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Vitamin D deficiency in early autumn among predominantly non-elderly, urban adults in Northern Poland (54°N)

Niedobór witaminy D w okresie wczesnej jesieni wśród dorosłych zamieszkujących tereny miejskie północnej Polski (54°N).

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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Summary

Introduction: Data on vitamin D status among non-elderly adults from Central Europe are insufficient. Natural sunlight allows for cutaneous vitamin D synthesis only from April through August at latitudes over 54° in the northern hemisphere. In this study we aimed at determining vitamin D status among adults in the first weeks of autumn in northern Poland.

Material and Methods: A convenience sample of community-dwelling, predominantly urban and non-elderly adults was recruited in an outpatient clinic. Questionnaire and laboratory examinations were performed from September 26 through November 8. The latter comprised serum alkaline phosphatase activity (ALP), 25-hydroxyvitamin D (25(OH)D), parathyroid hormone (PTH), calcium, and phosphorus concentrations.

Results: 180 women and 124 men were enrolled into the study, aged 46+/-14.1 years (mean+/-standard deviation, SD). Mean 25-hydroxyvitamin D concentration of the studied sample was 21.1+/-9.3 ng/ml. More than 50% of studied subjects were vitamin D deficient (i.e. had 25(OH)D concentrations of less than 20 ng/ml), only 15.1% reached vitamin D concentrations of ≥30 ng/ml (sufficiency). Median 25(OH)D concentrations were higher in participants who declared longer sun exposure as well as those who supplemented vitamin D. A negative correlation was found between PTH and 25(OH)D concentrations: r=-0.23, p<0.001 (Spearman rank order test).

Discussion: While there are a number of methodological limitations concerning the current study, the acquired results broaden the scarce amount of data on vitamin D status in Central Europe. Our data correspond well with those from previous studies. The presented study should be considered precursory to further research.

Key words: **vitamin D deficiency • cholecalciferol • parathyroid hormone • ultraviolet rays • adult**

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Abbreviations: **25(OH)D** – 25-hydroxyvitamin D, **ALP** – alkaline phosphatase, **BMI** – body mass index, **PTH** – parathyroid hormone, **SD** – standard deviation, **USD** – United States dollar.

Introduction

Hypovitaminosis D has been recorded worldwide and its negative effects have been demonstrated in ongoing research, particularly in the last two decades [3,17]. Strongest evidence of beneficial effects of vitamin D supplementation has been obtained in case of fall and fractures prevention [11,16]. A plethora of data has been accumulated on vitamin D's effects on both skeletal and extraskeletal health, however, 'highly convincing evidence of a clear role of vitamin D with highly significant results in both randomized and observational evidence does not exist for any [health] outcome' [11,12,16].

Vitamin D status of an individual is reflected by the serum concentration of 25-hydroxyvitamin D, 25(OH)D, the most abundant circulating and storage form of the group of compounds collectively known as vitamin D. The debate on optimal 25(OH) D concentration range for health outcomes is ongoing [10, 15]. In this paper we adopted 25(OH)D serum concentrations ranges for: deficiency at concentrations of less than 20 ng/ml, insufficiency (or suboptimal concentrations) at 20 to 30 ng/ml, and sufficiency at 30 to 100 ng/ml, in accordance with the Endocrine Society clinical practice guideline and 'Practical guidelines for the supplementation of vitamin D and the treatment of deficits in Central Europe' [4,9].

In the northern hemisphere 25-hydroxyvitamin D concentrations reaches annual peak concentrations in August and September [5,18]. From September to March at latitudes over 51° natural sunlight is insufficient for cutaneous vitamin D synthesis. In a study by Webb and co-workers. 25(OH)D concentrations were determined repeatedly in adult participants in Greater Manchester (51° N) each month for a year [18]. A minimum 32 ng/ml concentration has been put forward as a summer nadir value that decreased to non-deficient 25(OH)D concentrations during autumn and winter.

In the current study adults were recruited in the Tri-City agglomeration in Northern Poland (54° N) in the first six weeks of autumn, i.e. following the (presumed) peak 25(OH)D concentrations. A convenience sample was used in our study, which limits the conclusions that can be drawn from it. However, there is insufficient data concerning vitamin D status in Central Europe, including Poland, which warrants attributing considerable importance to the results acquired here [7].

Materials and Methods

The independent bioethics committee of the Medical University of Gdańsk approved the study. Subjects gave a written consent for participation in the study, which comprised questionnaire and laboratory examinations.

Recruitment of subjects

Adults were recruited for participation in an outpatient clinic in Gdańsk from September 25 through November 8 (in 2012). A convenience sample was enrolled. It consisted of persons presenting for doctor's appointments, and laboratory examinations, clinic's employees and members of their families, employees of two mechanical-engineering (n=81) and one printing company (n=20). 109 participants enrolled here were also examined in a similar study performed approximately 6 months prior to the examinations reported here (February through early April). Results acquired in that time-frame have already been published [6].

Questionnaire examination

A questionnaire was used to collect data regarding socioeconomic status, vitamin D supplementation intake, exposure to sunlight during six months preceding the study, self-assessed health status, frequency of physical exercise, number of infections during six the months preceding the examination, the incidence of the following diseases: hypertension, coronary artery disease, diabetes mellitus, thyroid disorders. The questionnaire was designed to allow for filling out quickly and easily, no details were asked, e.g. the dose of vitamin D supplement dose was not included.

Since no statistically significant differences in 25(OH)D concentrations were found depending on declared frequency of intake of vitamin D-rich foods in a previous study where a larger sample of subjects (448) was enrolled in the winter/spring period, questions on foods intake were not included in the current questionnaire [6].

Laboratory examinations

Serum was acquired by centrifuging blood (3,500 g for 10 minutes) drawn from subjects. After freezing, it was transported to the Central Diagnostic Laboratory of the Medical University of Gdańsk. Using a DiaSorin® Liaison® analyzer and the "25OH Vitamin D TOTAL" assay serum concentrations of 25-hydroxyvitamin D were determined. A Siemens IMMULITE® 1000 Immunoassay System with a dedicated assay was used to determine serum PTH concentrations. Alkaline phosphatase activity, calcium, and phosphorus concentrations were determined with an Abbott Architect® analyzer (spectrophotometric method).

Statistical analysis

Graphpad Prism 5 (GraphPad Software, Inc) software was used to analyze the collected data. Gaussian distribution was tested with Shapiro-Wilk test: 25(OH)D and PTH concentrations, age, and BMI were not distributed normally; non-parametric tests were applied. Spearman rank correlations were calculated. Significance level was set at 0.05.

Excluded data

Based on the laboratory results a strong suspicion of primary hyperparathyroidism was raised in case of one female. Her calcium (11.1 mg/dl), phosphorus (2.2 mg/dl) and PTH (209 pg/ml) concentrations were excluded from the statistical analysis. Another excluded result was ALP activity (283 U/l) of a study participant with choledocholithiasis.

Results

304 adults participated in the study, 180 women and 124 men. The vast majority resided in urban areas of the Tri-City agglomeration, almost 60% had a relatively high net household income per person of over 600 USD (the median gross salary in Poland was approximately 1130 USD in November 2012 [1]), Table 1. Mean age of study participants was 46.1 years (SD 14.1), almost 80% of enrolled subjects were less than 60 years old. Median age of men was statistically lower (40 years) than that of women (49 years).

Table 1. Socioeconomic data of enrolled study participants.

		All	Men	Women
n		304	124	180
Age [years]	Mean (SD)	46 (14.1)	40 (13.2)	46 (14.1)
	Median (IQR)	44 (35)	40 (15)	49 (22) *
Residence	urban	265	107	160
	rural	35	16	19
Income [USD]**	<600	96	37	59
	>600	177	76	101

* p<0.05 (Mann-Whitney test)

**in the questionnaire the participants were asked whether the estimated income per person in the household was lower or higher than ca. 600 USD; Polish currency was used (i.e. 2000 PLN).

Basic descriptive statistics of the acquired laboratory results are presented in Table 2. A weak positive correlation was found between age and ALP activity: correlation coefficient r=0.15, p<0.01, as well as a weak negative one between 25(OH)D concentration and ALP activity: r=-0.19, p<0.001. A slightly stronger negative correlation between 25(OH)D and PTH concentrations was recorded: r=-0.23, p<0.0001, Figure 1. PTH concentrations were elevated (>62 pg/ml) in 23 subjects, 15 women and 8 men.

Table 2. Laboratory results

	Ca [mg/dl]	P [mg/dl]	ALP [U/l]	PTH [pg/ml]	25(OH)D [ng/ml]
Reference range	8.9-10.0	2.3-4.7	40-150	10-62	30-80
n	303	303	303	303	304
Mean	9.6	3.5	66.7	36.9	21.1
SD	0.5	0.6	18.4	17.9	9.3
Median	9.6	3.5	64	33	19.7
Q1	9.2	3.1	53	25	14.8
Q3	9.9	4	78	45	26.4
Minimum	7.6	2	31	4	4
Maximum	11.5	5	170	117	58.6

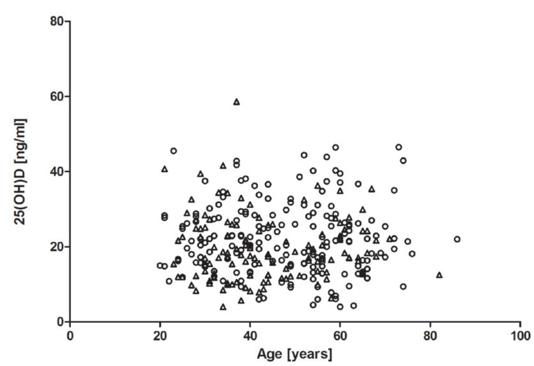

Fig. 1. 25(OH)D versus age and sex. Legend: The 'Δ' symbol was used to denote men and 'o' to denote women. Women had statistically higher median 25(OH)D concentrations – see Table 5

Mean 25-hydroxyvitamin D concentration of the studied sample was 21.1+/-9.3 ng/ml. More than 50% of studied subjects were vitamin D deficient (i.e. had 25(OH)D concentrations of less than 20 ng/ml), see Figure 2 and Table 3. Vitamin D sufficiency was recorded in 46 subjects, 15.1% (Table 3). The highest 25(OH)D concentration was 58.6 ng/ml, which is well below the toxic level [9].

Median 25(OH)D concentrations were higher in subjects who reported vitamin D supplementation (25.9 versus 18.4 ng/ml), and those declaring average daily sun exposure of more than one hour compared to those exposed for less than 30 minutes: 22.2 versus 18.4 ng/ml. Respective data are presented in Tables 4-5

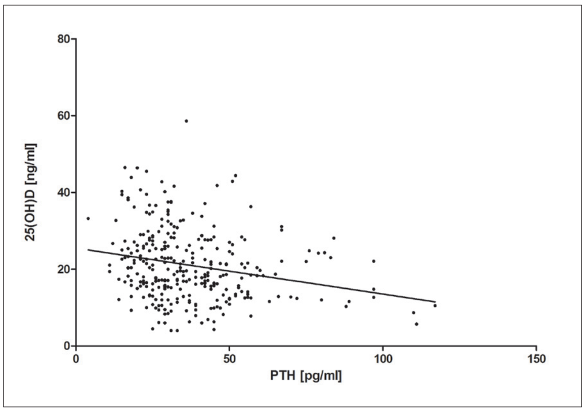

Fig. 2. Correlation between 25(OH)D and PTH.
Legend: r=-0.23, p<0.0001 (Spearman rank order test)

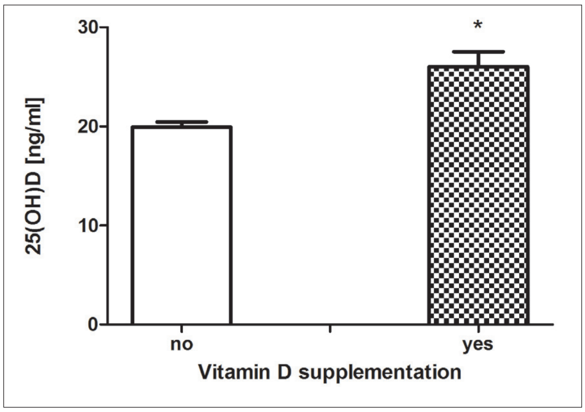

Fig. 3. 25(OH)D and vitamin D supplementation. Legend: Graphs present mean 25(OH)D concentrations, however, due to non-Gaussian distributions, nonparametric tests were used to compare the groups (medians differed significantly) – see Table 4, Materials and Methods, and Results

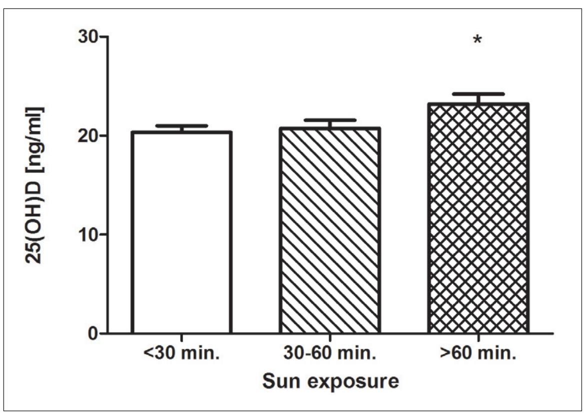

Fig. 4. 25(OH)D and daily sun exposure. Legend: Graphs present mean 25(OH)D concentrations, however, due to non-Gaussian distributions, nonparametric tests were used to compare the groups (medians differed significantly) – see Table 5, Materials and Methods, and Results

and Figures 3-4. There was no significant difference in 25(OH)D concentrations between subjects who declared sunscreen use (n=36) versus those who did not (n=37).

Table 3. Percentages of study participants according to 25(OH)D concentration ranges

25(OH)D [ng/ml]	% of subjects
<10	8.9
10-20	41.8
20-30	34.2
≥30	15.1

Table 4. 25(OH)D and vitamin D supplementation

	Vitamin D supplementation	
	no	yes
n	248	54
Mean	19.9	26
SD	8.3	11.3
SEM	0.5	1.5
Median	18.4	25.9 *
Q1	13.3	18
Q3	25.1	33.6

p<0.0001

Table 5. 25(OH)D and sun exposure duration

	Sun exposure [min.]		
	<30	30-60	>60
n	198	123	87
Mean	20.3	20.7	23.2
SD	9.4	9.2	9.1
SEM	0.7	0.8	1
Median	18.4	19.6	22.2 *
Q1	12.9	13.5	17
Q3	25.8	25.9	28.1

p<0.05 (Kruskal-Wallis test)
Average daily sun exposure during six preceding months was asked in the questionnaire.

Overall, women had higher 25-hydroxyvitamin D concentrations than men: 21.3 versus 18.2 ng/ml. 58.1% of men and 45.6% of women were vitamin D deficiency (25(OH)D<20 ng/ml).

Table 6. 25(OH)D concentrations, BMI, vitamin D supplementation and sun exposure according to age groups and sex.

Sex		Both	Women				Men			
Age group [years]		-	All	<40	40-60	≥60	All	<40	40-60	≥60
Age [years]	n	304	180	60	80	40	124	58	44	22
	Mean	46	47.6	31	50.7	66.6	40	32.3	48	64.5
	SD	14.1	(14.5)	5.5	6	5.6	13.2	4.6	6.3	5
	Median	44	49	31	52	65	40 *	33	48 *	64
	IQR	22	12.7	9.8	10.7	8	15	7	12.5	6.5
25(OH)D [ng/ml]	n	304	180	60	80	40	124	58	44	22
	Mean	21.1	22.1	22.9	21.9	21.3	19.6	20.3	17.5	23.7
	SD	9.3	9.5	8.6	10.1	9.8	8.6	10.2	6.9	15.8
	Median	19.7	21.3	22.1	20.4	21.4	18.2 *	18.5	16.8 *†	23.7 #
	IQR	11.6	12.8	12.1	13.7	11.7	11.7	13.6	8	7.3
BMI [kg/m2]	n	288	169	58	74	37	119	56	43	20
	Mean	25.7	24.7	22.8	25.3	26.5	27.1	25.4	27.6	30.7
	SD	4.3	4.3	3.6	4.1	4.6	3.9	3.5	3.4	3.3
	Median	25.4	24.2	22	24.8#	25.5#	26.9 *	24.8 *	27.5 *#	31.3 *#†
	IQR	5.6	5.6	4.4	5.8	3.2	5.4	4.3	4.8	5.1
Vit. D supplements use [n]		54	45	12	16	17	9 *	4 *	5 *	0 *
Sun exposure >1h [n]		87	45	9	7	29	42	21	12	9

Mann-Whitney and Kruskall-Wallis tests were used.
Age:
*p<0.05 for the men versus women comparisons (overall and for the middle age group).
25(OH)D:
*p<0.05 for the men versus women comparisons (overall and for the middle age group);
†# p<0.05 for male age groups: 40-60-year-olds' median 25(OH)D concentration differed from both remaining groups.
BMI:
* p<0.005 for the men versus women comparisons: overall and in all age groups;
†# p<0.0001 for male age groups (all three significant), and in women (youngest group versus both older groups).
Vitamin D supplements:
* statistically significantly more women than men supplemented vitamin D.

When divided into three age groups: of less than 40 years, 40 to 60 year-olds, and subjects aged 60 and older, the female subjects from the middle group had significantly higher 25(OH)D median concentration then respectively aged men (Table 6). Also, men had significantly lower median age than women (overall and in case of the middle age group).

25% of women declared taking vitamin D supplements, while only 7% of men did (Table 6). Almost 38% of men and 25% of women declared sun exposure of over one hour in the months preceding the study.

Median BMIs were higher in men versus women in all age groups and in general (26.9 versus 24.2 kg/m^2) as shown in Table 6. In case of both sexes, the older the age group, the higher the BMI medians were.

The general fitness of study participants may be reflected in the fact that 249 declared being able to climb at least 3 floors of stairs without resting. In respect to diseases listed in the questionnaire, there were no significant differences in 25(OH)D concentrations between those who declared the morbidities and their counterparts apart from coronary artery disease. 39 subjects declared this disease and 94 denied it; the former group had significantly higher median 25(OH)D concentrations – 25 versus 20.2 ng/ml. However, apart from the answers given by study participants no medical records were used in our study to verify the declarations.

Discussion

There are a number of limitations of the current study. Most importantly, as already mentioned, a convenience sample was used, and therefore, no far reaching conclusions can be drawn from it. Further, due to the assumed design, i.e. to allow the subjects to answer quickly, the questionnaire that was used lacked a number of details, among others the dose of supplemented vitamin D, factors influencing cutaneous vitamin D synthesis (skin pigmentation, clothing, possible holidays in countries with higher zenith angle), morbidities (different than included), medications. Also, no verification was performed of declared illnesses, body weight, and height. To exclude possible secondary hyperparathyroidism due to renal function impairment creatinine might have been examined. The study must be considered as precursory to further research.

On the other hand, results presented here undoubtedly broaden the current scare state of knowledge on vitamin D status in the population of Poland (and other Central European countries). In the review article by Płudowski and coauthors available data on 25(OH)D concentrations in Central Europe were analyzed - it is apparent the majority of studies recorded all-year, winter or summer concentrations. In our study, early autumn levels were recorded, and the results indicate widespread vitamin D deficiency shortly after summer. To our knowledge, data on vitamin D status in autumn in predominantly adults of both sexes from Central Europe were gathered only in two other studies. In one of them patients aged 20-70 hospitalized at a university hospital in Budapest between April 2009 and March 2010 had mean 25(OH)D concentrations of 23 to 27 ng/ml in October and November. The second study comprised community-dwelling men (239) and women (321) aged 53+/-14 years (mean+/-SD) who were examined from October 6 through November 28; their mean 25-hydroxyvitamin D concentration was 25(+/-4) ng/ml [7]. Results obtained in our study correspond well with these two reports.

While the obvious positive effect on supplementation on vitamin D status was recorded here, it should be underlined that in case of many study participants, the dose used was not sufficient. The results indicate the need for periodic testing of 25(OH)D.

The latter is especially valid in the context of hyperparathyroidism secondary to vitamin D deficiency. The negative correlation between 25(OH)D and PTH concentrations has been repeatedly recorded previously [8]. In line with our results a very similar correlation between these two hormones (-0.21) was recorded in winter in a different Polish city (Cracow, at 50° N) by Trofimiuk-Muldner, Kieć-Klimczak, and Hubalewska-Dydejczyk [13].

While it is well established that higher body weight, elderly age and sunscreen use lead to decreased vitamin D status, these relationships are not apparent in the data of the current study [2, 3, 14]. To account for our results, it has to be underlined, that the studied sample was characterized by high heterogeneity, and the methodological approach was simplistic.

Conclusions

Vitamin D deficiency was recorded in over half of the predominantly young and middle-aged, urban, community-dwelling adults from Northern Poland examined in the first six weeks of autumn. The data indicate the necessity of much wider as well as more adequate supplementation than currently prescribed, and/or sensible sun exposure to ensure non-deficient vitamin D status during autumn, winter and spring among adults from Central European countries. Further research is necessary to acquire population-representative data on vitamin D status in Poland.

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