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CALCIUM CONTENTS IN DIETS AND BONE MINERALIZATION IN GIRLS AND YOUNG WOMEN

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The influence of calcium intake on bone mineralisation was evaluated in 200 girls at the age of 11-15 years and 97 women at the age of 20-23 years from a random sample of general population. The nutritional value of diets was estimated with the use of a three-day record method. Bone mineral density (BMD) of two points of radius was measured by a p-DEXA device.

Mean daily intake of calcium accounted for 831±363 mg in girls and for 933±401 mg in women. An increase in calcium contents in the diet significantly influenced bone mineralisation only in girls. It was concluded that an insufficient calcium intake during puberty was connected with lower bone mineralization and thereafter risk of osteoporosis development.

INTRODUCTION

It is believed that a higher calcium content in diets results in better bone mineralization in the adolescence period, better calcium balance in bones, lower bone resorption in older age and a decreased risk of bone fractures, including osteoporotic fractures [Cromer & Harel, 2000; Cummings *et al.*, 1995; Osteoporosis Prevention, Diagnosis, and Therapy, 2000]. Therefore, the nutrition manner, particularly of girls and young women in the period of growth and consolidation of bone tissue, can be a factor determining the effective prophylaxis of osteoporosis. A particular role of appropriate calcium contents in diets is underlined as a factor allowing for the maximum – in comparison to genetic possibilities of the organism – mass and mineral density of bones, and therefore appropriately large amount and appropriate microstructure of the tissue [Bone Health and Osteoporosis, 2004]. The aim of this study was to indicate the relation between calcium content of diets and mineral density of the radial bone in the period of the highest metabolic activity of bone tissue.

MATERIAL AND METHODS

The study was conducted in 1996 on a group of girls (11--15 years of age) and young women (20-23 years of age) selected at random from all female inhabitants of four Warsaw settlements. Consumption data have been obtained by way of the method of recording consumption in three successive days, and calcium content was assessed with the use of a computer programme MICRONAP. In all studied persons, anthropometric measurements have been carried out and biological development has been assessed. Information on the age of menarche was obtained by retrospective method. Bone mineral density (BMD) of the radial bone of non-dominant limb has been measured in two sites (ultradistal and proximal). Measurements have been carried out by means of the method of dual-energy X-ray absorptiometry (DEXA) with an OSTEOSCAN p-Dexa apparatus, and the results were expressed in mg/cm^2. In order to indicate the relation between calcium contents in diets and BMD, regression analysis has been used, and the calculations have been carried out with STATISTICA 6.0. software. In the group of girls the analysis has been carried out using the BMD data standardized into the Body Mass Index (BMI), time passed since the first menarche and the indicator of breast development stage. In the group of women, bone mineralization variables have been standardised into BMI and the age of the first menstruation.

RESULTS

Average bone mineral density (BMD) of the radial bone in young women was significantly higher than in girls: by 63 mg/cm^2 in ultradistal site and by 89 mg/cm^2 in proximal site (Table 1). An increase in the BMD in the period of adolescence – between 11 and 15 years of age, was at the level of 54 mg/cm^2 in the ultradistal site and at 104 mg/cm^2 in the proximal site. In adolescence, between 11 and 15 years of age, BMD increased in total by 17.8% in the ultradistal site and by 17.6% in the proximal site. After the 15th year of age, a BMD increase continued and, consequently, in young women it was higher by 10.9% in the ultradistal site and by 5.6% in the proximal site in comparison to girls aged 15 years.

Calcium content of daily diets of girls and young women was too low and equalled 831 mg and 933 mg, respectively, which constituted as little as 76% and 85% of the safe level of the Polish RDA for this food component (Table 2).

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TABLE 1. Radius bone density (BMD) in girls and women (mg/cm^2).

	Age group (in years)	Bone density	
		ultradistal site $\bar{x}$ ± SD	proximal site $\bar{x}$ ± SD
Girls	11 (n=41)	303±35	595±40
	12 (n=40)	317±51	632±57
	13 (n=39)	331±47	644±51
	14 (n=38)	355±56	677±59
	15 (n=42)	357±38	699±51
	BMD gain between 11 and 15 year of age	54 (17.8%)	104 (17.6%)
	Girls (in total) (n=200)	333±50*	649±632#
	Women (n=97)	396±48*	738±39#
	BMD gain between girls at age 15 and women	39 (10.9%)	39 (5.6%)

* and # significant difference between girls and women, p<0.0001.

Results of linear regression analysis (Table 3) showed that in the group of girls the contents of calcium in diets explained the 2.4% BMD variability in the ultradistal site and 5.1% in the proximal site. Calcium contents in girls' diets have been significantly and positively related to the BMD in radial bone in both measurement sites.

In women, no significant relationship has been stated between calcium content and BMD both in ultradistal and in proximal site.

TABLE 2. Daily calcium intake by girls and women.

Group of subjects	Intake (mg/d) $\bar{x}$±SD	% of Polish RDA $\bar{x}$±SD
Girls 11-15 years in total	831±363 *	76±33
Women	933±401 *	85±36

* significant difference between girls and women, *p=0.0290.

TABLE 3. Influence of daily calcium intake on radius bone density* (BMD) in girls and young women (results of linear regression analysis).

Groups of subjects	Ultradistal site		Proximal site	
	Determination coefficient (corrected) R^2	Regression coefficient B	Determination coefficient (corrected) R^2	Regression coefficient B
Girls	2.4%	0.0173 (p=0.0169)	5.1%	0.0296 (p=0.0007)
Women	0.0%	NS	0.0%	NS

* in the group of girls BMD in both sites standardized into the BMI, time passed since the menarche and the indicator of breast development stage. In the group of women, BMD in both sites standardised into BMI and the age of menarche.

DISCUSSION

Calcium intake in adolescence has been related to the mineralization of radial bone and could facilitate the reaching of maximum – genetically depended – peak bone mass. This observation was confirmed by Wang *et al*. [2003], who indicated a strong significant relation between calcium contents in diets of girls (9-18 years of age) and peak bone mass of young (21-24 years of age) adult women. Moreover, the results of the NHANES III study indicated that the calcium consumption in childhood and adolescence was significantly positively related to the BMD of hip and thigh bones of young (20-39 years of age) and post-menopause women [Opotowsky & Bilezikian, 2003].

In the second studied demographic group – of young women – it was observed that calcium intake was not directly related to the BMD of radial bones. It must be underlined that the calcium content in women's diets has been significantly higher than in girls' diets, and the activity of bone tissue, due to the completion of the growth processes, was limited only to tissue consolidation. Furthermore, the organism could have adapted to an insufficient calcium content in diets, and too low dietary calcium content in adolescence could have been compensated for by increased intestinal absorption, which was proved by Wong *et al.* [2000] in studies on animals.

Similarly, the results of studies carried out on Inuit indicated the existence of a genetic adaptation of the organism to a low calcium intake, related to *bb* genotype of the vitamin D receptor (VDR) [Kiel *et al*., 1997; Sellers *et al*., 2003]. This genotype was a result of many centuries of organism adaptation to small amounts of calcium in a diet and was related to a more effective intestinal absorption of calcium. Although the above results may impair the necessity to increase calcium contents in diets, it must be borne in mind that in the Caucasian population, *bb* genotype enabling the adaptation of an organism to low calcium contents in diets, is met only in *ca*. 1/3 of the population.

However, Heaney [2003] believes that an increase in absorption and a decrease in excretion of calcium allow only for a partial adaptation of the organism to small calcium contents in a diet. In consequence, low calcium contents in diets in adolescence can limit the mineralization of bones and make the reaching of peak bone mass impossible, while the adaptation mechanisms do not completely protect against the results of deficiencies.

It must be underlined that although it is possible for an organism to adapt to a low calcium contents in a diet, adaptation abilities of an organism during the period of growth and consolidation of bone tissue are limited, which was proved by the results of the works quoted above.

CONCLUSIONS

Calcium intake during puberty in girls was significantly and positively related to the BMD in radial bone in ultradistal and proximal sites.

Prophylaxis aimed at increasing calcium contents in diets, and in this way decreasing the risk of osteoporosis development, must be definitely taken up at early stages of life of children and adolescents, and educational activities should also be directed at parents.

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ZAWARTOŚĆ WAPNIA W DIETACH A MINERALIZACJA KOŚCI U DZIEWCZĄT I MŁODYCH KOBIET

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Oceniono wpływ zawartości wapnia w diecie na stopień mineralizacji kości 200 dziewcząt w wieku 11-15 lat i 97 kobiet w wieku 20-23 lata wylosowanych z populacji generalnej. Oceniono wartość odżywczą diety za pomocą metody 3 dniowego zapisu. Zmierzono gęstość mineralną (BMD) w dwóch punktach kości promieniowej, z zastosowaniem aparatu p-DEXA. Stwierdzono, że średnia zawartość wapnia w dietach dziewcząt wyniosła 831±363 mg, a w dietach kobiet 933±401 mg. Wzrost zawartość wapnia w dietach istotnie wpływał na wzrost mineralizacji kości tylko u dziewcząt. Mała zawartość wapnia w dietach w okresie dojrzewania związana była z mniejszą mineralizacją kości, co mogło stanowić ryzyko rozwoju osteoporozy.