Original Research

PREVALENCE OF VITAMIN D DEFICIENCY AND ITS ASSOCIATION WITH POLYCYSTIC OVARY SYNDROME PHENOTYPE: A CROSS-SECTIONAL STUDY

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ABSTRACT

Introduction: Polycystic Ovary Syndrome (PCOS) is a common endocrine and metabolic disorder affecting women of reproductive age. It is characterized by clinical or biochemical hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology. Vitamin D deficiency has been increasingly recognized as a potential contributor to metabolic disturbances and hormonal imbalance in women with PCOS. However, the association between vitamin D status and different PCOS phenotypes remains unclear.

Aim: To assess the prevalence of Vitamin D deficiency and evaluate its association with different phenotypic presentations of Polycystic Ovary Syndrome among women of reproductive age.

Materials and Methods: A hospital-based cross-sectional observational study conducted in the Department of Obstetrics and Gynaecology at a tertiary care hospital over a period of 12 months. The study included 100 women of reproductive age diagnosed with Polycystic Ovary Syndrome (PCOS) according to Rotterdam criteria attending the Obstetrics and Gynaecology outpatient department.

Results: In the present study, the association between Vitamin D status and different Polycystic Ovary Syndrome (PCOS) phenotypes was evaluated among 100 patients. Among Vitamin D deficient patients, Phenotype A (HA + OD + PCOM) was the most common phenotype, observed in 38 (61.3%) patients, followed by Phenotype B (HA + OD) in 14 (22.6%) patients, Phenotype C (HA + PCOM) in 7 (11.3%) patients, and Phenotype D (OD + PCOM) in 3 (4.8%) patients.Among Vitamin D sufficient patients, Phenotype D (OD + PCOM) was predominant, seen in 20 (52.6%) patients, followed by Phenotype A in 8 (21.1%) patients, Phenotype B in 7 (18.4%) patients, and Phenotype C in 3 (7.9%) patients. The association between Vitamin D status and PCOS phenotype distribution was found to be statistically significant ($p < 0.0001$).

Conclusion: Vitamin D deficiency appears to be a common finding among women with PCOS and may be associated with specific clinical phenotypes. Assessment of Vitamin D status could serve as an important component in the comprehensive evaluation and management of PCOS.

KEYWORDS: Vitamin D Deficiency, Polycystic Ovary Syndrome, Pcos Phenotype, Hyperandrogenism, Ovulatory Dysfunction, Polycystic Ovarian Morphology, Cross-Sectional Study.

INTRODUCTION

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and metabolic disorders affecting women of reproductive age.

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It is a heterogeneous condition characterized by reproductive dysfunction, hormonal imbalance, and metabolic abnormalities. The syndrome is primarily defined by the presence of oligo/anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology. According to the Rotterdam criteria, PCOS can be diagnosed when at least two of these three features are present after excluding other causes of hyperandrogenism and menstrual irregularities. Due to its varied clinical presentation, PCOS is classified into different phenotypes depending on the combination of these features, including classic hyperandrogenic

phenotypes and milder forms without overt hyperandrogenism.[1]

PCOS affects approximately 6–20% of women of reproductive age depending on the diagnostic criteria used and the population studied. It is associated with significant reproductive consequences such as menstrual irregularities, infertility, pregnancy complications, and increased risk of endometrial abnormalities. In addition to reproductive manifestations, PCOS is strongly linked with metabolic disorders including insulin resistance, obesity, dyslipidemia, impaired glucose tolerance, and increased risk of type 2 diabetes mellitus and cardiovascular diseases. The clinical heterogeneity of PCOS suggests that multiple environmental, genetic, and lifestyle-related factors contribute to its development and progression [2].

Vitamin D is a fat-soluble hormone that plays an essential role in calcium metabolism, bone health, immune regulation, and endocrine function. Vitamin D receptors are expressed in various reproductive tissues, including ovarian granulosa cells, endometrium, and hypothalamic-pituitary structures, suggesting a possible role of Vitamin D in female reproductive physiology. Vitamin D influences ovarian steroidogenesis, follicular development, insulin sensitivity, and inflammatory pathways, all of which are important mechanisms involved in PCOS pathogenesis. [3]

Vitamin D deficiency has become a global health concern and is increasingly reported among women with PCOS. Several studies have demonstrated a high prevalence of reduced serum 25-hydroxy Vitamin D levels in women diagnosed with PCOS. The association between Vitamin D deficiency and PCOS may be explained by its effects on insulin resistance, chronic low-grade inflammation, and hormonal disturbances. Vitamin D deficiency has been linked with increased insulin resistance and compensatory hyperinsulinemia, which may stimulate ovarian androgen production and contribute to hyperandrogenic manifestations of PCOS. [4]

The relationship between Vitamin D status and PCOS phenotype is an area of growing research interest. Different phenotypes of PCOS show variation in clinical severity, hormonal profile, and metabolic risk. Women with hyperandrogenic PCOS phenotypes often demonstrate greater insulin resistance, obesity, and metabolic abnormalities compared with non-hyperandrogenic phenotypes. Studies have suggested that reduced Vitamin D levels may be more frequently associated with phenotypes characterized by hyperandrogenism and metabolic disturbances; however, the exact relationship between Vitamin D deficiency and specific PCOS phenotypes remains unclear. [5]

Vitamin D deficiency may also influence menstrual regularity and fertility outcomes in women with PCOS. Adequate Vitamin D levels have been associated with improved follicular development, better ovulatory function, and favorable reproductive outcomes. Conversely, deficiency may contribute to impaired ovarian function and reduced fertility potential. Vitamin D also regulates inflammatory cytokines and immune responses, while chronic inflammation has been proposed as an important contributing factor in PCOS development. [6,7]

Several investigations have reported that women with PCOS frequently have lower serum Vitamin D concentrations compared with healthy women. Low Vitamin D levels have been associated with increased insulin resistance and metabolic abnormalities, which are important features of PCOS. Muscogiuri et al. reported an association between low 25-hydroxyvitamin D levels and insulin resistance among women with PCOS, suggesting that Vitamin D deficiency may contribute to the metabolic phenotype of the syndrome. [8]

Although increasing evidence supports a relationship between Vitamin D deficiency and PCOS, findings remain inconsistent due to differences in study populations, diagnostic criteria, geographical variation, nutritional status, and methods used for Vitamin D assessment. Some studies have suggested that Vitamin D supplementation may improve metabolic and reproductive parameters in PCOS patients, but further evidence is required to establish its clinical role. [9]

Understanding the association between Vitamin D deficiency and PCOS phenotypes is important for early identification of women at increased risk of metabolic complications. Assessment of Vitamin D status may provide additional information for individualized management and preventive strategies in PCOS patients.[10]

The aim of this study is to assess the prevalence of Vitamin D deficiency and evaluate its association with different phenotypic presentations of Polycystic Ovary Syndrome (PCOS) among women of reproductive age. The study objectives are to determine the frequency of Vitamin D deficiency in PCOS patients, analyze the association between serum Vitamin D levels and various PCOS phenotypes, and evaluate the relationship of Vitamin D deficiency with clinical, hormonal, and metabolic characteristics of PCOS.

MATERIALS AND METHODS

Study Design: A hospital-based cross-sectional observational study.

Study Place: Department of Obstetrics and Gynaecology, at a tertiary care hospital**.**

Study Duration: The study will be conducted over a period of 12 months.

Study Population: Women of reproductive age diagnosed with Polycystic Ovary Syndrome (PCOS) according to Rotterdam criteria attending the Obstetrics and Gynaecology outpatient department**.**

Sample Size: A total of 100 women diagnosed with PCOS

Study Variables:

- Vitamin D Status
- Vitamin D Status and PCOS Phenotype
- Vitamin D Deficiency and BMI Category
- Vitamin D Deficiency and Menstrual Pattern
- Vitamin D Deficiency and Hyperandrogenism

Inclusion Criteria:

- Women of reproductive age group (18–40 years).
- Patients diagnosed with PCOS according to Rotterdam criteria.
- Patients willing to participate and provide informed consent.
- Women undergoing evaluation for menstrual irregularities, infertility, hyperandrogenism, or PCOS-related symptoms.

Exclusion Criteria:

- Pregnant women or women planning pregnancy at the time of study.
- Patients with thyroid disorders, hyperprolactinemia, Cushing syndrome, or congenital adrenal hyperplasia.
- Women receiving Vitamin D supplementation or hormonal therapy recently.
- Patients with chronic kidney disease, liver disease, or other major systemic illnesses.
- Patients unwilling to participate in the study.

Statistical Analysis:

For statistical analysis data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Data had been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. Two-sample t-tests for a difference in mean involved independent samples or unpaired samples. Paired t-tests were a form of blocking and had greater power than unpaired tests. A chi-squared test ($\chi 2$ test) was any statistical hypothesis test wherein the sampling distribution of the test statistic is a chi-squared distribution when the null hypothesis is true. Without other qualification, 'chi-squared test' often is used as short for Pearson's chi-squared test. Unpaired proportions were compared by Chi-square test or Fischer's exact test, as appropriate.

Explicit expressions that can be used to carry out various t-tests are given below. In each case, the formula for a test statistic that either exactly follows or closely approximates a t-distribution under the null hypothesis is given. Also, the appropriate degrees of freedom are given in each case. Each of these statistics can be used to carry out either a one-tailed test or a two-tailed test.

Once a t value is determined, a p-value can be found using a table of values from Student's t-distribution .If the calculated p-value is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis is rejected in favour of the alternative hypothesis.

P-value $\leq$ 0.05 was considered for statistically significant.

RESULT

Table 1: Distribution of Study Participants According to Vitamin D Status (n=100)

Vitamin D Status	Number of Patients	Percentage (%)
Deficient (<20 ng/ml)	62	62
Insufficient (20–29 ng/ml)	25	25
Sufficient (≥30 ng/ml)	13	13
Total	100	100

Table 2: Association between Vitamin D Status and PCOS Phenotype (n=100)

PCOS Phenotype	Vitamin D Deficient	Vitamin D Sufficient	Total	P value
Phenotype A (HA + OD + PCOM)	38 (61.3%)	8 (21.1%)	46	<0.0001
Phenotype B (HA + OD)	14 (22.6%)	7 (18.4%)	21	
Phenotype C (HA + PCOM)	7 (11.3%)	3 (7.9%)	10	
Phenotype D (OD + PCOM)	3 (4.8%)	20 (52.6%)	23	
Total	**62**	**38**	**100**	

Table 3: Association between Vitamin D Deficiency and BMI Category (n=100)

BMI Category (kg/m²)	Vitamin D Deficient n (%)	Vitamin D Sufficient n (%)	Total n (%)	P value
Normal weight (<25)	15 (24.2%)	18 (47.4%)	33 (33.0%)	0.047
Overweight (25–29.9)	25 (40.3%)	12 (31.6%)	37 (37.0%)	
Obese (≥30)	22 (35.5%)	8 (21.0%)	30 (30.0%)	
Total	62 (100%)	38 (100%)	100 (100%)	

Table 4: Association between Vitamin D Deficiency and Menstrual Pattern (n=100)

Menstrual Pattern	Vitamin D Deficient n (%)	Vitamin D Sufficient n (%)	Total n (%)	P value
Regular menstrual cycle	10 (16.1%)	16 (42.1%)	26 (26.0%)	0.025
Oligomenorrhea	40 (64.5%)	18 (47.4%)	58 (58.0%)	
Amenorrhea	12 (19.4%)	4 (10.5%)	16 (16.0%)	
Total	**62 (100%)**	**38 (100%)**	**100 (100%)**	

Table 5: Association between Vitamin D Deficiency and Hyperandrogenism among Study Participants (n=100)

Hyperandrogenism Status	Vitamin D Deficient n (%)	Vitamin D Sufficient n (%)	Total n (%)	P value
Present	48 (77.4%)	18 (47.4%)	66 (66.0%)	0.003
Absent	14 (22.6%)	20 (52.6%)	34 (34.0%)	
Total	62 (100%)	38 (100%)	100 (100%)	

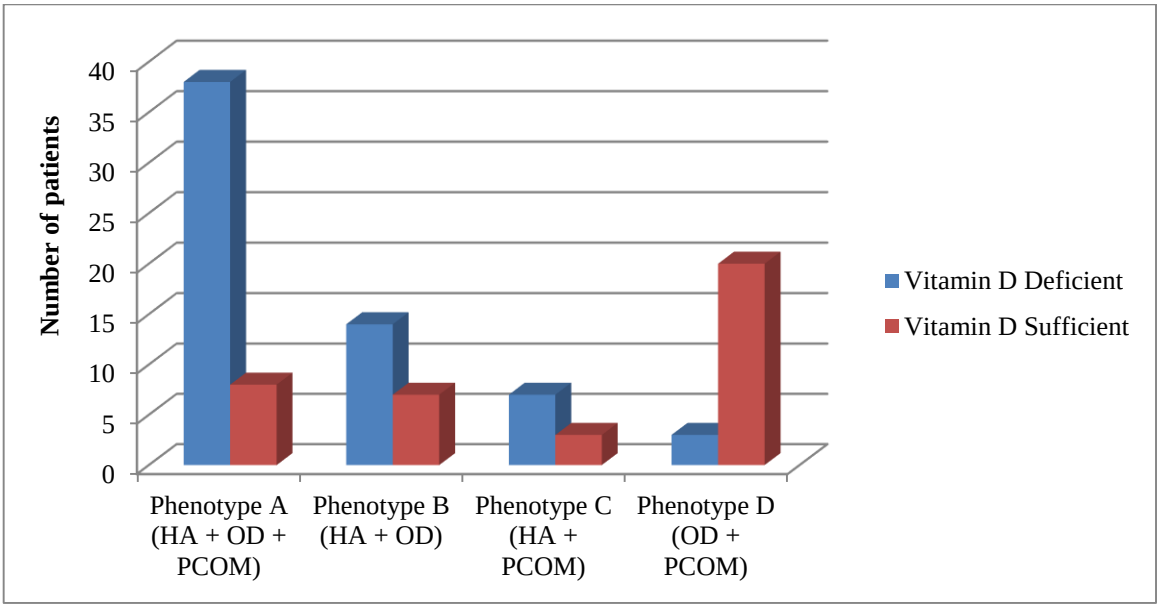

Figure 1: Association between Vitamin D Status and PCOS Phenotype (n=100)

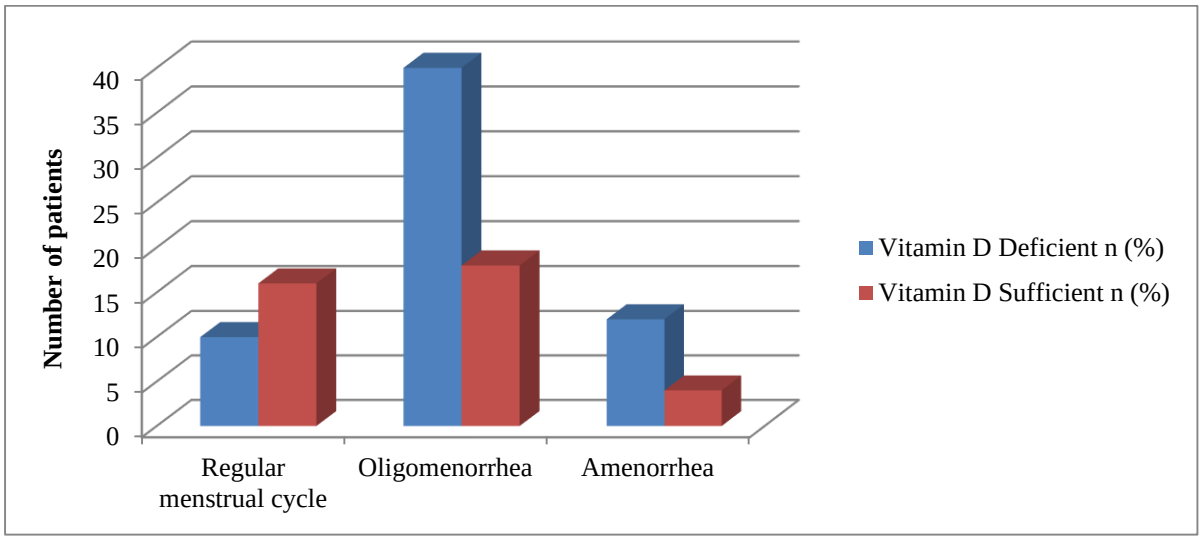

Figure 2: Association between Vitamin D Deficiency and Menstrual Pattern (n=100)

In the present study, among 100 women diagnosed with Polycystic Ovary Syndrome (PCOS), Vitamin D deficiency was observed in the majority of patients. Out of 100 participants, 62 (62%) patients had Vitamin D deficiency (<20 ng/ml), while 25 (25%) patients had Vitamin D insufficiency (20–29 ng/ml) and only 13 (13%) patients had sufficient Vitamin D levels (≥30 ng/ml). The distribution showed a higher prevalence of Vitamin D deficiency among women with PCOS. The difference in Vitamin D status distribution was found to be statistically significant ($p < 0.001$).

In the present study, the association between Vitamin D status and different Polycystic Ovary Syndrome (PCOS) phenotypes was evaluated among 100 patients. Among Vitamin D deficient patients, Phenotype A (HA + OD + PCOM) was the most common phenotype, observed in 38 (61.3%) patients, followed by Phenotype B (HA + OD) in 14 (22.6%) patients, Phenotype C (HA + PCOM) in 7 (11.3%) patients, and Phenotype D (OD + PCOM) in 3 (4.8%) patients.Among Vitamin D sufficient patients, Phenotype D (OD + PCOM) was predominant, seen in 20 (52.6%) patients, followed by Phenotype A in 8 (21.1%) patients, Phenotype B in 7 (18.4%) patients, and Phenotype C in 3 (7.9%) patients. The association between Vitamin D status and PCOS phenotype distribution was found to be statistically significant ($p < 0.0001$).

In the present study, the association between Vitamin D status and Body Mass Index (BMI) categories was assessed among 100 women with Polycystic Ovary Syndrome (PCOS). Among Vitamin D deficient patients, 15 (24.2%) patients were of normal weight (<25 kg/m²), 25 (40.3%) patients were overweight (25–29.9 kg/m²), and 22 (35.5%) patients were obese (≥30 kg/m²).Among Vitamin D sufficient patients, 18 (47.4%) patients had normal BMI, 12 (31.6%) patients were overweight, and 8 (21.0%) patients were obese. The association between Vitamin D status and BMI category was found to be statistically significant ($p = 0.047$).

In the present study, the association between Vitamin D status and menstrual pattern was evaluated among 100 women with Polycystic Ovary Syndrome (PCOS). Among Vitamin D deficient patients, 10 (16.1%) patients had regular menstrual cycles, 40 (64.5%) patients had oligomenorrhea, and 12 (19.4%) patients had amenorrhea. Among Vitamin D sufficient patients, 16 (42.1%) patients had regular menstrual cycles, 18 (47.4%) patients had oligomenorrhea, and 4 (10.5%) patients had amenorrhea. The association between Vitamin D status and menstrual pattern was found to be statistically significant ($p = 0.025$).

In the present study, the association between Vitamin D status and hyperandrogenism was assessed among 100 women with Polycystic Ovary Syndrome (PCOS). Among Vitamin D deficient patients, 48 (77.4%) patients had hyperandrogenism, while 14 (22.6%) patients did not have hyperandrogenism. Among Vitamin D sufficient patients, 18 (47.4%) patients had hyperandrogenism, whereas 20 (52.6%) patients had no evidence of hyperandrogenism. The association between Vitamin D status and hyperandrogenism was found to be statistically significant ($p = 0.003$).

DISCUSSION

The present cross-sectional study evaluated the prevalence of Vitamin D deficiency and its association with Polycystic Ovary Syndrome (PCOS) phenotypes, BMI, menstrual pattern, and hyperandrogenism among 100 women diagnosed with PCOS. In the current study, Vitamin D deficiency was observed in 62% of patients, while Vitamin D insufficiency was present in 25% and

only 13% had sufficient Vitamin D levels. This indicates a high prevalence of hypovitaminosis D among women with PCOS. Similar findings were reported by **Joham AE et al., [11]** who found that Vitamin D deficiency was common among women with PCOS and was associated with metabolic abnormalities and insulin resistance. Wang L **et al. [12]** also reported a high frequency of Vitamin D deficiency among PCOS patients and suggested its association with metabolic risk factors.

In the present study, a significant association was found between Vitamin D status and PCOS phenotypes ($p < 0.0001$). Vitamin D deficient patients were predominantly associated with Phenotype A (HA + OD + PCOM) (61.3%), followed by Phenotype B (22.6%). In contrast, Vitamin D sufficient patients showed a higher proportion of Phenotype D (52.6%). These findings suggest that Vitamin D deficiency may be more closely related to hyperandrogenic forms of PCOS. Similar observations were reported by **Contreras-Bolívar V et al., [13]** who demonstrated that low Vitamin D levels were associated with insulin resistance and metabolic features commonly observed in PCOS. **Mohan A et al. [14]** also suggested that Vitamin D deficiency may contribute to the pathogenesis and clinical manifestations of PCOS by affecting insulin sensitivity, inflammation, and ovarian function.

The present study demonstrated a significant association between Vitamin D deficiency and BMI categories ($p = 0.047$). Among Vitamin D deficient women, a higher proportion were overweight (40.3%) and obese (35.5%) compared with Vitamin D sufficient women. This finding supports the relationship between Vitamin D deficiency and obesity-related metabolic dysfunction in PCOS. **Jamilian M et al. [15]** reported that women with PCOS and low Vitamin D levels had higher insulin resistance and increased metabolic syndrome components. Similarly, **Barber TM et al. [16]** emphasized that obesity and metabolic disturbances are important contributors to the clinical severity of PCOS.

Regarding menstrual pattern, the present study showed that Vitamin D deficiency was significantly associated with menstrual irregularities ($p = 0.025$). Oligomenorrhea was the most common menstrual abnormality among Vitamin D deficient patients (64.5%), followed by amenorrhea (19.4%). Vitamin D sufficient patients had a greater proportion of regular menstrual cycles (42.1%). Similar findings were reported by **Grzeczka A et al. [17]** who highlighted the role of Vitamin D in ovarian physiology, follicular development, and reproductive function. Vitamin D deficiency may influence ovulatory dysfunction through effects on ovarian steroidogenesis and insulin resistance.

In the present study, Vitamin D deficiency was significantly associated with hyperandrogenism ($p = 0.003$). Hyperandrogenism was present in 77.4% of Vitamin D deficient patients compared with 47.4% of Vitamin D sufficient patients. This finding suggests that reduced Vitamin D levels may be linked with increased androgen excess in PCOS. **Trummer C et al. [18]** reported that Vitamin D plays an important role in reproductive hormone regulation and may influence androgen metabolism in women with PCOS. **Shojaeian Z et al. [19]** also reported that Vitamin D and calcium supplementation may have beneficial effects on metabolic and reproductive abnormalities associated with PCOS.

CONCLUSION

The present study concludes that Vitamin D deficiency is highly prevalent among women with Polycystic Ovary Syndrome (PCOS). A significant proportion of PCOS patients had reduced Vitamin D levels, with deficiency being more common than insufficiency or sufficient Vitamin D status. Vitamin D deficiency showed a significant association with PCOS phenotypes, particularly hyperandrogenic phenotypes, suggesting its possible role in the clinical expression of PCOS.The study also demonstrated a significant relationship between Vitamin D deficiency and higher BMI, menstrual irregularities, and hyperandrogenism among PCOS patients. These findings indicate that Vitamin D status may influence both metabolic and reproductive aspects of PCOS. Therefore, routine assessment of Vitamin D levels in women with PCOS may help in early identification of metabolic risk factors and assist in better individualized management strategies. Further large-scale studies are recommended to establish the therapeutic role of Vitamin D supplementation in improving PCOS outcomes.

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