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PREVALENCE OF PREDIABETES AND INSULIN RESISTANCE AMONG WOMEN WITH POLYCYSTIC OVARY SYNDROME

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Abstract

Background: Polycystic Ovary Syndrome (PCOS) is a widespread endocrine condition marked by major metabolic anomalies, especially insulin resistance and inability to regulate glucose levels. Pediatric prediabetes diagnosis is crucial to avoid the development of type 2 diabetes mellitus and associated problems in this group of the population.

Objective: To establish the prediabetes and insulin resistance prevalence and relationship in women with PCOS and to determine their correlations with clinical, anthropometric and biochemical outcomes.

Material & Methods: Cross-sectional descriptive study was done on 150 women diagnosed with PCOS according to the Rotterdam criteria. The assessments of glycemic status were conducted in terms of fasting blood glucose (FBG), 2-hour oral glucose tolerance test (OGTT), and HbA1c. The

Vol. 5 No. 2 (2026)

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Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was used to assess insulin resistance. Data analysis was done using SPSS and $p<0.05$ was taken as the statistical significance.

Results: The prediabetes and type 2 diabetes were 30.7 and 8.0 percent, respectively. 65.3% of the participants had insulin resistance (HOMA-IR > 2.0). Insulin resistance was also significantly correlated with BMI ($p<0.001$) with a prevalence of 47.4% among normal-weighted individuals and 86.7% among the obese individuals. There were strong positive relationships between HOMA-IR and HbA1c ($r=0.73$), FBG ($r=0.68$), and OGTT ($r=0.71$). OGTT was the most accurate in diagnosis (AUC=0.92), whereas combined screening methods demonstrated the best results (AUC=0.95).

Conclusion: Pre-diabetes and insulin resistance are quite common among women with PCOS. Timely identification and intervention of long-term complications are possible only through early and thorough metabolic screening with integrated diagnostic methods.

INTRODUCTION

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and metabolic disorders affecting women of reproductive age, with a prevalence estimated between 6% and 16% depending on diagnostic criteria and population studied. It is a heterogeneous condition characterized by a combination of reproductive, endocrine, and metabolic abnormalities, most commonly hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology. Over time, diagnostic approaches have evolved, with the Rotterdam criteria being the most widely accepted, requiring at least two of three features for diagnosis. This broadened definition has helped recognize PCOS as a spectrum disorder with varying phenotypes and clinical risks. Despite its high prevalence, PCOS remains underdiagnosed in many developing regions due to limited awareness, healthcare access, and variability in clinical presentation.1

PCOS typically manifests in adolescence or early reproductive life and is associated with menstrual irregularities such as oligomenorrhea or amenorrhea, infertility due to anovulation, and signs of androgen excess including hirsutism, acne, and alopecia. Beyond reproductive manifestations, it is

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Print ISSN 3007-2379
Fatima et al - 2026
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increasingly recognized as a metabolic disorder linked to insulin resistance, obesity, dyslipidemia, and impaired glucose metabolism. Insulin resistance is considered a central pathogenic feature, affecting nearly 50–70% of affected women, even in those who are lean. This suggests intrinsic defects in insulin signaling pathways beyond obesity-related mechanisms. Hyperinsulinemia further exacerbates ovarian androgen production and suppresses sex hormone-binding globulin, contributing to both metabolic and reproductive dysfunction.2

Impaired glucose metabolism in PCOS often progresses to prediabetes and type 2 diabetes mellitus, making early identification of glycemic abnormalities essential. Prediabetes, defined by impaired fasting glucose and impaired glucose tolerance, represents a reversible stage if detected early. Studies indicate that up to 30–40% of women with PCOS may have prediabetes, while a smaller proportion may already have diabetes at diagnosis. Screening methods recommended by the American Diabetes Association include fasting plasma glucose, HbA1c, and oral glucose tolerance test (OGTT), with OGTT being the most sensitive for early detection. Despite established guidelines, screening practices remain inconsistent, particularly in low-resource settings.3

Insulin resistance in PCOS can be assessed using the HOMA-IR index, which provides a practical and cost-effective estimate based on fasting glucose and insulin levels. Although not as precise as the hyperinsulinemic-euglycemic clamp technique, it is widely used in clinical and research settings. The presence of insulin resistance contributes not only to metabolic complications but also to reproductive dysfunction through hyperinsulinemia-mediated androgen excess. This creates a cycle that worsens both ovarian and metabolic abnormalities. Early detection of insulin resistance is therefore critical to preventing progression to prediabetes, diabetes, and cardiovascular disease.4

Despite growing research on PCOS, there remains a gap in comprehensive studies that simultaneously assess both insulin resistance and prediabetes using standardized diagnostic tools. Most existing literature focuses on either reproductive or metabolic aspects separately, limiting a holistic understanding of the disorder. This study is therefore designed to evaluate both glycemic status and insulin resistance in women with PCOS using fasting glucose, OGTT, HbA1c, and

Vol. 5 No. 2 (2026)

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HOMA-IR. The findings are expected to provide valuable local evidence, support early risk stratification, and improve clinical management strategies aimed at reducing long-term metabolic and cardiovascular complications in this population.5

Literature Review

Hussain et al. (2022) reported that women with PCOS have a significantly higher risk of impaired glucose metabolism, with 30.9% showing prediabetes and 7.1% diagnosed with type 2 diabetes mellitus using OGTT. The study included 84 women aged 18–40 years and demonstrated that abnormal glycemic status was strongly associated with increased BMI, indicating that obesity significantly worsens metabolic dysfunction in PCOS. These findings suggest that insulin resistance and early glucose abnormalities are common in this population and may appear even at a young age. The authors emphasized the importance of routine metabolic screening in women with PCOS to identify prediabetes early and prevent progression to diabetes and related complications, particularly in high-risk individuals with obesity or other metabolic risk factors.

Zheng et al. (2022) evaluated insulin resistance in women with PCOS using the HOMA-IR method and found that 72.2% of participants had insulin resistance above the diagnostic threshold. The study included women diagnosed according to Rotterdam criteria and highlighted that insulin resistance was not limited to obese individuals, as a considerable number of normal BMI participants also showed metabolic dysfunction. This indicates that PCOS has an intrinsic metabolic component independent of obesity. The study emphasized defects in insulin signaling pathways and post-receptor activity as key mechanisms. The authors recommended early metabolic assessment using HOMA-IR in both lean and obese PCOS patients to enable timely intervention and reduce the risk of progression to prediabetes and type 2 diabetes mellitus.

Choi et al. (2021) conducted a longitudinal cohort study to evaluate the progression of glucose abnormalities in women with PCOS over time. The study included 252 participants aged 13–42 years and found that 19.5% had prediabetes and 1.6% had diabetes at baseline. During follow-up,

Vol. 5 No. 2 (2026)

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Print ISSN 3007-2379

Fatima et al - 2026

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a significant proportion of normoglycemic women developed prediabetes, while some prediabetic individuals progressed to diabetes, although others reverted to normal glycemia after intervention. The study demonstrated that metabolic status in PCOS is dynamic and can improve or worsen depending on lifestyle and treatment. The authors also found that OGTT and fasting glucose were more sensitive than HbA1c for detecting early metabolic changes, highlighting the need for regular and comprehensive screening strategies.

Teede et al. (2018) conducted a systematic review and meta-analysis to evaluate the global metabolic risk associated with PCOS. The study found that women with PCOS have up to a 35-fold increased risk of developing type 2 diabetes compared to women without the condition. Insulin resistance was identified as a central pathophysiological feature, present even in young and non-obese women. The review emphasized that metabolic abnormalities are common across all phenotypes of PCOS and are not limited to overweight individuals. The authors strongly recommended universal metabolic screening for all women with PCOS, regardless of BMI, using fasting glucose, OGTT, and insulin resistance indices, along with early lifestyle and pharmacological interventions to reduce long-term complications.

Methodology

A cross-sectional descriptive study was designed to determine the prevalence of insulin resistance and prediabetes in women with PCOS. The study will be conducted at Chughtai Lab, Lahore, in the Department of Gynecology and Chemistry over a period of four months after approval of the synopsis. The required sample size was calculated using Cochran's formula, resulting in a minimum of 150 participants based on an assumed prevalence of 62% and a 5% margin of error. Patients with PCOS will be recruited through non-probability consecutive sampling. This design allows efficient estimation of metabolic abnormalities in a real-world clinical setting while maintaining feasibility within the study duration and available resources.

Vol. 5 No. 2 (2026)

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Fatima et al - 2026

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Women diagnosed with PCOS according to the Rotterdam criteria will be included, with an age range of 18 years and above, including both obese and non-obese individuals. Exclusion criteria will include patients with known diabetes mellitus, endocrine disorders such as thyroid dysfunction or Cushing's syndrome, pregnant or lactating women, and those unable or unwilling to participate. The study will utilize standard laboratory equipment, including an automated biochemistry analyzer, HbA1c analyzer, centrifuge, and appropriate vacutainers. Blood samples will be collected after 8–12 hours of fasting, followed by a 75 g oral glucose load for OGTT, with a second sample collected after two hours to assess glucose tolerance and metabolic status.

Ethical approval will be obtained from the institutional ethics committee, and all procedures will comply with established ethical guidelines. Written informed consent will be taken from all participants, ensuring voluntary participation. Confidentiality and anonymity of patient data will be strictly maintained, and participants will be informed that there are no risks or disadvantages associated with the study. They will also have the right to withdraw at any stage without any consequence. All data will be securely stored with password protection and restricted access to ensure privacy and data protection throughout the research process.

Data will be collected using a structured proforma to record demographic, clinical, and biochemical parameters. Fasting blood samples will be obtained using appropriate venous sampling techniques, and laboratory analysis will include fasting plasma glucose, HbA1c, and OGTT results. Insulin resistance will be assessed using fasting insulin levels and calculated HOMA-IR as a derived variable. Independent variables will include BMI, waist circumference, waist-to-hip ratio, ovarian morphology, menstrual irregularities, acne, and hirsutism. Data will be analyzed using SPSS software, with descriptive statistics expressed as mean ± standard deviation or frequencies and percentages, and inferential tests such as chi-square and t-tests applied, considering $p < 0.05$ as statistically significant.

Results

Vol. 5 No. 2 (2026)

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Print ISSN 3007-2379

Fatima et al - 2026

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The study included 150 women with PCOS, predominantly of reproductive age, with a mean age of 27.8 ± 6.4 years. Most participants were either overweight or obese, with a mean BMI of 26.3 ± 5.1 kg/m², indicating a substantial burden of central and general adiposity. Nearly half of the participants had a positive family history of diabetes mellitus, while more than half reported a sedentary lifestyle, both of which are recognized contributors to metabolic dysfunction. Anthropometric measurements, including waist circumference and waist-to-hip ratio, further confirmed a high prevalence of central obesity in the cohort. These baseline characteristics reflect a population already predisposed to insulin resistance and glucose dysregulation.

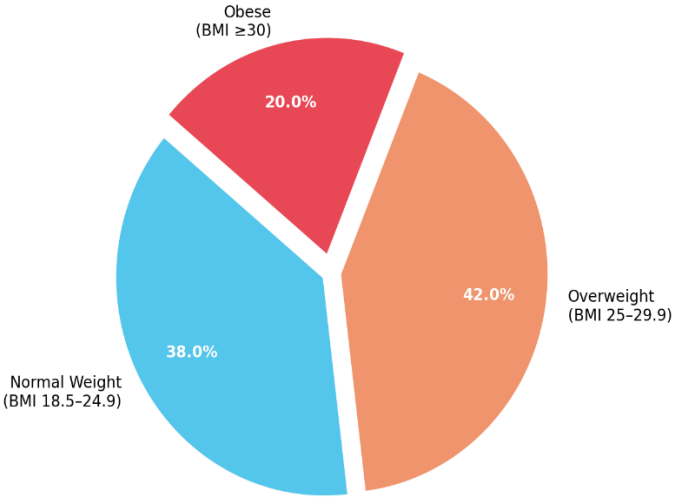

Figure 1: BMI Category Distribution Among PCOS Women (n=150)

Glycemic assessment revealed that only 61.3% of participants were normoglycemic, while 30.7% had prediabetes and 8.0% had type 2 diabetes mellitus. Overall, a substantial proportion exhibited abnormal glucose metabolism when combining prediabetes and diabetes cases. Significant elevations were observed in fasting blood glucose, HbA1c, and 2-hour OGTT values across worsening glycemic categories, confirming progressive deterioration of glucose homeostasis. Prediabetic and diabetic groups showed consistently higher mean values of all glycemic indices compared to normoglycemic

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Print ISSN 3007-2379

Fatima et al - 2026

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participants. These findings highlight a considerable metabolic burden among women with PCOS and emphasize early glucose dysregulation as a key feature of the syndrome.

Distribution of Glycemic Status Categories Using ADA Criteria (n=150)

Glycemic Category	Criteria	n	Percentage (%)	Cumulative (%)
Normoglycemic	FBG <100 mg/dL, HbA1c <5.7%, 2hr OGTT <140 mg/dL	92	61.3	61.3
Impaired Fasting Glucose (IFG)	FBG 100–125 mg/dL	28	18.7	80.0
Impaired Glucose Tolerance (IGT)	2hr OGTT 140–199 mg/dL	12	8.0	88.0
Combined IFG + IGT	Both criteria met	6	4.0	92.0
Total Prediabetes	IFG + IGT combined	46	30.7	—
Type 2 Diabetes Mellitus	FBG ≥126 or HbA1c ≥6.5%	12	8.0	100.0
Total	—	150	100.0	—

Insulin resistance was highly prevalent, affecting 65.3% of participants based on HOMA-IR criteria. The mean HOMA-IR value increased progressively from normoglycemic to diabetic groups, indicating worsening insulin sensitivity with deteriorating glycemic status. Importantly, a notable proportion of normal-weight participants also demonstrated insulin resistance, confirming that

Vol. 5 No. 2 (2026)

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Print ISSN 3007-2379

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PCOS-related metabolic dysfunction is not solely dependent on obesity. Fasting insulin levels showed a significant upward trend across glycemic categories, reflecting compensatory hyperinsulinemia. These results reinforce the concept that insulin resistance is an intrinsic metabolic abnormality in PCOS, contributing independently to both reproductive and glycemic disturbances.

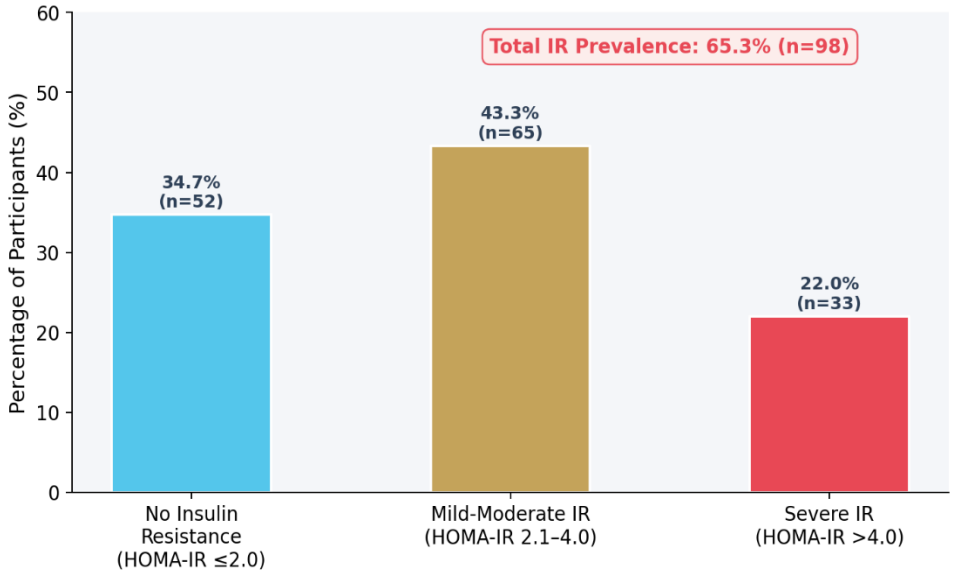

Figure: Distribution of Insulin Resistance by HOMA-IR Categories (n=150)

A significant association was observed between BMI and insulin resistance, with prevalence increasing steadily from normal-weight to obese participants. Statistical analysis confirmed a strong relationship between adiposity and metabolic impairment, although the presence of insulin resistance in lean individuals highlights additional underlying pathophysiological mechanisms. Biochemical analysis revealed dyslipidemia across all groups, with increasing total cholesterol, LDL, and triglycerides and decreasing HDL levels in worsening glycemic categories. Hormonal disturbances, particularly elevated LH:FSH ratio and testosterone levels, were also associated with poorer metabolic status, suggesting a close interaction between endocrine and metabolic dysfunction. Clinical features such as menstrual irregularity, hirsutism, anovulation, and acanthosis nigricans were significantly associated with insulin resistance. Acanthosis nigricans and weight gain showed the strongest statistical associations, reflecting their close link with hyperinsulinemia. However,

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Fatima et al - 2026

DOI: http://doi.org/10.5281/zenodo.20284724

polycystic ovarian morphology did not correlate significantly with insulin resistance, indicating that ovarian morphology alone does not reflect metabolic severity. Strong correlations were identified between HOMA-IR and glycemic parameters, including HbA1c, fasting glucose, and OGTT values, confirming the predictive value of insulin resistance in identifying glucose abnormalities. These findings demonstrate the multifactorial nature of PCOS involving reproductive, metabolic, and clinical dimensions.

Diagnostic performance analysis showed that 2-hour OGTT had the highest sensitivity and specificity for detecting glucose abnormalities, while HOMA-IR demonstrated strong accuracy for identifying insulin resistance. HbA1c alone was less sensitive in detecting early metabolic dysfunction compared to combined screening approaches. The integration of FBG, HbA1c, and HOMA-IR provided the highest diagnostic accuracy, supporting a multiparametric screening strategy. When compared with published literature, the study findings were consistent with regional and international data, confirming high prevalence of prediabetes and insulin resistance in PCOS populations. Overall, the results emphasize the need for early, comprehensive metabolic screening in women with PCOS to prevent long-term complications.

Discussion

The present study demonstrated a high burden of metabolic abnormalities among women with PCOS, particularly prediabetes and insulin resistance. The prevalence of prediabetes was 30.7% and type 2 diabetes mellitus was 8.0%, confirming that a substantial proportion of patients already exhibit disturbed glucose metabolism. Insulin resistance was observed in 65.3% of participants, highlighting its central role in PCOS pathophysiology. These findings collectively reinforce that PCOS is not limited to reproductive dysfunction but represents a complex metabolic disorder with long-term health implications. The results align closely with previous regional and international studies, suggesting consistent evidence across populations. Variations in prevalence may be linked to differences in diagnostic tools, population characteristics, and lifestyle factors, particularly in

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Fatima et al - 2026

DOI: http://doi.org/10.5281/zenodo.20284724

South Asian settings where risk factors are more pronounced and often under-recognized in early clinical stages.

A strong relationship was observed between insulin resistance and glycemic abnormalities, with significant correlations between HOMA-IR and HbA1c, fasting glucose, and OGTT values. This confirms that insulin resistance is a reliable predictor of worsening metabolic status in PCOS patients. Importantly, insulin resistance was also identified in normal-weight individuals, emphasizing that metabolic dysfunction is not exclusively dependent on obesity. These findings are consistent with earlier research showing intrinsic defects in insulin signaling pathways in PCOS. Additionally, increasing BMI was significantly associated with higher insulin resistance, indicating that obesity further aggravates but does not solely cause metabolic impairment. The combined effect of genetic predisposition, sedentary lifestyle, and central adiposity appears to contribute significantly to disease severity, highlighting the multifactorial nature of metabolic risk in PCOS populations.

Biochemical and hormonal findings further strengthened the evidence of metabolic disruption in PCOS patients. Dyslipidemia was highly prevalent, with elevated total cholesterol, LDL, and triglycerides, along with reduced HDL levels in prediabetic and diabetic groups. These abnormalities increase cardiovascular risk and reflect underlying insulin resistance. Hormonal disturbances, including elevated LH:FSH ratio and testosterone levels, were also observed in association with worsening metabolic status. However, LH and FSH alone did not show significant variation across groups, suggesting inconsistent hormonal patterns in PCOS. Clinically, features such as menstrual irregularity, hirsutism, acne, and acanthosis nigricans were strongly associated with insulin resistance, with acanthosis nigricans showing the strongest link. These clinical markers provide valuable, low-cost tools for early identification of high-risk individuals in routine clinical practice.

Conclusion

The study highlights the importance of early and comprehensive screening strategies in women with PCOS. Diagnostic performance analysis showed that OGTT had the highest accuracy, while combined use of FBG, HbA1c, and HOMA-IR provided the most reliable detection of metabolic

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Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.20284724

abnormalities. These findings support a multiparametric approach for early diagnosis and risk stratification. The study also emphasizes the need for lifestyle modification, including diet and physical activity, as first-line interventions to prevent progression to type 2 diabetes and cardiovascular disease. Despite limitations such as single-center design and cross-sectional nature, the results provide strong evidence for integrating metabolic screening into routine PCOS management. Early detection and intervention remain crucial in reducing long-term complications and improving overall reproductive and metabolic health outcomes.

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