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Effect of vitamin D supplementation on bone mineral density in people with low risk of osteoporosis

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Abstract

Introduction. With the increasing number of reports of vitamin D3 deficiency, public awareness of this vitamin is increasing. Therefore, more and more people are choosing to supplement it. One of the main results expected is increase of bone strength. Vitamin D3 intake and its effect on bone mineral density are well studied in groups at increased risk for osteoporosis, but there is insufficient data on the effect of vitamin D3 supplementation on bone mineral density in people at low risk of osteoporosis.

Aim of study. The aim of the study was to examine the effect of vitamin D3 supplementation on bone mineral density in people with low risk of developing osteoporosis.

Material and methods. The study involved 76 people (39 women and 37 men) aged 20-43. To examine bone composition and mineral density dual-energy X-ray absorptiometry method has been used (Hologic Inc., USA). Respondents received also surveys regarding the presence of osteoporosis risk factors and vitamin D3 supplementation.

Results. In the study group, 46.1% regularly supplements vitamin D3, of which 40% are women and 60% are men. There were no statistically significant differences ($p = 0.1753$) between bone mineral density values in people regularly supplementing vitamin D3 compared to people not taking vitamin D3.

Conclusions.

Vitamin D3 supplementation may not have a significant effect on bone mineral density in people who have a low risk of osteoporosis. Vitamin D3 supplementation is one of the most common supplements also among people with low risk of osteoporosis.

Key words: Osteoporosis; Vitamin D; Bone Mineral Density

Introduction

Considering current knowledge about vitamin D3, the important role of its adequate supply is indisputable. Its deficiencies increase the risk of developing cardiovascular diseases [1], negatively affect the body's immune capacity [2] and the level of testosterone secretion [3], promote the development of tumors [4,5,6] and are correlated with the occurrence of depression [7]. There is no doubt, however, that the basic role of vitamin D is to regulate calcium and phosphorus metabolism. It increases the absorption of both these minerals from food, positively affecting the mineralization and skeletal strength, but it also affects muscle and nerve cells, whose proper functioning reduces the risk of falling [8].

For this reason, insufficient vitamin D levels may increase the risk of osteoporosis, and among many forms of prophylaxis of this disease, an adequate supply of calciferol is indicated [9]. The current reference daily intake of vitamin D3 for adults (men and women), as determined by the United States National Institutes of Health, is 600IU (15 μg) per day [10]. The same value is indicated in the nutrition guidelines for the Polish population established by the Food and Nutrition Institute [11]. It should be remembered that in the case of vitamin D3, food is not its only source. It is also synthesized under the influence of UVB radiation absorbed together with the sunlight. Due to this, the amount of endogenously produced vitamin D varies depending on the season and exposure to the sunlight. Therefore, it is pointed out that in the period from October to February, synthesis of vitamin D3 in skin decreases to a minimum [12].

Current research indicates that vitamin D deficiency is a problem affecting a large part of society. Studies on the too low value of the 25 (OH) D metabolite in the blood, which is an indicator of the level of vitamin D in the body, show different results depending on the accepted deficiency threshold. According to the guidelines of the Institute of Medicine, accepted by the National Institutes of Health of the United States, insufficient levels of vitamin D3 are observed when the concentration of 25 dihydroxyvitamin D (25 (OH) D) in the blood drops below 30 ng / ml (75 nmol / l) [10] . According to the data published in Polish Endocrinology in 2013, the level in the concentration range of 20-30 ng / ml (50-75 nmol / l) is considered a suboptimal concentration, while the concentration below 20 ng / ml (50nmol / l) is considered as a deficiency of vitamin D [13]. In the 2014 study, which examined 2,687 Poles, it was found that as much as 67.5% of the respondents have a vitamin D deficiency, showing a 25 (OH) D metabolite concentration below 20 ng / ml.
Concentrations in the range of 20-30 ng / ml were noted in another 22.8% of respondents, which means that in total as much as 90% of the Polish respondents suffered from insufficient vitamin D levels [14].

Due to the widespread problem of vitamin D3 deficiency, taking cholecalciferol supplements has become extremely popular. Being almost as popular as vitamin C, it is the second monovitamin preparation most frequently bought by Poles. At the same time, the extremely common goal of the supplementation in Poland is to strengthen bones, muscles and joints [15]. And while vitamin D is the undisputed foundation for the optimal functioning of calcium and phosphorus metabolism, its role in relation to bone density is questioned. There

are even reports indicating the lack of relevance of the adequate levels of vitamin D3 in the prevention of osteoporosis [16, 17].

Due to the above, the aim of the study was to compare bone mineral density (BMD) values in people at low risk of osteoporosis who supplement vitamin D3 compared to those who do not use such supplementation. Perhaps this will determine whether taking vitamin D3 without clear medical indications significantly affects bone mineral density.

Material and methods

The study patients between 20 and 45 years of age were sought for the study, due to the high degree of hormone stability of people of this age. This allowed to minimize the risk of age-related fluctuations in hormones affecting calcium and phosphorus metabolism. 112 healthy volunteers participated in the study. The main criterion for taking part in the study was the low risk of osteoporosis. At the same time, the presence of any of the risk factors from the FRAX calculator (chronic glucocorticoid use, smoking, excessive alcohol consumption, past low energy fracture, rheumatoid arthritis, proximal femoral fracture in family history, low BMI, postmenopausal age in women) caused exclusion from research. Therefore, the first stage was an interview regarding the presence of osteoporosis risk factors. In the course of its analysis, the final group of 76 people (39 women and 37 men) was included in the study. The age of the respondents was within the range established as the inclusion criterion from 20 to 40 years (average 27.2 ± 6.5 years). Participants qualified for the study completed an original questionnaire regarding health, physical activity in everyday life and the use of supplementation. The questionnaire contained 17 questions, of which 3 related to lifestyle, 4 referred to training (type, intensity, frequency), 6 concerned supplementation (including mainly vitamin D3), while the remaining ones were related to the condition of health and organ systems whose functions are closely related to vitamin D levels. Subsequently, two groups were created, the study group - people supplementing vitamin D for a minimum period of the last 3 months and a control group - not supplementing vitamin D for at least the last year. 35 people (14 women and 21 men) were qualified to the study group, which regularly took vitamin D3. The control group consisted of 41 people (25 women and 16 men) who did not take supplements with vitamin D3.

All patients had their body mass measured using Tanita BC-420MA. To evaluate body composition and bone mineral density we performed measurements by dual-energy X-

ray absorptiometry (Hologic Horizon AS/N 201132 densitometer, Hologic Inc., USA). The first scan covered the whole body in the supine position with the feet turned inwards and allowed to determine the fat content in the bodies of the subjects. The second measurement allowed determination of bone mineral density. BMD was measured on the left femoral neck. Femoral neck antetorsion angle was also determined. Appropriate positioning of the left lower limb was obtained using a dedicated positioner.

As a result of the dual-energy X-ray absorptiometry, a projection of the whole body skeleton and the left femoral neck area was made. The total radiation dose delivered to one person was 9.4 cGy * cm^2.

Statistical analysis

Statistical analysis for bone density in the control and study groups was performed using the R Studio 1.1.463 program. Data distribution was determined using the Anderson-Darling test as normal in both groups. Student's T-test was used to assess the significance of differences in the results obtained between the groups. In addition, relationships between bone mineral density and body fat content using Pearson's correlation were sought.

Table 1. Characteristics of the study groups.

		Group with vitamin D supplementation	Group without supplementation
N N_F N_M		35 14 21	41 25 16
Age [years]	$\bar{x}$ min. max	26,86±6,28 20 40	27,53±6,77 20 40
Body weight [kg]	$\bar{x}$ min. max	73,65±14,87 44,9 104,8	72,05±16,4 47,9 111
Body height [cm]	$\bar{x}$ min. max	174,86±7,53 158 191	173,99±10,47 159 197
BMI [$\frac{kg}{m^2}$]	$\bar{x}$ min. max	23,56±3,35 17,99 30,64	23,6±3,83 17,8 34,36
Body fat content [%]	$\bar{x}$ min. max	26,17±4,3 19,52 34,49	27,9±6,58 17,85 38,9
Body fat content [g]	$\bar{x}$ min. max	4842,85±1039,19 3054,62 6790,41	5300,51±1388,85 3313,52 8988
Visceral adipose tissue mass [g]	$\bar{x}$ min. max	255,78±116,11 92,12 520,42	266,72±140,12 98,77 648,07
Visceral adipose tissue volume [cm^3]	$\bar{x}$ min. max	276,52±125,53 99,58 520,42	288,35±151,48 106,77 700,62
Visceral adipose tissue area [cm^2]	$\bar{x}$ min. max.	52,05±24,08 19,11 107,94	55,32±29,06 20,49 134,42
Femoral neck antetorsion angle [°]	$\bar{x}$ min. max	129±5,23 113,97 142,09	127,64±4,7 116,66 135,93

N_F- number of women; N_M – number of men

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Table 2. Level of physical activity in everyday life

Scales	Group with vitamin D supplementation	Group without supplementation
1. Very low	0	0
2. Low	5	5
3. Moderate	8	18
4. High	9	8
5. Very high	13	10

Table 3. Results of bone mineral density measurements of the subjects.

Bone mineral density [g/cm^2]			
		Group with vitamin D supplementation	Group without supplementation
F	$\bar{x}$	0,841±0,120	0,903±0,109
	min.	0,561	0,702
	max	1,069	1,125
M	$\bar{x}$	0,942±0,174	1,008±0,160
	min.	0,673	0,628
	max	1,241	1,249

F- female; M-male

Results

Based on the analysis of the respondents' answers, it was found that the most commonly taken daily doses of vitamin D in the form of dietary supplements is 1000-2000 IU of vitamin D3 a day (57.1% of the study group). 31.4% of the respondents used higher doses, in the range of 2000-5000 IU, while 11.5% take less than 1000 IU of vitamin D daily.

The duration of continuous vitamin D3 supplementation in 53% of the subjects ranged from 6 to 12 months. 41% of respondents took vitamin D for more than a year, while for 6% of respondents it was from 3 to 6 months. The average value of BMI in the study group was 23.59 ± 3.35, in the control group without supplementation 23.6 ± 3.83.

Average body fat content of people from the group using the vitamin D supplement was 26.17 ± 4.3%. 27 respondents exercised regularly (4.67 ± 1.49 training units per week on average). 23 subjects stated that strength training is their dominant type of exercise. The average rating

of the level of physical activity determined in this group on a scale of 1-5 (where 1 is very low and 5 very high) was 3.89 ± 1.1.

An average body fat content in the control group was 27.9 ± 5.58%. In this group, 35 people exercised regularly (4.2 ± 1.71 workouts on average). 17 people from this group declared that they most often do the strength training. The average rating of physical activity in this group on a scale of 1-5 was 3.86 ± 1.72. There was no significant correlation between bone mineral density and fat content (R = -0.381 in the control group and R = -0.087 in the study group).

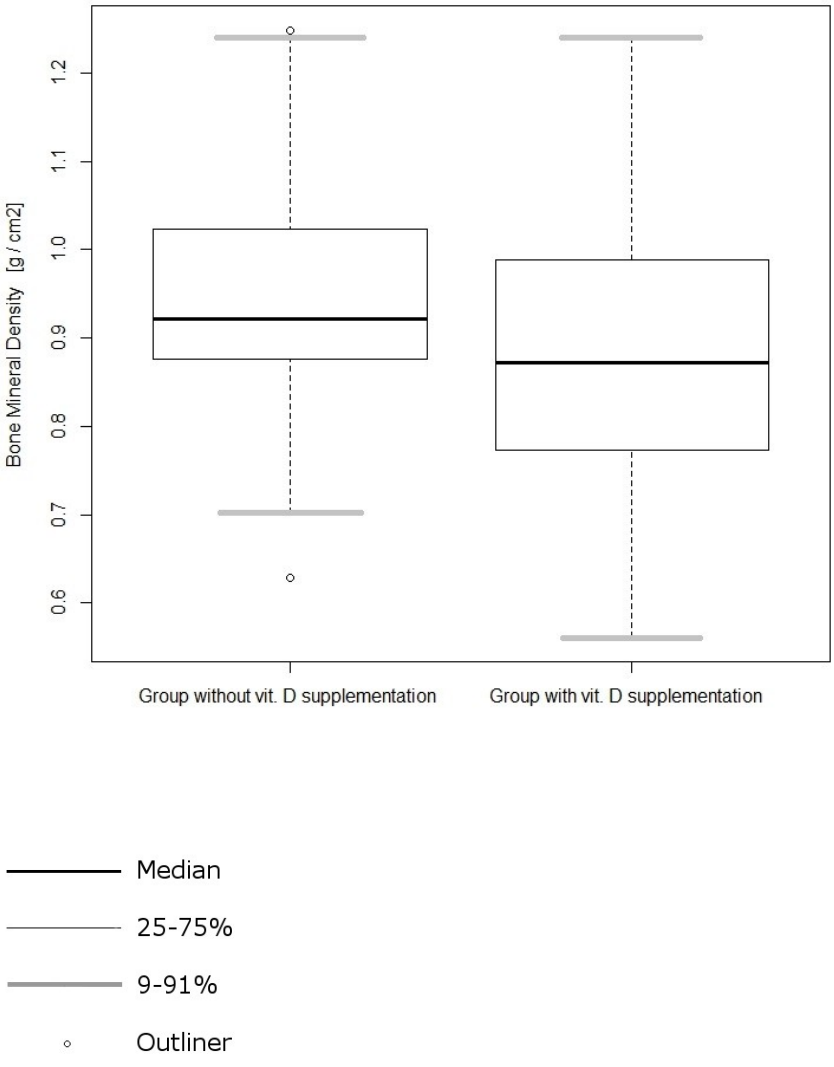

Fig. 1. Bone mineral density in a group with vit. D supplementation and in a group without vit. D supplementation.

The average value of bone mineral density on the left femoral neck among people regularly supplementing vitamin D3 was 0.987 ± 0.16 g / cm2 (with a minimum value of 0.561 and a maximum value of 1.241). On the other hand, it was 0.944 ± 0.139 g / cm2 (minimum value 0.628, maximum value 1.249) among members of the control group.
It was shown that the average values of mineral density (BMD) on the left femoral neck do not differ statistically ($p = 0.1753$) between groups (Fig. 1).

Discussion

The obtained results indicate the lack of statistically significant differences in bone mineral density between people supplementing vitamin D for a minimum of 3 months and those who do not supplement it. This calls into question the impact of vitamin D supplementation on bone mineral density in people not burdened with the risk of osteoporosis. When analyzing the survey data, it is worth noting that as much as 94% of respondents have been continuously supplementing vitamin D3 for over 6 months, and 41% of the study group has been taking it for over a year. Regular supplementation of vitamin D3 for such a period of time should give noticeable effects of its influence on bone mineral density. The results of the presented research coincide with previous scientific reports in which this problem was raised. Moreover, a study conducted by Donghu Zhen et al. in 2015 on a group of 10,100 people of Chinese nationality showed no correlation between reduced vitamin D3 levels and the risk of osteoporosis [17]. Also in a meta-analysis published in 2013 in the Lancet journal, a small influence of vitamin D supplementation on bone mineralization was shown [16]. This calls into question the use of preparations with vitamin D as a mean of effective prevention of osteoporosis.

Interpreting the research results, it should be noted that both the average BMD value in the control group and the study group were within the normal range. We also do not know the value of the bone mineral density of the subjects before they started using vitamin D. Therefore, it cannot be unequivocally stated that vitamin D did not positively affect the bone mineral density in people with its low values. However, the lack of a statistically significant difference between the control and the study group indicates that vitamin D supplementation

in healthy people, without factors predisposing to osteoporosis, does not affect the value of BMD, which undermines the effectiveness of vitamin D supplementation for this purpose.

Considering other researches, it can be assumed that the missing element, which causes that supplementation only with vitamin D does not significantly affect the value of bone mineral density in healthy people, is insufficient calcium supply, which is an extremely important element of osteoporosis prevention [18, 19, 20]. This is probably due to the high affinity of the activity of both these components in the body. Vitamin D is an essential regulator of calcium and phosphorus metabolism in the body, but in order for it to function properly, an adequate supply of these micronutrients is also necessary. The effect of taking vitamin D3 and calcium together is an area that can give a significant result in terms of the impact on bone mineral density in healthy people, as it seems to be the most appropriate osteoporosis prophylaxis scheme [21, 22, 23].

The results of the presented research can also be used to revise the goals of vitamin D3 supplementation. While taking into account the impact of vitamin D3 supplementation on calcium and phosphorus metabolism, one cannot deny the medical statement accepted by the European Union saying that the adequate vitamin D levels are necessary to maintain the proper structure of bones and teeth [24], expecting an increase in bone strength higher than physiological norms seems to be exaggerated. Due to the need for effective prevention of osteoporosis, it also seems important to conduct researches which could specify the impact of vitamin D supplementation in this matter and possibly indicate appropriate schemes for combining it with other diet components, if subsequent studies confirm the lack of satisfactory results of supplementation with vitamin D alone.

It is also worth noting that the social trend to significantly increase the supply of vitamin D3 is not only shown by sales statistics of dietary supplements. 88.5% of the control group took at least 1000 IU of vitamin D3 daily, which is more that the reference daily intake. This may indicate that people expect additional benefits from vitamin D3 over homeostasis. The above research indicates that this view regarding the condition of the skeleton is not true.

Conclusion

Based on the conducted research, it can be unequivocally stated that vitamin D3 supplementation is also popular among people with a low risk of osteoporosis. The results complement the current reports, which question the beneficial effect of vitamin D3

supplementation on bone mineral density in people at the low risk of osteoporosis. There is a need to conduct further researches on the influence of vitamin D3 supplementation on bone density in such individuals, as they could have an impact on osteoporosis prophylaxis and increase public awareness of supplementation.

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