RESEARCH PAPER

Correlation of Serum Vitamin C Levels with Hormonal and Metabolic Parameters in Women with Polycystic Ovary Syndrome

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ABSTRACT

Background: Polycystic Ovary Syndrome is one of the most common endocrine and metabolic disorders affecting women of reproductive age, characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology. In addition to reproductive abnormalities, PCOS is strongly associated with metabolic disturbances such as insulin resistance, dyslipidemia, obesity, and an increased risk of type 2 diabetes mellitus and cardiovascular disease. Emerging evidence suggests that oxidative stress plays a pivotal role in the pathophysiology of PCOS by contributing to both hormonal imbalance and metabolic dysfunction. Vitamin C (ascorbic acid), a potent water-soluble antioxidant, is known to neutralize reactive oxygen species and protect cellular integrity. However, limited clinical data exist regarding the relationship between serum Vitamin C levels and endocrine-metabolic alterations in PCOS.

Aim and Objectives: The present study aimed to evaluate the correlation between serum Vitamin C levels and hormonal as well as metabolic parameters in women diagnosed with PCOS. The specific objectives were to compare Vitamin C levels between PCOS patients and healthy controls, and to assess its association with insulin resistance, androgen levels, and lipid profile.

Materials and Methods: This hospital-based case-control study was conducted on a total of 100 women aged 18–35 years, comprising 50 diagnosed cases of PCOS and 50 age-matched healthy controls. Diagnosis of PCOS was based on the Rotterdam Criteria for PCOS. Fasting venous blood samples were collected for estimation of serum Vitamin C, hormonal parameters (LH, FSH, testosterone), and metabolic parameters including fasting blood glucose, fasting insulin, HOMA-IR, and lipid profile. Serum Vitamin C levels were measured using a spectrophotometric method. Statistical analysis was performed using Student's t-test for comparison and Pearson's correlation coefficient to assess relationships between variables. A p-value of <0.05 was considered statistically significant.

Results: The mean serum Vitamin C levels were significantly lower in PCOS patients compared to controls (0.68 ± 0.15 mg/dL vs 1.21 ± 0.22 mg/dL; $p < 0.001$), indicating reduced antioxidant status in PCOS. Hormonal analysis revealed significantly elevated luteinizing hormone (LH), increased LH/FSH ratio, and higher serum testosterone levels in PCOS patients ($p < 0.001$). Metabolic assessment showed significantly higher fasting insulin levels and HOMA-IR values along with decreased HDL cholesterol levels, confirming the presence of insulin resistance and dyslipidemia. Correlation analysis demonstrated a significant negative correlation between serum Vitamin C levels and serum testosterone ($r = -0.52$), fasting insulin ($r = -0.61$), and HOMA-IR ($r = -0.58$). Conversely, a significant positive correlation was observed between Vitamin C levels and HDL cholesterol ($r = +0.45$). These findings indicate that decreased Vitamin C levels are associated with worsening hormonal imbalance and metabolic dysfunction in PCOS.

Conclusion: The present study highlights a significant association between reduced serum Vitamin C levels and both hormonal and metabolic disturbances in women with PCOS. The findings support the role of oxidative stress in the pathogenesis of PCOS and suggest that Vitamin C may serve as a potential biomarker for disease severity. Furthermore, improving antioxidant status through dietary or therapeutic interventions may help in mitigating metabolic and endocrine abnormalities in PCOS.

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INTRODUCTION

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine disorders affecting women of reproductive age, with a reported global prevalence ranging between 6% and 12% depending on the population studied and diagnostic criteria used [1,2]. It is a heterogeneous disorder characterized by a combination of clinical, biochemical, and morphological abnormalities. The diagnosis of PCOS is commonly based on the Rotterdam Criteria for PCOS, which require the presence of at least two of the following features: oligo/anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology on ultrasonography [3].

In addition to reproductive dysfunction, PCOS is increasingly recognized as a metabolic disorder with significant long-term health implications. Women with PCOS frequently exhibit insulin resistance, compensatory hyperinsulinemia, dyslipidemia, obesity, and an increased risk of developing type 2 diabetes mellitus and cardiovascular diseases [4,5]. Insulin resistance is considered a central feature of PCOS and is present in approximately 50–70% of affected women, irrespective of obesity status [11].

The pathophysiology of PCOS is complex and multifactorial, involving interactions between genetic predisposition, environmental influences, and endocrine abnormalities. Among the various mechanisms proposed, oxidative stress has emerged as a key contributor to the development and progression of PCOS [6]. Oxidative stress refers to an imbalance between the generation of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms [7]. Excessive ROS production can lead to cellular damage, including lipid peroxidation, protein oxidation, and DNA damage, thereby impairing normal cellular function [8].

Several studies have demonstrated elevated oxidative stress markers and reduced antioxidant levels in women with PCOS compared to healthy controls [9,10]. Oxidative stress has been implicated in the pathogenesis of insulin resistance by interfering with insulin signaling pathways. ROS can impair insulin receptor substrate activity and reduce glucose transporter (GLUT-4) translocation, resulting in decreased glucose uptake and hyperglycemia. However, further studies focusing on safety, pharmacokinetics, extraction standardization, and clinical validation remain essential for its integration into modern evidence-based medicine. [11, 12]. This, in turn, leads to compensatory hyperinsulinemia, which plays a crucial role in the development of hyperandrogenism in PCOS [13].

Hyperinsulinemia enhances ovarian androgen production by stimulating theca cells and suppressing hepatic synthesis of sex hormone-binding globulin (SHBG), thereby increasing circulating free testosterone levels [13,14]. This hormonal imbalance contributes to the clinical manifestations of PCOS, including hirsutism, acne, menstrual irregularities, and infertility [14]. Thus, insulin resistance and hyperandrogenism form a vicious cycle that perpetuates the pathophysiology of PCOS.

In recent years, there has been growing interest in the role of antioxidants in the management of PCOS. Antioxidants help neutralize ROS and protect cells from oxidative damage. Among these, Vitamin C (ascorbic acid) is a potent water-soluble antioxidant that plays a critical role in maintaining redox balance [15]. It acts as a free radical scavenger and is involved in various physiological processes, including collagen synthesis, immune function, and hormone metabolism [16].

Vitamin C has also been shown to influence reproductive function by modulating steroidogenesis and improving ovarian follicular development [17]. Several studies have reported decreased levels of antioxidants, including Vitamin C, in women with PCOS, suggesting an impaired antioxidant defense system [18,19]. This deficiency may contribute to increased oxidative stress and worsening of metabolic and hormonal abnormalities.

Experimental and clinical studies have demonstrated that antioxidant supplementation, including Vitamin C, can improve insulin sensitivity, reduce androgen levels, and enhance ovulatory function in women with PCOS [20,21]. Vitamin C has also been shown to reduce inflammatory markers and improve lipid profiles, thereby reducing cardiovascular risk associated with PCOS [22]. Additionally, it enhances endothelial function and improves insulin-mediated glucose uptake, further supporting its role in metabolic regulation [23].

Recent studies have further highlighted the importance of oxidative stress in PCOS pathogenesis and the potential therapeutic role of antioxidants. Liu et al. [24] and Farhadi-Azar et al. [25] demonstrated that antioxidant therapy significantly improves metabolic and reproductive outcomes in PCOS patients. Similarly, Rudnicka et al. [26] emphasized the role of chronic inflammation and oxidative stress in PCOS, while He et al. [27] and Hassanein et al. [28] reported beneficial effects of dietary antioxidants on metabolic parameters.

Moreover, Zhao et al. [29] and Singh et al. [30] have shown that dietary antioxidant intake is inversely associated with the severity of PCOS symptoms, suggesting that nutritional interventions may play a significant role in disease management, particularly in developing countries like India.

Despite increasing evidence regarding the role of oxidative stress and antioxidants in PCOS, limited studies have specifically evaluated the correlation between serum Vitamin C levels and hormonal as well as metabolic parameters in PCOS patients. Furthermore, data from the Indian population remain scarce.

Therefore, the present study was undertaken to assess the correlation of serum Vitamin C levels with hormonal and metabolic parameters in women with PCOS, with the aim of providing insights into the potential role of antioxidant status in the pathophysiology and management of this condition.

MATERIAL AND METHOD

This was a hospital-based case-control study conducted in the Department of Biochemistry in collaboration with the Department of Obstetrics and Gynecology at a tertiary care teaching hospital over a period of 12 months.

Study Population

A total of 100 women aged 18–35 years were enrolled:

- **Cases:** 50 diagnosed PCOS patients
- **Controls:** 50 healthy age-matched females

Diagnostic Criteria

PCOS diagnosis was established based on the **Rotterdam Criteria**, requiring at least two of the following:

- Oligo/anovulation
- Clinical/biochemical hyperandrogenism
- Polycystic ovarian morphology on ultrasound

Inclusion Criteria

1. Women aged 18–35 years
2. Diagnosed cases of PCOS
3. Controls with regular menstrual cycles
4. Willing to provide informed consent

Exclusion Criteria

1. Thyroid disorders
2. Diabetes mellitus
3. Pregnancy or lactation
4. Chronic systemic illness
5. Use of hormonal therapy or antioxidant supplements in last 3 months

Sample Collection

- 5 mL fasting venous blood collected
- Serum separated and stored at −20°C

Biochemical Analysis

Hormonal Parameters

- LH, FSH → Chemiluminescence assay
- Testosterone → ELISA

Metabolic Parameters

- Glucose → GOD-POD method
- Insulin → ELISA
- HOMA-IR calculated

Vitamin C Estimation

- Measured by spectrophotometric method using 2,4-dinitrophenylhydrazine

Statistical Analysis

- Data expressed as Mean ± SD
- Student's t-test used for comparison

- Pearson correlation analysis performed
- $p < 0.05$ considered significant

RESULTS

Table 1: Demographic Profile

Parameter	PCOS (n=50)	Controls (n=50)	p-value
Age (years)	25.6 ± 4.2	24.9 ± 3.8	>0.05
BMI (kg/m²)	27.5 ± 3.2	23.1 ± 2.5	<0.001

The mean age was comparable between groups. However, BMI was significantly higher in PCOS patients, indicating obesity as a contributing factor.

Table 2: Serum Vitamin C Levels

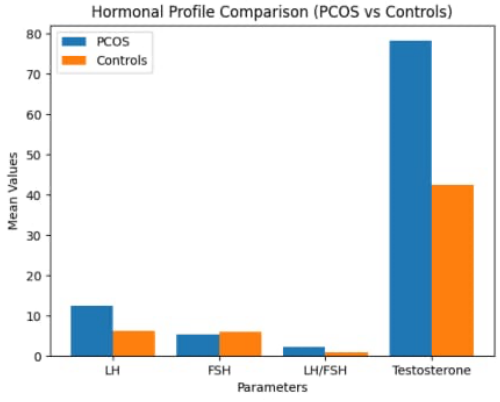
Parameter	PCOS	Controls	p-value
Vitamin C (mg/dL)	0.68 ± 0.15	1.21 ± 0.22	<0.001

Serum Vitamin C levels were significantly lower in PCOS patients, indicating increased oxidative stress and reduced antioxidant capacity.

Table 3: Hormonal Profile

Parameter	PCOS	Controls	p-value
LH	12.5 ± 3.1	6.2 ± 2.0	<0.001
FSH	5.4 ± 1.3	6.1 ± 1.5	<0.05
LH/FSH	2.3 ± 0.8	1.0 ± 0.3	<0.001
Testosterone	78.2 ± 15.4	42.5 ± 10.2	<0.001

PCOS patients showed significant hormonal imbalance with elevated LH, LH/FSH ratio, and testosterone, consistent with hyperandrogenism.



Graph 1: Hormonal Profile

Table 4: Metabolic Parameters

Parameter	PCOS	Controls	p-value
FBS	102 ± 12	89 ± 10	<0.01
Insulin	18.5 ± 5.2	9.4 ± 3.1	<0.001
HOMA-IR	4.6 ± 1.2	2.1 ± 0.8	<0.001
HDL	38 ± 6	48 ± 7	<0.001

PCOS patients exhibited insulin resistance and dyslipidemia, with significantly higher insulin and HOMA-IR and lower HDL levels.

Table 5: Correlation of Vitamin C

Parameter	r-value	p-value
Testosterone	-0.52	<0.001
Insulin	-0.61	<0.001
HOMA-IR	-0.58	<0.001
HDL	+0.45	<0.01

Vitamin C showed:

- Negative correlation with testosterone and insulin resistance
- Positive correlation with HDL

This suggests antioxidant deficiency worsens metabolic and hormonal imbalance.

The present study included a total of 100 participants, comprising 50 women diagnosed with Polycystic Ovary Syndrome and 50 age-matched healthy controls. The mean age of the PCOS group was 25.6 ± 4.2 years, while that of the control group was 24.9 ± 3.8 years. Statistical analysis revealed no significant difference between the two groups with respect to age ($p > 0.05$), indicating that both groups were comparable and age-matched.

However, a significant difference was observed in body mass index (BMI). The mean BMI of PCOS patients was 27.5 ± 3.2 kg/m², which was significantly higher compared to controls (23.1 ± 2.5 kg/m²) ($p < 0.001$). This finding suggests a higher prevalence of overweight and obesity among women with PCOS.

The increased BMI in PCOS patients reflects the strong association between obesity and PCOS, which plays a critical role in aggravating insulin resistance and metabolic disturbances. The findings support the concept that adiposity contributes significantly to the pathophysiology and clinical severity of PCOS.

Serum Vitamin C Levels

Serum Vitamin C levels were found to be markedly reduced in the PCOS group compared to the control

group. The mean serum Vitamin C level in PCOS patients was 0.68 ± 0.15 mg/dL, whereas in controls it was 1.21 ± 0.22 mg/dL. This difference was highly statistically significant ($p < 0.001$).

The significantly lower Vitamin C levels in PCOS patients indicate a state of increased oxidative stress and reduced antioxidant defense. Vitamin C, being a potent water-soluble antioxidant, plays a crucial role in neutralizing reactive oxygen species (ROS). Its depletion suggests excessive oxidative burden in PCOS patients.

This finding strongly supports the hypothesis that oxidative stress is a key contributor to the pathogenesis of PCOS. The reduced antioxidant capacity may lead to cellular damage, impaired ovarian function, and worsening of metabolic abnormalities.

Hormonal Profile

The hormonal analysis revealed significant alterations in reproductive hormone levels among PCOS patients. Serum luteinizing hormone (LH) levels were significantly elevated in the PCOS group (12.5 ± 3.1 IU/L) compared to controls (6.2 ± 2.0 IU/L) ($p < 0.001$). In contrast, follicle-stimulating hormone (FSH) levels were slightly lower in PCOS patients (5.4 ± 1.3 IU/L) compared to controls (6.1 ± 1.5 IU/L), and this difference was statistically significant ($p < 0.05$).

As a result, the LH/FSH ratio was markedly increased in PCOS patients (2.3 ± 0.8) compared to controls (1.0 ± 0.3) ($p < 0.001$). An elevated LH/FSH ratio is a hallmark feature of PCOS and reflects dysregulation of the hypothalamic-pituitary-ovarian axis.

Furthermore, serum testosterone levels were significantly higher in the PCOS group (78.2 ± 15.4 ng/dL) compared to controls (42.5 ± 10.2 ng/dL) ($p < 0.001$), confirming the presence of hyperandrogenism.

These findings indicate that women with PCOS exhibit significant endocrine imbalance characterized by increased LH secretion and androgen excess. This hormonal disturbance contributes to clinical manifestations such as menstrual irregularities, hirsutism, and infertility.

Metabolic Parameters

The metabolic evaluation showed significant differences between PCOS patients and controls. Fasting blood glucose levels were higher in PCOS patients (102 ± 12 mg/dL) compared to controls (89 ± 10 mg/dL), and this difference was statistically significant ($p < 0.01$).

Fasting insulin levels were markedly elevated in PCOS patients (18.5 ± 5.2 μIU/mL) compared to controls (9.4 ± 3.1 μIU/mL) ($p < 0.001$). Consequently, the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) was significantly higher in the PCOS group (4.6 ± 1.2) than in controls (2.1 ± 0.8) ($p < 0.001$), indicating the presence of significant insulin resistance.

In terms of lipid profile, HDL cholesterol levels were significantly lower in PCOS patients (38 ± 6 mg/dL) compared to controls (48 ± 7 mg/dL) ($p < 0.001$). Reduced HDL levels are indicative of dyslipidemia and increased cardiovascular risk.

These findings clearly demonstrate that PCOS is associated with metabolic derangements, including insulin resistance, impaired glucose metabolism, and dyslipidemia. These abnormalities contribute to the long-term risk of type 2 diabetes mellitus and cardiovascular disease in PCOS patients.

5. Correlation of Serum Vitamin C with Hormonal and Metabolic Parameters

Correlation analysis was performed to evaluate the relationship between serum Vitamin C levels and various hormonal and metabolic parameters in PCOS patients.

A significant negative correlation was observed between serum Vitamin C and testosterone levels ($r = -0.52$, $p < 0.001$), indicating that lower Vitamin C levels are associated with higher androgen levels. This suggests that oxidative stress may contribute to hyperandrogenism in PCOS.

Similarly, serum Vitamin C showed a strong negative correlation with fasting insulin levels ($r = -0.61$, $p < 0.001$) and HOMA-IR ($r = -0.58$, $p < 0.001$). These findings indicate that reduced antioxidant levels are associated with increased insulin resistance.

In contrast, a significant positive correlation was observed between serum Vitamin C and HDL cholesterol levels ($r = +0.45$, $p < 0.01$), suggesting a protective role of Vitamin C in lipid metabolism.

Overall, these correlations indicate that decreased Vitamin C levels are closely associated with worsening hormonal imbalance and metabolic dysfunction in PCOS. This supports the role of oxidative stress as a central mechanism linking endocrine and metabolic abnormalities in PCOS.

DISCUSSION

The present study demonstrated significantly reduced serum Vitamin C levels in women with PCOS, indicating increased oxidative stress and compromised antioxidant defense. This finding is consistent with earlier studies that have reported elevated oxidative stress markers and reduced antioxidant capacity in PCOS patients [6,9,26].

Oxidative stress plays a central role in the pathogenesis of PCOS by disrupting ovarian steroidogenesis and follicular maturation. Increased levels of reactive oxygen species (ROS) have been shown to impair granulosa cell function and induce apoptosis, leading to anovulation [8,10]. These alterations contribute significantly to reproductive dysfunction observed in PCOS.

In the present study, a significant negative correlation was observed between serum Vitamin C levels and insulin resistance parameters such as fasting insulin and HOMA-IR. This is in agreement with previous studies demonstrating that oxidative stress interferes with insulin receptor signaling pathways, thereby contributing to insulin resistance [11,12]. Hyperinsulinemia further aggravates hyperandrogenism by stimulating ovarian androgen production and reducing sex hormone-binding globulin (SHBG) synthesis [13,14].

Our findings are supported by recent studies conducted by Zhang et al. [21] and He et al. [27], who reported that antioxidant supplementation improves insulin sensitivity and reduces metabolic dysfunction in PCOS patients. Similarly, Johnston et al. [23] demonstrated that Vitamin C enhances insulin-mediated glucose uptake and improves endothelial function.

The significantly elevated testosterone levels observed in PCOS patients in the present study further support the role of oxidative stress in hyperandrogenism. Increased ROS activity has been shown to stimulate androgen synthesis in ovarian theca cells, thereby exacerbating clinical features such as hirsutism and acne [14].

Additionally, a positive correlation was observed between serum Vitamin C and HDL cholesterol levels, indicating a beneficial role in lipid metabolism. This finding is consistent with studies by Amer et al. [22] and Hassanein et al. [28], who reported that antioxidants improve lipid profiles and reduce cardiovascular risk in PCOS patients.

Recent studies (2024–2025) have emphasized the importance of antioxidant therapy in PCOS management. Saad et al. [20] demonstrated that Vitamin C supplementation significantly reduced oxidative stress and improved hormonal balance in experimental models. Similarly, Liu et al. [24] and Farhadi-Azar et al. [25] highlighted the role of antioxidants in improving reproductive and metabolic outcomes in PCOS.

Furthermore, Zhao et al. [29] and Singh et al. [30] have reported that dietary antioxidant intake is inversely associated with the severity of PCOS symptoms, suggesting that nutritional interventions may play a significant role in disease management.

Overall, the findings of the present study are consistent with global literature and reinforce the hypothesis that oxidative stress is a key mechanism linking hormonal imbalance and metabolic dysfunction in PCOS.

CONCLUSION

The present study on Polycystic Ovary Syndrome demonstrated a significant reduction in serum Vitamin C levels among affected women compared to healthy controls, highlighting the presence of increased oxidative stress and compromised antioxidant defense in PCOS.

A strong negative correlation was observed between serum Vitamin C levels and key hormonal and metabolic parameters, including serum testosterone, fasting insulin, and HOMA-IR, indicating that lower antioxidant status is associated with increased insulin resistance and hyperandrogenism. Additionally, a positive correlation with HDL cholesterol suggests a protective role of Vitamin C in lipid metabolism and cardiovascular risk reduction.

These findings support the concept that oxidative stress plays a pivotal role in the pathophysiology of PCOS by linking metabolic dysfunction with hormonal imbalance. The results are consistent with existing literature emphasizing the contribution of oxidative stress to insulin resistance and androgen excess in PCOS.

Furthermore, the study highlights the potential clinical significance of Vitamin C as both a biomarker of oxidative stress and a therapeutic adjunct in the management of PCOS. Improving antioxidant status through dietary modification or supplementation may help in ameliorating metabolic and endocrine abnormalities associated with the disorder.

In conclusion, serum Vitamin C is inversely associated with the severity of hormonal and metabolic disturbances in PCOS, and its assessment may provide valuable insights into disease progression and management strategies. Future large-scale, longitudinal studies are recommended to further establish its role in clinical practice.

LIMITATIONS

- Cross-sectional design
- Dietary intake not assessed
- Single-center study

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study

Consent to participate: There is consent to participate.

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: Author equally contributed the work.

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