

VITAMIN D AND FOREARM BONE MINERAL DENSITY IN ADOLESCENT GIRLS

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The objective of the study was to evaluate the content of vitamin D in the diet and in blood serum of adolescent girls and the impact thereof on the forearm bone mineral density. Fifty eight girls aged 12-13 years from Warsaw have been examined. Data regarding the intake of vitamin D have been obtained during three 24-h recalls undertaken in one year. The concentration of vitamin D in blood serum has been determined three times in the perspective of one year. Two measurements have been taken in winter, one in the summer. The forearm bone mineral density (BMD) in the non-dominating arm has been examined using p-DXA osteoplan in the middistal and ultradistal section. The diets of the girls examined are characterised by a very low content of vitamin D. The percentage of that content against recommended norm has remained at the level of 20-25%. In both winter periods the sufficient level of vitamin D in blood serum has been observed only among 8.9% of the girls. In the middistal section in the group of non-menstruating girls BMD have been significantly higher, when the level of vitamin D in blood serum exceeded 50 nmol/L.

INTRODUCTION

In relation to the increasing occurrence of osteoporosis, prophylaxis becomes of vital importance. The enhancement of prophylactic actions should occur in adolescence, since in that time the gain of bone mass is the highest. An important factor in the prophylaxis of osteoporosis is to gain the highest for a given individual, genetically driven, potential peak bone mass. The volume of peak bone mass depends on genetic, hormone and lifestyle factors (nutrition and physical activity in particular) [Salamone *et al.*, 1996]. Of the nutritional factors, vitamin D, apart from calcium, is the most important [Gunnes & Lefman, 1996]. The human body takes up the vitamin D from two sources – from the consumed food and from the skin synthesis driven by the solar radiation. It plays an important role in the homeostasis of calcium and phosphorus, increases the permeation of calcium inside the enterocyte and the rate of the flow and transfer of calcium through the base membrane to the cardiovascular system. It is also one of the factors stimulating the creation of collagen by osteoblasts, where new crystals of hydroxyapatite are built [Łukasiewicz, 2004]. Some scientists believe that even temporary deficiencies of vitamin D in intensively growing organisms may inhibit obtaining the genetically-conditioned peak bone mass [Docio *et al.*, 1998; Lehtonen-Veromoa *et al.*, 2003]. Taking into account the particular importance of vitamin D in the bone-building processes, the study aimed at the evaluation of the intake and content of vitamin D in blood serum and the impact thereof on the mass and mineral density of forearm bones in the ultradistal and middistal section by adolescent girls from Warsaw.

MATERIALS AND METHODS

Fifty eight girls aged 12-13 years from Warsaw were examined. The subjects were selected at random (response rate 47.2%). In a year, three 24-h recalls have been conducted and the concentration of vitamin D in blood serum has been measured three times (February-March 2002, August-September 2002, February-March 2003). In the final stage of the study, mineral density of forearm bone has been measured.

In the examination of nutrition, the portion sizes were estimated using the photo album of products and dishes [Szponar *et al.*, 2000] and using household and industrial measures. The content of vitamin D has been calculated using the "Dieta 2" computer program based on tables of nutritive values of food products and dishes applying a reduction by the volume of necessary losses, developed by the Food and Nutrition Institute [Nadolna *et al.*, 2000]. The results have been compared with the current norms at the recommended level [Ziemiański *et al.*, 1997].

The concentration 25-OH₃ of vitamin D in blood serum has been carried out using the HPLC method in the Danish Institute for Food and Veterinary Research [Andersen *et al.*, 2005].

Mass and mineral density of forearm bones have been measured using p-DXA osteoplan in the ultradistal and middistal section basing on the absorptiometry of double energy of X-ray radiation. Basing on the densitometric measurement the BMC value (bone mineral content or bone mass) and BMD value (bone mineral density).

The statistical analysis has been carried out using the Student-t test for non-combined samples.

RESULTS AND DISCUSSION

Mass and bone mineral density depending on the stage of physical maturity

The average value of BMD and BMC in both forearm sections under examination has been higher among menstruating girls than among non-menstruating girls. In the mid-distal section the differences have been highly statistically significant ($p < 0.0001$) (Table 1) despite the fact, that the age average differed by 0.4 year and in the group of menstruating girls amounted to 13.7 and in the non-menstruating girls group to 13.3. Because in the period preceding menarche bone-building processes are most intensive, not the age of girls but the occurrence of menarche has the significant impact on the bone mineral density.

Concentration of vitamin D in blood serum and in daily diets

In both assessments conducted in winter, the level of vitamin D (25OHD₃) in blood serum has been significantly higher as compared to the summer period. The average concentration of vitamin D in the first examination has amounted to 31.7 nmol/L, in the second to 61.9 nmol/L and in the third to 33.7 nmol/L. According to the criteria assumed by McKenna & Freaney [1998] in both winter periods the average concentration of vitamin D in the examined population has not been sufficient, but in the summer period, the average level has been sufficient (Table 2).

The sufficient level of vitamin D in blood serum (>50 nmol/L) in both winter periods has been observed only among 9% of girls, and in the summer period among 82.8% of girls (Table 3). Global studies show that the low level of vitamin D in blood serum and high season differences are quite common also in other countries [Tylavsky *et al.*, 2006; Lehtonen-Veromoa *et al.*, 1999; Looker *et al.*, 2002; Skeaff & Green, 2004].

The content of vitamin D in the diets of girls has been similar in all periods and ranged from 2.03 μ g in the last examination to 2.53 μ g in the first one. The intake of vitamin D has been met only 20-25% of the recommended norms level (Table 2). The intake of vitamin D has been similar

in all three periods and the level of concentration in blood serum has been statistically significantly higher in the summer ($p < 0.0001$), which means that skin synthesis is the main source of vitamin D in the examined group. In the latitude equivalent to Poland, the appropriate level of vitamin D may be reached in the period from March to September, which does not ensure the correct concentration in the autumn and winter [Łukasiewicz, 2004].

Very similar intake of vitamin D has been observed by Chlebna-Sokół & Błaszczak [2003] in the study of school-children from Łódź. The low content of vitamin D in the diet is a common phenomenon [Holick, 2004]. It is estimated that the average intake of that component in European countries amounts to 2-3 μ g [Ovesen *et al.*, 2003].

Concentration of vitamin D in blood serum against the parameters of bone structure

In order to establish the impact of the level of vitamin D content on the parameters of bone structure, the average level of the content of that vitamin D from three examinations has been calculated and the examined population has been divided into menstruating and non-menstruating girls because of the statistically significant differences in bone density and mass between the two groups. The sufficient level of vitamin D has been observed by 13.5% of menstruating girls and 28.6% of non-menstruating girls.

In the group of menstruating girls the level of vitamin D had not an influence on forearm bone density and mass in the ultradistal and middistal section. In the group of non-menstruating girls the bone mass have been significantly higher in girls, whose average vitamin D level exceeded 50 nmol/L, but only in middistal section (Table 4).

The results of other examinations confirm the beneficial impact of vitamin D in bone-building processes. While examining the level of vitamin D on forearm bone mineral density by Finnish girls [Outila *et al.* 2001], observed a significantly lower BMD values in the group of girls, whose vitamin D level amounted to less than 40 nmol/L. This relation results, among other things, from the fact that the lower concentration of vitamin D is accompanied by higher concentration of parathormon (PTH). Since PTH increases the

TABLE 1. Forearm bone mass and mineral density by menstruating and non-menstruating girls.

Group of girls	Ultradistal section		Middistal section	
	BMD (mg/cm ²)	BMC (mg/cm)	BMD (mg/cm ²)	BMC (mg/cm)
Menstruating	377 ± 37.9	1080 ± 154	602 ± 40.3*	850 ± 79.7**
Non-menstruating	363 ± 35.6	1058 ± 146	548 ± 39.0*	779 ± 97.3**

*, ** significantly different $p < 0.00018$

TABLE 2. Concentration of vitamin D in blood serum and in the diet in three examination periods.

Vitamin D	I Examination (winter)	II Examination (summer)	III Examination (winter)
Serum concentration (nmol/L) ¹	31.7 ± 14.1	61.9 ± 13.0	33.7 ± 11.6
Intake (μ g)	2.53 ± 2.46	2.15 ± 2.46	2.03 ± 1.50
Polish RDA (%)	25.3 ± 24.6	21.5 ± 24.6	20.3 ± 15.0

¹ OPTIFOR Project (Polish part)

TABLE 3. Frequency of hypovitaminosis of vitamin D in respective examinations.

Examination	Deficient level < 25 nmol/L	Insufficient level 25-50 nmol/L	Sufficient level > 50 nmol/L
	N (%)	N (%)	N (%)
1 (winter)	20 (34.5%)	33 (56.9)	5 (8.6%)
2 (summer)	0	10 (17.2%)	48 (82.8%)
3 (winter)	12 (20.7%)	41 (70.7%)	5 (8.6%)

TABLE 4. Concentration of vitamin D in blood serum against forearm bone mass and mineral density by menstruating and non-menstruating girls.

Serum level ¹	Ultradistal section			Middistal section	
	Menstruating girls N=37				
	N	BMD (g/cm ²)	BMC (g/cm)	BMD (g/cm ²)	BMC (g/cm)
<50 nmol/L	32	37±37.5	1071±154	604±39.8	857±78.8
> 50 nmol/L	5	39 ±37.8	1135±160	589±45.9	802±76.3
Non-menstruating girls N=21					
<50 nmol/L	15	358±38.3	1043±160	538±38.3 *	769±105
> 50 nmol/L	6	373±27.8	1093±108	573± 30.0*	803±76.4

* p<0.05; ¹ OPTIFOR Project (Polish part)

bone turnover, maintaining the correct level of vitamin D in blood serum may have positive impact on the correct development of bones [Willett, 2005].

CONCLUSIONS

Low levels of vitamin D in blood serum among adolescent girls may result in obtaining a low peak bone mass, which constitutes an osteoporosis risk factor. One of the ways of improving vitamin D intake in the autumn and winter season may be a change in the nutrition habits consisting mainly in the increased consumption of fish and fish products and vitamin D-enriched foodstuffs.

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WITAMINA D ORAZ WSKAŹNIK BMI A GĘSTOŚĆ KOŚCI DZIEWCZĄT W WIEKU POKWITANIA

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Celem badania była ocena zawartości witaminy D w diecie i w surowicy krwi u dziewcząt w wieku pokwitania oraz jej wpływ na gęstość mineralną kości przedramienia. Badaniami objęto 58 dziewcząt w wieku 12-13 lat z Warszawy. Dane o spożyciu witaminy D uzyskano na podstawie trzech wywiadów o spożyciu w ciągu 24godzin, przeprowadzonych w ciągu jednego roku. Stężenie witaminy D w surowicy krwi oznaczono trzykrotnie w ciągu roku. Gęstość mineralną kości przedramienia zbadano przy użyciu osteoplanu p-DXA w odcinku mid dystalnym i ultra dystalnym. Diety badanych dziewcząt charakteryzowały się bardzo małą zawartością witaminy D. W obu okresach zimowych wystarczający poziom witaminy w surowicy odnotowano tylko u 8,9% dziewcząt. W grupie dziewcząt nie miesiączkujących poziom witaminy D w surowicy miał istotny wpływ na masę kości w odcinku mid dystalnym.