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The influence of anthropometric indicators on the availability of vitamin D in residents of Southern Ukraine

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Abstract

The social role of the problem of obesity is determined by the threat of disability and a decrease in overall life expectancy due to the frequent development of serious concomitant diseases. Despite a significant number of studies on the effect of excess body weight on the level of 25(OH)D, there are still ongoing discussions about the role of vitamin D in the pathogenesis of obesity. The main described pathogenetic mechanism by which obesity negatively affects 25(OH)D levels is the redistribution of fat-soluble vitamin D in large amounts of adipose tissue. This leads to a decrease in the concentration of 25(OH)D in the blood serum.

Goal. To determine the dependence of the level of 25(OH)D in blood serum on anthropometric indicators in residents of the southern regions of Ukraine.

Materials and methods. During the study, 928 residents (women – 507; men – 421) of southern Ukraine aged 19 to 82 were examined.

The results. The level of 25(OH)D in blood serum among the study participants ranged from 4.31 - 89.19 ng/ml. The prevalence of deficiency, insufficiency and sufficient level of vitamin D in the study group was 33.6%, 33% and 33.4%, respectively. The body mass index in the study group ranged from 16.1 kg/m2 to 41.3 kg/m2, while the average BMI in men was 25.2±4.0 kg/m2, and in women it was 25.6±4.5 kg/m2. In addition, an anthropometric analysis was conducted, namely, a waist-to-hip ratio assessment was conducted in order to determine the influence of these indicators on the level of 25(OH)D in blood serum.

Conclusions. A higher negative correlation was established between the level of 25(OH)D and BMI than the waist-to-hip ratio index. The hypothesis of the connection of vitamin D with the specified anthropometric indicators was confirmed, in particular, when comparing groups by BMI. It is worth noting that among people of both sexes, regardless of age, with an increase in BMI and waist circumference, a decrease in the level of 25(OH)D in blood serum is observed.

Key words: **vitamin D; obesity; anthropometry; risk factors**

Introduction. Obesity is a chronic relapsing disease characterized by excessive accumulation of adipose tissue in the body and caused by metabolic disorders. The main pathogenetic factor of the disease is a positive energy balance. [1]

The social role of the problem of obesity is determined by the threat of disability and a decrease in the total life expectancy due to the frequent development of serious concomitant diseases. These include type 2 diabetes, hypertension, dyslipidemia, atherosclerosis and related diseases, sleep apnea syndrome, hyperuricemia, gout, reproductive dysfunction, gallstone disease, osteoarthritis, varicose veins of the lower extremities, and hemorrhoids. [2, 3]

According to statistics, the largest number of obese population is recorded in the Pacific Islands in the state of Nauru - 88.5%. More than 80% of the population is overweight in Palau, in the Marshall Islands. In Kuwait, 73% of the population is overweight, and in the USA - 67.9%. In European countries, the number of obese patients is different: in Great Britain, 63.75% of the population are overweight, in Spain - 61.6%, in the Czech Republic - 62.3%, in Lithuania - 57.8%, in Poland - 58.3%, in Estonia - 55.8%. [4] According to WHO data for 2016, 58.4% of Ukrainians over the age of 18 were overweight. [5]

Despite a significant number of studies on the effect of excess body weight on the level of 25(OH)D, there are still ongoing discussions about the role of vitamin D in the pathogenesis of obesity. [6] The main described pathogenetic mechanism by which obesity adversely affects 25(OH)D levels is the redistribution of fat-soluble vitamin D in large amounts of adipose tissue. This leads to a decrease in the concentration of 25(OH)D in the blood serum. [7] Despite the results of a number of studies, it was demonstrated that the level of the precursor of vitamin D in the skin (7-dehydrocholesterol) with excess body weight corresponds to its level in individuals with a normal body weight. In people who are overweight, 25(OH)D is distributed in a larger volume, which lowers its concentration in the blood serum. [6, 8] 25-hydroxyvitamin D is distributed mainly in adipose tissue and liver, which naturally increase in size during obesity. [8, 9]

Goal. To determine the dependence of the level of 25(OH)D in blood serum on anthropometric indicators in residents of the southern regions of Ukraine.

Materials and methods.

During the study, 928 residents (women – 507; men – 421) of southern Ukraine (Kherson, Mykolaiv and Odesa regions) aged 19 to 82 were examined (average age of women — 47.7±15.3 years, men — 46.7±15.5 years). Patients who were treated at the «Yes Medical Center» and the «ARTROMED» Sports Rehabilitation Medical Center from January to December 2020 took part in the study. All patients who participated in the study previously provided written consent to participate in the study. The study was conducted with the provision of safety measures for life and health, with respect for human rights and moral and ethical standards, which corresponds to the principles of the Helsinki Declaration of Human Rights and the Council of Europe Convention on Human Rights and Biomedicine (ETS-164) dated 04.04.1997.

The criteria for exclusion from the study were the presence of diseases of the endocrine system, autoimmune pathology, oncopathology, chronic liver and kidney diseases, pregnancy and lactation, as well as the use of drugs containing vitamin D during the last three months.

Determination of the level of vitamin 25(OH)D total (estimation of the total level of 25(OH)D2 and 25(OH)D3) was performed using an automatic immunochemical analyzer Architech i2000sr (Abbott, USA). The status of vitamin D was determined according to the recommendations of the Committee of Endocrinologists for the creation of clinical practice guidelines [10]: Vitamin D deficiency (VDD) - below 20 ng/ml or 50 nmol/l; Insufficiency of vitamin D (IVD) - from 21 to 29 ng/ml or from 50.1 to 74.9 nmol/l; A sufficient level of

vitamin D is above 30 ng/ml or 75 nmol/l; Vitamin D intoxication over 150 ng/ml or 375 nmol/l. Overweight and obesity were verified according to BMI classification (IOTF WHO, 1997). The type of adipose tissue distribution was assessed by values - waist circumference (WC). According to the criteria of NCEP ATP III (2001), the value of WC for women more than 80 cm, for men more than 102 cm and waist-to-hip ratio (WHR) more than 0.85 in women and more than 0.90 in men was considered a sign of abdominal (central) type of obesity.

Analysis and visualization of the obtained data was carried out using specialized open libraries for scientific computing NumPy, SciPy, Pandas, Matplotlib. For the statistical processing of the research results, we used primary descriptive statistics, testing for subordination of data to normal distribution, as well as methods of correlation analysis. Comparison of groups was performed using paired Student's t-tests. The null hypothesis was rejected at $p<0.05$.

Results and Discussion. The level of 25(OH)D in blood serum among the study participants ranged from 4.31 ng/ml to 89.19 ng/ml (the average level in women was 26.5±13.3 ng/ml, in men - 26 .8±11.7 ng/ml). The prevalence of deficiency, insufficiency and sufficient level of vitamin D in the study group was 33.6%, 33% and 33.4%, respectively. The percentage of patients with 25-hydroxyvitamin D levels below 30 ng/ml was almost identical in men (65.5%) and women (64.3%) (Table 1).

Table 1

Level of 25(OH)D in residents of the southern region of Ukraine depending on gender

Level 25(OH)D	Men		Women	
	Abs.	%	Abs.	%
Deficiency	136	32,30	176	34,71
Insufficiency	140	33,25	150	29,59
Sufficient	145	34,44	181	35,70

The body mass index in the study group ranged from 16.1 kg/m2 to 41.3 kg/m2, while the average BMI in men was 25.2±4.0 kg/m2, and in women it was 25.6±4.5 kg/m2. Correlation analysis of the relationship between BMI and serum 25(OH)D level showed the presence of a statistically significant feedback (Spearman's coefficient $r=-0.181$, $p<0.001$), fig. 1. This indicates that the level of 25(OH)D is dependent on BMI and indicates that overweight and obese people are more prone to vitamin D deficiency states.

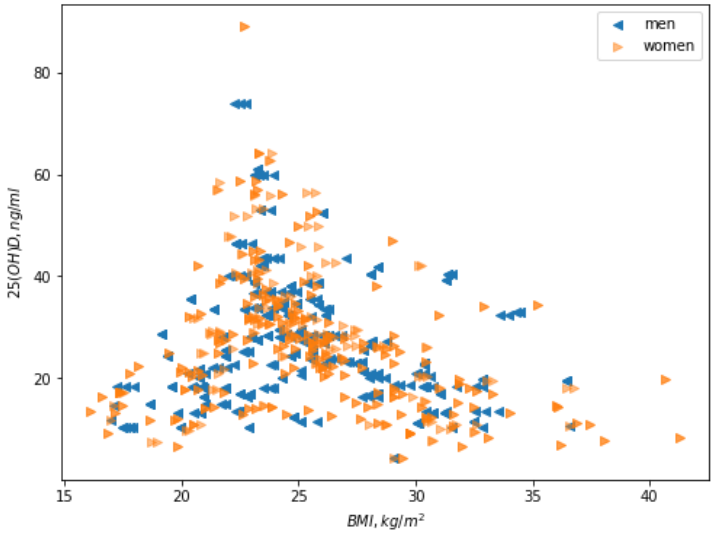

Fig. 1. Correlation of BMI and 25(OH)D level in residents of the southern region of Ukraine

Examination data show that the mean BMI in the study group was highest in patients with vitamin D deficiency and lowest in patients with sufficient 25(OH)D levels (Fig. 2).

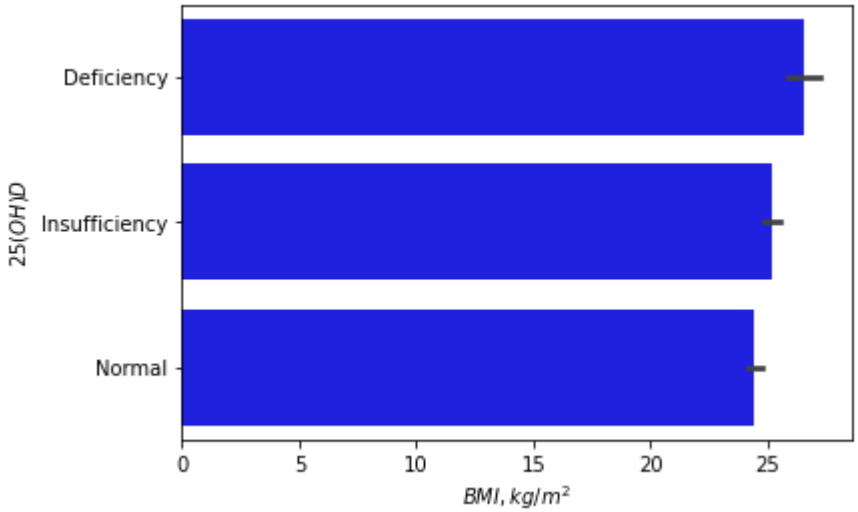

Fig. 2. Average body mass index depending on the level of 25(OH)D

A statistical comparison of the mean BMI in patients with vitamin D deficiency, insufficiency, and sufficient levels using the Student's t-test showed that these groups were significantly different from each other (Table 2), which confirms the conclusions made earlier about the susceptibility to vitamin D deficiency states in overweight and obese people.

Table 2

Statistical comparison of BMI depending on the level of 25(OH)D in residents of the southern region of Ukraine

Vitamin D level and average BMI, M±m, kg/m2		p-value
Deficiency, 26.6±6.1	Insufficiency, 25.2±3.0	<0.001
Deficiency, 26.6±6.1	Sufficient level, 24.5±2.6	<0.001
Insufficiency, 25.2±3.0	Sufficient level, 24.5±2.6	0.002

In addition, an analysis of anthropometric data was carried out, namely, WHR was assessed in order to determine the effect of these indicators on the level of 25(OH)D in blood serum.

The study showed that the level of correlation between the ratio of WHR and the level of vitamin D is lower compared to the similar indicator for BMI (Spearman's correlation coefficient is r=-0.09, p=0.006), fig. 3. This indicates that patients with a higher WHR index have a greater tendency to vitamin D deficient states, but this dependence is expressed to a lesser extent than for BMI.

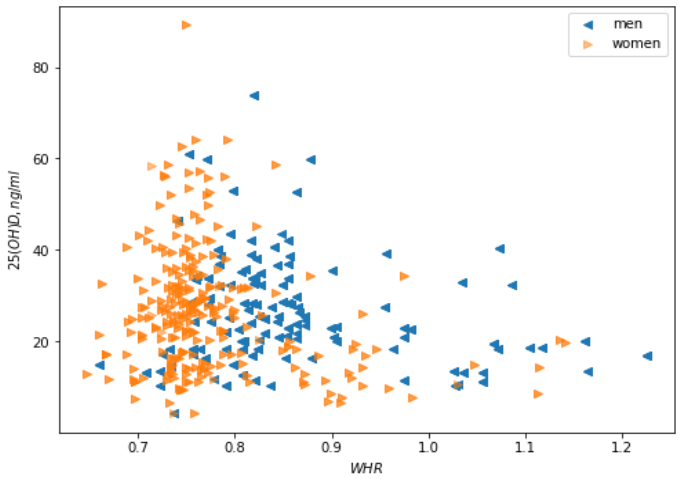

Fig. 3. Correlation ratio of WHR and 25(OH)D level in men and women

A statistical comparison of mean WHR indices for patients with different levels of vitamin D was also performed, which provided an additional indication of susceptibility to vitamin D deficient states in overweight patients. Average levels and standard deviations of the WHR index are shown in fig. 4.

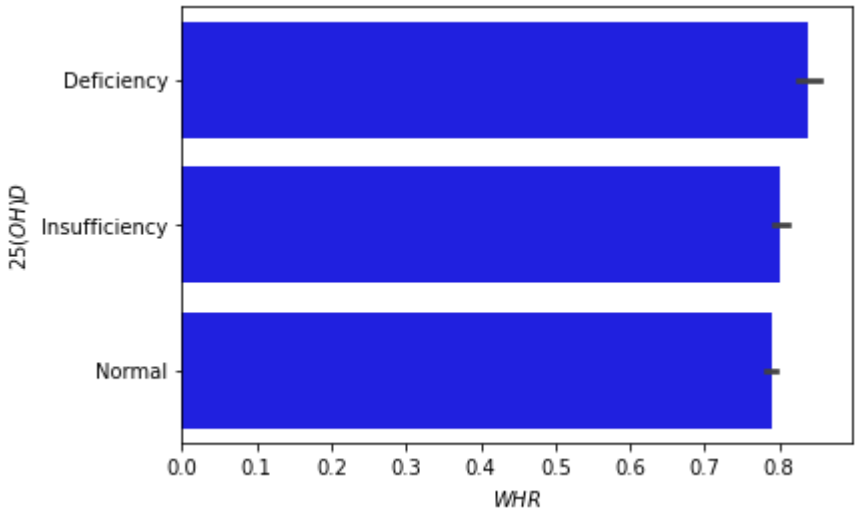

Fig. 4. Average ratio of WHR depending on the level of 25(OH)D

Statistical analysis of groups of patients with different levels of vitamin D using the Student's t-test showed that the mean ratio of WHR in these groups was significantly different from each other (Table 3). So, we can conclude that the predisposition to vitamin D deficient conditions in overweight and obese people is statistically confirmed.

Table 3

Statistical comparison of the WHR index depending on the level of 25(OH)D

Vitamin D level and mean WHR index, M±m		p-value
Deficiency, 0.84±0.14	Insufficiency, 0.8±0.08	<0.001
Deficiency, 0.84±0.14	Sufficient level, 0.79±0.07	<0.001
Insufficiency, 0.8±0.08	Sufficient level, 0.79±0.07	0.034

A detailed statistical analysis using elasticity coefficients allowed us to obtain a quantitative assessment of the dependence of serum 25(OH)D on BMI and WHR. Thus, with an increase in BMI by 1 kg/m2, the level of vitamin D decreases on average by 0.603 ng/ml ($p < 0.001$), and with an increase in waist circumference by 1 cm — by 0.163 ng/ml ($p < 0.001$). Therefore, it can be concluded that the degree of obesity belongs to the parameters associated with vitamin D deficiency.

During the BMI analysis, it was found that body weight deficiency was observed in 36 (men - 11; women - 25) patients, norm - 453 (men - 225; women - 228) patients, overweight in 284 (men - 113; women - 171) patients, obesity of the first degree - 127 (men - 65; women - 62), obesity of the second degree - 24 (men - 7; women - 17), obesity of the third degree - 4 (men - 0; women - 4).

Mean and standard deviations of serum 25(OH)D level were calculated for each of the groups in relation to BMI (Fig. 5). Calculations suggest that vitamin D deficiency and insufficiency is observed in underweight and obese patients (the mean vitamin D level in these groups was less than 20 ng/ml). It is also possible to note the tendency of the average level of vitamin D to decrease with increasing BMI.

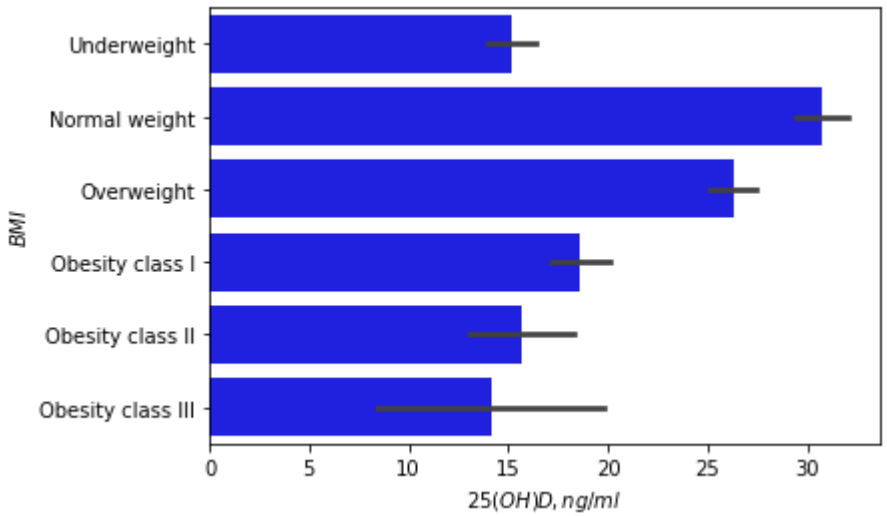

Fig. 5. Average level of 25(OH)D depending on BMI (by groups)

The largest number of patients who had a vitamin D level of less than 30 ng/ml was noted in the underweight and obese groups, and the smallest number of such patients was in the normal weight group (Table 4).

Table 4

Level of 25-hydroxyvitamin D depending on BMI

Level 25(OH)D	Assessment of body mass index					
	Insufficient weight	Norm	Overweight	Obesity class I	Obesity class II	Obesity class III
Deficiency	88.9%	23.2%	21.5%	69.3%	91.7%	100.0%
Insufficiency	11.1%	25.2%	52.8%	17.3%	0.0%	0.0%
Sufficient level	0.0%	51.7%	25.7%	13.4%	8.3%	0.0%

Comparison of groups formed by BMI showed statistically significant differences in the mean levels of 25(OH)D serum between all groups, excluding groups with obesity of class

I, II and III (table 5). Therefore, the conclusions obtained at the previous stages of the study regarding the hypothesis of the dependence of the level of vitamin D on BMI were confirmed.

Table 5

The average level of 25-hydroxyvitamin D in blood serum depending on BMI

BMI and average level of 25(OH)D, M±m, ng/ml		p-value
Insufficient weight, 15.1±3.7	Norm, 30.7±13.6	<0.001
Norm, 30.7±13.6	Overweight, 26.3±10.1	<0.001
Overweight, 26.3±10.1	Obesity class I, 18.6±8.4	<0.001
Obesity class I, 18.6±8.4	Obesity class II, 15.7±7.3	0.09
Obesity class II, 15.7±7.3	Obesity class III, 14.1±6.5	0.68
Insufficient weight, 15.1±3.7	Obesity class I, 18.6±8.4	<0.001

Conclusions. A statistical analysis of the degree of dependence of vitamin D levels on anthropometric parameters such as BMI and WHR ratio was performed. This study demonstrated a higher negative correlation between the level of 25(OH)D and BMI than the WHR index. The hypothesis of the connection of vitamin D with the specified anthropometric indicators was confirmed, in particular, when comparing groups by BMI. It is worth noting that among people of both sexes, regardless of age, with an increase in BMI and waist circumference, a decrease in the level of 25(OH)D in blood serum is observed. A decrease in vitamin D to the level where we can talk about its deficiency was most often noted among patients who were underweight and those who had a BMI ≥ 30.

Low levels of vitamin D in underweight and obese patients can significantly influence the development of comorbid pathology. In order to timely detect vitamin D deficiency and prevent many diseases, it is necessary to periodically monitor the status of 25(OH)D blood serum in patients with body weight deficiency and obesity. The prospect of further research is to determine preventive doses of vitamin D depending on anthropometric indicators and seasonality.

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