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INTAKE OF CALCIUM CONTAINED IN MILK AND DAIRY PRODUCTS IN DIETS OF CHILDREN AND TEENAGERS IN POLAND IN VIEW OF OTHER EUROPEAN COUNTRIES

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Background. In many European countries a trend to eliminate milk and dairy products from everyday diet may be observed with increasing frequency. Elimination of milk and dairy products from the diet is connected with a reduced supply of calcium required for normal growth and development in children and adolescents
Material and methods. The aim of the study was to assess calcium intake related with the consumption of milk and dairy products by children and adolescents aged 10-18 years in Europe, particularly Poland. Respondents came from families of a good socio-economic position, were aware of principles of rational nutrition and could freely consume dairy products.
Results. Based on conducted investigations it was found that calcium intake by respondents in Poland was 297.2 mg/day, at a European mean of 493.6 mg/day (575.2 mg/day/person ♂, 411.9 mg/day/person ♀). Calcium supply in individual countries is not correlated with the amount of consumed milk and dairy products. The biggest amounts of milk and dairy products are consumed by children and adolescents in Croatia (1396.2 g day/person), while the lowest in Germany (378.5 g/day/person). In Poland the consumption of milk and dairy products is 413.5 g/day/person.
Conclusions. Conducted investigations showed a very low calcium intake in examined children and adolescents aged 10-18 years. These levels are too low, as they account for 38% daily calcium allowance recommended by WHO/FAO for this age group, amounting to 1300 mg/day/person.

Key words: calcium, dairy products, osteoporosis

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INTRODUCTION

In many European countries a trend to eliminate milk and dairy products from everyday diet may be observed with increasing frequency. This problem becomes of particular importance when the rejection of dairy products concerns healthy children and adolescents, with no allergy to milk or lactose intolerance. There may be numerous causes to this phenomenon, such as e.g. imitation of inappropriate eating habits of adults, willingness to reduce fat content or socio-economic situation. Sometimes children and adolescents are forced to accept such a situation when parents do not purchase milk and dairy products when doing shopping. Elimination of milk and dairy products from the diet is connected with a reduced supply of calcium required for normal growth and development in children and adolescents [Black et al. 2002, Du et al. 2002, Kalkwarf et al. 2003]. Calcium is necessary to ensure adequate bone mineralisation [Ilich and Kerstetter 2000, Dodiuk-Gad et al. 2005].

The skeletal system accumulates 99.5% total amount of systemic calcium. Apart from its supportive and locomotion functions, the skeleton serves the role of a calcium store, which is used especially by the developing organism. Calcium content in the human body changes from approx. 20-50 g in newborns to 1200-1300 g in adults. This variation constitutes the cause of differences in the requirement for this element depending on the age and sex [Murphy et al. 1994, Kardinaal et al. 1999, Teegarden et al. 1999]. An important factor determining a reliable assessment of calcium requirement is connected with eating habits of a given society [Harel et al. 1998, Gueguen and Pointillart 2000]. Low calcium intake in the diet is the most frequent cause of osteopenia or osteoporosis [Bronner and Pansu 1999, Bonnick and Shulman 2006]. Although osteoporosis is usually associated with the elderly population, the disease can begin in childhood. Prevention strategies such as balanced nutrition, regular exercise, and the avoidance of risk factors should be implemented from an early age. In adult years, these prevention strategies, as well as early identification and management of at-risk patients will reduce the individual and socioeconomic burden associated with the disease [Riggs and Melton 1995, Gold 2001]. All patients with osteopenia and osteoporosis should be encouraged to adopt a bone-healthy diet and lifestyle, as it is never too early to improve bone strength and reduce the risk of future fracture [Collins 2007].

The aim of the study was to assess calcium intake related with the consumption of milk and dairy products by children and adolescents aged 10-18 years from Poland in relation to selected European countries. Their eating habits and consumer preferences were analysed in terms of their sex. A dependence was presented between calcium supply in the diet and the degree of potential risk of osteopathy, osteopenia or even osteoporosis.

MATERIAL AND METHODS

Consumption of milk and dairy products. The experiment was based on a survey conducted among 222 children and adolescents aged 10-18 years. The survey was carried out in 6 European cities: Poznań (Poland), Cork (Ireland), Split (Croatia), Rennes (France), Berlin (Germany) and Budapest (Hungary). In each city a total of 37 individuals of school age were surveyed, including 18 boys and 19 girls. Children and adolescents participating in the survey were healthy, came from family of a good socio-

economic position and regularly consumed at least 3 meals a day. The respondents repeatedly declared that they watched commercials, read leaflets, participated in educational programs on the role of milk and dairy products in appropriate daily diet. All participating children and adolescents filled in a questionnaire in their native language, anonymously and independently, not aided by adults. The level of consumption for 11 individual assortment groups of dairy products was defined in servings. A serving of milk was assumed to be 250 dm^{-3}, a serving of yoghurt, kefir and other fermented drinks to be 150 g, for cheeses coagulated by enzymes (hard cheeses) it was a 40 g slice, for cheeses coagulated by enzymes (soft cheeses), cheeses coagulated by lactic acid (fresh white) and cheeses based on lactic acid curd it was a 10 g slice, for processed cheese it was a serving of 25 g, while for desserts it was 150 g and ice-cream – that of 100 g, respectively. The respondents gave data on the consumption of milk and dairy products during 1 month. The survey was conducted in the spring and summer months of 2009.

Calcium content in milk and dairy products. Calcium in dairy products was determined using the ASA methodology [ISO... 2007]. Material for experiments comprised samples of commercial products available in retail in cities, where the survey was conducted (n = 66).

Statistical analysis. Statistical calculations were performed using a data analysis software system STATISTICA (version 8.0) by StatSoft Inc. [2008].

RESULTS AND DISCUSSION

Mean daily consumption of calcium contained in milk and dairy products by children and adolescents aged 10-18 years, living in Poland was 297.2 mg/day/person, respectively (Fig. 1). On average all polled children and adolescents consumed 493.6 mg/day/person (575.2 mg/day/person ♂, 411.9 mg/day/person ♀). This amount constitutes only 38% daily calcium allowance recommended by the WHO/FAO, defined as 1300 mg/day/person. It is a small amount, especially since it is recommended to cover 50-80% daily calcium requirement with milk and dairy products. However, when analysing the diet of children and adolescents from individual countries and in terms of respondents' sex it may be stated that the biggest amount of calcium in milk and dairy products is consumed by boys in France (926.5 mg/day/person) and Hungary (850 mg/day/person), as well as girls in Croatia (870 mg/day/person). The lowest amounts of calcium contained in milk and dairy products are consumed by children and adolescents in Poland (297.2 mg/day/person) and Germany (319.1 mg/day/person). Diet of girls in Germany was poorest in calcium, which amounted to as little as 192.4 mg/day/person. Calcium supply in individual countries is not correlated with the amount of consumed milk and dairy products. It is caused by the varied amounts of calcium in products, resulting from the condensation rate of processed milk solids, formulation or processing technology. The biggest amounts of milk and dairy products are consumed by children and adolescents in Croatia (1396.2 g day/person), while the lowest – by those in Germany (378.5 g/day/person). In Poland the consumption of milk and dairy products is 413.5 g/day/person.

The least calcium in milk and dairy products is found in the diet of girls living in Germany (192.4 mg/day), while its highest content is recorded in Croatia (870 mg/day; Fig. 2). The lowest calcium intake by boys was recorded in Poland (335.1 mg/day),

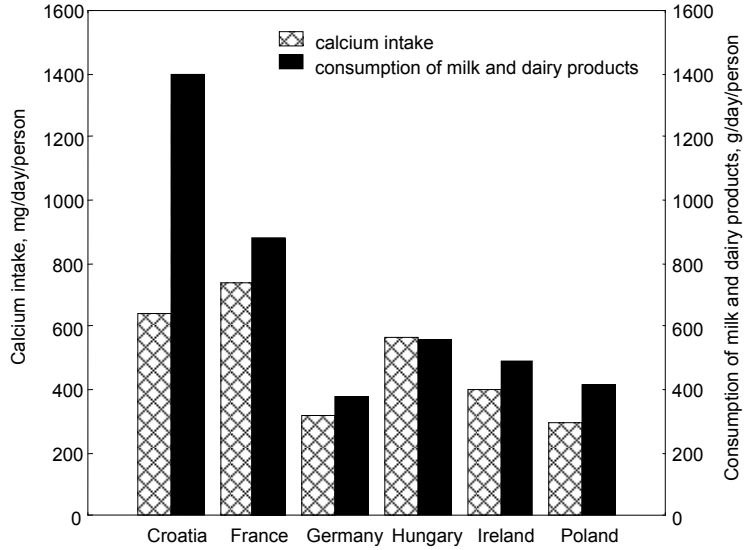

Fig. 1. Consumption of milk and dairy products and related calcium intake by children and adolescents aged 10-18 years in Poland in view of selected EU countries, n = 222

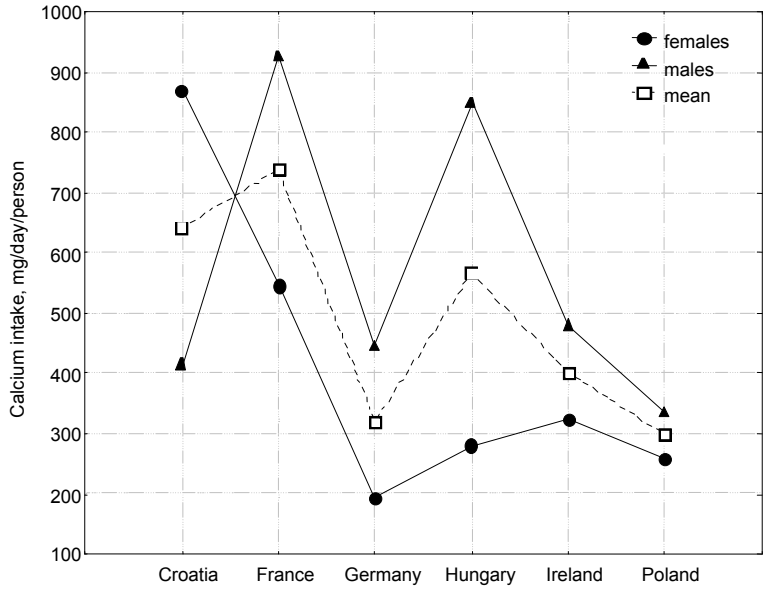

Fig. 2. Mean daily intake of calcium contained in milk and dairy products by children and adolescents aged 10-18 years in terms of their sex in Poland in view of selected EU countries, n = 222

while the highest in France (926.5 mg/day). Considerable disproportions in calcium intake by boys in relation to girls were observed in Hungary (over 3-fold) and in Germany (over 2-fold). In the other countries this difference was similar, amounting on average to 50%. However, only in Croatia boys consumed less calcium than girls did.

Cheeses coagulated by enzymes (hard cheeses), processed cheese and cheeses coagulated by enzymes (soft cheeses) are rich sources of calcium (Table 1). In turn, the least valuable sources in terms of calcium contents were cheeses coagulated by lactic acid (fresh white cheese) and cheeses based on lactic acid curd. A low calcium content was also reported for fermented milks due to the presence of other components and a low condensation rate of milk solids.

Table 1. Calcium content (mean ±SD) in milk and dairy products and its intake by children and adolescents aged 10-18 years from different European countries, n = 222

Item	Product	Calcium content mg·100 g^{-1}	Calcium intake mg/day/person
1	Milk	110.3 ±7.8	642.8
2	Yoghurt	134.8 ±36.2	1 112.2
3	Kefir	99.3 ±5.1	286.6
4	Fermented milks	77.2 ±7.6	424.2
5	Cheeses coagulated by enzyme (hard)	957.0 ±54.7	6 175.3
6	Cheeses coagulated by enzyme (soft)	214.3 ±61.8	1 715.0
7	Cheeses coagulated by lactic acid (fresh white)	81.0 ±19.0	32.2
8	Cheeses based on lactic acid curd	68.2 ±12.7	51.7
9	Processed cheese	363.3 ±64.2	184.8
10	Dairy dessert	110.7 ±10.3	452.6
11	Ice-cream	99.7 ±32.3	50.4

Dairy products are consumed on a daily basis by 69.8% teenagers in Croatia, 40% in France, 27.9% in Hungary and Poland, 19.4% in Ireland and only 10.8% in Germany. The other respondents consumed milk and dairy products usually once or twice a week.

The biggest amounts of milk are drunk by children and adolescents from Ireland (52.5 g/day/person) and in Hungary (34.2 g/day/person; Table 2). The lowest amounts of milk are consumed in Germany (1.7 g/day/person). Such an amount is drunk by only 7 boys out of the group of 37 respondents and this is most frequently only once a month at a level of max. 250 ml at a time. Consumption of yoghurts was declared by respondents ranging from 59.4% (in Hungary) to 100% polled children and adolescents in Ireland, France and Croatia. In these countries yoghurt was consumed most frequently once a week (Ireland and Croatia) and 5 times a week (in France). Kefir was consumed by all polled children in Croatia, 67.6% children in Hungary and 10.8% in Poland. Children from the other countries did not consume kefir. However, they consumed other fermented milks. In Ireland fermented milks are consumed by 40.5% respondents, but at a maximum twice a month. Among 81.1% children in Germany consuming fermented milks as many as 50% do it regularly 3 times a week. The consumption of cheeses

Table 2. Structure of calcium intake related with consumption of milk and dairy products by children and adolescents aged 10-18 years in Poland in view of selected EU countries, n = 222

	Product	Structure of calcium intake, %					
		Croatia	France	Germany	Hungary	Ireland	Poland
1	Milk	3.6	2.9	0.6	6.7	14.4	10.8
2	Yoghurt	7.7	19.9	10.9	1.2	10.9	6.3
3	Kefir	6.2	0	0	6.3	0	0.7
4	Fermented milks	7.2	0	6.7	0.3	0.6	2.7
5	Cheeses coagulated by enzyme (hard)	4.8	67.3	63.1	80.4	69.9	69.5
6	Cheeses coagulated by enzyme (soft)	69.5	1.9	0.3	0.2	0.4	0
7	Cheeses coagulated by lactic acid (fresh white)	0.8	0	0.1	0.2	0	0.6
8	Cheeses based on lactic acid curd	0	0	0	0	0	4.7
9	Processed cheese	0	0.7	13.6	0	0	0.3
10	Dairy dessert	0	6.4	4.5	4.3	3.7	3.7
11	Ice-cream	0.2	0.9	0.2	0.4	0.1	0.7

coagulated by enzymes (hard cheeses) varies considerably. The lowest amounts are eaten by children in Croatia (3.2 g/day/person). These are very small amounts, which are consumed by as little as 8.1% respondents. The consumption of cheeses coagulated by enzymes (hard cheeses) by children in Poland is also low (21.6 g/day/person), despite the fact that they are eaten by 70.3% respondents. The highest consumption level is declared by children in France (51.7 g/day/person) and Hungary (47.5 g/day/person). A high level of consumption of hard cheeses coagulated by enzymes is accompanied by consumption of soft cheeses coagulated by enzymes. Among children and adolescents, who do not eat hard or soft cheeses coagulated by enzymes, fresh white cheeses coagulated by lactic acid and cheeses based on lactic acid curd were popular. The highest amounts of these two types of cheese are eaten by children in Poland, at a total level of 22.7 g/day/person. Cheeses of this type are also popular in Germany. In turn, in France and Ireland no children declared their consumption within a period of one month. The highest consumption of processed cheeses was recorded in Germany (12 g/day/person), where it was declared by 91.9% polled adolescents. Processed cheeses are also willingly eaten by children in Poland. They are consumed by 32.4% polled adolescents at least twice a month. Different desserts produced on the basis of milk constitute a valuable source of calcium for children and adolescents. The highest demand for such products was recorded in France (42.5 g/day/person). They were eaten by all children up to 4 times a week. All children in Hungary declared consumption by a 50% lower (22.5 g/day/person). In turn, in Germany and Ireland desserts were consumed by 79.8% children at a frequency of once a week. The lowest amounts of desserts were consumed by

children and adolescents in Poland (10 g/day/person). Not only desserts, but also ice-creams are willingly consumed by children in France. The level of ice-cream consumption was highest among all respondents and amounted to 7.3 g/day/person. In Poland and Croatia the amount of consumed ice-creams was much lower (2 g/day/person). Ever lower amounts of ice-creams are consumed by children in Germany and Ireland. Jointly in these countries the consumption of ice-cream was declared by 18.9% children and adolescents.

The sex of children and adolescents has a significant effect on their consumer preferences (Fig. 3). Boys eat almost 5 times more cheeses based on lactic acid curd than girls do, while for hard cheeses coagulated by enzymes it is over 2 times more. Boys also more willingly drank milk (by 80%), kefirs (by 60%) and ate desserts (by 30%). In turn, girls ate 3.5 times more soft cheeses coagulated by enzymes. The level of consumption for yoghurt (538.7 mg/day/person ♂, 573.5 mg/day/person ♀), fresh white cheeses coagulated by lactic acid (15.3 mg/day/person ♂, 16.9 mg/day/person ♀) and ice-cream (24.6 mg/day/person ♂, 25.8 mg/day/person ♀) was almost identical in both sexes.

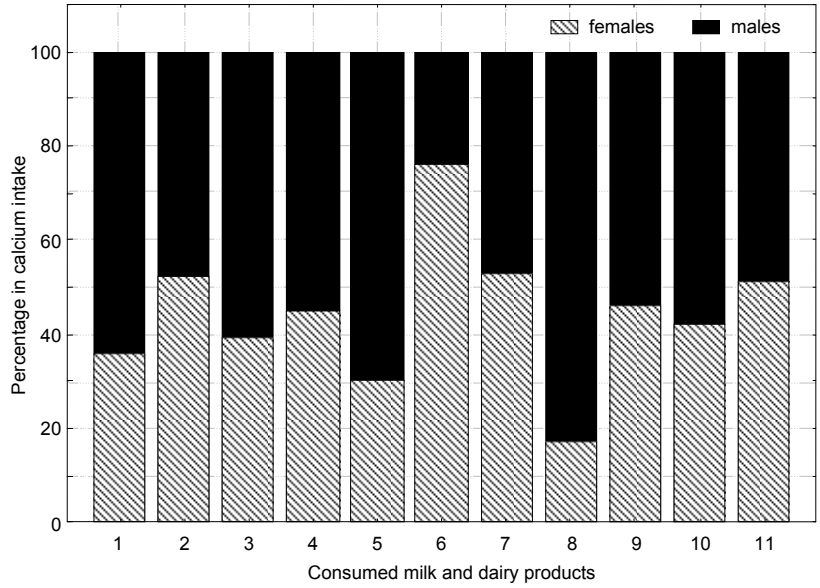

Fig. 3. Intake of calcium contained in milk and dairy products by children and adolescents aged 10-18 years in different European countries in terms of their sex, n = 222. Denotations as in Table 1

The amount of calcium absorbed in the alimentary tract depends on many factors, which include the composition of the feed ration, age, sex, physiological condition, possible diseases, as well as nutritional status. The consumption of calcium by children and adolescents aged 10-18 years, recommended for the population of Poland, is consistent with that of RDA and amounts to 1200 mg/day. In Ireland for girls and boys aged

11-18 years this amount is also 1200 mg/d [Roche et al. 1999]. In turn, the WHO/FAO [2004] recommends for adolescents aged 10-18 years the consumption of 1300 mg/day.

Analyses conducted within the framework of an international programme CALEUR showed that in terms of calcium consumption by girls and young women, Poland ranks in the middle of the list and calcium intake with the diet is 800-900 mg/day. The biggest calcium intake coming from the diet was found in Finland and Denmark (1120-1200 mg/day), and it was lowest in Italy (609-680 mg/day) [Kardinaal et al. 1996]. It results from investigations conducted in the years 1982-1992 by Rogalska-Niedźwiedź et al. [1992] that calcium content in food rations of adolescents was 502-760 mg/day, while the recommended allowance is realised in max. 82%. Jaworski and Lorenc [1998] observed that in the group of children and adolescents aged from 7 to 18 years calcium intake shows an upward trend with age (from 848 to 1353 mg/day). Daily calcium intake by boys was slightly higher than that of girls of the same age.

Long-term, chronic calcium deficit in the diet leads to growth disorders in children and adolescents and prevents reaching peak bone mass. In adults, particularly postmenopausal women, too low calcium supply may cause osteopenia or osteoporosis. An increasing body of data indicates that the calcium intake level recommended in respective standards is also necessary in the prevention and treatment of arterial hypertension, obesity, diabetes type 2 as well as many cancers [Zemel 2003, Zemel and Miller 2004, Barba and Russo 2006].

The level of relative risk and the quotient of risk for the incidence of osteoporotic fractures depend on the low calcium intake, listed as one of the risk factors for osteopenia and osteoporosis. Primary locations of such fractures include vertebral bodies, forearms, brachia and the proximal end of the femoral bone. The number and location of fractures depend on the population. The lowest number of fractures per 10 thousand inhabitants is found in Ireland, while the highest in Sweden. According to data concerning 14 EU countries the number of hip fractures in 2000 was over 480 thousand and it was by 27% higher than 4 years earlier. It is forecasted that in the year 2050 the number of fractures will increase up to 270% [Pluskiewicz and Műnzer 2009]. Infante and Torno [2000], when investigating bone density in children e.g. suffering from lactose intolerance showed a highly significant correlation of osteopenia with the percentage of recommended daily calcium allowance. Approximately 20% children aged 7 exhibited signs of osteoporosis.

In view of the alarming forecasts it is necessary to undertake effective preventive measures. The World Health Organization included osteoporosis in the group of civilisation-related diseases. The number of patients is forecasted to increase in the nearest future, which will be connected with considerable costs related with treatment, but first of all the asthenia found in the population [Riggs and Melton 1995, Burge et al. 2007].

A healthy lifestyle is essential to help prevent osteoporosis and reduce fracture risk. Measures that have a positive impact on bone health include a balanced diet rich in calcium and vitamin D, regular weight-bearing and muscle-strengthening exercise, smoking cessation, avoidance of excessive alcohol consumption, and prevention of falls.

Bone mass contains a high proportion of calcium, and vitamin D regulates calcium absorption. A diet rich in calcium and vitamin D is vital to achieve optimal peak bone mass [Chapuy et al. 1992, Zemel et al. 2002]. After menopause, intestinal calcium absorption is decreased, and renal secretion of calcium is greater than before menopause. This leads to an increase in calcium requirements.

Dairy products are the best sources of calcium because of their high content of elemental calcium, high absorption rate, and low cost. Dietary sources of vitamin D include vitamin D-fortified products and fatty fish. For those unable to consume enough dietary calcium and vitamin D, supplements are available. Because of absorption limitations, calcium supplements should be taken in divided dosages of 500 to 600 mg or less. The most common forms of calcium supplements are calcium carbonate and calcium citrate. Calcium carbonate is best absorbed when taken with food, whereas calcium citrate is absorbed well when taken on an empty stomach or with food. Two types of vitamin D supplements are vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol). Previous research has suggested that vitamin D_3 is a better choice than vitamin D_2. However, more recent studies show that vitamin D_2 and vitamin D_3 are equally good for bone health [Black et al. 2002].

Numerous studies documented a positive correlation between milk consumption during childhood and adolescence and bone mineral density in later years of life [Sandler et al. 1985, Melton et al. 1997, O`Connell and Stamm 2004, Felsenberg and Boonen 2005]. Apart from calcium, milk and dairy products contain several bioactive substances, with a potential significant effect on the human organism. Casein phosphopeptides (CPP), formed as a result of casein hydrolysis as well as L-lysine and L--arginine are, next to lactose, significant factors facilitating intestinal absorption of calcium [Gueguen and Pointillart 2000]. Under experimental conditions casein phosphopeptides exhibit a positive effect on solubility, efficient absorption of calcium, iron and zinc, as well as mineralisation of the bone tissue [Scholz-Ahrens and Schrezenmeir 2000]. It was shown experimentally that also whey proteins play a role in the absorption of minerals and inhibition of bone tissue resorption [Bos et al. 2000]. Toba et al. [2000] found active compounds in milk, capable of inhibiting osteoclastic resorption of the bone tissue as well as the development of these cells in *in vitro* experiments. The presence of the above mentioned factors was observed in the milk basis protein (MBP). Further experiments showed that after being consumed with food MBP does not lose its "anti-resportion" properties in relation to the bone tissue, and after absorption it increases bone strength in ovariectomised rats. MBP inhibits resorption of the bone tissue thanks to its direct effect on osteoclasts, stimulates bone formation and synthesis of collagen [Toba et al. 2000]. The effect of milk on the bone tissue is also documented by the results of a study by Cadogan et al. [1997]. A significant increase in bone density in girls consuming over 0.5 dm^3 milk a day is accompanied by an increased level of IGF I. In the period of growth this factor stimulates chondrocytes within the growth plate. In kidneys it intensifies transport of inorganic phosphates and synthesis of 1,25(HO)2D, while in the bone tissue it stimulates proliferation and differentiation of osteoblasts [Lambert et al. 2001]. A lack of changes in concentrations of biochemical markers of bone turnover between the control and the group consuming additional amounts of milk, recorded in this study, indicates that an increase in BMD is not an effect of transitory inhibition of internal bone transformation. It is assumed that IGF may modulate the effects of anabolic action of PTH on bones and may be a factor balancing the course of resorption and bone formation during the process of internal transformation of the bone tissue, induced by the action of PTH. It is suggested that a permanent increase in BMD, shown by Bonjour et al. [Bonjour et al. 1994], is an effect of a stimulation of IGF I production within the skeleton under the influence of PTH (this hormone is one of the stimulators of IGF I formation by the bone tissue), and thus leading to enhanced structural modelling of bones.

CONCLUSION

Conducted investigations showed a very low calcium intake in the examined children and adolescents aged 10-18 years. In order to improve this situation it is necessary to change eating habits of children and adolescents through education on nutrition and presentation of knowledge on calcium content in individual dairy products, as well as the bioavailability of this element. Conducted analyses will be continued and extended in terms of the population size of investigated groups. Collected results show an alarming need to provide an adequate supply of calcium in a balanced daily diet of children and adolescents. These tasks should be realised by dieticians, specialists in nutrition and technologists of dairy industry.

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SPOŻYCIE WAPNIA ZAWARTEGO W MLEKU I JEGO PRZETWORACH W DIECIE DZIECI I MŁODZIEŻY W POLSCE NA TLE INNYCH KRAJÓW EUROPY

Wprowadzenie. W wielu krajach europejskich coraz częściej obserwuje się eliminowanie z codziennej diety mleka i jego przetworów. Wiąże się ze zmniejszeniem podaży wapnia niezbędnego do prawidłowego wzrostu i rozwoju dzieci i młodzieży
Materiał i metody. Celem pracy była ocena spożycia wapnia w mleku i jego przetworach przez dzieci i młodzież w wieku 10-18 lat w Europie, a zwłaszcza w Polsce. Ankietowani pochodzili z rodzin o dobrej sytuacji socjo-ekonomicznej, byli świadomi zasad prawidłowego odżywiania oraz mogli bez zastrzeżeń spożywać produkty mleczne.
Wyniki. Na podstawie przeprowadzonych badań stwierdzono, że spożycie wapnia przez badanych w Polsce wyniosło 297,2 mg/dzień, a średnio w Europie 493,6 mg/dzień (575,2 mg/dzień/osobę ♂, 411,9 mg/dzień/osobę ♀). Podaż wapnia w poszczególnych państwach nie koreluje z ilością spożywanego mleka i jego przetworów. Najwięcej mleka i jego przetworów spożywają dzieci i młodzież w Chorwacji (1396,2 g/dzień/osobę), a najmniej w Niemczech (378,5 g/dzień/osobę). W Polsce spożycie mleka i jego przetworów wynosi 413,5 g/dzień/osobę.
Wnioski. Przeprowadzone badania wykazały bardzo małe spożycie wapnia przez badane dzieci i młodzież w wieku 10-18 lat. Są to ilości zbyt małe, gdyż stanowią 38% rekomendowanej przez WHO/FAO wielkości dobowego zapotrzebowania na wapń w tej grupie wiekowej ustalonej na poziomie 1300 mg/dzień/osobę.

Słowa kluczowe: wapń, produkty mleczne, osteoporoza

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