International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:12, No:5, 2018

Vitamin D Deficiency and Insufficiency in Postmenopausal Women with Obesity

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Abstract**—**Deficiency and insufficiency of Vitamin D is a pandemic of the 21st century. Obesity patients have a lower level of vitamin D, but the literature data are contradictory. The purpose of this study is to investigate deficiency and insufficiency vitamin D in postmenopausal women with obesity. We examined 1007 women aged 50-89 years. Mean age was 65.74±8.61 years; mean height was 1.61±0.07 m; mean weight was 70.65±13.50 kg; mean body mass index was 27.27±4.86 kg/m^2, and mean 25(OH) D levels in serum was 26.00±12.00 nmol/l. The women were divided into the following six groups depending on body mass index: I group – 338 women with normal body weight, II group – 16 women with insufficient body weight, III group – 382 women with excessive body weight, IV group – 199 women with obesity of class I, V group – 60 women with obesity of class II, and VI group – 12 women with obesity of class III. Level of 25(OH)D in serum was measured by means of an electrochemiluminescent method - Elecsys 2010 analyzer (Roche Diagnostics, Germany) and cobas test-systems. 34.4% of the examined women have deficiency of vitamin D and 31.4% insufficiency. Women with obesity of class I (23.60±10.24 ng/ml) and obese of class II (22.38±10.34 ng/ml) had significantly lower levels of 25 (OH) D compared to women with normal body weight (28.24±12.99 ng/ml), p=0.00003. In women with obesity, BMI significantly influences vitamin D level, and this influence does not depend on the season.

Keywords**—**Obesity, body mass index, vitamin D deficiency/insufficiency, postmenopausal women, age.

I. Introduction

OBESITY is a complex disease that in 2016 affects more than 650 million adults; and more than 1.9 billion adults were overweight. According to the World Health Organization (WHO), in 2016 overweight was reported in 39% of the adult population (39% of men and 40% of women) and obesity - in 13% (11% of men and 15% women). The factors that determine the development of obesity include: genetic, demographic, socio-economic, psychological, behavioral, and neuroendocrine disorders. However, the pathogenesis of this disease is complex and completely unclear. Vitamin D plays a significant role in obesity development as evidenced by epidemiologic, genetic and metabolic data [1]. The relationship between obesity and level 25(OH)D was examined in numerous studies [2]-[6]. The results obtained are contradictory.

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According to the Ministry of Health of Ukraine, about 20.1% of population suffers from obesity (male obesity occurs in 15.9% and female in 25.7%). Adulthood obesity prevalence forecasts for 2010–2030 predict that in 2020, 32% of men and 10% of women will be obese. By 2030, the model reveals that 49% of men and 6% of women will be obese [7]. In the Ukrainian population, vitamin D deficiency (under 20 ng/ml) was determined in 81.8% of people, vitamin D insufficiency (21–29 ng/ml) – in 13.6% [8], [9]. The data presented above prompted this investigation.

The aim of this study is to examine vitamin D deficiency and insufficiency prevalence in postmenopausal women suffering from obesity.

II. Materials and Methods

The study involved 1007 postmenopausal women (50-89 years old). These were either in-house patients undergoing treatment for musculoskeletal disorders at the Department of the Clinical Physiology and Pathology of Locomotor Apparatus or subjects referred to the Ukrainian Scientific-Practical Center for Osteoporosis on an out-patient basis.

Women were classified according to their BMI into six groups: I group – 338 women with normal body weight (BMI 18.5-24.9 kg/m^2), II group – 16 women with insufficient body weight whose BMI was <18.5 kg/m^2 , III group – 382 women with excessive body weight (BMI 25.0-29.9 kg/m^2), IV group – 199 women with obesity of class I (BMI 30.0-34.9 kg/m^2), V group – 60 women with obesity of class II (BMI 35.0-39.9 kg/m^2) and VI group – 12 women with obesity of class III (BMI ≥40 kg/m^2). BMI was calculated by the formula based on a ratio of height and weight (kg/m^2). There were no differences in mean age or height across all groups.

All subjects were evaluated as to the total level of 25(OH)D in serum. Analyses were performed by means of electrochemiluminescent method - Elecsys 2010 analyzer (Roche Diagnostics, Germany) and cobas test-systems.

Vitamin D status was evaluated according to the latest classification [10], according to which vitamin D deficiency is diagnosed when serum levels of 25(OH)D are lower than 20 ng/ml, vitamin D insufficiency is diagnosed when serum levels of 25(OH)D are between 20 and 30 ng/ml. Serum levels of 25(OH)D within the range of 31-100 ng/ml are considered normal.

The study results are presented in the following manner: M±SD, where M stands for mean values and SD for standard deviation. We performed a one-way ANOVA test, regression and correlation analysis. Significance was set at $p<0.05$. “Statistika 6.0” © StatSoft, Inc. was used for data processing

purposes.

III. Results

The average level of 25(OH)D in examined women was 26.0±11.9 ng/ml (50-89 years); 28.4±12.9 ng/ml (50-59 years); 28.4±12.9 ng/ml (60-69 years); 23.5±11.7 ng/ml (70-79 years); 21.8±12.2 ng/ml (80-89 years). Vitamin D deficiency was found in 346 (34.4%) postmenopausal women, deficiency in 316 (31.4%) and normal levels in 346 (34.4%).

Analysis of 25(OH)D concentration depending on body mass index (Table I) showed the 25(OH)D highest level in women with normal body weight (28.24±12.99 ng/ml), while the lowest level is found in women with obesity of class I (23.60±10.24 ng/ml) and obesity of class II (22.38±10.34 ng/ml). According to one-way ANOVA analysis, the BMI significantly influenced 25(OH)D values (F=5.81; p=0.00003).

TABLE I
Clinical Characteristics and Level of 25(OH)D in Examined Patients Depending on Body Mass Index

Groups	Age, Years	Height, m	Weight, kg	BMI, kg/m^2	25(OH)D, ng/ml
Normal body weight (n=338)	64.97±8.93	1.62±0.07	59.05±6.08	22.61±1.63	28.24±12.99
Insufficient body weight (n=16)	66.88±9.29	1.63±0.11	45.94±6.10	17.33±1.18	21.53±11.48
Excessive body weight (n=382)	66.33±8.71	1.61±0.07	70.80±7.19	27.36±1.40	26.12±11.76
Obesity of class I (n=199)	65.87±7.83	1.60±0.06	82.57±6.88	32.02±1.36	23.60±10.24
Obesity of class II (n=60)	65.36±8.20	1.61±0.07	94.94±9.28	36.67±1.27	22.38±10.34
Obesity of class III (n=12)	66.58±9.82	1.58±0.06	106.83±12.13	42.79±2.66	23.00±12.70
F	1.04	1.50	558.04	1989.93	6.16
p	0.413	0.202	<0.0001	<0.0001	0.0001

TABLE II
Level of Vitamin D in Examined Patients Depending on Age

Groups	n	BMI, kg/m^2	25(OH)D, ng/ml
50-59 years			
Normal body weight	111	22.60±1.64	30.75±12.56
Insufficient body weight	3	17.90±0.09	23.16±8.86
Excessive body weight	94	27.29±1.35	28.62±12.39
Obesity of class I	46	32.15±1.48	26.30±12.29
Obesity of class II	16	37.29±1.28	21.31±6.84
Obesity of class III	4	43.62±2.53	17.72±9.74
F		566.73	2.93
p		<0.0001	0.01
60-69 years			
Normal body weight	128	22.79±1.63	28.47±12.43
Insufficient body weight	8	17.53±0.67	22.62±14.73
Excessive body weight	153	27.30±1.42	27.28±10.99
Obesity of class I	90	32.05±1.37	23.29±9.80
Obesity of class II	28	36.49±1.23	25.50±10.49
Obesity of class III	3	42.40±1.91	27.56±20.54
F		789.77	2.59
p		<0.0001	0.02
70-79 years			
Normal body weight	82	22.41±1.55	25.94±13.42
Insufficient body weight	3	15.97±2.31	18.99±8.77
Excessive body weight	111	27.43±1.42	23.09±11.77
Obesity of class I	54	31.88±1.18	22.30±9.05
Obesity of class II	11	36.71±1.22	16.56±4.95
Obesity of class III	4	42.84±3.76	24.32±12.38
F		501.72	1.74
p		<0.0001	0.13
80-89 years			
Normal body weight	17	22.34±1.93	21.38±14.48
Insufficient body weight	2	17.68±0.14	18.49±9.59
Excessive body weight	24	27.55±1.48	22.91±10.95
Obesity of class I	9	31.88±1.67	20.59±8.20
Obesity of class II	5	35.60±0.61	21.16±20.68
Obesity of class III	1	40.44±0.00	25.09±0.00
F		101.83	0.09
p		<0.0001	0.99

Women in the age group of 50-59 years with normal body weight have a higher vitamin D level than patients with obesity of class I (30.75±12.56 vs 26.30±12.29; p=0.04) and obesity of class II (30.75±12.56 vs 21.31±6.84; p=0.004). Also, we have detected probable differences in the levels of vitamin D in the age group of 60-69 (28.47±12.43 vs 23.29±9.80; p=0.001) (Table II).

Correlation and regression analyses of relations between 25(OH)D and BMI are shown in Fig. 1 and Table III.

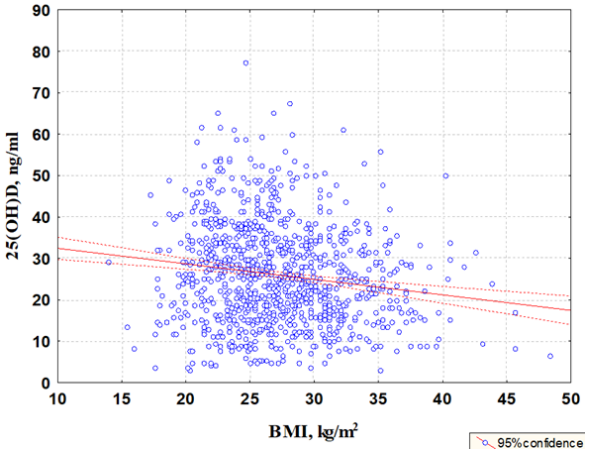

Fig. 1 Correlation between 25(OH)D level and BMI: 25(OH)D (ng/ml) = 28.9 – 0.06×BMI (kg/m^2) – r=0.15; t=4.88; p=0.000001

The highest correlation coefficient between the 25(OH)D levels and BMI was observed in women of 50-59 years (r=-0.22; p=0.0002). Regression analysis of relation between 25(OH)D levels and BMI is shown in Table III.

The distribution of patients according to the level of vitamin D depending on BMI is presented in Table IV.

TABLE III
LINEAR REGRESSION EQUATION FOR CALCULATING 25(OH)D LEVELS DEPENDING ON BODY MASS INDEX

Age group	Linear regression equation	n	r	t	p
50-59	25(OH)D level = 42.91 - 0.54*BMI, kg/m^2	274	-0.22	-3.73	0.0002
60-69	25(OH)D level = 34.89 - 0.30*BMI, kg/m^2	410	-0.13	-2.57	0.01
70-79	25(OH)D level = 34.04 - 0.39*BMI, kg/m^2	265	-0.16	-2.57	0.01
80-89	25(OH)D level = 18.81 + 0.11*BMI, kg/m^2	58	0.05	0.34	0.73

Notes: n – number of patients; r – correlation coefficient; t – Student criterion.

χ^2 showed a significant difference between normal levels of vitamin D in patients with normal body weight and obesity of class I (χ^2= 13.9; p=0.002) and obesity of class II (χ^2= 12.2; p=0.005).

Patients were further divided into two groups depending on season: winter-spring – serum 25(OH)D was determined in Nov 1 to April 30; summer-autumn – May 1 to Oct 31. Correlation and regression analysis of 25(OH)D and BMI are shown in Fig. 2 and Table V. We detected a probable effect of BMI on the level of vitamin D in the winter-spring and summer-autumn periods.

TABLE IV
DISTRIBUTION OF PATIENTS ACCORDING TO THE 25(OH)D LEVELS DEPENDING ON BODY MASS INDEX

Groups	n	Normal	Deficiency	Insufficiency
Normal body weight	338	142 (42.0%)	96 (28.4%)	100 (29.6%)
Insufficient body weight	16	4 (25.0%)	4 (25.0%)	8 (50.0%)
Excessive body weight	382	133 (34.8%)	125 (32.7%)	124 (32.5%)
Obesity of class I	199	52 (26.1%)	67 (33.7%)	80 (40.2%)
Obesity of class II	60	11 (18.3%)	20 (33.3%)	29 (48.4%)
Obesity of class III	12	3 (25.0%)	4 (33.3%)	5 (42.7%)

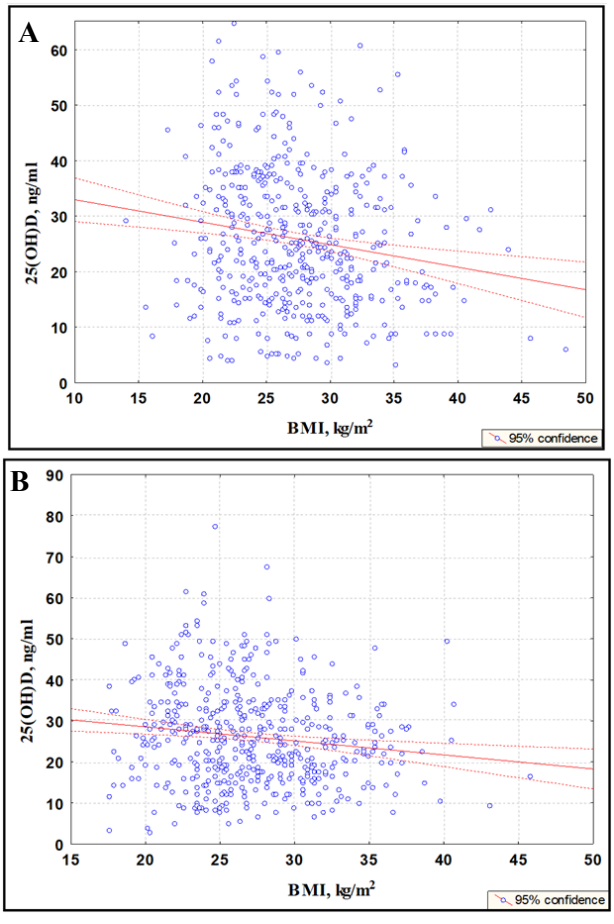

Fig. 2 Correlation between level of 25(OH)D in the winter-spring (A) and summer-autumn (B) periods *Note.* Linear regression equations: A – 25(OH)D level = 37.00 - 0.40*BMI, kg/m^2 (r=-0.16; p<0.0003); B – 25(OH)D level = 35.40 - 0.34*BMI, kg/m^2 (r=-0.14; p<0.001)

TABLE V
25(OH)D LEVELS DEPENDING ON SEASON

Groups	n	Age, years	BMI, kg/m^2	25(OH)D, ng/ml
winter-spring				
Normal body weight	160	64.15±8.33	22.54±1.64	28.25±13.03
Insufficient body weight	7	71.29±8.42	16.62±1.53	22.00±12.57
Excessive body weight	188	65.40±8.20	27.42±1.38	25.99±12.20
Obesity of class I	99	66.23±7.49	31.97±1.37	24.05±10.99
Obesity of class II	29	66.07±9.28	36.94±1.37	21.10±12.24
Obesity of class III	7	65.29±10.75	43.34±2.90	20.20±10.40
F		1.68	990.21	2.97
p		0.132	<0.0001	0.001
summer-autumn				
Normal body weight	178	65.71±9.41	22.68±1.63	28.25±13.00
Insufficient body weight	9	63.44±8.85	17.87±0.29	21.17±11.33
Excessive body weight	194	67.22±9.10	27.30±1.42	26.25±11.36
Obesity of class I	100	65.52±8.18	32.07±1.35	23.15±9.47
Obesity of class II	31	64.71±7.13	36.42±1.13	23.58±8.19
Obesity of class III	5	68.40±9.21	42.03±2.36	26.92±15.76
F		1.13	974.66	3.19
p		0.340	<0.0001	0.007

IV. CONCLUSION

In Ukrainian patients with obesity, significant influence of BMI was found on the level of vitamin D, which did not depend on the season. Vitamin D deficiency was found in 34.4% of postmenopausal women, insufficiency in 31.4% and normal levels in 34.4%. 25(OH) D levels were significantly lower in women with obesity of class I (23.60±10.24 ng/ml) and obesity of class II (22.38±10.34 ng/ml), compared with women who had normal body weight (28.24±12.99 ng/ml). Obesity negatively influenced vitamin D level values. The study results revealed a weak correlation between 25(OH)D level and BMI (r=0.15). The presented results should be taken into account for prevention and treatment of vitamin D

deficiency in obese women.

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