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CHEMICAL ANALYSIS OF MINERALS CONTENT IN DAILY DIETS OF CHILDREN AND ADOLESCENTS GROWN UP IN KRAKOW ORPHANAGES

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ABSTRACT

Background. Numerous studies attest to the role that inappropriate food product groups in the human diet, including children and adolescents diet, leading to abnormal intakes of many important nutrients, such as minerals.

Objectives. These studies were undertaken to assess the coverage of the recommended values for chosen minerals by 205 children and adolescents between the ages of 4 and 20 years, grown up in Krakow orphanages.

Materials and Methods. Sodium, magnesium, zinc, iron, copper, calcium and potassium concentrations in 112 diets of children and adolescents from 7 selected orphanages in Krakow in every season of the year were performed using AAS method. Results obtained were compared to recommended standards in Poland.

Results. Intakes of calcium and potassium were usually too low whilst adequate levels of dietary magnesium and calcium were seen only for the youngest children. Recommended dietary levels of zinc were met in all cases and mostly also for iron and copper. Sodium intakes were however excessive.

Conclusions. The study demonstrates that regular a monitoring and adjusting of the diet is necessary for the assessed children and adolescents in order to correct dietary abnormalities.

Key words: *minerals, nutritive value, children, adolescents, chemical analysis, orphanages*

STRESZCZENIE

Wprowadzenie. Niewłaściwy udział grup produktów spożywczych w diecie człowieka, w tym również dzieci i młodzieży, stwierdzany w licznych badaniach, może prowadzić do niezgodnego z normami spożycia, istotnych z żywieniowego punktu widzenia, m.in. składników mineralnych.

Cel. Badania podjęto w celu oceny pokrycia zapotrzebowania na wybrane składniki mineralne przez 205 wychowanków w wieku od 4 do 20 lat, przebywających w krakowskich domach dziecka.

Materiał i metody. Metodą AAS oznaczano poziom sodu, magnezu, cynku, żelaza, miedzi, wapnia i potasu ogółem w 112 racjach pokarmowych, pobieranych o każdej porze roku z siedmiu domów dziecka. Uzyskane wyniki porównano do obowiązujących norm.

Wyniki. Spożycie wapnia i potasu przez ocenianą populację było najczęściej zbyt małe. Właściwe ilości magnezu i wapnia dostarczały jedynie racje pokarmowe najmłodszych dzieci. Wychowankowie wszystkich ocenianych domów dziecka w pełni pokrywali zapotrzebowanie na cynk, natomiast zapotrzebowanie na żelazo i miedź większość z nich. Natomiast spożycie sodu przez wszystkich uczestniczących w badaniach było zbyt duże.

Wnioski. Uzyskane wyniki badań wskazują na konieczność regularnego monitorowania i korygowania błędów żywieniowych ocenianej populacji dzieci i młodzieży.

Słowa kluczowe: *składniki mineralne, wartość odżywcza, dzieci, domy dziecka*

INTRODUCTION

Children and adolescents belong to the population which is particularly vulnerable to any inadequate eating habits. Some factors, like intensive growth and psychophysical development along with the mental effort and physical activity which is associated with the sport, increase the demand for energy and nutrients. Eating habits which are inadequate to the needs of the organism may lead to disturbances of development and health

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[37, 38]. It has been proved that deficiency or excess of nutrients, which is maintaining for a long time, may play a role in the etiology of certain metabolic chronic non-communicable diseases, among others, cardiovascular diseases, osteoporosis, diabetes or certain forms of cancer [2].

Numerous studies on nutritional habits of children and adolescents confirm an unsatisfactory frequency of consumption of milk, vegetable and wholemeal bakery products; while excessive fats, sugar, sweets and salt. An insufficient daily dietary supply of these products results in deficiencies of essential nutrients, i.e.: valuable protein, vitamins or mineral compounds [38].

Therefore, studies were undertaken to assess the level of selected minerals in the daily diets of children of the orphanages, located in Krakow, in terms of either deficiency or excess of these elements, established based on the current recommendations.

MATERIALS AND METHODS

Chemical analysis of the levels of six mineral compounds, listed below, in 112 daily diets of children and adolescents from the selected, seven orphanages located in Krakow were collected in every season of year (i.e. in the spring, summer, autumn, and winter) for four days in the week (including Saturday and Friday due to different eating habits). The population evaluated consisted of 205 children between the ages of 4 and 20 yrs, of which 82 were girls and 123 were boys (Table 1).

Table 1. Characteristic of children and adolescents from orphanages

Orphanage	Boys [n]	Girls [n]	Age [yrs]		Body mass [kg]	
			range	$\bar{x}$	range	$\bar{x}$
I	12	8	4-6	5.0	13-15	13.6
II	8	15	7-13	11.0	13-43	25.3
III	-	30	11-18	15.0	55-61	59.3
IV	26	14	8-20	15.0	20-79	48.7
V	12	8	14-20	16.6	42-72	52.0
VI	40	-	13-20	16.7	35-96	55.4
VII	25	7	16-18	17.6	20-90	59.8

The content of mineral compounds was established basing on a chemical analysis of the freeze-dried daily diets (lyophilizer Christ Alpha 1-4).The levels of following minerals were established: sodium and magnesium - by means of the flame atomic absorption spectroscopy (AAS), after microwave mineralization [24], zinc, iron and copper - using the flame atomic absorption spectroscopy (AAS), after microwave mineralization [23], calcium and potassium – according to the internal procedure developed in the Department of Gastronomic Technology and Consumption, Food Technology Faculty, University of Agriculture in Krakow [24].

The results obtained have been compared to the current recommendations [15]. In the case of: magnesium, iron, zinc, copper – to the Estimated Average Requirement (EAR), calcium, potassium, sodium - to the Adequate Intake (AI), zinc – additionally to the Upper Level (UL).

To assess the probability of insufficient intake of minerals in comparison to the EAR value (in this study reported as a weighted average of EAR value), Z-score factor was calculated from equation, based on the theory of probability and calculated as:

$$\text{z-score} = \frac{D}{SD_D} = \frac{y - EAR}{\sqrt{SD_z^{\,2} + \left(\frac{SD^2_s}{n}\right)}}$$

where:
D - differences between individual intake of nutrient (y) and EAR value of this nutrient;
SD_D - variability (standard deviation) of the D value;
SD_z^2 - variance of requirements in group;
SD_s^2 - individual variance of consumption of nutrient; N - no of days during which the intake of nutrients was assessed [15].

RESULTS

Statistical analysis revealed that, in general, there were no statistically significant differences in the level of mineral compounds intake, depending on the research season. Thus, the results were discussed based on an average yearly intake and have been presented in Table 2.

The chemical analysis of the daily diets of children and adolescents of the orphanages in Krakow proved that the dietary calcium intake was generally insufficient (Table 2). The average yearly intake of calcium cowered 36-102% of the AI value. Sufficient intake of this mineral was only in the orphanage I, which residents were the youngest children.

In the case of magnesium, discrepancies were observed in its content in the daily diets of assessed population. It has been found, that four institutions out of seven participating in this study, faced the risk of inadequate dietary intake of magnesium; in the remaining institutions, intake of this mineral fully met of the Estimated Average Requirement (EAR) value (Table 2). Assessment of the probability of inadequate daily dietary intake of magnesium showed that adolescents in the oldest age group were exposed to the greatest risk of Mg deficiency (Table 3).

The average iron content in daily diets of children and adolescents was generally satisfactory and fully

Table 2. An average intake of minerals by children and adolescents with daily diets in orphanages

Orphanage	Calcium			Magnesium			Iron			Zinc			Copper			Potassium			Sodium		
	Intake [mg/person/day] $\bar{x} \pm SD$	Coverage of the AI [%] $\bar{x}$	Min-Max	Intake [mg/person/day] $\bar{x} \pm SD$	Coverage of the EAR [%] $\bar{x}$	Min-Max	Intake [mg/person/day] $\bar{x} \pm SD$	Coverage of the EAR [%] $\bar{x}$	Min-Max	Intake [mg/person/day] $\bar{x} \pm SD$	Coverage of the EAR [%] $\bar{x}$	Min-Max	Intake[mg/person/day] $\bar{x} \pm SD$	Coverage of the EAR[%] $\bar{x}$	Min-Max	Intake [mg/person/day] $\bar{x} \pm SD$	Coverage of the AI [%] $\bar{x}$	Min-Max	Intake[mg/person/day] $\bar{x} \pm SD$	Coverage of the AI [%] $\bar{x}$	Min-Max
I	713.7 ±205.5	102.0	646.1-826.0	166.4 ±37.1	151.2	124.3-201.2	5.0 ±2.2	124.3	4.4-5.9	6.4 ±1.7	160.8	5.4-8.9	0.47 ±0.19	157.4	0.22-0.58	2575.3 ±515.7	85.7	2238.6 -3233.1	2734.6 ±773.4	283.3	2123.5 -3176.3
II	565.6 ±173.9	61.2	450.9-759.3	175.5 ±35.5	127.7	139.9-204.7	6.2 ±1.8	126.7	4.1-8.7	7.0 ±1.4	141.3	5.5-8.8	1.09 ±0.23	247.3	0.79-1.41	2293.2 ±551.3	65.0	1600.3 -2702.9	3015.4 ±758.8	260.7	2837.1 -3450.1
III	472.6 ±122.4	36.4	398.5-517.1	153.2 ±36.2	63.0	127.4-184.8	6.3 ±1.7	79.6	4.4-8.6	7.9 ±2.3	110.6	6.6-11.0	0.73 ±0.35	105.0	0.40-1.02	2535.9 ±746.6	50.3	1933.2 -2993.7	3775.6 ±924,9	245.4	3204.5 -4153.3
IV	765.3 ±282.6	63.0	673.3-883.3	271.5 ±48.4	99.7	210.3-314.0	11.5 ±3.7	147.9	7.9-13.6	12.0 ±3.0	156.5	9.2-13.9	1.01 ±0.37	185.5	0.69-1.35	4006.6 ±1000.6	78.2	3660.1 -4717.4	4912.0 ±1453.2	347.3	3614.1 -6653.3
V	679.8 ±134.9	52.3	560.5-777.1	258.1 ±51.8	75.9	218.8-309.9	9.9 ±2.6	124.4	6.3-12.8	12.3 ±3.1	144.9	7.9-16.6	1.19 ±0.45	172.5	0.92-1.59	3283.0 ±459.3	82.0	2894.4 -4060.6	5770.8 ±1360.4	384.8	5078.4 -7341.9
VI	923.0 ±351.9	74.3	629.3-1628.4	227.8 ±38.9	81.3	191.2-256.8	11.6 ±4.0	144.9	8.7-15.4	12.0 ±3.4	149.5	9.2-15.6	0.86 ±0.27	139.8	0.55-1.17	3363.6 ±303.9	72.5	2530.1 -4819.9	4632.8 ±1381.3	312.3	3145.8 -6092.2
VII	604.8 ±233.0	52.3	345.5-874.0	276.0 ±84.2	90.2	203.2-392.1	8.9 ±3,0	121.7	8.3-9.5	11.4 ±3.7	137.6	9.3-13.5	1.07 ±0.23	163.9	0.42-1.65	3651.3 ±1379.4	75.5	2498.9 -4965.7	5096.5 ±1516.7	344.8	3725.6-6989.8

Table 3. Probability of inadequate intake of minerals in relation to the Estimated Average Requirement values [%]

Minerals	Orphanages	Spring	Summer	Autumn	Winter
Magnesium	I	2	15	2	2
	II	50	2	2	2
	III	98	98	98	98
	IV	50	25	50	70
	V	98	98	98	80
	VI	98	98	95	98
	VII	95	98	98	85
Iron	I	50	50	50	50
	II	50	50	30	50
	III	50	50	50	50
	IV	15	20	25	50
	V	50	30	50	50
	VI	30	50	50	20
	VII	50	50	50	50
Zinc	I	50	50	25	50
	II	50	50	30	50
	III	50	50	30	50
	IV	50	15	15	25
	V	50	30	15	50
	VI	50	50	50	20
	VII	50	50	30	50
Copper	I	2	2	2	2
	II	2	2	2	2
	III	98	98	2	2
	IV	10	2	2	2
	V	2	2	2	2
	VI	98	85	2	2
	VII	2	25	2	2

met of the EAR value. But evaluation of the probability of inadequate iron intake showed, that in all analyzed seasons of the year, half children in the institution I, III and VII faced a deficiency of this component; the high risk of insufficient iron intake, ranging from 50 to 70%, was also observed in the institution II, and V. Analysis of the probability proved that with regard to iron content, the daily diets from the institution IV were relatively the best balanced; in this institution from 50% children (in the winter) to 15% (in the spring) have not had their requirements covered (Table 3).

None of the analyzed institutions was at risk of inadequate average zinc intake with the daily diets. Intake of this constituent was consistent or exceeded the EAR value. The recommended value coverage fluctuated between 111% and 161%. At the same time, the tolerable Upper Level (UL) for zinc has not been exceeded. It is the level of chronic intake of a nutrient, physiologically tolerable, and judged to be unlikely to pose a risk of adverse health effects to the human organism in the longer period of time [15]. Analysis of the probability of inadequate zinc intake proved that although an average daily intake of this constituent exceed demand, generally, half the young people in the institutions investigated faced the risk of its deficiency. The highest probability of consumption, corresponding to the demand, was recorded in the autumn season (from 50 to 85%) in majority of the analysed institutions, which is consistent with earlier findings (Table 3).

In all examined institutions, the amounts of copper in daily diets were at the level exceeding the EAR (Table 2); average Cu intake ranged from 105% to 247% of EAR value. Despite the complete coverage of the EAR value, the probability of inadequate to requirement showed, that there was a risk of copper deficiency. In the spring and summer seasons it was observed in the institution III and VI, where an inadequate intake was reported in even 98% the population examined. But in the autumn and winter seasons in all investigated institutions the probability of the intake meeting demand concerned 98% children and adolescents (Table 3).

Potassium intake with daily diets was insufficient in all examined institutions. The coverage of AI value fluctuated between 50% and 86%.

Compared to the Adequate Intake (AI), food diets of all orphanages delivered excessive amounts of sodium. As the intake of nutrient exceeds the AI value, there is low probability of insufficient intake of this constituent. However, sodium dietary intake exceeded even almost 4 times the recommended value in orphanages V (Table 2).

DISCUSSION

Chemical analysis of children's and adolescent's daily diets from orphanages showed alarmingly low intake of calcium. Some authors reported daily dietary intake of calcium at the level below 50% of recommended value [9, 26, 32] or higher intake of this mineral, but still not sufficient to fully meet the demand [6, 13, 19, 21, 31]. According to *Wawrzyniak* et al. [36], who assessed nutrition patterns of children from an orphanage, the coverage of Ca recommended value was less than 80%. Analysis of the children's menus in school-and-education care centres in the Malopolska Region showed that there was divergence in results; average Ca intake in these institutions covered of Recommended Dietary Allowances (RDA) value in 129% [11]. Compare to the other European countries, insufficient intake of milk and dairy products in Poland, providing calcium, reported *Cais-Sokolińska* and *Borski* [4]. According to *Hopp* et al. [14] study, average intake of calcium by Polish children and adolescents, aged 10-18 years, was 297 mg/day/person, by German youth 319 mg/day /person, while intake of this mineral by French boys, Hungarian boys and Croatian girls was 927, 850 and 870 mg/day/person respectively. Compared to the recommended value, higher intake of calcium was found among the

Finnish adolescents. Insufficient calcium intake by adolescents reported also other authors [1, 16, 17].

The results of studies conducted in Poland indicate on the apparent problem of too low calcium intake among children and adolescents as well as other population groups. Its accumulation in bones runs most actively during infancy and puberty that is the rapid growth of the organism [39]. Chronic calcium deficiency in the diet of children and adolescents can carry the risk of osteopenia, earlier occurring osteoporosis, and a fracture risk appearing with age [15]. Another part of this study, published by *Pysz* et al. [25] revealed that daily dietary protein intake was high, exceeding considerably the amounts set in the requirements. The protein negatively affects calcium saturation in the organism; calcium excretion in urine rises with excess dietary protein intake (by 0.5 mg for each gram of dietary protein, when intake was above 47 g/day). This, in turn, may negatively affect bone status, particularly if calcium intake is inadequate. Furthermore, high sodium content in the diet, proved here, reduces calcium retention in the organism through its increasing excretion in urine. However, no association was found between salt intake and skeletal development in the case of children and adolescents [15].

The average magnesium content in daily diets of children and adolescents of Krakow orphanages varied substantially being from 63% to 151% what the EAR sets. These findings are congruent with the literature data [9, 13, 31]. Magnesium deficiency is very common as relates to about 30-60% of the population. Some studies show that there is s a trend toward a fall in the Mg content in the daily diet of Poles; its average intake decreased by 20% [29]. Magnesium intake with the Polish diet, estimated based on data obtained from household budget surveys, conducted by Central Statistical Office, met 76-79% of the recommended value [8]. Other authors also reported insufficient supply of this macroelement [1, 16, 17, 27]. Some other authors reported a proper Mg intake from the diet [14, 28]; or greater than recommended intake of this mineral [11, 36].

In children, Mg deficiency may reduce, among other, their ability to concentrate and to absorb knowledge and, in consequence, may lower their intellectual effort. Deep deficiencies of this constituent may pose a health threat, mainly from the neuromuscular and cardiovascular systems. There are also metabolic changes such as hypocalcemia, which develops when magnesium deficiency is moderate or acute; but even mild deficiency of this component can result in a significant Ca reduction in the blood serum [15].

This research revealed, that average iron intake generally fully covered the EAR value. Adequate [11, 35, 36] or excessive [32] dietary intake of iron, corresponding to the results presented in this paper, was registered by another authors. The results proving the sufficient daily intake of iron from a diet are rarely reflected in the literature. Studies on nutrition patterns of various population groups indicate that children and young people in our country intake too little amount of iron [3, 9, 35]. Similarly, *Hopp* et al. [14] demonstrated adequate intake of iron among Finnish adolescents.Too small iron intake by South African children [17] and in the United States, was reported [1]. Other foreign authors also reported insufficient supply of this mineral with daily diets [14, 18, 30].

The results obtained, combined with those reported by other authors and quoted above, may prove that with regard to iron supply the diet of children from Krakow orphanages is relatively better balanced. However, as other authors claim, recently discussions are more and more frequently focusing on the effects of excessive iron intake from the diet. The main symptoms of this phenomenon are: reduced absorption of other mineral compounds (zinc, copper); an elevated risk of the occurrence of infections; excessive iron accumulation in tissues leading to their damages (e.g. of the pancreas - diabetes, a bone marrow- anemia); as well as formation of free radicals that increases the risk of cancer and coronary disease [12].

Average zinc amounts provided with daily diets in the participating institutions allowed for the full coverage of the EAR value. These results correspond to those reported by other authors who investigate nutritional habits of Polish children [36]. In Poland, it is very often observed that the levels of this mineral in daily diets are insufficient, as is illustrated by numerous literature data [9, 35]. The percentage of children in the United States, who did not cover EAR value, was very low [1], but a very high percentage affected children from South Africa [17]. Inadequate intake of this mineral was also noted by another foreign author [16, 27].

The average copper intake by children of Krakow orphanages demonstrated that there was no risk of its inadequate intake, which is consistent with the findings of other authors, who compiled studies on nutrition patterns of children and adolescents in our country [28]. *Wawrzyniak* et al. [36], who estimated eating habits of children and adolescents of an orphanage in Poznan, proved that their Cu intake was 170% of the EAR value. In Poland, inadequate daily dietary intake of this mineral compound has been observed very often, that is reported by another author [9, 35]. Copper was also a deficit mineral in the daily diets of South African children. The percentage of children, who did not met the RDA was below 90% in 2000 years and 77% three years later [17]. Similarly low intake of copper showed *Klimis-Zacas* et al. [16].

Zinc and copper are essential trace elements necessary for functioning living organisms. As components and activators of many enzymes, they have an effect on several biochemical and physiological processes. Through participation in immune and inflammatory reactions they may also influence the course of diseases which are induced be these reactions. They play a fundamental role in early childhood, when take place intensive processes of growth and development (quot. from *Piotrowska-Jastrzębska* et al. [22]).

Chemical analysis of daily diets showed that participants from all surveyed institutions had an inadequate average daily potassium intake. Other authors in their studies also demonstrated an insufficient potassium intake with a diet in Polish children and adolescents [3, 6, 10, 13, 28]. *Wawrzyniak* et al. [36], when assessing nutritional habits of children in an orphanage, reported dietary potassium intake enough to cover 80% of the AI value. Similarly, among of children living in South Africa, as reported *MacKeown* et al. [17], consumption of potassium was insufficient. Similar results showed *Klimis-Zacas* et al. [16]. The literature data presented above are consistent with the results referring to the children of Krakow school-and-education institutions and most often suggest that potassium intake in children and adolescents is inadequate.

According to the previous epidemiological and clinical studies, association has been confirmed between potassium content in a diet and blood pressure, incidence of stroke, and arrhythmia. It is believed that the intake of large amounts of potassium, especially from natural products such as: vegetables, fruits, nuts, and eggs, protects against the development of hypertension and in the case of patients suffering from hypertension makes it easier to control this state [5].

Daily diets of Krakow children and adolescents, participating in this study, characterized high sodium content that resulted in a significant excess (even up to 285%) of the AI standard. In practice, sodium content in the diet is expressed as the level of a salt consumption. The sodium intake recommended by the authors of WHO report concerning diet, nutrition and non-communicable diseases (WHO, 2003) should not exceed 5 g of salt, which is equivalent to 1958 mg Na/day [15]. The results obtained in this study revealed that intake of sodium exceed considerably the level recommended, since its consumption ranged within 2123-7342 mg/day. This compares with the literature data, which confirm an excessive intake of sodium from a diet. In 2003, the cross-national study has been curried on sodium intake in children and adolescents aged from 1 to 18 yrs. The sodium intake in the youngest children was 510% of the recommended value, and in children aged 4 to 6 years was 654% of the recommended value. In a group of 7-9-year-olds a mean Na intake was 161% what the recommended value sets. In adolescents, aged 13-15 years, the coverage of the sodium recommended value was the highest, being 855%. Similar values were observed in a diet of adolescents ranging in age from 16 to 18 yrs [33]. High sodium intake was also noted by another authors [6, 7, 13, 20, 28].

The results obtained in this research along with those quoted above suggest that although the organism of the child and adult has its own mechanisms for regulation of sodium dietary intake and excretion of the excess, too high intake of this constituent may induce several diseases [30]. Several epidemiological studies revealed that high sodium consumption correlates positively with the occurrence of hypertension, stroke and cancer of the gastrointestinal tract. As earlier said, in the human body there is association between the amount of the salt consumed and the amount of the calcium excreted from the body. In a view of calcium deficiency commonly observed in children and adolescents and reported also in this paper, it is an important aspect of this problem [34].

CONCLUSIONS

Average intake of calcium and potassium with daily diets of children grown up in Krakow orphanages was generally low and ranged in 30-131% and 37-107% of the recommended values. Adequate amounts of magnesium, like calcium, were provided only in daily diets of the youngest children. Diets of the remaining institutions were usually found to be deficient in magnesium. Intake of zinc fully covered requirement in all investigated orphanages, while iron and copper intake in the majority of them. At the same time intake of sodium was too excessive.

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Conflict of interest
The authors declare no conflict of interest.

REFERENCES

1. *Albertson A.M., Thompson D.R., Franko D.L., Holschuh N.M.*: Weight indicators and nutrient intake in children and adolescents do not vary by sugar content in ready-to-eat cereal: results from National Health and Nutrition Examination Survey 2001-2006. Nutr Research 2011;3:229–236.
2. *Bolesławska I., Przysławski J., Schlegel-Zawadzka M., Grzymisławski M.*: The contents of mineral compounds in daily food rations taken by men and woman under

traditional and low carbohydrate “optimal” diet. Zywn Nauk Technol Ja 2009;4(65):303-311 (in Polish).
3. *Bronkowska M., Karcz I.*: Evaluation of minerals contents in daily food rations of low physically active woman. Rocz Panstw Zakl Hig 2007;58(4):609-615 (in Polish).
4. *Cais-Sokolińska D, Borski K.*: Intake of calcium contained in milk and dairy products in diets of children and teenagers in Poland in view of other European countries. Acta Sci Pol Technol 2010;9(3):351-362.
5. *Ciborowska H., Rudnicka A.*: Dietetics. Healthy and Sick Human Nutrition. Dietetyka. Żywienie Człowieka Zdrowego i Chorego. Warszawa, PZWL, 2004 (in Polish).
6. *Czapska D., Ostrowska L., Stefańska E., Karczewski J.*: Assessment of the levels of chosen mineral components in daily food rations of medical university students in the years 2003/2004 and 2008/2009. Bromat Chem Toksykol 2009;42(3):723-727 (in Polish).
7. *Drewnowski A., Rehm C.D.*: Sodium intakes of US children and adults from foods and beverages by location of origin and by specific food source. Nutrients 2013;5:1840-1855.
8. *Dybkowska E.,* Świderski *F., Waszkiewicz-Robak B.*: Mineral components intake in Polish diet. Żyw Człow Metab, Suppl. 1, 2005;1:200-204 (in Polish).
9. *Figurska-Ciura D., Wencel D., Łoźna K., Biernat J.*: Nutrition evaluation of 13 years old adolescents from little town. Rocz Panstw Zakl Hig 2009;60(3):235-239(in Polish).
10. *Frąckiewicz J., Hamułka J., Wawrzyniak A., Górnicka M.*: Students nutrients intke and risk of cardiovascular diseases. Rocz Panstw Zakl Hig 2009;60(3):269-274 (in Polish).
11. *Gacek M.*: Evaluation of collective feeding in a group of school children with mental disability in special educating childcare centres. Rocz Panstw Zakl Hig 2009;60(3):247-250 (in Polish).
12. *Gawęcki J.* (red.): Human Nutrition. Basics of Food Science. Żywienie Człowieka. Podstawy Nauki o Żywieniu. Warszawa, PWN, 2010 (in Polish).
13. *Harton A., Gałązka A., Gajewska D., Bawa S., Myszkowska-Ryciak J.*: Assessment of the intakes of selected minerals by adolents. Bromat Chem Toksykol 2012;15(3):949-955 (in Polish).
14. *Hopp U., Lehtisalo J., Tapanainen H., Pietinen P.*: Dietary habits and nutrient intake of Finnish adolescents. Public Health Nutr 2010;13(6A):965-972.
15. *Jarosz M., Bułhak-Jachymczyk B.* (Ed.): Polish dietary reference intakes. Principles of prevention of obesity and non-communicable diseases. Normy Żywienia człowieka. Podstawy prewencji otyłości i chorób niezakaźnych. Warszawa, PZWL, 2008 (in Polish).
16. *Klimis-Zacas D.J., Kalea A.Z., Yannakoulia M., Matalas A., Vassilakou T., Papoutsakis-Tsarouhas C., Yiannakouris N., Polychronopoulos E., Passos M.*: Dietary intakes of Greek urban adolescents do not meet the recommendations. Nutr Res 2007;27:18-26.
17. *MacKeown J.M, Pedro T.M., Norris S.A.*: Energy, macro- and micronutrient intake among a true longitudinal group of South African adolescents at two interceptions (2000 and 2003): the Birth-to-Twenty (Bt20) Study. Public Health Nutr 2007;10(6):635–643.
18. *Maliye CH., Deshmukh PR., Gupta SS., Kaur S., Mehendale AM., Garg BS.*: Nutrient intake amongst rural adolescent girls of Wardha. Indian J Community Med 2010;35(3):400-402.
19. *Marzec Z, Koch W*: Assessment of selected nutrients intake with students' daily food rations. Probl Hig Epidemiol 2013;94(3),619-621 (in Polish).
20. *Marzec Z., Koch W., Marzec A.*: Evaluation of selected nutrients with student daily diets in Lublin. Bromat Chem Toksykol 2009;42(3):604-609 (in Polish).
21. *Marzec Z., Koch W., Marzec A.*: The influence of supplementation with vitamin/mineral preparations on the total intake of calcium and magnesium among students of universities in Lublin. Bromat Chem Toksykol 2010;43(3):287-292 (in Polish).
22. *Piotrowska-Jastrzębska J., Piotrowska-Depta M., Borawska M., Kaczmarski M., Markiewicz R., Hukałowicz K.*: The content of the chosen trace elements in hair of children with food allergy. Nowa Pediatria 2004;1:13-17 (in Polish).
23. PN-EN 14084:2004: Foodstuffs. Determination of trace elements - determination of lead, cadmium, zinc, copper and iron by atomic absorption spectrometry (AAS) after microwave digestion (in Polish).
24. PN-EN 15505:2008: PN-EN 15505:2008: Foodstuffs. Determination of trace elements - determination of sodium and magnesium by flame atomic absorption spectrometry (AAS) after microwave digestion (in Polish).
25. *Pysz K., Leszczyńska T., Nowacka E.*: Assesment of the energy and basic nutrients intake with daily diets by of residents of chosen orphanages located in Krakow. Zdrowie Publiczne i Zarządzanie, 2013;11(3):250-259 (in Polish).
26. *Sadowska J., Kałdońska K.*: Evaluation of nutrition manner and nutritional status of children with type 1 diabetes mellitus. Bromat Chem Toksykol 2009;42(2):137-146.
27. *Schenkel T.C., Stockman N.K.A., Brown J.N., Duncan A.M.*: Evaluation of energy, nutrient and dietary fiber intakes of adolescent males. J Am Coll Nutr 2007;26(3):264-271.
28. *Socha K., Borawska M.H., Markiewicz R., Charkiewicz W.J.*: An evaluation of the nutritional habits of the students of the institute of cosmetology and health care in Białystok. Bromat Chem Toksykol 2009;42(3):704-708 (in Polish).
29. *Stefańska E., Ostrowska L., Czapska D., Karczewski J.*: Nutrition manner and magnesium content in the hair of students of the Medical University in Bialystok Żyw Człow Metab 2005;32(Suppl. 1):191-195 (in Polish).
30. *Storey K.E., Hanning R. M., Lambraki I.A., Driezen P., Fraser S. N., McCargar L.J.*: Determinants of diet quality among Canadian adolescents. Can J Diet Pract Res 2009;70(2):58-65.
31. *Szczepańska E., Bielaszka A., Mikoda M., Kiciak A.*: Evaluation of calcium and iron content in menus of secondary school girl students living in villages and cities of Silesia. Hygeia Public Health 2011;6(2):266-272.

32. *Szczerbiński R., Markiewicz-Żukowska R., Karczewski J.*: Regulatory nutrients in food rations of the youths living in boarding houses of the county of Sokółka. Bromat Chem Toksykol 2010;43(3):293-299 (in Polish).
33. *Szponar L., Ołtarzewski M.*: Sodium intake by children and adolescents in Poland, a risk factor for health. Spożycie sodu przez dzieci i młodzież w Polsce czynnikiem ryzyka zagrożenia zdrowia. Ped Pol 2004;79(12):983-992 (in Polish).
34. *Szponar L., Respondek W., Zaręba M.*: Sodium chloride in food rations and dinners in mass catering institutions. Rocz Panstw Zakl Hig 2001;52(4):285-293 (in Polish).
35. *Ustymowicz-Farbiszewska J., Smorczewska-Czupryńska B., Goss B., Karczewski J.*: Analysis of chosen microelements and vitamins in the daily food rations of female students of UM on Białystok in the aspect of health-promoting behaviours concerning rational nutrition. Bromat Chem Toksykol 2009;42(3):709–713 (in Polish).
36. *Wawrzyniak A., Hamułka J., Brenk M.*: Assessment of children and teenagers daily food rations in one of the orphanages. Rocz Panstw Zakl Hig 2010;61(2):183-189 (in Polish).
37. *Weker H., Barańska M., Riahi A., Dyląg H., Strucińska M., Więch M., Kurpińska P., Klemarczyk W., Rowicka G.*: Analysis of energy and nutritional value of diets of Polish children aged 13-36 months – nation-wide study. Probl Hig Epidemiol 2013;94(1):116-121 (in Polish).
38. *Wielgos B., Piątkowska E., Kopeć A., Leszczyńska T., Cieślik E., Pysz M.:* Assessment of selected vitamin intake with daily diets by school children (aged 10-12 years) from the Malopolska Region. Probl Hig Epidemiol 2013;94(2): 398-405 (in Polish).
39. *Wlodarek D.*: The role of diet in the prevention of osteoporosis. Endokrynol. Otyl Zab Przem Mat 2009;5(4):245-253 (in Polish).

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