Endokrynologia Polska
DOI: 10.5603/EP.a2017.0042
Tom/Volume 68; Numer/Number 5/2017
ISSN 0423–104X

Evaluation of vitamin D concentration in a population of young, healthy women — the effects of vitamin D supplementation

Ocena stężenia witaminy D u młodych zdrowych kobiet — skuteczność suplementacji witaminą D

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Abstract

Introduction: The goal of the study was an evaluation of serum vitamin D concentrations in healthy young women.
Material and methods: A total of 106 healthy women, aged 20–30 years, were included in the study. Monthly evaluation — for three months — of the effects of calcium (500 mg) and vitamin D (1500 IU) administration in women with baseline values of vitamin D < 20 ng/mL (Group 1) plus the effects of an 800 IU/d dose in women with the baseline value of D > 20 ng/mL (Group 2). Additionally, calcium and PTH concentrations were assessed at the study onset and after a three-month supplementation. Only 67 women adhered to the prescribed therapeutic regime during the three months of observation.
Results: The mean vitamin D concentration in the entire study group was 16.56 ng/mL, being 12.6 ng/mL in Group 1 and 25.22 ng/mL in Group 2. In the course of vitamin D administration, its concentration increased statistically significantly, both in the entire group and in the subgroups, at all time points compared with the study onset. Moreover, its concentration in the whole population and in Group 1 was significantly higher in each of the time points not only in relation to the baseline, but also in comparison with the results of the previous measurements (after 1 and 2 months of supplementation). In Group 2, vitamin D levels also increased systematically throughout the whole study period, and after 3 months its concentration was significantly higher than after 1 and 2 months. Although there were no differences in calcium concentration after those three months, a statistically significant drop of PTH ($p < 0.05$) was recorded in the entire population and in Group 1.
Conclusions: A moderate deficiency of vitamin D was observed in the studied population of young women. A supplementation with calcium plus vitamin D brought about an increase of vitamin D concentration as early as in the first month of administration. The optimal concentration of > 30 ng/mL was achieved in Group 1 after three months of vitamin D administration in 1500 IU/d dose.
(Endokrynol Pol 2017; 68 (5): 533–540)

Key words: *vitamin D, supplementation, young women, aged 20–30*

Streszczenie

Wstęp: Celem badania była ocena stężeń witaminy D w surowicy u młodych kobiet.
Materiał i metody: Do badania zostało włączonych 106 zdrowych kobiet w wieku 20–30 lat. Uczestniczki badania z początkowym stężeniem witaminy D < 20 ng/ml (grupa 1) otrzymywały 500 mg wapnia oraz 1500 j.m. witaminy D na dobę, a kobiety z wyjściowym stężeniem witaminy D > 20 ng/ml (grupa 2) 500 mg wapnia oraz 800 j.m. witaminy D dziennie. Stężenie witaminy D badano co miesiąc. Ponadto u wszystkich pacjentek na początku badania i po 3 miesiącach suplementacji oceniano stężenia wapnia i PTH w surowicy. Tylko 67 kobiet przyjmowało leki zgodnie z zaleceniami.
Wyniki: Średnie stężenie witaminy D w całej populacji wyniosło 16,56 ng/ml oraz odpowiednio 12,6 ng/ml w Grupie 1 i 25,22 ng/ml w Grupie 2 (≥ 20 ng/ml). W wyniku zastosowanej podaży witaminy D odnotowano istotny statystycznie wzrost jej stężenia w całej populacji oraz w obu grupach, we wszystkich badanych punktach czasowych względem poziomu podstawowego. Ponadto stężenie witaminy D w całej populacji oraz w Grupie 1 było znamiennie wyższe w każdym z badanych punktów czasowych nie tylko względem poziomu początkowego, ale również w stosunku do wyników poprzednich pomiarów (po 1 i 2 miesiącach suplementacji). W Grupie 2 stężenie witaminy D również wzrastało systematycznie w trakcie całego okresu obserwacji i po 3 miesiącach było istotnie wyższe w porównaniu z wartościami po 1 i 2 miesiącach.
Mimo że nie było istotnych statystycznie różnic w stężeniu wapnia po 3 miesiącach, stwierdzono znamienny spadek PTH ($p < 0,05$) w całej populacji oraz w Grupie 1.
Wnioski: W badanej populacji młodych kobiet stwierdzono niedobór witaminy D. Suplementacja wapniem i witaminą D spowodowała znaczący wzrost stężenia witaminy D w surowicy już po pierwszym miesiącu leczenia. W Grupie 1 po 3. miesiącach podaży 1500 j.m. witaminy D na dobę uzyskano dolną wartość przedziału optymalnego stężenia tej witaminy w surowicy.
(Endokrynol Pol 2017; 68 (5): 533–540)

Słowa kluczowe: *witamina D, suplementacja, młode kobiety, wiek 20–30 lat*

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Introduction

Calcium is a mineral component that is very important not only for the skeleton structure but also as a nutrient, required for nerve conduction, muscle contraction, hormone and enzyme secretion, and blood clotting. An adequate calcium intake is essential for normal growth and development of the skeleton and teeth and also for adequate bone mineralisation. Optimised bone mass accretion in youth and adolescence is critical to attaining peak bone mass in adulthood [1]. In adulthood, low calcium intake is associated with an increased risk for osteoporosis [2], bone fractures, and falls [3, 4]. The Institute of Medicine supports the key combined role of calcium and vitamin D in the maintenance of skeletal health, recommending a daily intake of 1.2 g of calcium and 800 IU of vitamin D for women in their prime [5].

Vitamin D helps calcium absorption and its role in bone health has been well characterised [6]. Vitamin D and calcium are necessary for proper modelling and remodelling of bones and the optimal bone mass depends on their appropriate supplementation. Vitamin D is also responsible for modulation of cell growth, neuromuscular and immune function, and reduction of inflammation [7]. It has been shown that high-dose vitamin D3 significantly reduced CD4+ T-cell activation compared to low-dose vitamin D3, providing human evidence that vitamin D can influence cell-mediated immunity [8].

Apart from maintaining adequate serum calcium and phosphate concentrations, there is some evidence that vitamin D may help prevent colon, prostate, and breast cancers [7]. Vitamin D deficiency may contribute to certain chronic diseases [9]. It may also play an important role in the prevention and treatment of diabetes [10, 11], cardiovascular disease [12], chronic heart failure and autoimmune diseases (e.g. multiple sclerosis, chronic thyroiditis, ulcerative colitis) [13], mental illnesses, such as depression [14], schizophrenia [15, 16], neurodevelopmental disorders, and intellectual disabilities [17].

In humans, the major volumes of circulating vitamin D are synthesized from cholesterol, following exposure to sunlight ultraviolet B, whereas a smaller amount is derived from diet and dietary supplements. Diet contributes only between 10% and 20% to 25(OH)D levels, but becomes more important when sunshine exposure is low [18]. Calcium in the diet contributes to about 50% of the recommended intake [5].

Vitamin D deficiency and insufficiency are respectively defined as 25(OH)D levels < 20 ng/mL (50 nmol/L) and 25(OH)D between 20 and 29 ng/mL (50 nmol/L and 75 nmol/L), although different definitions exist [19]. In Europe, the mean serum 25(OH)D levels, reported in population-based studies, vary from 18 ng/mL (29 nmol/L) in Italy to 30 ng/mL (75 nmol/L) in Norway [20]. It has been observed that more than 40% of U.S. and European men and women, and more than 50% of postmenopausal women, are affected by vitamin D deficiency [7, 21], including Poland, where it is found in approximately 90% of the general population [22–24]. In some populations, the deficit is ever stronger, e.g. 98.8% of Mongolian women, 18–44 years of age, demonstrate serum 25(OH)D < 20 ng/mL (50 nmol/L) [25]. There are some factors that can influence the deficiency of vitamin D, e.g. in the Swiss adult population, the prevalence of vitamin D insufficiency or deficiency is high and varies by season, BMI category, and speaking region. The association of speaking regions with vitamin D status is independent of major potential confounders [21].

Gahche et al. have shown that vitamin D supplements have increased over time in adult populations, while their consumption by children and adolescents appears to be stable [26]. The daily contribution of supplemental calcium in the United States (2005–2006) for women at the age of 19–30 years was 283 ± 18.7 mg/dL and the daily intake of vitamin D was 7.5 ± 0.7 ug. Calcium intake from diet, demonstrated by women at the age of 19–30 years, was 945 ± 29.8 mg/d and vitamin D intake was 5.8 ± 0.3 ug/d [27].

The goal of the study was an evaluation of serum vitamin D concentration in healthy women, aged 20–30 years, and to update the prevalence of vitamin D deficiency and insufficiency, defined as vitamin D Total (25(OH)D) less or more than 20 ng/mL. Additionally, in one-month evaluation — for three months — the effects of calcium (500 mg) and vitamin D (800 IU or 1500 IU) supplementation were evaluated.

Material and methods

A total number of 106 healthy females, aged 20–30 years, were enrolled into the study. The exclusion criteria included:

1. Chronic administration of bone metabolism improving agents: bisphosphonates, strontium ranelate, sodium fluoride, denosumab, oestrogens or hormonal replacement therapy, selective oestrogen receptor modulators, glucocorticosteroids, anti-epileptic drugs, aromatase inhibitors, GnRH analogues, and chemotherapy.
2. Endocrine disorders, significantly affecting bone resorption processes, such as: hyperparathyroidism, active hyperthyroidism, hyperprolactinaemia, and hypogonadism.
3. Chronic renal failure (glomerular filtration rate < 35 mL/min [25].

4. Malabsorption.
5. Diagnosed cancer, malignant tumour, or process.
6. Chronic systemic disease that could have significantly affected bone metabolism.
7. Refusal to submit written consent to participate in the study.

The women were assigned to two groups, depending on baseline serum level of vitamin D. Group 1 was composed of women with baseline vitamin D concentrations below 20 ng/mL and the rest of the study population formed Group 2. All the participants received daily oral supplementation of calcium (calcium carbonate) in a dose of 1250 mg and vitamin D3 in a dose of 1500 IU (Group 1) or 800 IU (Group 2) for three months. Calcium and vitamin D3 supplements were provided free of charge by their manufacturer (Axellus LLC). The adherence to therapy was assessed on the basis of patient declarations and returned empty drug packaging units. In cases of non-compliance to visit schedules, the patients were contacted by phone.

The women who were qualified to the study paid visits every month in order to replenish their supplement stock, for evaluation of compliance with prescribed supplement administration schedules and regimes and for planned examinations. Blood samples were collected from fasting patients at the inclusion visit and after 1, 2, and 3 months to assay total vitamin D, total calcium, phosphates, and alkaline phosphatase concentrations and after three months to assay parathormone (PTH) level. In order to exclude thyroid dysfunction, an additional blood sample was collected for baseline TSH assay.

The women' height and weight were measured and BMIs were calculated twice (at enrolment and after three months) in all the patients. All the enrolled patients remained under care of the Outpatient Clinic of Endocrinology throughout the whole study period.

Only 67 women adhered to therapy during the three months of observation and completed the study.

Laboratory tests

Biochemical assays were carried out by means of the following methods and sets:

1. Serum alkaline phosphatase concentrations, as well as total serum calcium and phosphate levels, were assessed using a colorimetric method with an Olympus analyser (Olympus Life and Material Sciences, O'Callaghan's Mills, Ireland) and Beckman Coulter (Brea, California) kits, according to the manufacturer's instructions.
2. Serum total vitamin D (25-hydroxyvitamin D2 and 25-hydroxyvitamin D3), PTH, and TSH concentrations were evaluated by the electrochemiluminescence method with a Cobas e411 analyser (Roche Diagnostics, Penzberg, Germany) and Roche Diagnostics kits in compliance with the manufacturer's recommendations. Reference values for total vitamin D levels were 30 to 70 ng/mL and for PTH 15 to 65 pg/mL.

The serum, used to assay total vitamin D, TSH, and PTH concentrations, was frozen immediately after centrifugation of collected blood and stored at –70°C until use. The other laboratory tests, i.e. calcium, phosphate, and alkaline phosphatase concentrations in serum, were measured immediately after sampling.

Statistical analysis

The study data are presented as means, means ± SD, and means ± SEM. For all statistical analyses, the level of significance (p value) was determined at 0.05. Data distribution normality was checked in each group, using the Shapiro-Wilk's test.

In cases where there was no reason to reject the hypothesis that the distribution is normal, ANOVA with repeated measures was used. However, in cases of non-normal distribution, we used the Friedman test (or the Wilcoxon test for comparing two points). The Newman-Keuls test was used to compare significant differences between time points.

The Spearman's rank correlation coefficient test was employed to evaluate correlations between assessed parameters.

In order to compare changes in vitamin D levels in relation to the categorised groups according to their baseline levels and their changes in time periods, two-way repeated measure analysis of variance (ANOVA) was applied. In case of categorised measurements, the variables were independent. During ANOVA procedures, not only simple effects were verified (e.g. the dependence between variable increase or decrease in terms of individual effect), but also interactions of effects were examined.

Results

In our study, the mean concentration of total vitamin D in the whole group was 16.56 ng/mL. During each month, we observed increased concentrations of this vitamin: the highest above 30 ng/mL after three months (Tab. I).

Vitamin D concentration changes for all the examined women at three time points of supplementation were statistically significant. We also observed significant differences between vitamin D levels in the second and third month, in comparison to its concentration in the first and second month of supplementation (Fig. 1).

Table I. *Vitamin D concentrations in the whole population at 4 time points: 0 — at baseline; 1 — after 1 month; 2 — after 2 months; 3 — after 3 months of calcium and vitamin D supplementation*

Tabela I. *Stężenia witaminy D w całej populacji w 4 punktach czasowych: 0 — na początku badania; 1 — po miesiącu; 2 — po 2 miesiącach; 3 — po 3 miesiącach suplementacji wapnia i witaminy D*

	N	Mean	95% CI		Median	SD	SE	Statistics chi² Friedman's	Level p
Vitamin D (0)	67	16.5563	14.7295	18.3830	16.5500	7.4893	0.9150	120.10	< 0.0001
Vitamin D (1)	67	26.6491	25.1593	28.1390	26.5300	6.1080	0.7462		
Vitamin D (2)	67	29.0546	27.3083	30.8010	27.6500	7.1594	0.8747		
Vitamin D (3)	58	32.1688	30.2726	34.0650	32.7600	7.2117	0.9469		

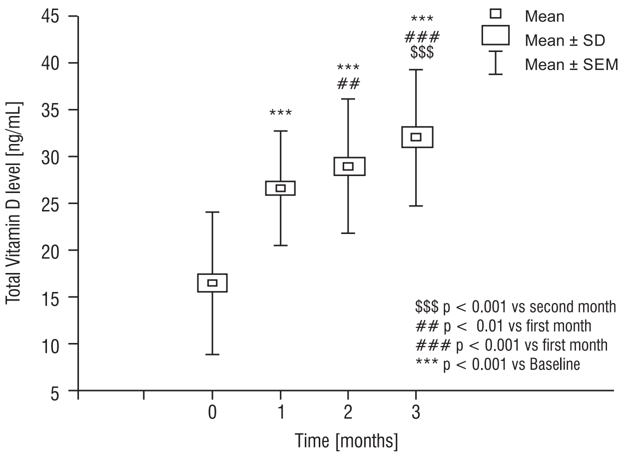

Figure 1. *Vitamin D concentration changes for the whole population at 3 time points of continued supplementation*

Rycina 1. *Zmiany stężenia witaminy D w całej populacji w 3 punktach czasowych w trakcie stosowania ciągłej suplementacji*

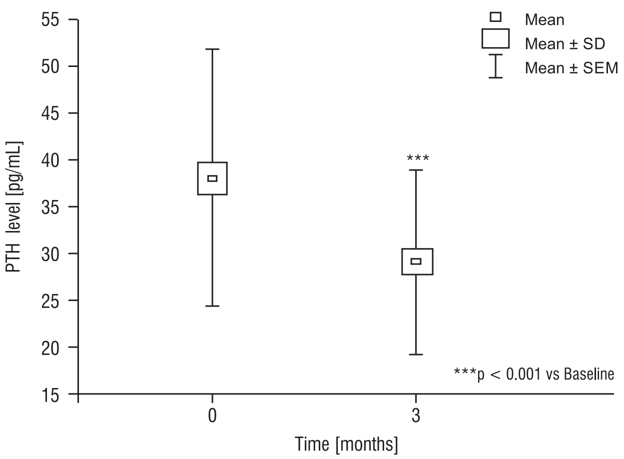

Figure 2. *Changes in PTH concentration at baseline and after 3 months of supplementation*

Rycina 2. *Zmiany stężenia PTH po 3 miesiącach suplementacji w porównaniu z wartościami początkowymi*

Statistically significant changes in PTH were observed between baseline and after 3 months of supplementation (Tab. II and Fig. 2).

Table II. *Correlations between some parameters at baseline and after 3 months of supplementation for all the examined groups*

Tabela II. *Korelacje między wartościami niektórych parametrów zmierzonymi na początku badania i po 3 miesiącach suplementacji we wszystkich grupach badanych*

	N	T Statistics	Normalized Z statistics	p value
PTH (0) & PTH (3)	**58**	**288.000**	**4.393782**	**0.0000**
ALP (0) & ALP (3)	58	750.000	0.391540	0.6954
Ca (0) & Ca (3)	67	1055.000	0.322598	0.7470
P (0) & P (3)	58	657.000	1.536856	0.1243
BMI (0) & BMI (3)	64	434.00	0.470923	0.6377

In whole group, no correlation was observed between changes in PTH and vitamin D concentrations and between changes in BMI and vitamin D (data not shown).

In Group 1 (patients with baseline total vitamin D level < 20 ng/mL), which was supplemented with daily dose of 500 mg of calcium and 1500 IU of vitamin D, we observed a statistically significant increase in vitamin D throughout the whole study period (Tab. III). Significant differences were noticed between vitamin D levels in the second and third month, in comparison to its concentrations in the first month of supplementation (see Fig. 3). The highest rise of vitamin D was seen after the first month of its supplementation.

In Group 2 (patients with baseline total vitamin D level > 20 ng/mL), which was supplemented with daily dose of 500 mg of calcium and 800 IU of vitamin D, we also noticed a statistically significant increase of vitamin D throughout the whole study period (see Table IV).

The increase of vitamin D during three months was not as great as in the group of women with deficit and deficiency of vitamin D (< 20 ng/mL). In that group, significant differences were noticed among vitamin D levels in the third month in comparison to its concentration in the first and the second month of supplementation (Fig. 4).

Table III. *Vitamin D concentrations in Group 1 at 4 time points: 0 — at baseline; 1 — after 1 month; 2 — after 2 months; 3 — after 3 months of calcium and vitamin D supplementation*

Tabela III. *Stężenia witaminy D w grupie 1 w 4 punktach czasowych: 0 — na początku badania; 1 — po miesiącu; 2 — po 2 miesiącach; 3 — po 3 miesiącach suplementacji witaminy D*

	N	Mean	95% CI		Median	SD	SE	chi^2 Friedman's statistics	p value
Vitamin D (1)	46	12.6020	11.1698	14.0342	12.5600	4.8228	0.7111	80.07	< 0.0001
Vitamin D (2)	46	24.9750	23.4069	26.5431	24.8900	5.2805	0.7786		
Vitamin D (3)	46	27.8354	25.7302	29.9406	27.3550	7.0891	1.0452		
Vitamin D (4)	36	29.4197	27.3702	31.4692	30.5200	6.0573	1.0095		

Table IV. *Vitamin D concentrations in Group 2 at 4 time points: 0 — at baseline; 1 — after 1 month; 2 — after 2 months; 3 — after 3 months of calcium and vitamin D*

Tabela IV. *Stężenia witaminy D w grupie 2 w 4 punktach czasowych: 0 – na początku badania; 1 — po miesiącu; 2 — po 2 miesiącach; 3 — po 3 miesiącach suplementacji wapnia i witaminy D*

	N	Mean	95% CI		Median	SD	SE	chi^2 Friedman's statistics	p value
Vitamin D (1)	21	25.2171	23.2826	27.1517	24.9500	4.2499	0.9274	35.27	< 0.0001
Vitamin D (2)	21	30.3162	27.4441	33.1882	28.1400	6.3095	1.3768		
Vitamin D (3)	21	31.7252	28.6660	34.7845	31.5000	6.7207	1.4666		
Vitamin D (4)	19	36.9189	33.8510	39.9869	36.9500	6.3652	1.4603		

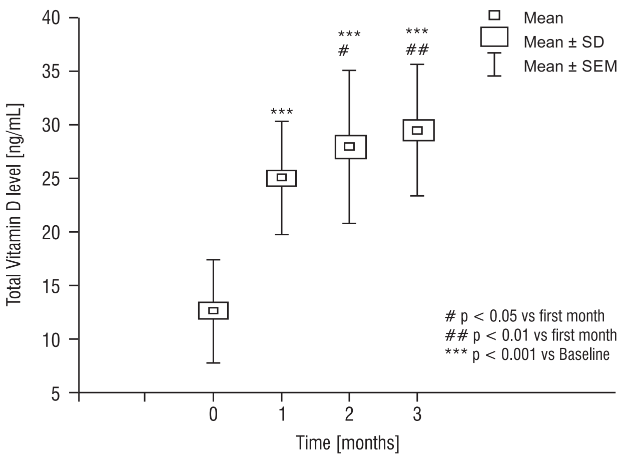

Figure 3. *Changes in total vitamin D concentrations at baseline and after 1, 2, and 3 months of supplementation in Group 1*

Rycina 3. *Zmiany stężenia całkowitej witaminy D w grupie 1 po 1, 2 i 3 miesiącach suplementacji w porównaniu z wartościami początkowymi*

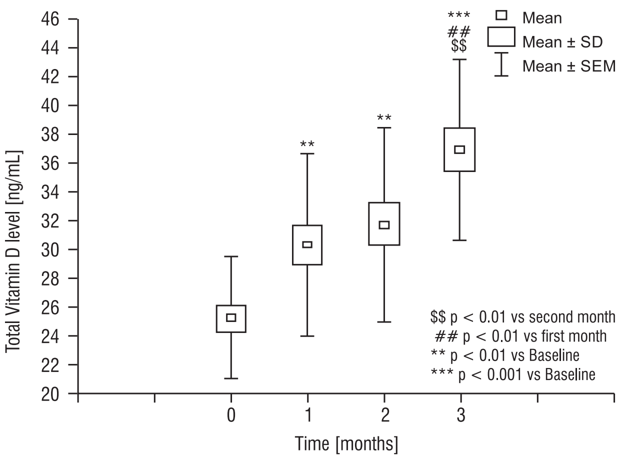

Figure 4. *Changes in total vitamin D concentration at baseline and after 1, 2, and 3 months of supplementation in Group 2*

Rycina 4. *Zmiany stężenia całkowitej witaminy D w grupie 2 po 1, 2 i 3 miesiącach suplementacji w porównaniu z wartościami początkowymi*

We also compared vitamin D level changes in relation to categorised groups, according to their baseline levels (0–10 ng/mL; 10–20 ng/mL; > 20 ng/mL) and their changes over time periods. The increase of vitamin D concentrations in the group 0–10 ng/mL was significantly higher than that in the other two groups (10–20 and > 20 ng/mL) in all the examined time periods. The rise of vitamin D levels in group 10–20 ng/mL in comparison to group > 20 ng/mL was insignificant during any of the time periods (Tab. V and Fig. 5).

Discussion

Vitamin D and calcium deficiencies are preventable global public health problems in infants, children, and adolescents. According to international rickets prevention

Table V. *Vitamin D concentration changes between: baseline and after 1 month (1), after 2 months (2), and after 3 month (3) in 3 subgroups of women with concentration of vitamin D at the baseline 0–10 ng/mL; 10–20 ng/mL; and > 20 ng/mL*

Tabela V. *Zmiany stężenia witaminy D w stosunku do wartości wyjściowych po miesiącu (1), 2 miesiącach (2) i 3 miesiącach (3) w 3 podgrupach kobiet z początkowym stężeniem witaminy D wynoszącym 0–10 ng/ml, 10–20 ng/ml i > 20 ng/ml*

Vitamin D ng/ml (0)	Changes in concentrations	N	Mean	SD	SE
0–10	Changes vit. D (1)	15	2.6404	1.6293	0.4207
	Changes vit. D (2)	15	3.1049	2.1413	0.5529
	Changes vit. D (3)	15	3.5773	2.6802	0.6920
10–20	Changes vit. D (1)	31	0.7175	0.2391	0.0429
	Changes vit. D (2)	31	0.9431	0.4719	0.0848
	Changes vit. D (3)	25	1.1091	0.4213	0.0843
> 20	Changes vit. D (1)	21	0.2185	0.2569	0.0561
	Changes vit. D (2)	21	0.2778	0.3079	0.0672
	Changes vit. D (3)	18	0.4358	0.2345	0.0553

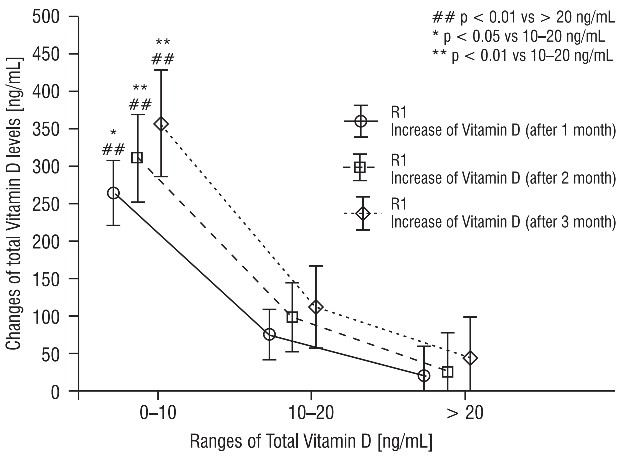

Figure 5. *Statistical analysis of changes in vitamin D levels in relation to the categorised groups, according to their baseline levels (0–10 ng/mL; 10–20 ng/mL; > 20 ng/mL) and their changes over time periods. Bars represent 95% Confidence Intervals*

Rycina 5. *Analiza statystyczna zmian stężenia witaminy D w odniesieniu do podziału na grupy w zależności od wyjściowego stężenia tej witaminy (0–10 ng/ml; 10–20 ng/ml; > 20 ng/ml) oraz zmiany stężenia w różnych okresach. Słupki przedstawiają 95% przedziały ufności*

programs, implementation, including supplementation and food fortification, is an urgently required measure [28, 29].

The role of adequate calcium and vitamin D intake benefits in health and the prevention of several chronic diseases has been the main focus for many scientists in the past few decades. Most of the observations have shown a positive influence of supplementation [13, 17]. Some facts, which indicate that not only osteoporosis, but also obesity, cancer, diabetes, hypertension, and others may be linked to inadequate calcium and vitamin D metabolism [30–35], suggests an extraordinary potential in these two agents [36]. However, some authors raise the question of whether the role of calcium and vitamin D is overweighed [37].

The Institute of Medicine supports the key role of calcium and vitamin D in the maintenance of skeletal health and recommended a daily intake of 1.2 g of calcium and 800 IU of vitamin D for women in older age [5]. In Poland, 90% of people have insufficiency of vitamin D [23, 24, 38].

The goal of our study was to examine vitamin D concentrations in a population of young, healthy women and to evaluate the optimal dose of vitamin D supplementation. Daily supplementation of calcium in the United States for women aged 19–30 years is 283 ± 18.7 mg/dL and daily intake of vitamin D 7.5 ± 0.7 ug (300 ± 28 IU) [27]. In our study, the women, aged 20–30 years, were divided into two groups depending on total vitamin D concentration at baseline. Serum total vitamin D consists of 25-hydroxyvitamin D2 and 25-hydroxyvitamin D3. In Poland, there is no vitamin D2 in tablets. Our source of this vitamin is thus limited to diet. In Group 1, which received supplementation of 1250 mg of calcium carbonicum and 1500 IU vitamin D for three months, the concentration of total vitamin D increased by about 16 ng/mL from 12.60 ± 0.71 ng/mL to 29.42 ± 1.01 ng/mL. Similarly, in Group 2, which received 1250 mg of calcium carbonicum and a supplementation of 800 IU vitamin D for three months, the concentration of vitamin D total increased by about 12 ng/mL from 25.22 ± 0.93 ng/mL to 36.92 ± 1.46 ng/mL. The study was started in January and finished in May. It is comparable with other observations. In a study of 112 white women, aged 19 to 35 years, randomly assigned to placebo or 800 IU/d vitamin D3 for one year, the mean serum 25(OH)D levels increased by 14 ng/mL from 25 ng/mL to 39 ng/mL [39]. In a study, performed in winter in Antarctica, where exposure to ultraviolet B rays is zero, 55 men and women, aged 39 to 44 years, were given vitamin in D doses of 400, 1000, or 2000 IU/d. Mean serum 25(OH) D levels increased from baseline of 18 ng/mL to 23, 25, and 28 ng/mL, respectively [40]. In two placebo-controlled studies of young men and women between 29 and 41 years old in Boston (MA, USA), 1000 IU/d of vitamin D2 or D3 increased serum 25OHD from 18 to 28 ng/mL and from 20 to 28 ng/mL [41, 42]. Vitamin D3 supplementation with 1000 IU/d in children (aged 8–14 years) with mean baseline 25(OH)D concentration < 20 ng/mL effectively raised their mean 25(OH)D concentration to ≥ 20 ng/mL but failed to reach 30 ng/mL. In this paper vitamin D supplementation had no effect on PTH concentrations [43].

Other findings from our study include serum PTH drops after vitamin D intake. In the young women in Group 1, PTH decreased from 38.03 ± 1.69 to 28.85 ± 1.37 ($p < 0.0001$). In our observations, no correlation was identified between PTH and total vitamin D. Other authors did find a significant inverse correlation between serum 25OHD and PTH [44, 45], but their examined populations were larger. There might also be another explanation for this. Shieh et al. observed that the percentage change in iPTH was significantly associated with change in free (but not total) vitamin D, without and with adjustment for supplementation regimen [46]. They suggested that vitamin D3 increased total (25-hydroxyvitamin D2 and 25-hydroxyvitamin D3) and free 25(OH)D levels to a greater extent than vitamin D2. Free 25(OH)D may be superior to total 25(OH)D as a marker of vitamin D bioactivity.

We did not see any side effects during calcium and vitamin D supplementation. The women in our groups were young (20–30 years old). It was confirmed that the incidence of hypercalciuria and hypercalcaemia is lower in younger women than that reported for older women [47, 48].

Our study authorises us to make a recommendation for the population of young women in Poland. A dose of vitamin 1500 IU/d increases total serum vitamin D concentration by 17 ng/mL, whereas 800 IU/d increases serum 25OHD by 12 ng/mL in young white women. Recently, the IOM suggested that RDA for people at the age group 19 to 50 years should be 600 IU/d [5]. In Poland, according to our recommendations, the dose of vitamin D should be higher [49], especially in case of its deficiency, which is often seen in younger populations who are still building peak bone mass.

Conflict of interest

The study was supported by Axellus LLC (Poland).

References

1. Bone Health and Osteoporosis: A Report of the Surgeon General.: Office of the Surgeon General (US). SourceRockville (MD) 2004.
2. NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy, March 7-29, 2000: highlights of the conference. South Med J. 2001; 94(6): 569–573, indexed in Pubmed: 11440324.
3. Dawson-Hughes B. Calcium insufficiency and fracture risk. Osteoporosis International. 1996; 6(S3): 37–41, doi: 10.1007/bf01623763.
4. Bischoff-Ferrari HA, Rees JR, Grau MV, et al. Effect of calcium supplementation on fracture risk: a double-blind randomized controlled trial. Am J Clin Nutr. 2008; 87(6): 1945–1951, indexed in Pubmed: 18541589.
5. Ross AC, Taylor CL, Yaktine AL, et al. Calcium, Institute of Medicine Committee to Review Dietary Reference Intakes for Calcium and Vitamin D. National Academies Press (US) : 2011.
6. DeLuca HF. Evolution of our understanding of vitamin D. Nutr Rev. 2008; 66(10 Suppl 2): S73–S87, doi: 10.1111/j.1753-4887.2008.00105.x, indexed in Pubmed: 18844850.
7. Holick MF. Vitamin D deficiency. N Engl J Med. 2007; 357(3): 266–281, doi: 10.1056/NEJMra070553, indexed in Pubmed: 17634462.
8. Konijeti GG, Arora P, Boylan MR, et al. Vitamin D Supplementation Modulates T Cell-Mediated Immunity in Humans: Results from a Randomized Control Trial. J Clin Endocrinol Metab. 2016; 101(2): 533–538, doi: 10.1210/jc.2015-3599, indexed in Pubmed: 26653112.
9. Jones G, Strugnell SA, DeLuca HF. Current understanding of the molecular actions of vitamin D. Physiol Rev. 1998; 78(4): 1193–1231, indexed in Pubmed: 9790574.
10. Penckofer S, Kouba J, Wallis DE, et al. Vitamin D and diabetes: let the sunshine in. Diabetes Educ. 2008; 34(6): 939–40, 942, 944 passim, doi: 10.1177/0145721708326764, indexed in Pubmed: 19075078.
11. Holick MF. Diabetes and the vitamin d connection. Curr Diab Rep. 2008; 8(5): 393–398, indexed in Pubmed: 18778589.
12. Guessous I, Bochud M, Bonny O, et al. Calcium, vitamin D and cardiovascular disease. Kidney Blood Press Res. 2011; 34(6): 404–417, doi: 10.1159/000328332, indexed in Pubmed: 21677437.
13. Pludowski P, Holick MF, Pilz S, et al. Vitamin D effects on musculoskeletal health, immunity, autoimmunity, cardiovascular disease, cancer, fertility, pregnancy, dementia and mortality-a review of recent evidence. Autoimmun Rev. 2013; 12(10): 976–989, doi: 10.1016/j.autrev.2013.02.004, indexed in Pubmed: 23542507.
14. Bertone-Johnson ER. Vitamin D and the occurrence of depression: causal association or circumstantial evidence? Nutr Rev. 2009; 67(8): 481–492, doi: 10.1111/j.1753-4887.2009.00220.x, indexed in Pubmed: 19674344.
15. Chiang M, Natarajan R, Fan X. Vitamin D in schizophrenia: a clinical review. Evid Based Ment Health. 2016; 19(1): 6–9, doi: 10.1136/eb-2015-102117, indexed in Pubmed: 26767392.
16. Clelland JD, Read LL, Drouet V, et al. Vitamin D insufficiency and schizophrenia risk: evaluation of hyperprolinemia as a mediator of association. Schizophr Res. 2014; 156(1): 15–22, doi: 10.1016/j.schres.2014.03.017, indexed in Pubmed: 24787057.
17. Grant WB, Wimalawansa SJ, Holick MF, et al. Emphasizing the health benefits of vitamin D for those with neurodevelopmental disorders and intellectual disabilities. Nutrients. 2015; 7(3): 1538–1564, doi: 10.3390/nu7031538, indexed in Pubmed: 25734565.
18. Holick MF. Vitamin D: physiology, molecular biology and clinical applications. Totowa, New Jersey: Humana Press. ; 1999: 1–16.
19. Rosen CJ. Clinical practice. Vitamin D insufficiency. N Engl J Med. 2011; 364(3): 248–254, doi: 10.1056/NEJMcp1009570, indexed in Pubmed: 21247315.
20. Schoor Nv, Lips P. Worldwide vitamin D status. Best Practice & Research Clinical Endocrinology & Metabolism. 2011; 25(4): 671–680, doi: 10.1016/j.beem.2011.06.007.
21. Guessous I, Dudler V, Glatz N, et al. Swiss Survey on Salt Group. Vitamin D levels and associated factors: a population-based study in Switzerland. Swiss Med Wkly. 2012; 142: 0, doi: 10.4414/smw.2012.13719, indexed in Pubmed: 23188555.
22. Płudowski P, Konstantynowicz J, Jaworski M, et al. Standardy Med Pediatria. 2014; 11: 609–617.
23. Kmieć P, Żmijewski M, Lizakowska-Kmieć M, et al. Widespread vitamin D deficiency among adults from northern Poland (54°N) after months of low and high natural UVB radiation. Endokrynol Pol. 2015; 66(1): 30–38, doi: 10.5603/EP.2015.0006, indexed in Pubmed: 25754279.
24. Kmieć P, Żmijewski M, Waszak P, et al. Vitamin D deficiency during winter months among an adult, predominantly urban, population in Northern Poland. Endokrynol Pol. 2014; 65(2): 105–113, doi: 10.5603/EP.2014.0015, indexed in Pubmed: 24802733.
25. Ganmaa D, Holick MF, Rich-Edwards JW, et al. Vitamin D deficiency in reproductive age Mongolian women: a cross sectional study. J Steroid Biochem Mol Biol. 2014; 139: 1–6, doi: 10.1016/j.jsbmb.2013.09.011, indexed in Pubmed: 24076033.

26. Wilger-Gahche JJ, Bailey RL, Burt VL, et al. Mean daily intake of calcium, folate and vitamin D from dietary supplements and the proportion getting above certain Dietary Reference Intake (DRI) levels, in the U.S. population ages 14 years and older: Third National Health and Nutrition Examination Survey (NHANES III) and NHANES, 1999-2006. The FASEB Journal 2009; 23. ; 341: 7.
27. Bailey RL, Dodd KW, Goldman JA, et al. Estimation of total usual calcium and vitamin D intakes in the United States. J Nutr. 2010; 140(4): 817–822, doi: 10.3945/jn.109.118539, indexed in Pubmed: 20181782.
28. Munns CF, Shaw N, Kiely M, et al. Global Consensus Recommendations on Prevention and Management of Nutritional Rickets. J Clin Endocrinol Metab. 2016; 101: 394–415.
29. Munns CF, Shaw N, Kiely M, et al. Global Consensus Recommendations on Prevention and Management of Nutritional Rickets. Horm Res Paediatr. 2016; 85(2): 83–106, doi: 10.1159/000443136, indexed in Pubmed: 26741135.
30. Heaney RP. Calcium and obesity: effect size and clinical relevance. Nutr Rev. 2011; 69(6): 333–334, doi: 10.1111/j.1753-4887.2011.00392.x, indexed in Pubmed: 21631514.
31. Sun Z, Wang PP, Roebothan B, et al. Calcium and vitamin D and risk of colorectal cancer: results from a large population-based case-control study in Newfoundland and Labrador and Ontario. Can J Public Health. 2011; 102(5): 382–389, indexed in Pubmed: 22032106.
32. Mitri J, Dawson-Hughes B, Hu FB, et al. Effects of vitamin D and calcium supplementation on pancreatic β cell function, insulin sensitivity, and glycemia in adults at high risk of diabetes: the Calcium and Vitamin D for Diabetes Mellitus (CaDDM) randomized controlled trial. Am J Clin Nutr. 2011; 94(2): 486–494, doi: 10.3945/ajcn.111.011684, indexed in Pubmed: 21715514.
33. Wang Lu, Manson JE, Buring JE, et al. Dietary intake of dairy products, calcium, and vitamin D and the risk of hypertension in middle-aged and older women. Hypertension. 2008; 51(4): 1073–1079, doi: 10.1161/HYPERTENSIONAHA.107.107821, indexed in Pubmed: 18259007.
34. Tamer G, Mesci B, Tamer I, et al. Is vitamin D deficiency an independent risk factor for obesity and abdominal obesity in women? Endokrynol Pol. 2012; 63(3): 196–201, indexed in Pubmed: 22744625.
35. Garanty-Bogacka B, Syrenicz M, Rać M, et al. Serum 25-hydroxyvitamin D (25-OH-D) in obese adolescents. Endokrynol Pol. 2011; 62(6): 506–511, indexed in Pubmed: 22144216.
36. Rosen CJ, Adams JS, Bikle DD, et al. The nonskeletal effects of vitamin D: an Endocrine Society scientific statement. Endocr Rev. 2012; 33(3): 456–492, doi: 10.1210/er.2012-1000, indexed in Pubmed: 22596255.
37. Bolland MJ, Grey A, Reid IR. Should we prescribe calcium or vitamin D supplements to treat or prevent osteoporosis? Climacteric. 2015; 18(sup2): 22–31, doi: 10.3109/13697137.2015.1098266.
38. Pludowski P, Grant W, Bhattoa H, et al. Vitamin D Status in Central Europe. Int J Endocrinol. 2014; 2014: 1–12, doi: 10.1155/2014/589587.
39. Nelson ML, Blum JM, Hollis BW, et al. Supplements of 20 microg/d cholecalciferol optimized serum 25-hydroxyvitamin D concentrations in 80% of premenopausal women in winter. J Nutr. 2009; 139(3): 540–546, doi: 10.3945/jn.108.096180, indexed in Pubmed: 19158226.
40. Smith SM, Gardner KK, Locke J, et al. Vitamin D supplementation during Antarctic winter. Am J Clin Nutr. 2009; 89(4): 1092–1098, doi: 10.3945/ajcn.2008.27189, indexed in Pubmed: 19225122.
41. Holick MF, Biancuzzo RM, Chen TC, et al. Vitamin D2 is as effective as vitamin D3 in maintaining circulating concentrations of 25-hydroxyvitamin D. J Clin Endocrinol Metab. 2008; 93(3): 677–681, doi: 10.1210/jc.2007-2308, indexed in Pubmed: 18089691.
42. Biancuzzo RM, Young A, Bibuld D, et al. Fortification of orange juice with vitamin D(2) or vitamin D(3) is as effective as an oral supplement in maintaining vitamin D status in adults. Am J Clin Nutr. 2010; 91(6): 1621–1626, doi: 10.3945/ajcn.2009.27972, indexed in Pubmed: 20427729.
43. Rajakumar K, Moore CG, Yabes J, et al. Effect of Vitamin D3 Supplementation in Black and in White Children: A Randomized, Placebo-Controlled Trial. J Clin Endocrinol Metab. 2015; 100(8): 3183–3192, doi: 10.1210/jc.2015-1643, indexed in Pubmed: 26091202.
44. Gallagher JC, Jindal PS, Smith LM. Vitamin D supplementation in young White and African American women. J Bone Miner Res. 2014; 29(1): 173–181, doi: 10.1002/jbmr.2010, indexed in Pubmed: 23761326.
45. Cosman F, Shen V, Morgan D, et al. Biochemical responses of bone metabolism to 1,25-dihydroxyvitamin D administration in black and white women. Osteoporos Int. 2000; 11(3): 271–277, doi: 10.1007/s001980050292, indexed in Pubmed: 10824245.
46. Shieh A, Chun RF, Ma C, et al. Effects of High-Dose Vitamin D2 Versus D3 on Total and Free 25-Hydroxyvitamin D and Markers of Calcium Balance. J Clin Endocrinol Metab. 2016; 101(8): 3070–3078, doi: 10.1210/jc.2016-1871, indexed in Pubmed: 27192696.
47. Gallagher JC, Sai A, Templin T, et al. Dose response to vitamin D supplementation in postmenopausal women: a randomized trial. Ann Intern Med. 2012; 156(6): 425–437, doi: 10.7326/0003-4819-156-6-201203200-00005, indexed in Pubmed: 22431675.
48. Gallagher JC, Peacock M, Yalamanchili V, et al. Effects of vitamin D supplementation in older African American women. J Clin Endocrinol Metab. 2013; 98(3): 1137–1146, doi: 10.1210/jc.2012-3106, indexed in Pubmed: 23386641.
49. Płudowski P, Karczmarewicz E, Bayer M, et al. Practical guidelines for the supplementation of vitamin D and the treatment of deficits in Central Europe - recommended vitamin D intakes in the general population and groups at risk of vitamin D deficiency. Endokrynol Pol. 2013; 64(4): 319–327, indexed in Pubmed: 24002961.