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The correlation of vitamin D level with body mass index in women with PCOS

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ABSTRACT

Objectives: The aim of this study is to analyze correlation between vitamin D level and BMI in polycystic ovary syndrome (PCOS) women.

Material and methods: The study group consisted of 311 patients with PCOS. Patients were categorized according to four phenotypes. All of the women participating in the study had their blood tested in the appropriate phase of the menstrual cycle and after proper preparation for the tests. The ultrasound examination and anthropometric measurements were performed.

Results: Vitamin D concentration was assessed in all study subgroups. The majority of patients had vitamin D deficiency or insufficient level. Variables included in the study, such as level of vitamin D, low density lipoprotein (LDL), sex hormone binding globulin (SHBG), testosterone, androstenedione, Anti-Müllerian Hormone (AMH) and BMI were correlated. A negative correlation was observed with the the level of SHBG, vitamin D and AMH. Subsequently, positive correlations were shown with testosterone, LDL and free testosterone level. An analysis of the correlation between BMI and vitamin D concentration showed that in phenotype I of PCOS this correlation was statistically significant and in the remaining PCOS phenotypes the correlation was close to statistical significance.

Conclusions: Most PCOS patients have a deficiency or insufficient level of vitamin D. Women with PCOS have shown a significant negative correlation between BMI and SHBG serum level and between BMI and AMH level. A positive correlation exists between BMI and total and free testosterone and LDL.

There is a negative correlation between BMI and vitamin D level in PCOS patients and in phenotype I this correlation was statistically significant.

Key words: polycystic ovary syndrome; body mass index; vitamin D

INTRODUCTION

Polycystic ovary syndrome (PCOS) is a complex endocrine and metabolic disorder. It is the most common in women of reproductive age, with a prevalence of 6–15% depending on the criteria used and ethnic differences [1]. Clinical features are heterogeneous, with manifestations typically arising in childhood and then evolving across adolescent and adult life. According to European Society of Human Reproduction and Embryology (ESHRE) criteria, two out of the three following should be met to diagnose patient with PCOS: 1) ovulatory dysfunction resulting in oligo- and/or anovulation, 2) hyperandrogenism clinical or biochemical and 3) the presence of polycystic ovarian morphology [2, 3]. The diagnostic criteria generate four phenotypes. The full-blown syndrome (phenotype I) is characterized by the presence of clinical and/or biochemical hyperandrogenism, menstrual disorders in the form of infrequent menstruation and the associated rare or absent ovulation and the characteristic appearance of polycystic ovaries on ultrasound examination. Accordingly, the phenotype II comprises oligo- and/or anovulation and clinical and/or biochemical hyperandrogenism, the phenotype III — clinical and/or biochemical hyperandrogenism and polycystic ovarian morphology and finally the phenotype IV contains oligo- and/or anovulation and polycystic ovarian morphology [4]. Pathophysiologically abnormalities occur in gonadotropin secretion or action, ovarian folliculogenesis and steroidogenesis.

PCOS patients are at high risk of glucose intolerance, type 2 diabetes mellitus, insulin resistance, dyslipidemia, overweight, obesity, metabolic syndrome, hypertension among many others, less common, such as iron metabolism disorders or abnormal level of vitamin D3 [5].

In PCOS women, vitamin D level may contribute to the pathophysiology of this disorder. The variety of serum vitamin D concentration is associated with metabolic and endocrine disturbances, including especially overweight and obesity [6, 7]. Vitamin D is a pro-hormone best known for its main role in bone metabolism and calcium homeostasis. Non-skeletal actions of vitamin D are including the role in autoimmune diseases, metabolic syndromes and cardiovascular disease [8]. Vitamin D is the term used to describe both vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol). Both the plant/fungus-derived vitamin D_2 and the animal-derived vitamin D_3 forms can be found in human foods. However, vitamin D_3 is also produced in the skin by the action of ultraviolet B radiation from the sun [9].

Recently, it has been reported that vitamin D deficiency was a common complication of PCOS and vitamin D status was associated with reproductive ability and metabolic alterations of PCOS patients [6]. The relationship between weight and vitamin D status has not been clarified yet. There is ongoing discussion if vitamin D level is body mass index (BMI) dependent [10].

The aim of this study is to analyze correlation between vitamin D level and BMI in PCOS women and in individual PCOS phenotypes.

MATERIAL AND METHODS

The study involved 311 Polish women, newly diagnosed with PCOS, hospitalized in the Department of Endocrinological Gynecology from December 2021 to September 2022. Inclusion criteria were age 18–40 and PCOS diagnosis. The diagnosis of PCOS was based on ESHRE criteria from 2018. Patients were categorized according to phenotypes. Patients with hypothalamic-pituitary dysfunction or insufficiency, Cushing’s syndrome, acromegaly, decreased ovary reserve, congenital adrenal hyperplasia were excluded. Three months before hospital admission patients were informed to stop taking any kinds of supplements, including vitamin D supplementation.

All the women participating in the study had their blood tested between 2nd and 6th day of menstrual cycle, 12 hours from their last meal, on an empty stomach. Samples of venous blood were withdrawn in the morning between 8.00 and 10.00 AM. The blood samples were collected and delivered to the diagnostic laboratory in the hospital. Using the colorimetric method, the markings in the lipid profile serum and glucose (analyzer AU 680 with reagents from Beckman Coulter (Brea, California, USA)) were made. Using the method of chemiluminescence (with microparticles and chemiluminescence marker (CMIA) and reagents by Abbott (Architect i2000SR; Chicago, Illinois, USA)), the following serum concentrations were marked: estradiol, follicle stimulating hormone (FSH), luteinizing hormone (LH), total and free testosterone, 17-OH-progesterone, androstenedione, cortisol, dehydroepiandrosterone sulfate (DHEAS), sex hormone binding globulin (SHBG) and insulin. Vitamin D3 was marked using the Cobas e801 (Roche Diagnostics) immunochemistry analyzer. The ultrasound examination was performed with the Voluson 730 Expert. Anthropometric measurements (body mass and height) were performed, and BMI was calculated according to standardized criteria (BMI = body mass [kg]/height $[m]^2$). The classification was made in accordance with the standards provided by the World Health Organization, where BMI = 18.5–24.9 was assumed as normal body weight, 25.0–29.9 as an overweight, 30.0–34.9 as I degree of obesity, 35.0–39.9 as II degree of obesity and ≥ 40 as III degree of obesity.

RESULTS

The study group consisted of 311 patients with PCOS. There were 51.8% (n = 161) patients with type phenotype I of PCOS, 13.8% (n = 43) with phenotype II, 18% (n = 56) with phenotype III and with phenotype IV was 16.4% (n = 51). The study also included the degree of obesity assessed in 5 categories according to the scale of the World Health Organization. The study included 3.5% (n = 11) of underweight women, 48.2% (n = 150) of normal weight, 24.4% (n = 76) of overweight women, 11.5% (n = 36), with I degree of obesity, 7.7% (n = 24) with II degree of obesity, and 4.5% (n = 14) with III degree of obesity. The analysis of BMI frequency depending on the phenotype of PCOS showed no statistically significant differences (p = 0.3) (Tab. 1). After combining the underweight and normal weight groups vs. overweight vs. obesity depending on the phenotype of PCOS also showed no statistically significant differences (p = 0.2).

Vitamin D concentration was assessed in all study subgroups. The majority of patients had vitamin D deficiency, and this concerned 47.2% (n = 147). Insufficient level of vitamin D occurred in 32.8% (n = 102) of PCOS women, 17% (n = 53) had normal level of vitamin D, 2.9% (n = 9) of patients had high level of vitamin D, and none had potentially toxic level of vitamin D.

Variables included in the study, such as level of vitamin D, low density lipoprotein (LDL), SHBG, total and free testosterone, androstenedione, Anti-Müllerian Hormone (AMH) and BMI were correlated. Raw BMI values were correlated with all variables except androstenedione. The strongest correlation was observed with the level of SHBG and it was a negative correlation (R = –0.63). A negative correlation was also observed with the vitamin D level (R = –0.25) and AMH level (R = –0.13). Subsequently, positive correlations were shown with testosterone (R = 0.20), LDL (R = 0.37) and free testosterone level(R = 0.39).

An analysis of the correlation between BMI and vitamin D concentration was also performed for all patients (Fig. 1) and for individual PCOS phenotypes. In the phenotype I of PCOS, the correlation value was R = –0.38 and was statistically significant (Fig. 2). In the remaining PCOS phenotypes the correlation values ranged from R = –0.23 to R = –0.25 and were close to statistical significance (Fig. 3–Fig. 5).

DISCUSSION

The present work confirms that the most common disorder associated with vitamin D3 is its deficiency. This also applies to PCOS patients, where vitamin D deficiency is quite common and what is consistent with other research results [6]. Vitamin D3 deficiency, defined as concentration below 20 ng/mL, occurred more often than insufficient level of vitamin D3 (21–29 ng/mL), and both parameters together much more often than normal level of vitamin D3, even though patients who were hospitalized in months with more sunlight were also qualified for the study.

The paper has shown a significant negative correlation between BMI and SHBG serum level. Many independent studies showed that serum SHBG levels are decreased in women with PCOS, especially obese [11]. Also, a negative correlation occurred between BMI and AMH level. Obesity negatively impacts reproductive health, including ovarian function and thus alters the production of the AMH. Despite the fact that in the presented study this correlation was negative, there are reports that do not show a relationship between the level of AMH and only an obesity [12]. A positive correlation occurred between BMI and total and free testosterone and LDL. Hyperandrogenism is the key feature of PCOS and play a significant role in metabolic dysfunction, which has been proven in many studies. The increase in global adiposity may be due to high androgen levels [13]. The consequences of obesity can be severe and include not only increased risks of metabolic disorders but also cardiovascular diseases. In the presented study, there was a positive correlation between BMI and LDL, but as other authors show, such a correlation also exists between fasting insulin and homeostatic model assessment for insulin resistance (HOMA-IR) [14].

In the presented work, a negative correlation occurred between BMI and vitamin D3 level. An analysis of the correlation between BMI and vitamin D concentration in individual PCOS phenotypes was also performed. In the I phenotype of PCOS the correlation value was statistically significant, in the remaining phenotypes the correlation values were close to statistical significance. The problem of the relationship between BMI and vitamin D in PCOS patients, especially when considering PCOS phenotypes, in the literature is inconsistent. Eftekhar et al. [15] in his work proves that there is no significant difference in the serum vitamin D level of the different phenotypes of PCOS. The work of Nestler et al. [16] stands in opposition to this. The author proves that obese women with PCOS had significantly lower serum vitamin D levels at baseline than age- and BMI-matched controls, which is consistent with the results of the presented work. The divergence in these results could be due to variation in study design including differences in case definition, control group selection or the small number of study participants, type of serum vitamin D analyses, and analytical methods [17,18].

CONCLUSIONS

Most PCOS patients have a deficiency or insufficient level of vitamin D.

Women with PCOS have shown a significant negative correlation between BMI and SHBG serum level. Also, a negative correlation occurred between BMI and AMH level in the study group of women. A positive correlation occurred between BMI and total and free testosterone and LDL.

There is a negative correlation between BMI and vitamin D level in PCOS patients. An analysis of the correlation between BMI and vitamin D concentration in individual PCOS phenotypes shows that in the I phenotype of PCOS the correlation value is statistically significant and in the remaining phenotypes the correlation values are close to statistical significance.

Authors contribution

AN, MW: concept, assumptions, study design; KB: statistical analasis, elaboration of results; DG: analysis and interpretation of data, acquisition of data; JD: analysis of data; DP: final evaluation and comments

Conflict of interest

The authors declare no conflict of interests

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Table 1. Frequency of BMI categories depending on PCOS type

Phenotype of PCOS	Underweight	Normal weight	Overweight	Obesity I	Obesity II	Obesity III
I	7	69	42	22	11	10
	63.64%	46.00%	55.26%	61.11%	45.83%	71.43%
	4.35%	42.86%	26.09%	13.66%	6.83%	6.21%
II	0	21	11	3	5	3
	0.00%	14.00%	14.47%	8.33%	20.83%	21.43%
	0.00%	48.84%	25.58%	6.98%	11.63%	6.98%

III	1	33	15	4	3	0
	9.09%	22.00%	19.74%	11.11%	12.50%	0.00%
	1.79%	58.93%	26.79%	7.14%	5.36%	0.00%
IV	3	27	8	7	5	1
	27.27%	18.00%	10.53%	19.44%	20.83%	7.14%
	5.88%	52.94%	15.69%	13.73%	9.80%	1.96%

BMI — body mass index; PCOS — polycystic ovary syndrome

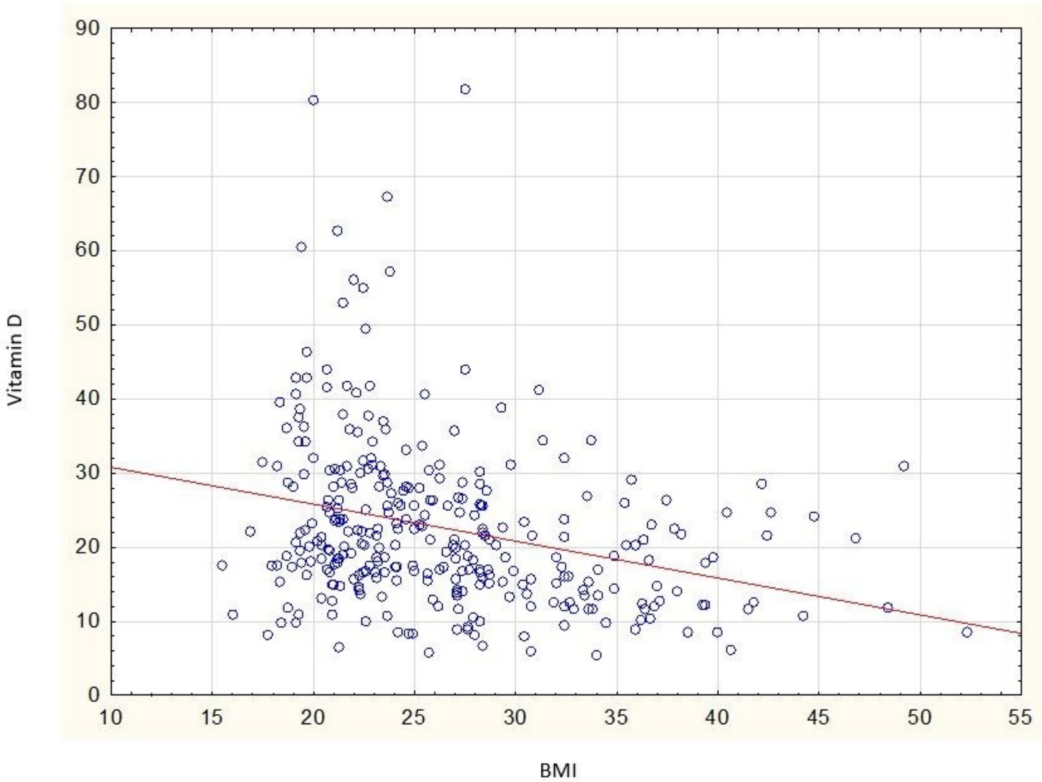

Figure 1. Correlation between vitamin D concentration and BMI (body mass index)

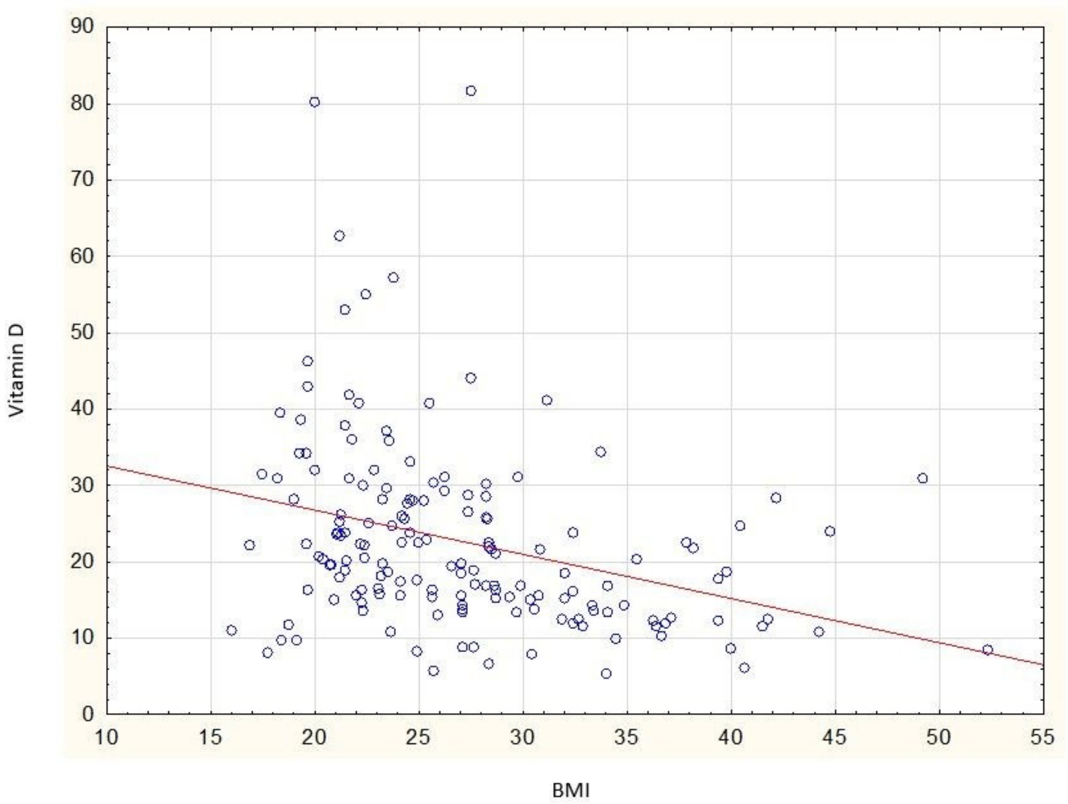

Figure 2. Correlation between BMI level and vitamin D concentration in a group of women with phenotype I of PCOS (polycystic ovary syndrome)

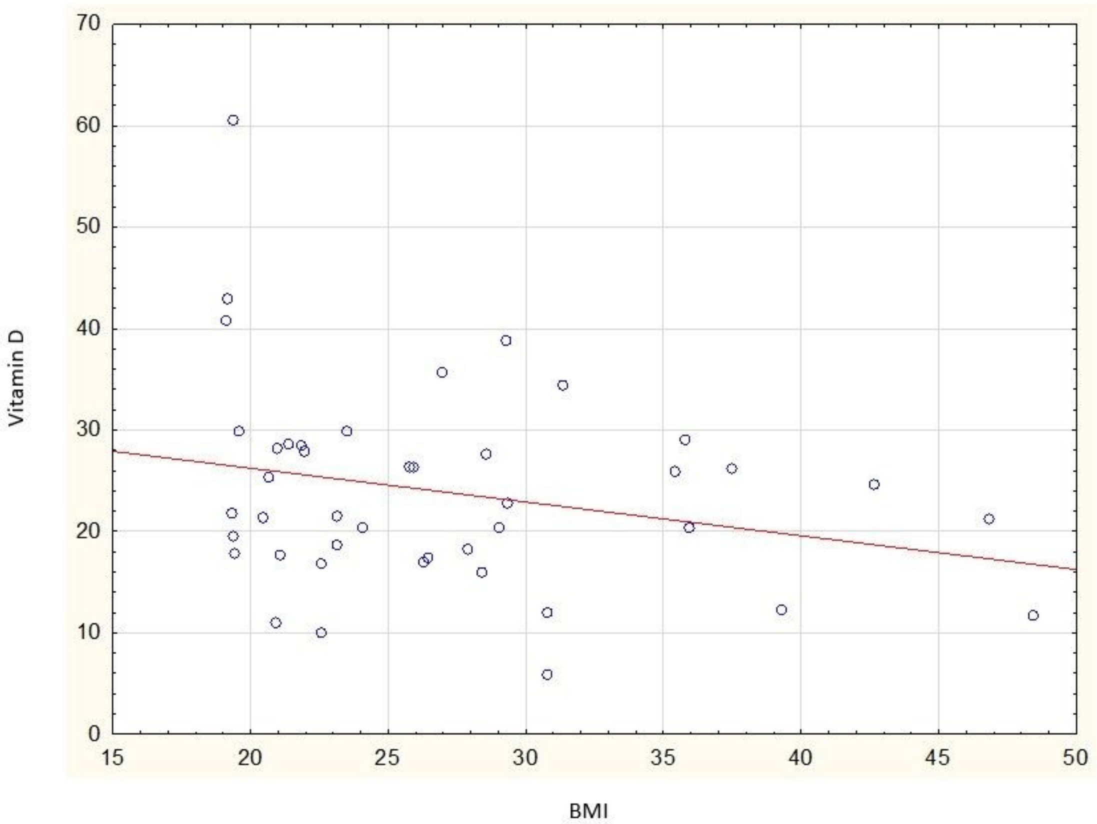

Figure 3. Correlation between BMI (body mass index) level and vitamin D concentration in a group of women with phenotype II of PCOS (polycystic ovary syndrome)

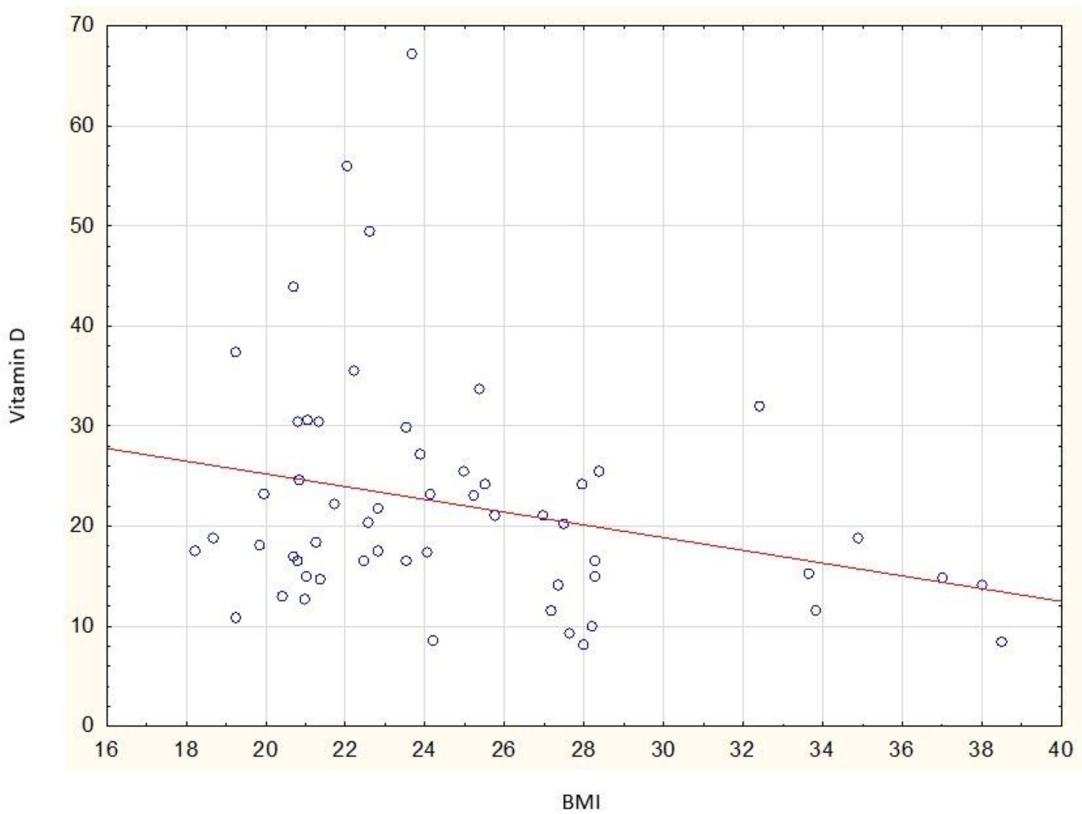

Figure 4. Correlation between BMI (body mass index) level and vitamin D concentration in a group of women with phenotype III of PCOS (polycystic ovary syndrome)

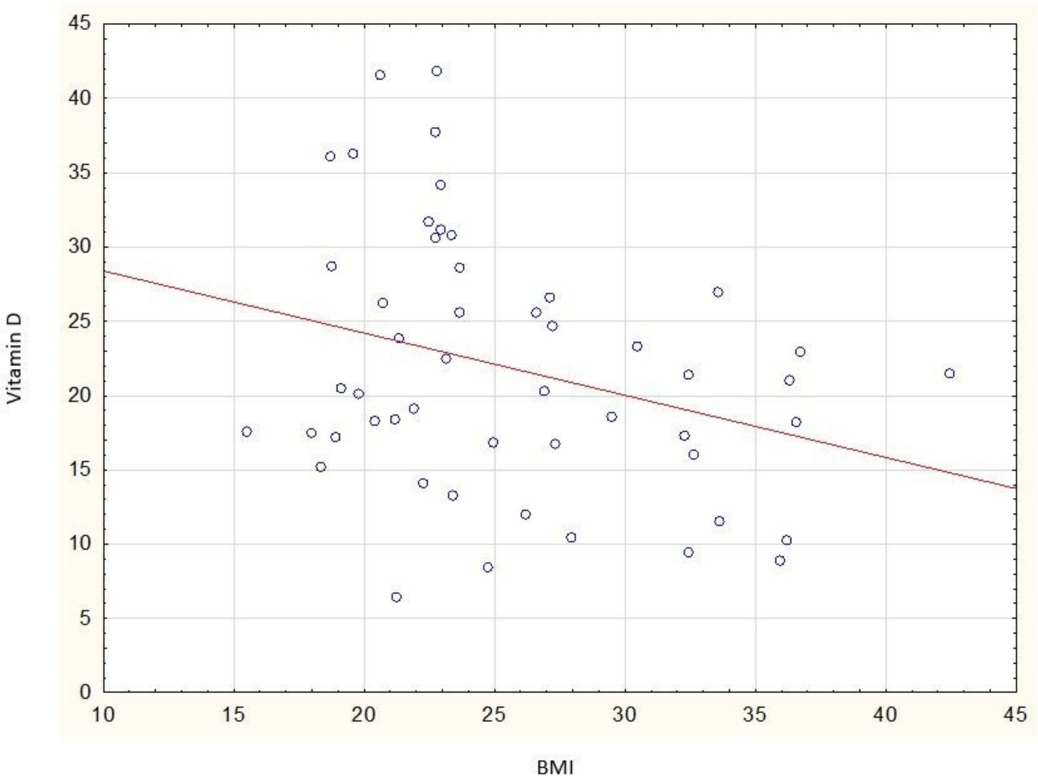

Figure 5. Correlation between BMI (body mass index) level and vitamin D concentration in a group of women with phenotype IV of PCOS (polycystic ovary syndrome)