.41 (1.25-1.72)	0.79-2.39	EAR 0,9 RDA 1,0	p < 0.05
	Vitamin B2 (mg)	1.6	1.49 (1.37-2.27)	1.03-2.9	EAR 0,9 RDA 1,0	p < 0.05
	Vitamin PP (mg)	16.62	15.48 (13.28-21.56)	9.61-26.66	EAR 9 RDA 12	p < 0.05
	Vitamin B6 (mg)	1.85	1.79 (1.51-2.25)	1.23-2.88	EAR 1,0 RDA 1,2	p < 0.05
	Vitamin B12 (µg)	3.36	2.66 (2.15-3.49)	1.23-10.14	EAR 1,5 RDA 1,8	p < 0.05
	Vitamin C (mg)	34.89	29.69 (19.37-54.8)	13.98-71.33	EAR 40 RDA 50	p=0.1
	Folates (µg)	192.77	186.2 (162.95-241.4)	104.49-315.74	EAR 250 RDA 300	p < 0.05
Girls 10–12 years	Vitamin A (µg)	943.65	784.49 (538.5 – 1006.65)	338.16 – 2192.39	EAR 430 RDA 600	p < 0.05
	Vitamin D (µg)	3.59	3.05 (2.32 – 3.78)	0.83 – 11.14	RDA 25-50	p < 0.05
	Vitamin E (mg)	8.25	7.71 (5.86 – 9.77)	3.68 – 15.38	AI 8	p < 0.05
	Vitamin B1 (mg)	1.38	1.15 (0.95 – 1.85)	0.75 – 2.39	EAR 0,8 RDA 1,0	p < 0.05
	Vitamin B2 (mg)	1.59	1.56 (1.34-2.08)	0.82-2.47	EAR 0,8 RDA 1,0	p < 0.05
	Vitamin PP (mg)	18.55	16.97 (11.96-26.32)	5.81-30.09	EAR 9 RDA 12	p < 0.05
	Vitamin B6 (mg)	1.91	1.82 (1.36-2.43)	0.68-2.96	EAR 1,0 RDA 1,2	p < 0.05
	Vitamin B12 (µg)	2.73	2.36 (1.97-3.21)	1.23-10.14	EAR 1,5 RDA 1,8	p < 0.05
	Vitamin C (mg)	48.39	44.06 (28.26-67.6)	11.39-81.27	EAR 40 RDA 50	p=0.09
	Folates (µg)	208.95	198.38 (171.9-268.72)	108.8-332.17	EAR 250 RDA 300	p < 0.05

AI – Adequate Intake; EAR - Estimated Average Requirement; RDA - Recommended Dietary Allowances

vitamin found in the diet are the result of consumption of a large amount of butter in younger groups, and consumption of a large amount of cheese in older groups, and for the study group as a whole, the consumption of cooked dishes in which margarine is used. A diet poor in vitamin D among pregnant women is associated with an increased risk of Caesarean delivery, gestational diabetes, preeclampsia, and pre-term delivery [17]. A deficit of vitamin D is also linked to a sedentary lifestyle, characterized by long periods of time spent indoors (in front of the computer or television), and less outdoor activity [17, 23].

According to Polish recommendations, if healthy children aged 4–10 years sunbath with uncovered forearms and legs for 15–30 minutes between 10:00–15:00 without sunscreen, additional supplementation is not required, although the supplementation in this case is safe and still recommended. If these conditions of being exposed to sunlight are not fulfilled, supplementation of cholecalciferol in a dose 600 – 1,000 IU/day is recommended throughout the year, based on body weight and dietary vitamin D intake. In healthy adolescents, in the event of sunbathing with uncovered forearms and legs for 30–45 minutes between 10:00 – 15:00, the recommendations for supplementation are similar although not necessary, and are safe. If these guidelines are not fulfilled, supplementation based on cholecalciferol in a dose of 1,000 – 2,000 IU/day is recommended throughout the year, based on body weight and dietary vitamin D intake [17]. It is estimated that nowadays, 90% of the population worldwide suffer from a deficiency of vitamin D [2, 20]. An excess of natural vitamin D is not harmful as the body disposes of it by producing skin pigment [2, 9, 20, 24].

A deficiency of vitamin A in the diet, similarly to vitamin D, can impair the formation of the teeth, and lead to underdevelopment of the dentine, or periodontal diseases [24]. At

Table 4. Daily vitamin intake among children aged 13-15 years considering the statistical significance regarding differences in vitamin intake in the groups depending on the BMI value

Gender/age	Analyzed variable	Mean	Median (IQR)	Min.–Max	Reference values	p-value
Boys 13–15 years	Vitamin A (µg)	995.13	845.74 (538.5 – 1144.33)	332.41 – 1942.29	EAR 630 RDA 900	p=0.28
	Vitamin D (µg)	4.66	3.52 (2.37-6.6)	1.25-12.48	RDA 25-50	p=0.13
	Vitamin E (mg)	9.61	8.57 (7.89-14.17)	3.68-20.01	AI 10	p=0.15
	Vitamin B1 (mg)	1.65	1.54 (1.34-2.1)	0.91-2.87	EAR 1,0 RDA 1,2	p < 0.05
	Vitamin B2 (mg)	2.02	2.05 (1.51-2.78)	1.07-3.63	EAR 1,1 RDA 1,3	p=0.15
	Vitamin PP (mg)	22.05	20.97 (16.97-27.16)	11.39-42.43	EAR 12 RDA 16	p < 0.05
	Vitamin B6 (mg)	2.31	2.25 (1.8-2.94)	1.15-4.43	EAR 1,1 RDA 1,3	p < 0.05
	Vitamin B12 (µg)	4.08	3.18 (2.39-5.73)	1.25-16.98	EAR 2,0 RDA 2,4	p < 0.05
	Vitamin C (mg)	56.27	56.95 (37.5-94.57)	12.07-137.32	EAR 65 RDA 75	p < 0.05
	Folates (µg)	259.36	241.45 (218.35-359.95)	137.78-469.57	EAR 330 RDA 400	p=0.35
Girls 13–15 years	Vitamin A (µg)	1155.83	895.85 (655.29 – 2055.56)	332.41 – 2876.27	EAR 490 RDA 700	p < 0.05
	Vitamin D (µg)	4.17	3.57 (2.62 – 5.13)	0.95 – 13.55	RDA 25-50	p < 0.05
	Vitamin E (mg)	9.37	8.0.8 (6.80 – 9.63)	4.02 – 17.38	AI 8	p < 0.05
	Vitamin B1 (mg)	1.51	1.39 (1.25 – 1.93)	0.66 – 2.81	EAR 0,9 RDA 1,1	p < 0.05
	Vitamin B2 (mg)	1.79	1.7 (1.44-2.38)	0.68-3.08	EAR 0,9 RDA 1,1	p < 0.05
	Vitamin PP (mg)	21.13	20.66 (16.53-26.32)	6.37-34.21	EAR 11 RDA 14	p < 0.05
	Vitamin B6 (mg)	2.15	2.15 (1.59-2.75)	0.71-3.89	EAR 1,0 RDA 1,2	p < 0.05
	Vitamin B12 (µg)	3.16	2.62 (2.12-3.91)	0.82—14.58	EAR 2,0 RDA 2,4	p < 0.05
	Vitamin C (mg)	55.18	49.73 (37.5-87.35)	14.90-142.89	EAR 55 RDA 65	p < 0.05
	Folates (µg)	242.88	239.22 200.08-287.97	137.78-375.81	EAR 330 RDA 400	p < 0.05

AI – Adequate Intake; EAR - Estimated Average Requirement; RDA - Recommended Dietary Allowances

the same time, vitamins A, E and C, which are natural anti-oxidants, protect nervous system cells from oxidising damage by inhibiting the harmful action of free radicals and removing any excess from the body. The best sources of anti-oxidants are: onion, broccoli and spinach – vegetables that are most often disliked by children. Even if the recommended intake of vitamin E in the diet is exceeded several dozen times, this does not cause overdose symptoms, which can include muscle weakness, headaches and impaired vision [6, 8, 25]. The children and adolescents in the Belgian study had an insufficient intake of vitamin E with the median intake from food at between 73–92% of the AI [5]. Vitamin C, a natural anti-oxidant, seals the walls of the blood vessels, accelerates the healing of wounds and lowers the risk of cancer. Levels of vitamin C intake vary enormously [24], with the diets of the pupils in the study meeting 20–278% of the recommended dietary allowance (RDA). The lowest daily intake of vitamin C was just above 8 mg, compared to a requirement of 50 mg. Such a low intake of the vitamin can cause an over-active thyroid gland, depression or scurvy. Among those who may suffer from complications resulting from insufficient vitamin C are those taking iron supplements [25–28].

Appropriate levels of group B vitamins in the diet have a positive effect on the central and peripheral nervous system [2, 29]. The current study shows that the maximum daily intake of group B was comparatively high in relation to the recommended dietary allowance (RDA). However, analysis of the minimum daily intake of group B vitamins showed that in the older age groups the intake was insufficient and did not even meet 50% of the daily requirement. This phenomenon was noted more often among the girls than the boys.

Comparison of the results obtained from the current study into the intake of group B vitamins with research by other authors is difficult as their availability is limited. Insufficient

Table 5. Daily vitamin intake among children aged 16-18 years considering the statistical significance regarding differences in vitamin intake in the groups depending on the BMI value.

Gender/age	Analyzed variable	Mean	Median (IQR)	Min.–Max	Reference values	p-value
Boys 16–18 years	Vitamin A (µg)	1126.9	1089.35 (865.01 – 1356.52)	332.41 - 2045.01	EAR 630 RDA 900	p=0.24
	Vitamin D (µg)	5.86	5.45 (3.74-7.85)	1.23-18.46	RDA 25-50	p=0.21
	Vitamin E (mg)	12.4	9.59 (8.91-16.72)	7.19-23.99	AI 10	p=0.13
	Vitamin B1 (mg)	1.75	1.6 (1.56-2.25)	1.16-2.68	EAR 1,0 RDA 1,2	p=0.09
	Vitamin B2 (mg)	2.37	2.4 (1.89-3.24)	1.4-3.6	EAR 1,1 RDA 1,3	p=0.46
	Vitamin PP (mg)	24.07	25.29 (19.37-30.1)	11.39-40.26	EAR 12 RDA 16	p=0.24
	Vitamin B6 (mg)	2.5	2.44 (1.92-3.01)	1.47-3.5	EAR 1,1 RDA 1,3	p=0.36
	Vitamin B12 (µg)	5.09	4.49 (2.83-6.8)	2.20-16.98	EAR 2,0 RDA 2,4	p=0.53
	Vitamin C (mg)	65.36	54.66 (45.89-69.89)	15.85-137.47	EAR 65 RDA 75	p=0.27
	Folates (µg)	301.06	297.0 (236.23-373.74)	181.92-421.23	EAR 330 RDA 400	p=0.64
Girls 16–18 years	Vitamin A (µg)	944.34	766.14 (637.44 – 1119.58)	332.41 – 1433.97	EAR 490 RDA 700	p=0.09
	Vitamin D (µg)	5.5	4.41 (3.23 – 6.04)	0.85 – 14.31	RDA 25-50	p=0.34
	Vitamin E (mg)	9.89	8.69 (7.66 – 10.28)	5.52 - 18.95	AI 8	p=0.43
	Vitamin B1 (mg)	1.52	1.39 (1.25 – 1.82)	0.66 – 2.62	EAR 0,9 RDA 1,1	p=0.23
	Vitamin B2 (mg)	1.93	1.64 1.51-2.52	0.68-3.24	EAR 0,9 RDA 1,1	p < 0.05
	Vitamin PP (mg)	20.63	21.19 15.83-28.67	6.37-30.16	EAR 11 RDA 14	p=0.13
	Vitamin B6 (mg)	2.14	2.01 1.75-2.55	0.71-3.63	EAR 1,0 RDA 1,2	p=0.36
	Vitamin B12 (µg)	3.89	2.8 2.2-5.3	0.82-16.58	EAR 2,0 RDA 2,4	p=0.31
	Vitamin C (mg)	58.23	56.71 37.78-88.13	15.85-142.89	EAR 55 RDA 65	p=0.15
	Folates (µg)	254.79	243.11 200.51-321.87	162.47-395.49	EAR 330 RDA 400	p < 0.05

AI – Adequate Intake; EAR - Estimated Average Requirement; RDA - Recommended Dietary Allowances

levels of vitamin B in the diet leads to impaired memory and concentration, but also mouth infections, atrophy of lingual papillae, dysphagia, muscle weakness, heart problems, and in the case of severe, long-term deficiency – beri-beri disease [29]. Research has shown that correct levels of this vitamin in the diets of children and adolescents plays a key role in preventing cardio-vascular diseases (CVD) in adult life [29–31].

Group B vitamins are present in a wide range of foodstuffs, but despite this, modern lifestyles foster deficiencies of this vitamin. Drinking coffee, which can be observed among young teenagers, increases the risk of a vitamin B1 deficiency. The best naturally available vitamin B12 is found in animal products which, in an age of limitations on the intake of red meat due to the risk of colorectal cancer and the increasing popularity of vegetarian diets, may paradoxically lead to deficiencies of this vitamin.

Vitamin B12 deficiency is the most common deficiency that requires treatment. The main symptom of this deficiency is severe anaemia. Low levels of vitamin B12 may also be a risk factor in ischemic heart disease [7, 30, 31]. Folic acid (vitamin B9) is a key component of the diet, and is vital for the formation and maturing of human body cells. A deficiency of the vitamin may lead to degenerative disorders, as well as anaemia and cardiovascular disease [8, 29]. The current study shows that the average daily intake of folic acid in all study groups did not even meet the estimated average requirement (EAR).

Puberty is a time of accelerated growth and increased nutrient requirement. Entering adult life with nutrient deficiencies bears the risk of deficiencies in early adulthood. The reproductive period is between the ages of 15–49. Many young girls become pregnant before they have reached the height and body mass typical for the age of a young woman,

and pregnancy during puberty is a relatively common phenomenon [32–35]. A deficiency in folic acid at the time of conception is strongly linked to the risk of congenital defects of the brain and spine. Taking folic acid before conception and in early pregnancy has a significant impact on reducing the risk of such defects [36, 37].

A study into Filipino pupils living in rural areas showed that 61–93% of the study population were affected by a deficiency in folic acid [3]. The low levels of the vitamin in the diet may be caused by limited access to fresh food [20]. One solution to vitamin deficiencies can be enriching foods with vitamins. In Belgium, this is compulsory for margarines and spreadable fats. The Belgian Supreme Health Council recommends adding vitamin D to foods for the whole population [5]. Similar enrichment of foods has been introduced in Finland where vitamin D is added to dairy products and fats [24]. As prescribed by law, in Poland it is obligatory to enrich margarines with vitamins D and A [17, 23]. In the USA, enrichment of foodstuffs with vitamins has led to the recommended intake being met for vitamins A, D and E in part of the population [26]. Before such enrichment is introduced, it is important to discover which vitamins can be safely added to foods and in what amounts. In preventing vitamin deficiencies in this way, it is crucial not to cause excessive consumption of vitamins and overdosing [27].

The growing problem of excessive body weight caused the WHO to take action aimed at preventing the frequent occurrence of obesity among children [4]. Over the years, in countries with a high *per capita* income, this resulted in the introduction of diets both low in energy, but also poor in nutrients. As a result, in spite of high standards of living, this caused an increase in dietary deficiencies [5]. Analysis in the current study found that 21% of pupils who lived in rural areas suffered from excessive body weight, and that despite excessive intake of kilocalories, there were cases of insufficient vitamin intake.

Vitamins play a key role in the correct functioning of the human body. It is therefore important not only to discover the content of children's and adolescents' diets, but also the types of products that they consume. It is also crucial to discover how hot dishes have been prepared (frying, stewing or steaming) as it must be remembered that the amount of vitamins in the diet may vary depending on how food is prepared, even if the same products are consumed.

According to the authors of numerous studies, the promotion of healthy eating must be started in childhood, as it is at this age that dietary habits are formed which later become consolidated and have a decisive effect on dietary habits in adult life [3, 4, 29]. A key element in the correct composition of the diet can also be the financial aspect, which affects the variety of foods consumed, that is, the intake of fruit and vegetables over the winter period [19].

A limitation of the current study was that participants and their parents used their own containers (devices) for measuring the amount of food products consumed, which could have affected the precision of determining the size of portions. However, both the study participants and their parents were trained in how to determine the size of portions, and how to record foodstuffs. Young people and their parents willingly filled in the questionnaire, which may testify to their interest in nutrition.

It should be highlighted that lifestyle modification in a child is most effective if it involves all members of the family [10], while the primary care doctor plays a crucial role in the screening and early diagnosis of eating disorders and vitamin deficiencies. Providing children with appropriate healthcare significantly reduces the risk of occurrence of any disorders and diseases [38, 39]. Analysis of dietary patterns will allow for adapting appropriate dietary interventions for the studied groups of children and adolescents. These interventions could have a direct impact on the public health of society, and constitute an active participation in preventive healthcare [10].

CONCLUSION

The amount of vitamins in the diet is not in line with recommendations on the correct dietary habits and, as such, requires the implementation of educational activities on the correct composition of the diet, in particular the variety of foodstuffs consumed. The daily supply of vitamin D was insufficient, and therefore must be supplemented, in particular during the autumn and winter seasons. The frequent occurrence of excessive body weight among the children and adolescents in the study indicates the need to change dietary habits.

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