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Clinico Biochemical Profiling of PCOS: Comparative Analysis of Integrated Serum Biomarker Patterns

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Introduction

Polycystic Ovary Syndrome (PCOS) is a prevalent endocrine disorder affecting women of reproductive age, characterized by hormonal imbalances, metabolic abnormalities, and reproductive challenges. PCOS is also the most common endocrine disorder among females of reproductive age worldwide [1]. It is a multifaceted endocrine disorder affecting approximately 8–13% of reproductive-aged women [2]. The disorder significantly impacts various metabolic parameters, notably serum glucose and lipid profiles, and is associated with an increased risk of developing metabolic syndrome, type 2 diabetes, and cardiovascular diseases. The estimation of serum calcium, glucose, and cholesterol levels in PCOS patients provides critical insights into the metabolic derangements associated with the condition, facilitating better clinical management and therapeutic strategies. Recent studies have elucidated the connection between varying serum markers and the overall metabolic health of PCOS patients. For instance, a study highlighted the utility of serum markers like HbA1c and HOMA-IR in predicting glucose intolerance among women with PCOS [3]. This aligns with findings indicating dysregulated glucose metabolism, including elevated fasting glucose levels, are prevalent among PCOS patients [4]. The inclusion of glucose metrics can provide valuable information about the risk of developing type 2 diabetes and metabolic syndrome in this patient demographic. In terms of lipid metabolism, individuals with PCOS often exhibit dyslipidemia characterized by elevated triglycerides and low levels of high-density lipoprotein (HDL) cholesterol. Studies showed a significant correlation between insulin resistance and dyslipidemia in PCOS patients, this is a critical feature of PCOS, impacting approximately 50–70% of women with the condition [5-6]. The altered lipid profile not only exacerbates the risk of cardiovascular diseases but also reflects the underlying pathophysiology related to insulin sensitivity, which is often impaired in these patients. Through biochemical assessments, including serum cholesterol levels,

this survey aims to establish concrete correlations between these metabolic abnormalities and PCOS. Emerging research indicates the necessity of examining serum calcium levels in PCOS, as calcium metabolism has been implicated in insulin signaling pathways [7]. Dysregulated calcium levels may contribute to the insulin resistance characteristic of PCOS, suggesting a potential area for therapeutic intervention. While direct studies measuring serum calcium in PCOS are limited, the connection between calcium metabolism and insulin sensitivity warrants further investigation. Moreover, the assessment of HOMA-IR values, where values above 2.5 indicate significant insulin resistance, is valuable in illustrating the relationship between insulin sensitivity and glucose levels [5].

Calcium plays a crucial role in various metabolic processes, and findings suggest its association with metabolic syndrome, particularly in women with PCOS. Research indicates that serum calcium levels have been positively correlated with blood glucose and cholesterol levels [8-9]. The implications of these associations highlight a potential pathophysiological link between serum calcium dysregulation and metabolic disturbances commonly observed in PCOS patients [10]. Furthermore, studies have indicated an impact of calcium on insulin sensitivity and glucose metabolism, suggesting that alterations in calcium homeostasis might exacerbate insulin resistance seen in these patients [11-12]. Findings of low calcium levels in conjunction with high triglyceride and low-density lipoprotein (LDL) cholesterol levels underline the importance of evaluating serum calcium as a potential marker of metabolic dysfunction in PCOS [8,10]. Notably, intervention studies have reported improvements in lipid profiles with calcium supplementation, highlighting its possible therapeutic role [12]. Dyslipidaemia, characterized by elevated total cholesterol, triglycerides, and reduced HDL cholesterol, is a well-documented phenomenon in women with PCOS [13]. Menstrual irregularity in PCOS patients can be exacerbated by dyslipidaemia profiles, which increase their cardiovascular risk [14]. Studies indicate that approximately 70% of women with PCOS exhibit disturbances in their lipid profiles, with significant

elevations in total cholesterol and LDL levels being particularly concerning [15].

The primary objective of this survey is to systematically evaluate the serum levels of calcium, glucose, and cholesterol in a cohort of women diagnosed with PCOS. By correlating these biochemical markers with clinical presentations of insulin resistance and metabolic dysregulation, we aim to enhance the understanding of PCOS and inform future clinical practices. The survey will build upon existing literature that shows the comprehensive metabolic challenges faced by women with PCOS, providing a foundational framework for intervention strategies that consider not only hormonal aspects but also the broader metabolic profile [16-17].

Materials And Methods

Study Design

This case control study was conducted at R. P. Shaha University, Narayanganj-1400, Bangladesh. stratifying participants into three distinct cohorts: clinically diagnosed PCOS patients (case group), females manifesting PCOS-associated symptomatology (symptoms group), and ostensibly healthy individuals devoid of PCOS indicators (control group). The study systematically interrogated perturbations in key biochemical parameters, specifically serum calcium, glucose, and cholesterol concentrations, to elucidate metabolic and endocrine deviations across these stratified populations.

Participant Eligibility Criteria

Inclusion criteria included female participants aged 18–25 years who were students of university, willing to provide informed consent, and who voluntarily agreed to provide blood samples for biochemical analysis. Participants in the case group had a prior clinical diagnosis of PCOS, while those in the symptoms group reported menstrual irregularities, hirsutism, acne, or other PCOS-related symptoms. Control participants had no history or symptoms suggestive of PCOS. Exclusion criteria included pregnant women, individuals with chronic systemic diseases, those receiving hormonal therapy or calcium supplementation, and participants unwilling to provide blood samples.

Sampling Technique and Estimation

Purposive sampling was used to identify eligible participants from the university population. This approach was selected to ensure targeted inclusion of individuals meeting the clinical and symptomatic criteria of PCOS, as well as suitable healthy controls. Participants were screened through questionnaire-based assessments and self-reported medical history prior to final enrollment. Sample size determination in descriptive observational studies is critical to ensure reliability of prevalence estimates and adequate representation of key outcomes. The standard formula for estimating the minimum required sample size for a single proportion was:

$$N = \frac{Z^2 \times p \times (1-p)}{d^2},$$

where n = required sample size, Z = Z-score for the desired confidence level (1.96 for 95% confidence), P = expected prevalence of the outcome of interest, and d = acceptable margin of error. This formula is widely used in epidemiological and prevalence studies.

Given the absence of precise prior estimates for awareness of ovarian cysts or PCOS in this population, a conservative expected

proportion (P) of 0.50 was assumed to maximize sample size. A margin of error (d) of 0.05 (5%) was selected for acceptable precision. Substituting these parameters yields:

$$N = \frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.05)^2} \approx 384. \text{ Thus, a minimum of 384}$$

participants would provide reliable estimates at 95% confidence with a 5% margin of error. A total of 384 responses were initially collected, among them 224 responses were excluded due to failure to meet the inclusion criteria and incomplete questionnaire responses, hence 160 participants (32.2%) were included in the final analysis. Based on the number of consent responses treated as the achieved sample, the precision of the prevalence estimates was recalculated [18].

$$\begin{aligned} d &= Z \times \frac{\sqrt{P(1-P)}}{n} \\ d &= 1.96 \times \frac{\sqrt{0.5 \times (1-0.5)}}{160} \\ d &= 1.96 \times \frac{\sqrt{0.25}}{160} \\ d &\approx 0.077 \\ d &\approx 7.7\% \end{aligned}$$

Thus, the $N=160$ respondents provided an estimated prevalence with a margin of error of approximately $\pm 7.7\%$ at 95% confidence, which is acceptable for exploratory analysis [19].

Data Collection Tool

To ensure the relevance and originality of the survey instrument, a structured review of existing literature related to PCOS, ovarian cysts, and associated clinical symptoms was conducted using PubMed and Google Scholar databases. The questionnaire was designed through a multi-step process based on commonly reported clinical features of PCOS and prior epidemiological studies. Content validity was ensured through review by academic researchers and healthcare professionals with expertise in reproductive health, who evaluated the clarity, relevance, and appropriateness of the items. The final questionnaire consisted primarily of close-ended questions with dichotomous and categorical response options, along with one multiple-response item. It covered demographic information (age), awareness of ovarian cysts and PCOS, self-reported PCOS diagnosis, menstrual cycle regularity, healthcare-seeking behavior, PCOS-related symptoms (including acne, hair loss, mood changes, and weight changes), fatigue, and self-reported diabetes status. The instrument was designed to facilitate efficient data collection while capturing key clinical and awareness-related variables relevant to PCOS.

Operational Definitions

Serum calcium, serum glucose, and serum cholesterol levels were assessed using standard biochemical methods. Based on laboratory reference ranges provided by the reagent manufacturers, normal serum calcium levels were defined as 8.4–10.4 mg/dL, normal fasting serum glucose levels as 4.2–6.2 mmol/L, and serum cholesterol levels within the manufacturer's stated reference range were considered normal. Serum calcium levels below 8.4 mg/dL were categorized as hypocalcemia. Any deviation of serum glucose or cholesterol levels beyond the reference ranges was considered abnormal.

Laboratory Procedures

Approximately 5 mL of venous blood was collected from each participant under aseptic conditions using metal-free sterile test tubes. Samples were allowed to clot at room temperature for 10–15 minutes and subsequently centrifuged at 3000 rpm for 15 minutes to separate serum. The separated serum was transferred into labeled Eppendorf tubes and stored under appropriate conditions until analysis. Serum calcium levels were measured using a commercially available calcium test kit based on a colorimetric method. Serum glucose was determined using an enzymatic glucose assay kit, while serum cholesterol levels were assessed using a standard colorimetric cholesterol test kit. All reagents and samples were equilibrated to room temperature prior to analysis. Blank, standard, and sample preparations were performed according to the manufacturer's instructions, and absorbance readings were obtained using a biochemical analyzer. Results were recorded systematically for each participant.

Statistical Analysis

Data were analyzed using SPSS software (version 26.0; IBM SPSS Corp). Continuous variables were summarized as mean $\pm$ standard deviation, while categorical variables were expressed as frequencies and percentages. Comparisons among the three study groups were conducted using appropriate statistical tests, with statistically significant. Data were also visualized using tables, bar chart to distributions and highlight key trends.

Ethical Considerations

Prior permission was taken from the Institutional Review Board, Center for Research & Innovation (CRI) of R. P. Shaha University, Narayanganj, Bangladesh, IRB Number: RPSU/EC/PHR/2025/08. Accordance with the principles of the Declaration of Helsinki for Medical Research Involving Human Subjects 1964 [20-21]. Written informed consent was obtained from all participants prior to questionnaire administration and blood sample collection.

Bias and Limitations

The study may be subject to selection bias due to purposive sampling and a relatively small sample size. Additionally, biochemical analysis was limited to a subset of participants who consented to blood donation. Despite these limitations, the study provides valuable preliminary evidence regarding biochemical alterations associated with PCOS in young women.

Result

The demographic and clinical profile of the study cohort is delineated in Table 1, wherein the majority of participants ($n = 160$) were concentrated within the 20–22-year age bracket (72.5%), with comparatively fewer individuals aged 17–19 years (17.5%) and 23–25 years (10.0%). Although the self-reported prevalence of ovarian cysts (11%), clinically diagnosed PCOS (6%), and diabetes mellitus (2%) was relatively low, a disproportionately high frequency of PCOS-associated symptomatology was observed. Specifically, persistent fatigue was reported by 27% of respondents, episodic acne by 52%, menstrual irregularities by 38%, and excessive facial or body hair indicative of hyperandrogenism by 18%. Alarming, healthcare-seeking behavior remained markedly inadequate, as only 13% of participants experiencing menstrual irregularities had consulted healthcare professionals. Assessment of disease-specific awareness.

Discussion

While this study focused primarily on biochemical parameters, the symptom profile observed has important implications for

psychological well-being and quality of life. Research has demonstrated that patients with PCOS show greater psychological disturbances across multiple dimensions, including obsessive-compulsive tendencies, interpersonal sensitivity, depression, anxiety, aggression, and psychoticism, along with lower life satisfaction in domains of health, self-perception, and sexuality. Health-related quality of life assessments have revealed significantly decreased scores for physical role function, bodily pain, vitality, social function, emotional role function, and mental health in women with PCOS [22]. The high prevalence of symptoms such as acne (52%), menstrual irregularities (38%), and excessive hair growth (18%) observed in this study likely contributes to psychological burden among affected individuals. Depression has been identified as the largest contributor to reduced quality of life in PCOS, followed by acne and obesity [23]. The mood swings commonly reported by PCOS patients may be attributable to hyperandrogenism-related disruption of monoamine balance, potential contributing factors to the greater prevalence of depressive symptoms in PCOS-positive women include obesity, insulin resistance, hyperandrogenism, inflammation, and infertility, though precise mechanisms remain incompletely understood [24]. The recognition of mood changes as a PCOS symptom by 62.5% of participants in this study suggests awareness of psychological manifestations, yet this awareness may not translate into appropriate help-seeking behavior. Education and counseling around the chronic nature of PCOS, along with psychological support, are vital aspects of management [25]. Clinicians should routinely evaluate each patient with PCOS from a mental health perspective and remain aware of the impact of the condition on psychological well-being [26].

The findings of this study carry significant implications for clinical practice and public health policy. The high prevalence of PCOS-related symptoms coupled with low diagnostic rates and inadequate healthcare-seeking behavior suggests a substantial burden of unrecognized and untreated disease. This gap between symptom experience and clinical recognition may contribute to delayed intervention and progression of metabolic complications. The biochemical abnormalities observed particularly the graded differences in calcium, cholesterol, and glucose across clinical strata, support the importance of metabolic screening in women presenting with PCOS-related symptoms, even in the absence of formal diagnosis. Early identification of metabolic disturbances may enable preventive interventions that reduce long-term cardiovascular and metabolic risk. Weight loss interventions in overweight and obese women with PCOS may improve subsequent pregnancy rates; however, studies have found that only half of surveyed physicians recommended lifestyle changes for treatment of fertility-related issues [27]. This underutilization of lifestyle interventions represents a missed opportunity for addressing both reproductive and metabolic aspects of the syndrome. Management of PCOS can be achieved through better lifestyles, and recognition of environmental, occupational, and dietary factors in PCOS development supports comprehensive approaches to prevention and treatment [28].

The knowledge gaps identified in this study underscore the need for targeted awareness and education initiatives. The finding that only 35% of participants had heard of PCOS despite high symptom prevalence suggests that public health messaging has not adequately reached young women. Education and career field have been associated with the degree of PCOS knowledge, as have diabetes history and personal PCOS history [29]. These associations suggest that educational interventions should be

tailored to reach diverse populations and should leverage existing healthcare encounters as opportunities for awareness-building. Recent studies have highlighted fields for improvement including deeper knowledge and greater PCOS awareness among healthcare providers, along with patient desires for more reassurance, access to PCOS specialists, and information tools [30]. The development of comprehensive educational resources for both patients and providers may help address the current gaps in recognition and management.

Limitations and Future Directions

While this study provides valuable insights, several limitations warrant consideration. The relatively small sample size for biochemical analyses limits statistical power and generalizability of findings. The case control design precludes determination of causal relationships between biochemical parameters and PCOS status. Self-reported symptom data may be subject to recall bias and varying interpretations of symptom severity. Future research should employ larger sample sizes and longitudinal designs to better characterize the temporal relationships between symptom development, biochemical changes, and disease progression. Investigation of additional biomarkers, including anti-Müllerian hormone levels as recommended in updated guidelines, may enhance diagnostic accuracy and risk stratification. Qualitative research exploring barriers to healthcare-seeking and factors influencing awareness may inform more effective intervention strategies.

Conclusion

This study demonstrates a compelling intersection between heightened symptom prevalence, suboptimal disease awareness, and pronounced biochemical derangements in a cohort of young women. The findings of hypocalcemia, dyslipidemia, and impaired glycemic regulation across the spectrum from healthy controls through symptomatic individuals to diagnosed PCOS patients reinforce the complex endocrine-metabolic continuum underlying this syndrome. The marked inadequacy of healthcare-seeking behavior, of those experiencing menstrual irregularities consulting healthcare professionals, represents a critical gap requiring urgent attention. Comprehensive approaches integrating public awareness campaigns, healthcare provider education, and systematic screening protocols are needed to address the substantial burden of unrecognized and undertreated PCOS in this population.

Table 1: Prevalence of PCOS-Related Symptoms and Medical History

Variable	Category	N (%)
Age	17–19	28 (17.5%)
	20–22	116 (72.5%)
	23–25	16 (10.0%)
Do you have/had ovarian cysts?	Yes	18 (11%)
	No	142 (89%)
Do you have PCOS?	Yes	10 (6%)
	No	150 (94%)
Do you have diabetes?	Yes	3 (2%)
	No	157 (98%)
Do you feel fatigued all the time?	Yes	43 (27%)
	No	117 (73%)
Do you suffer from acne from time to time?	Yes	83 (52%)
	No	77 (48%)
Are you facing an irregular period cycle?	Yes	61 (38%)
	No	99 (62%)
If yes, have you ever visited healthcare professionals for Irregular Periods?	Yes	21 (13%)
	No	139 (87%)
Do you think you have excessive facial and body hair compared to others?	Yes	29 (18%)
	No	131 (82%)

Table 2: Knowledge Assessment: Identification of PCOS Symptoms

Variable	Category	N (%)
Have you heard about ovarian cysts?	Yes	88 (55%)
	No	62 (39%)
	Maybe	10 (6%)
Have you ever heard about PCOS (polycystic ovarian syndrome)?	Yes	56 (35%)
	No	104 (65%)
Symptoms of PCOS (Multiple responses)	Hair loss	112 (70.0%)
	Mood Changes	100 (62.5%)
	Acne	83 (51.9%)
	Irregular Periods	61 (38.1%)
	Weight changes	40 (25.0%)
	Hormonal Imbalance	29 (18.1%)

Parameter	Group	n	Mean ± SE	Mean ± SD	Min–Max (mg/dL)
Serum Calcium (mg/dL)	Cases	54	8.70 ± 0.16	8.70 ± 1.18	6.8 – 10.9
	Symptom Group	53	9.05 ± 0.14	9.05 ± 1.02	7.2 – 11.1
	Control Group	53	9.42 ± 0.12	9.42 ± 0.87	8.0 – 11.0
Serum Glucose (mg/dL)	Cases	54	119.5 ± 4.9	119.5 ± 36.0	75 – 205
	Symptom Group	53	131.2 ± 5.6	131.2 ± 40.8	82 – 240
	Control Group	53	93.4 ± 2.6	93.4 ± 18.9	70 – 140
Serum Cholesterol (mg/dL)	Cases	54	202.4 ± 3.9	202.4 ± 28.6	145 – 265
	Symptom Group	53	188.6 ± 4.5	188.6 ± 32.8	130 – 270
	Control Group	53	169.8 ± 3.1	169.8 ± 22.6	120 – 220

Declaration Section

Data Availability Statement:

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Funding Statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest Disclosure

The authors declare no conflicts of interest related to this work.

Ethics Statement

The study was approved by the Institutional Review Board, Center for Research & Innovation (CRI), R. P. Shaha University, Bangladesh (IRB No: RPSU/EC/PHR/2025/08), and conducted in accordance with the Declaration of Helsinki.

Patient Consent Statement

Written informed consent was obtained from all participants prior to participation and sample collection.

Permission to Reproduce Material

No material from other sources requiring permission was reproduced in this manuscript.

Author Contributions

Md Faiazul Haque Lamem led the study design, data analysis, and manuscript preparation. Maimuna Hasan contributed to data collection, supervision, literature review, and drafting. Muaj Ibne Sahid assisted with laboratory work and data analysis. Rumman Maisha supported data collection and manuscript revision. All authors approved the final manuscript.

Ethics and Integrity Compliance

The authors confirm that this manuscript adheres to the journal's ethics and integrity policies, including standards for human subject research, informed consent, data accuracy, originality, and responsible authorship.

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