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ASSESSMENT OF VITAMIN D STATUS IN CHILDREN AGED 1-5 WITH SIMPLE OBESITY

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ABCTRACT

Background. Proper vitamin D intake is important due to its pleiotropic effect. It seems that obese population is a groups at risk of the vitamin D deficiency.

Objective. To assess the vitamin D status in 1-5-year-old children with simple obesity.

Material and Methods. The study included 100 children: classified according to their body mass index (BMI) as obese – Group I (n=50) and non-obese – Group II (n=50). Their serum 25-hydroxyvitamin D (25(OH)D) concentrations were determined in the spring-summer and autumn-winter seasons and vitamin D intake (diet/supplements) was assessed. The study results were statistically analysed by means of Statistica 10PL.

Results. In Group I the mean serum 25(OH)D level was 23.6±10.8 ng/ml, while in Group II it reached 26.6±9.8 ng/ml (p=0.08). The concentration ≤30 ng/ml was observed in 80% of children in Group I and in 70% of Group II. In autumn-winter and spring-summer period, respectively, 88.5% and 70.9% of the obese children had an insufficient vitamin D status (p=0.002). The mean daily intake of vitamin D was 128 IU (3.2 µg) in Group I and 188 IU (4.7 µg) in Group II.

Conclusions. Children aged 1-5 (obese and non-obese) are a group at risk of the vitamin D deficiency, as a consequence of its insufficient intake and the lack of appropriate supplementation. Those particularly exposed to that risk are obese children in the autumn-winter season. Children aged 1-5 should be monitored with regard to their vitamin D status.

Key words: *vitamin D, obesity, children, obese children, vitamin D deficiency*

STRESZCZENIE

Wstęp. Prawidłowe zaopatrzenie w witaminę D jest istotne ze względu na jej plejotropowe działanie. Jedną z grup narażonych na niedobór tej witaminy wydają się być otyłe dzieci.

Cel badań. Ocena zaopatrzenia w witaminę D dzieci w wieku 1-5 lat z otyłością prostą.

Materiał i metody. Badaniami objęto 100 dzieci, w tym 50 z otyłością prostą (grupa I) i 50 z prawidłową masą ciała (grupa II) odpowiednio dobranych pod względem wieku. U dzieci oznaczono stężenie 25 hydroksywitaminy D (25(OH)D) w surowicy krwi w okresach wiosenno-letnim i jesienno-zimowym oraz oceniono podaż witaminy D (dieta/suplementy). Przeprowadzono analizę statystyczną wyników badań (Statistica 10PL).

Wyniki. Średnie stężenie 25(OH)D w surowicy krwi dzieci z otyłością prostą (grupa I) wynosiło 23,6±10,8 ng/ml, a z prawidłową masą ciała (grupa II) - 26,6±9,8 ng/ml (p=0,08). Stężenie 25(OH)D≤30 ng/ml stwierdzono u 80% dzieci z grupy I i u 70% dzieci z grupy II. U 88,5% dzieci otyłych w okresie jesienno-zimowym oraz u 70,9% w okresie wiosenno-letnim występował niedobór witaminy D (p=0,002). Średnia zawartość witaminy D w dietach dzieci z grupy I i II wynosiła odpowiednio 128 IU (3,2 µg) i 188 IU (4,7 µg).

Wnioski. Dzieci w wieku 1-5 lat, otyłe i z prawidłową masą ciała, stanowią grupę ryzyka wystąpienia niedoboru witaminy D, co jest konsekwencją małego spożycia i braku odpowiedniej suplementacji. Na niedobór tej witaminy są szczególnie narażone dzieci otyłe w okresie jesienno-zimowym. Dzieci w wieku 1-5 lat wymagają monitorowania stanu zaopatrzenia organizmu w witaminę D.

Słowa kluczowe: *witamina D, otyłość, dzieci przedszkolne, dzieci otyłe, niedobór witaminy D*

INTRODUCTION

In the last several years the pleiotropic function of vitamin D has attracted a lot of attention. This function is related to the presence of the vitamin D receptors (VDRs) in the tissue of the majority of organs as well as to the 1-α-hydroxylase-dependent local calcitriol synthesis [8]. The deficiency of vitamin D has been commonly observed worldwide across all the age groups. However, obese children and adults seem to be a

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group which is most exposed to this risk. The aim of this study was to assess vitamin D status in children aged 1-5 with simple obesity.

MATERIAL AND METHODS

The study included 100 children aged 1-5 (45 males and 55 females) who were the patients of the Gastroenterology Outpatient Clinic in the Institute of Mother and Child in Warsaw. Parents of all participation children gave written informed consent.

Group I consisted of children (n=50) with simple obesity, while Group II – of age-matched children (n=50) with normal body weight. In Group I the inclusion criterion was the body mass index BMI>97^{th} percentile (according to the WHO percentile chart), and in Group II -BMI>15th to ≤85^{th} percentile and no history of diseases that could have affected vitamin D metabolism. At the first examination all the children had serum 25-hydroxyvitaminum D (25(OH)D) concentration determined using chemiluminescence method (DiaSorin kits). Since the concentration of vitamin D in serum can vary depending on the season, the serum samples were collected in the autumn/winter (October – March) and spring/summer (April – September) seasons. The results were analysed according to *Prophylaxis of vitamin D deficiency – Polish recommendations 2009* [3] as well as to the *Practical guidelines for the supplementation of vitamin D and the treatment of deficits in Central Europe (2013)* [19].

The daily vitamin D intake in the children's diet was assessed by means of 3-day food records combined with a recall-record method. In order to evaluate the individual portion sizes we used an 'Album of Photographs of Food Products and Dishes' [26]. The data about the mean daily intake of vitamin D were processed in accordance with the nutrition research methodology by means of *Dieta 5.0* software [27]. The results were referred to the latest recommendations on the vitamin D intake in children [10].

Statistical analysis of the study results was performed by means of Statistica 10PL. The *Mann–Whitney* U test was used for the purpose of comparing both groups in terms of the differences between their mean values of anthropometric traits and indicators as well as their mean 25(OH)D serum concentration. The Chi^2 test was performed to examine the relation between the season when blood specimens were collected (spring-summer/autumn-winter) and the 25(OH)D serum concentration. In addition to that, the same test was applied to find out if there is a relation between the season and the vitamin D supplementation. The significance level was established at $p<0.05$.

RESULTS

The characteristics of the groups of children are presented in Table 1. The mean age of obese and non-obese children was 3.2±1.1 and 3.0±1.2 years, respectively. There were significant differences between children from Group I and II with regard to anthropometric parameters.

Mean 25(OH)D serum concentrations were not significantly different in both groups of children (Table 2).

In the group of obese children the inadequate 25(OH)D serum concentrations in the autumn and winter were observed more frequently in comparison to the spring-summer season according to both – Polish recommendations 2009 [3] ($Chi^2=12.7$; $p=0.002$*), and Practical guidelines for the supplementation of

Table 1. Characteristics of studied children

Parameter	Obese children (n=50)		Non-obese children (n=50)		Significance level p
	Mean ± SD	Median	Mean ± SD	Median	
Age (years)	3.2±1.1	3.2	3.0±1.2	3.0	ns
Body weight (kg)	23.0±6.3	22.8	14.2±3.1	14.0	<0.001*
Height (cm)	101.5±10.9	104.0	95.5±10.0	95.5	<0.05*
BMI (kg/m^2)	22.0±3.2	21.2	15.4±1.5	15.2	<0.001*
BMI z-score	3.8±1.8	3.3	-0.2±1.2	-0.2	<0.001*

SD – standard deviation
ns – statistically non-significant
* - statistically significant differences

Table 2. The 25(OH)D serum concentration in both groups of studied children

Parameter	Obese children (n=50)		Non-obese children (n=50)		Significance level p
	Mean ±SD	Median	Mean±SD	Median	
25(OH)D serum concentration (ng/ml)	23.6±10.8	22.8	26.6±9.8	25.8	0.08
(nmol/l)	59.0±27.0	57.0	66.5±24.5	64.5	

SD – standard deviation

Table 3. The 25(OH)D serum concentration in both groups of studied children with reference to Polish recommendations (2009) [3]

25(OH)D serum concentration	Obese children (n=50)			Non-obese children (n=50)		
	Total n (%)	Spring-summer period n (%)	Autumn-winter period n (%)	Total n (%)	Spring-summer period n (%)	Autumn-winter period n (%)
Optimal 20 - 60 ng/ml (50-150 nmol/l)	29/50 (58%)	20/24 (83.3%)	9/26 (34.6%)	39/50 (78%)	21/23 (91.3%)	18/27 (66.7%)
Deficiency ≥10<20 ng/ml (≥25 <50 nmol/l)	18/50 (36%)	4/24 (16.7%)	14/26 (53.9%)	9/50 (18%)	2/23 (8.7%)	7/27 (25.9%)
Severe deficiency <10 ng/ml (<25 nmol/l)	3/50 (6%)	-	3/26 (11.5%)	2/50 (4%)	-	2/27 (7.4%)

Table 4. The 25(OH)D serum concentration in both groups of studied children with reference to *Practical guidelines for the supplementation of vitamin D (2013)* [19]

25(OH)D serum concentration	Obese children (n=50)			Non-obese children (n=50)		
	Total n (%)	Spring-summer period n (%)	Autumn-winter period n (%)	Total n (%)	Spring-summer period n (%)	Autumn-winter period n (%)
Optimal >30 ≤50 ng/ml (>75 ≤125 nmol/l)	10/50 (20%)	7/24 (29.1%)	3/26 (11.5%)	15/50 (30%)	9/23 (39.1%)	6/27 (22.2%)
Suboptimal ≤30 ≥20 ng/ml (≤75 ≥50 nmol/l)	19/50 (38%)	13/24 (54.2%)	6/26 (23.1%)	24/50 (48%)	12/23 (52.2%)	12/27 (44.5%)
Deficiency <20 ng/ml (<50 nmol/l)	21/50 (42%)	4/24 (16.7%)	17/26 (65.4%)	11/50 (22%)	2/23 (8.7%)	9/27 (33.3%)

Table 5. The mean intake of vitamin D in studied children

Group of children	Dietary intake of vitamin D (μg*)	Percent of realisation of recommended daily intake [10]	Significance level p
	Mean ± SD		
Obese children (n=50)	3.2±2.7	64	ns
Non-obese children (n=50)	4.7±5.4	94	

*1 μg – 40 IU of vitamin D
ns – statistically non-significant

vitamin D (2013) [19] (Chi^2=12.2; p=0.002*). No such association was observed in non-obese children (Table 3 and Table 4).

Mean vitamin D dietary intake was insufficient in both groups (Table 5). Even though the diets of non--obese children contained more vitamin D than those of the obese ones, the difference was still insignificant.

The major sources of vitamin D in the diets in both groups of children were vitamin D fortified milk formulas, eggs and fish. Milk formulas were given to 32% of children (16/50) from Group I and 38% (19/50) from Group II. The obese children consumed the average of 253.0±139.8 ml of milk formulas, while non-obese - 297.5±209.0 ml, which ensured the supply

Table 6. The vitamin D supplementation in studied groups of children regarding the dose and the season.

	Obese children n (%)	Non-obese children n (%)	Type of statistical analysis
Vitamin D supplementation	11/50 (22%)	12/50 (24%)	*Pearson's Chi²* test Chi^2=7.2, p=0.12 (ns)
- In autumn–winter period	7/50 (8%)	3/50 (6%)	
- In spring–summer period	4/50 (14%)	9/50 (18%)	
Dose of vitamin D supplementation (μg) (IU)	9.1 364	6.3 252	*Mann-Whitney* U test; Z=-1.74, p=0.08 (ns)

ns – statistically non-significant

of 4.7 µg (189.8 IU) and 5.6 µg (223.5 IU) of vitamin D, respectively. Other children consumed not fortified cow's milk. The children from Group I and II, who were given cow's milk, consumed the average of 242.3±1.96 and 161.8±1.14 ml, which provided them respectively 0.03 µg (1.2 IU) and 0.02 µg (0.8 IU) of vitamin D.

Table 6 contains data about the vitamin D supplementation in children from both groups by its dose and the season. There was no relation between children's nutritional status and the frequency of vitamin D supplementation in spring-summer and autumn-winter season. The difference in mean doses of vitamin D supplementation was not statistically significant in studied groups of children.

DISCUSSION

The number of obese children, also the youngest ones, has been growing steadily over the last years. According to epidemiological data, in Poland overweight and obesity affect 20% of toddlers and 9-18% of children in pre-school age [11, 18]. Obesity increases the risk of many diseases and can result in physical disability. Therefore, the process aiming at the identification of all obesity risk factors in children as well as at launching successful prophylactic and therapeutic programmes should be started as soon as possible.

The relationship between obesity and the vitamin D deficiency has already been proven. Major factors of this deficiency in obese population include limited sun exposure and the decreased bioavailability of vitamin D due to its sequestration in their adipose tissue. It is a subject of controversy whether the vitamin D deficiency is a consequence of or a factor predisposing to obesity. The adipose tissue is not only a form of energy storage, but it is also an endocrine organ where adipokines and cytokines are produced. It contains both the VDRs and 1-α-hydroxylase. Not only is it regulated by vitamin D, but it also plays a role in its metabolism. The mechanism of how vitamin D increases the risk of obesity is not yet known. Some research results suggest that it takes place through modulating the catabolic and anabolic activity of adipocytes [9].

It is generally acknowledged that, due to its long half-life (2-3 weeks), 25(OH)D serum concentration is the best indicator of the vitamin D status [17]. However, the biochemical criteria of the vitamin D deficiency still remain controversial. According to the Polish recommendations 2009 [3], serum concentration of 25(OH)D in children and youth that is optimal for the pleiotropic function is 20-60 ng/ml, while its concentration below 10 ng/ml indicates severe vitamin D deficiency [3]. On the other hand, 'the Practical guidelines for the supplementation of vitamin D' (2013) [19] state that serum concentration of 25(OH)D below 20 ng/ml is regarded as deficiency, 20-30 ng/ml is seen as suboptimal, and 30 to 50 ng/ml indicates the optimal status of vitamin D [19].

Numerous studies that have been conducted in the last several years confirm that the vitamin D deficiency is common among children and adolescents as a result of its insufficient intake, reduced outdoor activity, sunscreen use and increasingly common obesity [21]. The insufficient vitamin D intake has been reported in many European populations living above the 35th degree of north latitude, beyond which skin synthesis of vitamin D falls in winter. Poland also belongs to this group of countries. The vitamin D deficiency is diagnosed even in early childhood. *Hintzpeter* et al. [7] and *Cashman* [2] reported 25(OH)D serum concentrations below 50 nmol/l (20 ng/ml) in 30% of German children aged 1-3 and in 20% of British children aged 18 months to 4 years.

The results of some studies on children and adolescents show the inverse association between the 25(OH)D serum concentration and the BMI, the adipose tissue volume as well as its abdominal location [20, 24]. *Alemzadeh* et al. [1] reported that obese children and teenagers (n=127) with the vitamin D deficiency had higher BMI and higher content of fat tissue in comparison to children with the adequate vitamin D status. Also, *Ghergerechi* et al. [6] observed that the BMI in obese children aged 4-16 was an essential risk factor for the vitamin D deficiency, nevertheless *Mark* et al. [15] did not confirm the association between 25(OH)D and adiposity.

In our study the mean 25(OH)D serum concentration was decreased (<30 ng/ml) in 80% of obese children and 70% with normal body weight, what indicated insufficient status of vitamin D with reference to the 'Practical guidelines' (2013) [19]. Although the 25(OH)D serum concentration was lower in the obese children than in non-obese ones, the difference was insignificant.

Many authors emphasize the seasonal variations of the vitamin D serum concentration in children [16, 23]. Our study confirms that in the autumn–winter period a significantly larger number of obese children had hypovitaminosis D than in the spring-summer time. Similar conclusions were drawn by *Alemzadeh* et al. [1] who observed that the vitamin D deficits were more common among children and adolescents in the autumn-winter than in the spring-summer (98.4% vs. 49.2 %, p<0.01).

According to *Stoian* et al. [25], beside the season (winter) and excessive body weight the other vitamin D deficiency risk factors among 2-13 year-olds (n=1442) included: a child's older age, the colour of skin other than white, shorter time spent outdoors and the daily intake of vitamin D lower than 200 IU (5 µg).

Numerous study results show that the vitamin D intake is generally below recommendations. Two Polish studies revealed that diets of 80% of children aged 13-36 months and 99% of four-year-old children did not contain adequate amounts of vitamin D [4, 28]. In our study the vitamin D content was insufficient in the diets of both the obese and the non-obese children, amounting to 3.2±2.7 µg (128 IU) and 4.7±5.4 µg (188 IU) respectively. *Sharma* et al. [22] also reported insufficient intake of the vitamin D (3.8 µg/152 IU) by children (n=32) aged 13-24 months.

Vitamin D fortified milk formulas are an important dietary source of this vitamin for young children [12]. In both groups the major source of vitamin D was a milk formula (for 32% of the children with obesity and 38% of children with healthy weight). Another important vitamin D source were eggs and fish.

In the study by *Fantino* and *Gourmet* [5] the mean daily intake of vitamin D was decreasing as the children were getting older as the consequence of gradual withdrawal of milk formulas from their diets. It was 4.6 µg (184 IU) and 1.3 µg (52 IU) in children aged 13-18 and 31-36 months respectively.

According to the Polish experts [3] children aged 1-18 should be given 400 IU (10 µg) of vitamin D, taking into account their exposure to sun, dietary intake and/or supplementation. It has been suggested that in the case of children with excessive body weight, who are a group at risk of the vitamin D deficiency, a daily intake should be increased to 800-1000 IU (20-25 µg).

In conformity with the 2013 guidelines [19] on the vitamin D supplementation an intake recommended for children aged 1-18 is 600-1000 IU (15-25 µg), depending on the body weight, from September to April or throughout the whole year if sufficient skin synthesis of vitamin D is not ensured in the summer. The recommended intake for obese children and adolescents is 1200-2000 IU (30-50 µg). In our study only 22% of the obese children and 24% of the non-obese ones were supplemented with vitamin D. The obese children received the average of 9.1 µg daily (364 IU), whereas the non-obese children - 6.3 µg daily (252 IU). Other authors also underline the frequent lack of supplementation and a great variability in administrated doses of vitamin D, often below the level recommended in national guidelines. A multi-centre survey conducted in France showed that 53.4% of children (671/1256) aged 19 months to 5 years had never been given any vitamin D supplements or their supplementation doses were lower than recommended. That did not apply to children below 18 months of age, out of whom only 3.8% had prescription under the recommended levels [13, 14]. Also the authors of the report on comprehensive assessment of diet of children aged 13-36 months in Poland confirmed that the proportion of children receiving vitamin D supplements was decreasing as they were growing older – from 25.5 % of children aged 13-18 months to 10.4% of those older than 18 months [28].

The changes in children's diet in their first years of life due to gradual replacing milk formula by cow's milk and increasing proportion of foods that are poor sources of vitamin D as well as frequent discontinuation of vitamin D supplementation are the potential risk factors leading to inadequate vitamin D status in young children. The results of our study have proven that not only it is necessary to promote the guidelines for the vitamin D supplementation but it is also essential to make certain that the prophylactic recommendations are observed carefully as a child grows older.

CONCLUSIONS

1. Children aged 1-5, both obese and non-obese, were a group at risk of the vitamin D deficiency as a consequence of its insufficient intake and the lack of appropriate supplementation.
2. Obese children are exposed to that risk particularly in the autumn-winter season.
3. Children aged 1-5 should be monitored with regard to their vitamin D status.

Conflict of interest

The authors declare no conflict of interest.

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