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ORIGINAL ARTICLE

FREQUENCY OF CONSUMPTION OF FOODS RICH IN CALCIUM AND VITAMIN D AMONG SCHOOL-AGE CHILDREN

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ABSTRACT

Background. Calcium is one of the most important minerals for the human body which is essential for healthy bones and teeth. Vitamin D has hormone-like properties in the human body. It is supplied with the diet, but it is also synthesized by the body under exposure to UV radiation. Vitamin D controls calcium and phosphorus metabolism and is responsible for bone modeling and mineralization.

Objective. The objective of this study was to evaluate eating habits and food preferences of school-age children meet the demand for calcium and vitamin D, and estimate the frequency of consumption of foods rich in these nutrients.

Material and methods. A total of 197 parents of 7- to 9-year-olds attending randomly selected primary schools in Lublin and Świdnik were asked to fill out a questionnaire designed by the authors. The results were processed by the *Chi*-squared test in the Excel application.

Results. Considerable differences in the consumption of milk and dairy products were observed between age groups. In the group of 7-year-olds, 57.5% of children drank milk and ate dairy products at least once a day, whereas in the group of 9-year-olds, only 16.6% of children ate dairy products at least once a day. The intake of foods rich in vitamin D was equally low among the surveyed children.

Conclusions. School-age children may be at risk of calcium and vitamin D deficiencies due to low consumption of milk, dairy products and fish, and inadequate vitamin D supplementation. Parents should be educated about nutrition to change the family's eating habits.

Key words*: calcium, vitamin D, children, dietary supplements*

STRESZCZENIE

Wprowadzenie. Wapń jest składnikiem mineralnym niezbędnym do prawidłowego funkcjonowania organizmu, jest podstawowym materiałem budulcowym kości i zębów. Witamina D w organizmie ludzkim ma właściwości hormonu, jej źródło stanowią światło słoneczne, pokarm, suplementacja. Pełni bardzo ważną funkcję w organizmie człowieka, wpływa regulująco na gospodarkę wapniowo-fosforanową oraz modelowanie i mineralizację kości.

Cel. Celem badań była ocena nawyków i preferencji żywieniowych dzieci szkolnych pod kątem pokrycia zapotrzebowania na wapń i witaminę D oraz ocena częstości spożycia produktów bogatych w te składniki odżywcze.

Materiał i metody. Badania przeprowadzono za pomocą autorskiego kwestionariusza ankiety wśród 197 rodziców dzieci w wieku 7-9 lat uczęszczających do losowo wybranych szkół podstawowych w Lublinie i Świdniku. Przeprowadzono analizę otrzymanych wyników testem chi-kwadrat oraz w programie Excel.

Wyniki. Zauważono znaczące różnice w spożyciu mleka i jego przetworów pomiędzy grupami wiekowymi. Wśród 7 latków 57,5 % dzieci piło mleko i spożywało produkty mleczne co najmniej raz dziennie, natomiast w grupie 9 latków tylko 16,6% dzieci przynajmniej 1 raz w ciągu dnia spożywało produkt nabiałowy. Stwierdzono również niską konsumpcję produktów będących źródłem witaminy D.

Wnioski. Dzieci w wieku szkolnym mogą stanowić grupę ryzyka zagrożoną występowaniem niedoborów wapnia i witaminy D, co jest konsekwencją niskiego spożycia mleka i produktów mlecznych, ryb oraz brakiem odpowiedniej suplementacji witaminą D. Konieczna jest edukacja żywieniowa rodziców prowadząca do zmiany sposobu żywienia w rodzinie.

Słowa kluczowe*: wapń, witamina D, dzieci, suplementy diety*

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INTRODUCTION

Calcium is an essential nutrient for healthy body function. The total calcium content of the human body is estimated at 1.4-1.66% of body weight, 99% of which is accumulated in bones in the form of hydroxyapatites produced during osteogenesis [15]. Calcium is the basic building material in bones and teeth, and it plays a very important role in regulating various cell activities. Calcium ions control neuromuscular excitability, blood clotting, transport across plasma membranes, enzymatic reactions and the release of hormones and neurotransmitters [17].

Calcium is supplied with the diet, but it may not be absorbed in quantities that adequately meet the body's nutrient requirements for a variety of reasons. Hypocalcemia, or the drop in serum Ca concentrations below 84 mg/l, can lead to overstimulation of nerves and muscles, tetany seizures, Parkinson's disease symptoms, sensory loss, anxiety and psychosis [14, 22].

Calcium absorption in the gastrointestinal tract is influenced by various factors and substances that stimulate and inhibit this process, including vitamin D_3, magnesium, phosphorus, inulin, sugars, amino acids, casein phosphopeptides, short-chain fatty acids, fiber and oxalic acid [9, 10].

Bone mineralization in children requires calcium and phosphorus. Mother's milk or modified milk are the only sources of calcium for infants and small children. According to the recommendations of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), the Ca:P ratio for healthy bone growth is 1.4-2.0 : 1. Daily calcium demand is determined by the child's age and is estimated at 400 mg/day up to 6 months of age, 800 mg/day up to 10 years of age, and 1200-1500 mg/day in children older than 10 years [24]. The recommended daily allowances (RDA) for adults were estimated in metabolic studies aiming to achieve a daily balance, namely to ensure that amount of calcium supplied with the diet makes up for the loss of calcium which is excreted with feces, urine and sweat. Daily loss of calcium with feces is estimated at 100 to 130 mg [2], with urine – at 150 mg, with sweat – 15 mg [23], and total endogenous losses reach 265-295 mg per day. Daily demand for calcium has been set at 1000 mg by the European Food Safety Authority (EFSA) [19].

Milk and dairy products meet calcium requirements in around 75%. Diets deficient in protein and phosphorus as well as diets highly abundant in those nutrients reduce the availability of calcium and decrease bone mass. The calcium-to-protein ratio (mg calcium/1 g protein) is very important in the diet, and it ranges from 33 to 36 for milk and cheese. Excessive intake of dietary protein can promote the loss of calcium when the above ratio is below 20. For most foods of plant and animal origin, excluding cabbage, the calcium-to-protein ratio is significantly below 20 [37].

Dietary calcium is absorbed in the proximal part of the small intestine in the presence of vitamin D. Lactase deficiency inhibits the absorption of calcium from milk and dairy products. Unbalanced diets, intestinal absorption disorders, chronic diarrhea and bowel inflammations can disrupt bone formation in children and lead to osteoporosis in both children and adults.

The density and calcium content of bones begin to increase at the end of adolescence. According to recent research, peak bone mass is achieved at the age of around 30 years. Peak bone mass is determined by both endogenous (genes, race, sex) and exogenous factors (diet, physical activity, nutritional status, pharmacological treatment, chronic diseases). Bone tissue is lost progressively with age due to the disappearance of bone trabeculae and bone resorption near the marrow cavity. Women lose 35-50% of cancellous bone mass and 25-30% of cortical bone mass, and men – 15-45% and 5-15%, respectively. Insufficient peak bone mass increases the risk of osteoporosis in later life [20, 28].

The main source of calcium are dairy products, followed by grain products, fruit and vegetables. Meat is characterized by low calcium concentrations and high phosphorus levels, and it does not cover even minimal demand for calcium. Products of plant origin such as soybeans, runner beans, kale, sunflower, sesame and hazelnuts contain significant amounts of calcium, but they are also rich in fiber, oxalates and phytates which inhibit calcium absorption in the gastrointestinal tract [11].

Vitamin D has hormone-like properties in the human body. It is supplied with the diet, but it is also synthesized by the body under exposure to UV radiation. Vitamin D controls calcium and phosphorus metabolism and is responsible for bone modeling and mineralization. Vitamin D deficiency has serious implications for the body's physiological balance, and it increases the risk of many chronic diseases [34, 356]. According to recent research, diseases linked to low levels of vitamin D have reached pandemic proportions and pose a threat to public health [17, 30]. The main causes of the growing incidence of vitamin D deficiency in children include less time spent outdoors, use of sunscreen products and decreased intake of foods rich in vitamin D, in particular fish and functional foods [31]. According to estimates, 50% of people in highly industrialized countries do not consume adequate amounts of vitamin D, and 10% of consumers are deficient in this vital nutrient. Vitamin D is involved in the proliferation and differentiation of immune system cells, and vitamin D deficiency in children and adolescents was found to be correlated with hypersensitivity to selected allergens [18, 30].

Vitamin D deficiency is a global problem that should be addressed through pharmacological supplementation, in particular when serum calcidiol levels drop below 50 nmol/l (20 ng/ml) [6]. There are no clear recommendations with regard to a daily dose of vitamin D that would guarantee optimal calcidiol levels in the blood. An increase in serum calcidiol levels from 50 to 80 nmol/l (20 to 32 ng/ml) leads to a 45-65% improvement in the effectiveness of calcium transport in the intestines [12, 33].

The objective of this study was to evaluate eating habits and food preferences of school-age children meet the demand for calcium and vitamin D, and estimate the frequency of consumption of foods rich in these nutrients.

MATERIAL AND METHODS

The study was performed with the use of a questionnaire developed by the author. The questionnaire was addressed to the parents of children aged 7 to 9 years attending primary schools in Lublin and Świdnik. Primary schools situated in residential districts were selected at random, and their students were included in the study upon the principal's prior consent. From the group of 500 prospective subjects, 197 parents agreed to participate in the survey, correctly filled in and returned the questionnaires.

The questionnaire was divided into two parts. The first part consisted of closed-ended questions about the child's health, body mass, height, the family's financial status and the number of family members. Based on the anthropometric data measured by the parents, the children's nutritional status was determined by calculating *Cole's* index [16]. The second part of the questionnaire contained 25 open-ended questions concerning the child's nutritional habits, eating preferences, frequency of consuming meals and various food products, and the quantity and type of beverages in the children's diet. Selected questions addressed the amount of milk and dairy products in the children's daily diet and their consumption frequency. The parents were also asked about the children's physical activity levels, type and duration of physical activity, the number of hours spent on outdoor activities, the use of sunscreen creams and nutritional supplements, in particular vitamin D.

The results were processed in the Excel application. The answers to questions concerning the children's consumption of milk and dairy products, gender, age, nutritional status and the number of children in the family were processed by the chi-squared test. Critical values of C_a^2 were read from the chi-squared distribution table at a significance level of α=0.05 and (r-1) (k-1) degrees of freedom.

The surveyed sample consisted of 197 parents, including 51 (26%) parents of children aged 9 years, 73 parents (37%) of children aged 7 years, and 73 parents (37%) of children aged 8 years (Table 1). The majority of children were girls (55.3%) and children with at least one sibling (64%). Only 11.6% of the surveyed subjects evaluated their financial status as poor, whereas the remaining parents claimed to have a good and very good financial standing. The children's nutritional status was calculated with the use of *Cole's* index based on the classification system proposed by *McLaren* (Table 2).

Table 1. Average height and weight of children in the evaluated groups, per age category.

Demographics			
Parameter (number of children)	n (73)	n (73)	n (51)
Age [years]	7	8	9
Average height [cm] ± SD	118±9	128±11	136±12
Average weight [kg] ± SD	24±3.3	28±5.6	33±5.1

Table 2. The children's nutritional status proposed by *McLaren*

Cole's index	Nutritional status	Girls n = 109	Boys n = 88
> 120%	obesity	-	-
110-120%	overweight	14	16
90-110%	standard	75	59
85-90%	mild malnutrition	9	7
75-85%	moderate malnutrition	11	6
< 75%	severe malnutrition	–	–

RESULTS

The results indicate that most 7-year-olds ate 3 or more meals per day, but 20.5% of the subjects from that group ate only 2 meals per day, and those children were statistically more likely to be mildly to moderately undernourished. The percentage of children consuming 4 and 5 meals per day increased with age.

Lunch was the meal that was most frequently eaten by all children. A total of 191 children always had lunch, and half of them ate lunch both at home and in school, regardless of gender and age. There was a predominance of children from families with 2 and more children in the group of students who ate lunch in school. Breakfast was eaten regularly by 88% of the surveyed children, and it consisted mostly of sandwiches (n=123), cereal with milk (n=78) and dairy products containing sugar (n=93). Cereals with milk and milk soups were the most popular breakfast foods in the youngest group, regardless of gender. Ninety percent of the respondents were provided with second breakfast packed for school, mostly sandwiches (n=134), fruit (n=45), fruit juice or nectar (n=101), sweet pastry (n=68) and vegetables

Table 3. Most popular foods and dishes subject to gender and age

	Girls			Boys		
	7 year-olds **(n)**	8 year-olds **(n)**	9 year-olds **(n)**	7 year-olds **(n)**	8year-olds **(n)**	9 year olds **(n)**
Breakfast						
Sandwiches	19	24	26	17	26	11
Cereals with milk	24	10	9	17	12	6
Yoghurt/cream cheese	17	15	16	13	15	17
Fruit	3	7	6	1	5	2
Other (pasta, dumplings)	2	3	1	2	4	3
Second breakfast (elevenses)						
Sandwiches	27	24	18	20	24	21
Teacakes/donuts	9	16	11	8	14	10
Sweets	7	10	10	9	13	11
Cakes	4	7	5	2	8	3
Fruit	12	8	6	7	9	3
Fruit juice/nectar	19	17	15	23	11	16
Vegetables	3	4	1	6	8	5
Lunch/dinner at school	23	33	22	25	30	17
Lunch/dinner at home	23	24	20	19	26	19
Late dinner/supper						
Sandwiches	17	20	19	15	21	13
Salads	8	11	9	7	5	6
Sweets/cakes/pastry	3	5	1	4	2	6
Cereals with milk/milk porridge/groats	17	15	4	10	7	8
Hot supper	9	21	15	10	14	17

(n=27) (Table 3). Dinner was the least regular meal, and 15% of girls and 11% of boys skipped dinner, mostly because they had a late lunch or went to sleep early.

In the analyzed population, differences in milk consumption were noted between age groups. In general, the consumption of pure milk decreased with age (Table 4). In the group of 7-year-olds, 57.5% of children drank milk and ate dairy products at least once a day, whereas in the group of 9-year-olds, only 16.6% of children ate dairy products at least once a day and, according to the parents, more often on school days than on weekends.

Table 4. Frequency of milk and dairy product consumption, per age group

Age	How often does your child drink milk and eat dairy products?	**n**
7 years	a) daily, during one meal	33
	b) daily, during two meals	9
	c) every other day	19
	d) once a week	8
	e) never	4
8 years	a) daily, during one meal	15
	b) daily, during two meals	8
	c) every other day	28
	d) once a week	12
	e) never	10
9 years	a) daily, during one meal	7
	b) daily, during two meals	0
	c) every other day	20
	d) once a week	13
	e) never	11

No differences were observed between boys and girls. In the group of 9-year-olds, differences resulting from the number of children in the family were noted. Milk and dairy products were more often served in large families (mostly at breakfast) than in families with one child. The children's nutritional status and the family's financial situation did not influence the frequency of milk and dairy product consumption ($x^2<x^2_\alpha$).

The children's preferences regarding calcium-rich products changed with age (Figure 1). Milk and yogurt were most popular with 8-year-olds, whereas 7-year-olds showed a preference for ripened cheese and processed cheese. Children were least likely to opt for fermented milks, such as natural yogurt and kefir, whereas flavored milk was the most popularly selected food. The family's financial standing was not correlated with the consumption of milk and dairy products, but children from more affluent families more often ate yogurt and flavored cream cheese products ($x^2>x^2_\alpha$).

In the analyzed population, the average consumption of milk and dairy products was determined at 321±125 g/day. It was highest among 7-year-old girls and lowest among 9-year-old boys.

Calcium deficiencies can be effectively remedied with mineral water enriched with this nutrient. According to questionnaire data, children did not drink fruit juice supplemented with calcium. In the analyzed population, daily fluid intake reached 1550 ± 350 ml regardless of sex or age. Most children reached for fruit nectar (73.1%), carbonated fruit drinks (53.8%),

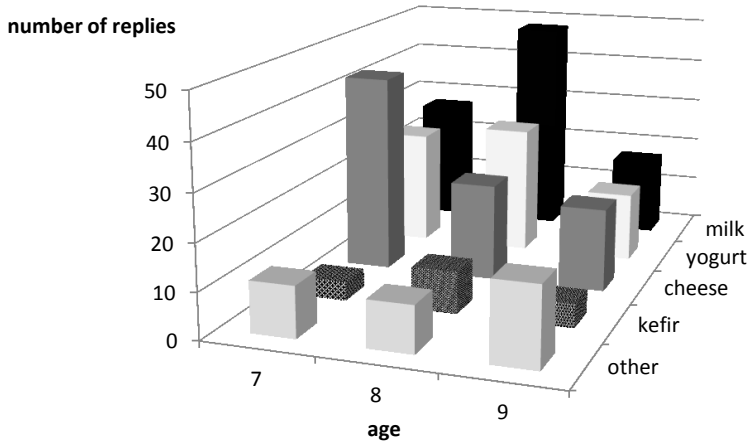

Figure 1. Dairy products most frequently chosen depending on the age of the children (the ability to choose multiple answers)

tea (43.1%), flavored mineral water (37%) and mineral water (33%). Mineral water and flavored mineral water were chosen more frequently by children who were more physically active than children who were not involved in any forms of physical activity outside of school, but no differences were observed between the sexes or age groups.

The children's average intake of mineral water (most children had a preference for regional brands with medium mineral levels, such as Nałeczowianka and Cisowianka) ranged from 280±90 ml in girls to 450±120 ml in boys, which translates into daily Ca^{2+} intake of 30.8±9.9 to 58.5±15.6 mg.

The consumption of phytate-rich foods, which can reduce the availability of dietary calcium, was very low in the analyzed population. Only 11 children ate legumes, soybeans and chickpeas in the amount of 1 serving per week. Oatmeal was more popular, mostly in the form of porridge or muesli, and it was consumed by 22 children at 1-2 servings per week. No differences were observed between genders or age groups, but students from families with 2 or more children ate porridge more frequently. Products rich in oxalates, such as rhubarb, figs, berries, nuts, whole-grain bread, cocoa and chocolate milk, were consumed sporadically.

Outdoor activities can boost vitamin D synthesis in the skin due to increased exposure to sunlight. Children from all age groups spent an average of 1.5 hours ± 25 minutes outdoors every day. Boys from all age groups played outdoors 30 minutes longer than girls on average. Prolonged physical activity, such as riding a bicycle or playing ball for 2-3 hours, was declared by 23.3% of 7-year-olds, 33% of 8-year-olds and 27.4% of 9-year-olds. The study was carried out in spring when most children play outdoors between 2 p.m. and 6 p.m., which should support optimal vitamin D synthesis in the skin.

In the studied population, only 23.3% of children liked fish, preferably fried or smoked. One serving of fish per week was the norm for 43.1% of the surveyed subjects, whereas only 20% of the children ate fish more than once a week. Ripened cheese and eggs were the most frequently consumed sources of vitamin D in the studied population. In this study, only 21.9% of 7-year-olds, 17.8% of 8-year-olds and 15.7% of 9-year-olds received vitamin D supplements in winter months.

DISCUSSION

Calcium and vitamin D are mutually dependent nutrients that are vital for bone health. In children and adolescents, calcium and vitamin D deficiencies, in particular in periods of intensive growth, decrease peak bone mass, which compromises age-related involution and can lead to the achievement of the bone fracture threshold at an earlier age. Milk and low-processed dairy products should be the main source of calcium and vitamin D in children's diets. Two daily servings of milk and 2 daily servings of dairy products should supply 800-1000 mg of calcium. In this study, only 9.1% of children consumed the recommended amount of calcium-rich products covering their minimum daily requirements for this nutrient. Ripened cheese, a popular food in all age groups, is abundant in calcium, but also fat, including saturated fat, as well as phosphorus. Frequent cheese consumption can contribute to weight gain and lower the availability of calcium. In Poland, the daily consumption of milk and dairy products among children and adolescents aged 10-18 years is estimated at 413.5 g/person [3].

According to the literature, the consumption of ripened cheese, processed cheese and fruit-flavored yogurt continues to increase in Poland at the expense of pure milk. *Szczepaniak* et al. [32] studied 787 secondary school students in the area of Mrągowo, Sosnowiec and Kępno to demonstrate very low consumption of pure milk (only 14% of respondents) and a significant increase in the popularity of ripened cheese and yogurt.

Wądołowska et al. [35] evaluated school children's preferences and frequency of milk and dairy product consumption. The cited authors surveyed 1498 school children (820 girls and 678 boys aged 15 to 19 years) from selected regions in northern, central and eastern Poland. The respondents had a clear preference for fruit--flavored fermented milk beverages and ripened cheese. The students' choices of dairy products were based mainly on the product's quality, its sensory attributes and, less frequently, nutritional value. No significant differences in factors influencing the respondents' choices were observed between genders.

The results of a national survey confirmed that the age-related decrease in the consumption of pure milk is probably the main factor responsible for the low dietary intake of calcium among children and adolescents [25]. Children are increasingly likely to eat calcium--deficient diets due to lower intake of dairy products and growing popularity of foods containing substances that reduce calcium absorption by even 50% [27]. Calcium deficiencies were noted in groups of pre-school children [26] and school students [4] characterized by low consumption of milk and dairy products. Calcium intake was inadequate regardless of sex and season [5].

A study conducted in the United States confirmed that frequent consumption of sweetened beverages before the age of 5 years could be responsible for the limited intake of pure milk among adolescents and adults [1].

According to the recommendations formulated as part of the Polish program for the prevention of vitamin D deficiency [7], children and adolescents aged 2-18 years should receive vitamin D supplements in the amount of 10 µg/day (400 IU) between October and March as well as in the remaining months of the year when exposure to sunlight is insufficient to promote vitamin D synthesis in the skin. Only around 20% of the surveyed children received single-vitamin and multi--vitamin supplements containing vitamin D, mostly in the daily amount of 3±2 µg. The diets of the remaining children were not supplemented, the parents were not aware of the need for supplementation, and they had never discussed such an option with their pediatrician.

It is generally believed that 15 minutes of daily sun exposure with 18% of body surface area without sunblock protection provides adequate amounts of vitamin D, but at Poland's latitude, this is only effective from April to October between 10 a.m. and 3 p.m. In the remaining months of the year (November to March), the children's diet should be the main source source of vitamin D.

In the summer months, 68.8% of girls and 60.2% of boys had sunscreen applied before playing outdoors in the sun. The parents used sunscreen products to protect their children against harmful effects of UV radiation or protect children with hypersensitive skin. Children are particularly exposed to the harmful effects of sunlight and UV radiation on the skin, therefore, sunscreen use should be accompanied by oral supplementation with vitamin D [29]. According to research, creams with SPF15 block vitamin D synthesis in 99% and products with SPF8 – in 92%.

Recent studies of European populations aged 1-18 years also revealed severe vitamin D deficiency regardless of the respondents' age or region of origin [8, 13].

The children evaluated in this study were characterized by average levels of physical activity. In every age group, more than 20% of children were reluctant to become involved in any form of exercise, which is a very worrying phenomenon that could be exacerbated with age and, together with an unbalanced diet, contribute to weight gain in the future. Similar results were reported by *Marcysiak* et al. [21] in a study of primary and secondary school students in the Ciechanów county. Nearly 30% of the surveyed population from all age groups had a sedentary lifestyle and preferred to spend their free time using a computer or watching television.

More than half of the parents surveyed in this study (56.3%) showed an interest in the role that calcium and vitamin D play in healthy growth, whereas 25.7% of the respondents did not recognize the importance of healthy nutrition and were not willing to expand their knowledge in that area. The issue was more likely to attract the attention of mothers than fathers and of parents of single children. The parents' attitudes were not influenced by the family's financial standing.

CONCLUSIONS

1. The consumption of calcium-rich foods, in particular milk and dairy products, was low in the analyzed population.
2. Mineral water can be an additional source of calcium, but it covers less than 10% of the daily demand for this nutrient.
3. The surveyed children did not have a preference for foods rich in vitamin D. The use of sunscreen cream can also lower vitamin D synthesis in the skin under exposure to sunlight.
4. Only less than 20% of the surveyed children received vitamin D supplements, and most parents were of the opinion that only infant and toddler diets required supplementation with vitamin D.
5. Parents and caretakers require comprehensive nutritional education in order to effectively change the eating habits of the entire family.

Conflict of interest
The Author declare no conflict of interest.

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