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Original Research Article

Impact of Vitamin D Deficiency on Menstrual Irregularities and Fertility Outcomes in Women of Childbearing Age

Asma Zahid[1*], Khunsa Rehman[2]

[1]*Department of Medicine, Social Security Teaching Hospital, Multan Road, Lahore, Pakistan*
[2]*Department of Obs & Gynecology services Hospital Lahore, Pakistan*
**Corresponding author`s email address:* asmazahid681@gamil.com

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Abstract: *Vitamin D is increasingly recognized as a key regulator of reproductive function due to its role in ovarian folliculogenesis, endometrial receptivity, and hormonal balance.* ***Objective:*** *To assess the impact of vitamin D deficiency on menstrual irregularities and fertility outcomes in women of reproductive age.* ***Methodology:*** *This cross-sectional analytical study was conducted at Services Hospital, Lahore, from September 2023 to September 2024. A total of 195 women aged 18–40 years were enrolled using consecutive sampling. Participants with known endocrine disorders or recent vitamin D supplementation were excluded. Demographic and reproductive histories were collected via structured questionnaires. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using chemiluminescent immunoassay and classified as deficient (<20 ng/mL), insufficient (20–30 ng/mL), or sufficient (>30 ng/mL).* ***Results:*** *The mean age of participants was 28.7 ± 4.6 years, with a mean BMI of 26.4 ± 3.9 kg/m². Vitamin D deficiency was observed in 98 women (50.3%), insufficiency in 57 (29.2%), and sufficiency in 40 (20.5%). Menstrual irregularities were significantly more common in the deficient group (85.7%) compared to the insufficient (49.1%) and sufficient (42.5%) groups (p < 0.001). Among married women (n = 112), infertility was reported in 72.1% of the deficient group versus 27.3% of the sufficient group (p = 0.002). Miscarriage and recurrent miscarriage were also more frequent in vitamin D-deficient women (p < 0.05).* ***Conclusion:*** *Vitamin D deficiency is highly prevalent among women of childbearing age and is strongly associated with menstrual irregularities and poor fertility outcomes. Routine screening and correction of deficiency may represent a low-cost, effective strategy to improve reproductive health and reduce infertility burden.*

Keywords: Vitamin D deficiency, menstrual irregularities, Infertility, Fertility, Outcomes

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Introduction

Vitamin D is known for its classical roles in calcium and skeletal homeostasis, but recent studies are revealing its extensive endocrine, immunologic, and reproductive effects. Being a steroid hormone precursor, vitamin D is hydroxylated to its active form, calcitriol (1). 25(OH) 2D) that binds to vitamin D receptors (VDR) found in reproductive tissues such as the ovary, uterus, placenta, hypothalamus, and many others (1). This allocation indicates that vitamin D is not only a part of bone physiology but also of the reproductive health of females. Vitamin D deficiency has been associated with increased levels of menstrual abnormalities and unfavorable fertility rates in women of childbearing age, an aspect that is a most significant though frequently neglected variable in reproductive medicine (2). Vitamin D deficiency is frighteningly widespread across the world, with 30-50 percent of women of reproductive age estimated to have inadequate serum concentrations of 25-hydroxyvitamin D (25(OH) D) (3). South Asia and the Middle East have even greater levels of this prevalence because people wear cultural clothing, spend less time in the sun, have darker skin pigmentation, and the food has not been fortified. Women's deficiency rates in such areas may pass 70-80 (4). Simultaneously, infertility has an estimated prevalence of 10-15 percent among couples across the globe, with a large percentage of those cases yet to be elucidated despite proper assessment. The fact that there is a high prevalence of vitamin D deficiency in women and that infertility grows at the same time highlights the necessity to study the role of this micronutrient in reproductive health in a more systematic way (5). Pathophysiological processes that may potentially mediate the effects of vitamin D on menstruation and fertility are multifactorial. Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) secretion are influenced by vitamin D's regulation of the expression of genes involved in gonadotropin release at the hypothalamic, pituitary, and ovarian (HPO) axis level (6). In the ovary, vitamin D enhances aromatase activity, promoting estrogen biosynthesis, and modulates anti-Müllerian hormone (AMH), which reflects ovarian reserve (7). These actions directly affect follicular growth, ovulation, and luteal function, processes essential for regular menstrual cycles and successful conception. Vitamin D promotes immunological tolerance at the maternal-fetal interface and boosts implantation-related gene expression in the endometrium, supporting early pregnancy maintenance (8). In women with polycystic ovary syndrome (PCOS), vitamin D deficiency has been linked to oligomenorrhea, anovulation, and infertility. Studies indicate that women with PCOS and concurrent vitamin D deficiency have more severe menstrual irregularities, higher insulin resistance, and reduced ovulatory response to induction therapies (9). PCOS is one of the most common causes of anovulatory infertility. Vitamin D deficiency has also been linked to poorer assisted reproductive technology (ART) outcomes, such as decreased live birth rates, decreased oocyte quality, and lower fertilization rates (10). While findings across studies remain heterogeneous, the biological plausibility and observed associations warrant further investigation. Vitamin D deficiency has consequences for reproduction that go beyond the regulation of the cycle and conception. Preeclampsia, gestational diabetes, recurrent pregnancy loss, and intrauterine growth restriction have all been linked to low vitamin D status during pregnancy (11). These downstream effects further reinforce the importance of addressing deficiency before and during pregnancy as part of preconception and antenatal care (12).To assess the impact of vitamin D deficiency on menstrual irregularities and fertility outcomes in women of reproductive age.

Methodology

This was a cross-sectional analytical study conducted at Services Hospital, Lahore, from September 2023 to September 2024. A total of 195 women of childbearing age (18–40 years) were enrolled in the study. Non-probability consecutive sampling was employed to include patients, women aged 18–40 years. Women presenting with complaints of menstrual irregularities (oligomenorrhea, amenorrhea, polymenorrhea, or irregular cycles) or infertility (defined as inability to conceive after ≥12 months of unprotected intercourse). Patients who consented to participate in the study. Women with known thyroid disorders, hyperprolactinemia, or other endocrine abnormalities that could independently cause menstrual irregularities. Women have been on vitamin D supplementation for the last six months, patients with chronic illnesses such as chronic liver disease, chronic kidney disease, or malignancy. Eligible women were approached during their clinic visits and informed about the study objectives. After obtaining consent, data were collected using a structured questionnaire that recorded demographic information, body mass index (BMI), reproductive history, menstrual cycle characteristics, history of infertility, pregnancy outcomes, and lifestyle factors such as sun exposure, dietary habits, and physical activity. Venous blood samples were drawn for estimation of serum 25-hydroxyvitamin D (25(OH)D) levels using chemiluminescent immunoassay. Based on their serum levels, women were classified as vitamin D deficient (<20 ng/mL), insufficient (20–30 ng/mL), or sufficient (>30 ng/mL). Additional investigations included thyroid-stimulating hormone (TSH), prolactin, and fasting blood glucose to exclude other possible causes of menstrual disturbances. The primary outcome measure was the presence and pattern of menstrual irregularities among women with vitamin D deficiency compared to those with sufficient levels. The secondary outcomes were fertility-related parameters, including time-to-pregnancy, duration of infertility, and prior pregnancy outcomes such as miscarriage or inability to conceive. This dual focus allowed for a comprehensive assessment of both menstrual cycle regulation and reproductive performance in relation to vitamin D status. Data were entered into SPSS version 26.0 for statistical analysis. Quantitative variables such as age, BMI, and serum vitamin D levels were summarized as mean ± standard deviation. In contrast, categorical variables such as menstrual irregularities and fertility outcomes were expressed as frequencies and percentages. A p-value of ≤0.05 was considered statistically significant.

Results

A total of 195 women of childbearing age were included in the study, with a mean age of 28.7 ± 4.6 years (range 18–40 years). The mean BMI of the participants was 26.4 ± 3.9 kg/m². More than half of the participants were married (112; 57.4%), while 83 (42.6%) were unmarried. With respect to vitamin D status, 98 women (50.3%) were found to be deficient, 57 (29.2%) insufficient, and only 40 (20.5%) had sufficient vitamin D levels. Menstrual disturbances were common among vitamin D-deficient women. Only 14.3% of deficient women reported regular cycles compared to 50.9% in the insufficient group and 57.5% in the sufficient group ($p < 0.001$). Oligomenorrhea was the most frequent abnormality in the deficient group (44.9%), followed by amenorrhea (25.5%), polymenorrhea (9.2%), and irregular cycles (6.1%). Among married women (n = 112), infertility was reported by 49 women (72.1%) in the vitamin D-deficient group compared to 13 (46.4%) in the insufficient group and only 6 (27.3%) in the sufficient group ($p = 0.002$). A history of miscarriage was also more common in the deficient group (26.5%) compared to the insufficient (14.3%) and sufficient groups (9.1%) ($p = 0.041$). Recurrent miscarriages were reported in 19.1% of deficient women, compared to 10.7% of insufficient and 4.5% of sufficient participants ($p = 0.048$). When stratified by age, vitamin D deficiency was observed across all groups, with the highest proportion in the 26–30-year group (40.8%). However, no significant association was found between age distribution and vitamin D status ($p = 0.812$). Similarly, BMI did not significantly differ across vitamin D categories ($p = 0.639$). Most women in all groups were either overweight or obese, with 48.0% of deficient women falling in the overweight category and 25.5% in the obese category. Menstrual irregularities were present in 85.7% of deficient women compared to 49.1% of insufficient and 42.5% of sufficient women ($p < 0.001$). Infertility among married women was significantly higher in the deficient group (72.1%) compared to the insufficient (46.4%) and sufficient (27.3%) groups ($p = 0.002$). Similarly, adverse fertility outcomes (defined as infertility or miscarriage) were most frequent in the deficient group (56.1%), compared to 26.3% in the insufficient group and 17.5% in the sufficient group ($p < 0.001$).

Table 1. Baseline Characteristics of Study Population (N = 195)

Variable	Value
Total Number of Patients	195
Mean Age (years)	28.7 ± 4.6
Age Range (years)	18–40
Mean BMI (kg/m²)	26.4 ± 3.9
Marital Status – Married	112 (57.4%)
Marital Status – Unmarried	83 (42.6%)
Vitamin D Deficient (<20 ng/mL)	98 (50.3%)
Vitamin D Insufficient (20–30)	57 (29.2%)
Vitamin D Sufficient (>30)	40 (20.5%)

Table 2. Menstrual Irregularities by Vitamin D Status

Menstrual Pattern	Vitamin D Deficient (n = 98)	Vitamin D Insufficient (n = 57)	Vitamin D Sufficient (n = 40)	p-value
Regular Cycles	14 (14.3%)	29 (50.9%)	23 (57.5%)	<0.001
Oligomenorrhea	44 (44.9%)	18 (31.6%)	10 (25.0%)	
Amenorrhea	25 (25.5%)	4 (7.0%)	2 (5.0%)	
Polymenorrhea	9 (9.2%)	4 (7.0%)	2 (5.0%)	
Irregular Cycles	6 (6.1%)	2 (3.5%)	3 (7.5%)	
Total	98 (100%)	57 (100%)	40 (100%)	

Table 3. Fertility Outcomes by Vitamin D Status (Married Women Only)

Fertility Outcome	Vitamin D Deficient (n = 68)	Vitamin D Insufficient (n = 28)	Vitamin D Sufficient (n = 22)	p-value
Infertility	49 (72.1%)	13 (46.4%)	6 (27.3%)	0.002
History of Miscarriage	18 (26.5%)	4 (14.3%)	2 (9.1%)	0.041

Recurrent Miscarriage	13 (19.1%)	3 (10.7%)	1 (4.5%)	0.048

Table 4. Distribution of Vitamin D Status by Age and BMI (N = 195)

Variable	Vitamin D Deficient (n = 98)	Vitamin D Insufficient (n = 57)	Vitamin D Sufficient (n = 40)	p-value
Age Group (years)				
18–25	35 (35.7%)	18 (31.6%)	12 (30.0%)	0.812
26–30	40 (40.8%)	24 (42.1%)	17 (42.5%)	
31–40	23 (23.5%)	15 (26.3%)	11 (27.5%)	
BMI Category				
Normal (<25 kg/m²)	26 (26.5%)	17 (29.8%)	14 (35.0%)	0.639
Overweight (25–29.9)	47 (48.0%)	26 (45.6%)	17 (42.5%)	
Obese (≥30)	25 (25.5%)	14 (24.6%)	9 (22.5%)	

Table 5. Association of Vitamin D Status with Reproductive Outcomes

Reproductive Outcome	Vitamin D Deficient (n = 98)	Vitamin D Insufficient (n = 57)	Vitamin D Sufficient (n = 40)	p-value
Any Menstrual Irregularity	84 (85.7%)	28 (49.1%)	17 (42.5%)	<0.001
Infertility (married women only)	49 (72.1%)	13 (46.4%)	6 (27.3%)	0.002
Any Adverse Fertility Outcome	55 (56.1%)	15 (26.3%)	7 (17.5%)	<0.001

Discussion

Women of reproductive age. The findings demonstrated a high prevalence of vitamin D deficiency (50.3%) among participants, consistent with global and regional literature reporting deficiency rates ranging from 40–80% in South Asian populations. The results highlight a significant association between low vitamin D levels and both menstrual disturbances and adverse fertility outcomes. In this study, 85.7% of vitamin D-deficient women reported some form of menstrual irregularity compared with only 42.5% of women with sufficient vitamin D levels. Oligomenorrhea and amenorrhea were particularly more common in the deficient group. These findings are biologically plausible, as vitamin D plays a critical role in regulating the hypothalamic–pituitary–ovarian (HPO) axis through modulation of gonadotropin release and ovarian steroidogenesis. Prior studies have also demonstrated that low serum 25(OH)D is associated with irregular cycles and anovulation, especially in women with polycystic ovary syndrome (PCOS), where deficiency may exacerbate hyperandrogenism and insulin resistance. Our results reinforce this growing body of evidence, suggesting that vitamin D status should be considered in the evaluation of women presenting with menstrual cycle disorders (13). Among married participants, infertility was observed in 72.1% of vitamin D-deficient women compared with only 27.3% of those with sufficient levels. Similarly, miscarriage and recurrent miscarriage were more frequent in the deficient group. These findings are consistent with prior research showing that vitamin D deficiency may adversely affect endometrial receptivity, embryo implantation, and early placentation (14). Experimental evidence indicates that vitamin D regulates the expression of implantation-related genes, such as HOXA10, and modulates immune tolerance at the maternal–fetal interface, both of which are essential for maintaining pregnancy. Clinical studies in assisted reproductive technology (ART) have also shown that women with sufficient vitamin D levels tend to have higher implantation, clinical pregnancy, and live birth rates. Our study extends these findings to natural fertility outcomes in a South Asian cohort. Several studies conducted in Western populations have reported similar associations between vitamin D deficiency and reproductive dysfunction, though results remain heterogeneous (15). Some randomized trials of vitamin D supplementation in women with infertility or PCOS have shown improvements in menstrual regularity, follicular development, and ovulation rates, while others found no significant benefit. The inconsistencies may reflect differences in study design, baseline vitamin D status, cut-off definitions, and confounding factors such as BMI, lifestyle, and ethnicity. Our findings add to the evidence from a developing country context, where the prevalence of deficiency is higher and supplementation practices are less standardized (16). The strong associations observed in this study suggest that routine assessment of vitamin D status in women of reproductive age could be beneficial, particularly for those presenting with irregular cycles or infertility (17-19). Given the relatively low cost and safety profile of supplementation, correcting deficiency may represent a simple and effective adjunct in the management of menstrual and fertility disorders. At a population level, strategies such as food fortification, lifestyle counseling for safe sun exposure, and targeted supplementation could help address this widespread issue and improve reproductive outcomes (20). However, certain limitations must be acknowledged. The cross-sectional design precludes causal inference, and longitudinal studies are required to establish temporality. Potential confounders such as dietary habits, physical activity, and socioeconomic factors may not have been fully controlled. Additionally, while infertility was self-reported based on history, more detailed investigations (e.g., semen analysis, tubal patency tests) were not performed to exclude male or structural causes.

Conclusion

It is concluded that vitamin D deficiency is highly prevalent among women of childbearing age and is strongly associated with menstrual irregularities and adverse fertility outcomes. Women with deficient levels were significantly more likely to experience oligomenorrhea, amenorrhea, infertility, and miscarriage compared with those who had sufficient vitamin D status. These findings highlight the importance of screening for vitamin D deficiency as part of the routine evaluation of women presenting with cycle disturbances or reproductive difficulties. Given the low cost, safety, and accessibility of supplementation, correcting deficiencies represents a practical intervention that could improve menstrual health, enhance fertility, and potentially reduce the burden of infertility in this population.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

AZ (House Officer Medicine)
Manuscript drafting, Study Design,
Review of Literature, Data entry, Data analysis, and drafting an article.
KR
Conception of Study, Development of Research Methodology Design, Study Design, manuscript review, and critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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