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Endocrine, Metabolic and Reproductive Dysfunction in Women with Polycystic Ovarian Syndrome: A Cross-Sectional Study from Saudi Arabia

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Abstract **Introduction:** The endocrine condition called polycystic ovarian syndrome (PCOS) consists of three distinctive features including hyperandrogenism combined with ovulatory malfunction and polycystic ovarian appearance. The endocrine and metabolic and reproductive complications of PCOS affect approximately ten percent of women within their childbearing years. **Objective:** PCOS patients require evaluation of their clinical features along with hormonal imbalance and metabolic abnormalities and reproductive system problems. **Methods:** The study involved assessing 350 women who received Rotterdam criteria diagnosis. The research analyzed hormonal results along with reproductive histories and lipid examination data through SPSS 25. **Results:** About three-fourths (75%) of females exhibited high testosterone while 70% revealed HOMA-IR higher than 2.5 and 80% presented abnormal menstrual rhythms. Forty percent of patients mentioned infertility as their condition while twenty percent encountered recurrent miscarriages. Research showed that metabolic syndrome affected 45% of the patient group under study. **Conclusion:** Women with PCOS need early recognition followed by combined medical treatments from various health professionals because this condition creates multiple medical issues.

Key Words Hyperandrogenism, Ovulatory Dysfunction, Hormonal Imbalance, Infertility, Insulin Resistance, Menstrual Irregularities, Recurrent Miscarriages, Lipid Profile Abnormalities, Endocrine Disorders

INTRODUCTION

Polycystic ovarian syndrome (PCOS) is one of the most common yet complex endocrine disorders affecting women of reproductive age, with a prevalence that varies globally, estimated between 5% and 20% depending on the diagnostic criteria applied [1,2]. First described by Stein and Leventhal in 1935, PCOS presents as a heterogeneous condition encompassing endocrine, metabolic and reproductive dysfunctions. Its manifestations range from hyperandrogenic symptoms like hirsutism, acne and alopecia to metabolic disturbances such as insulin resistance and dyslipidemia. This multifaceted nature of PCOS poses significant diagnostic and therapeutic challenges [3,4].

At its core, PCOS is driven by a disruption of normal ovarian function, with hyperandrogenism being a hallmark feature. This results from increased androgen production by theca cells, often exacerbated by insulin resistance, a common metabolic abnormality in PCOS [5,6]. Insulin resistance, observed in 70% of women with PCOS, contributes to hyperinsulinemia, which acts synergistically with Luteinizing Hormone (LH) to promote excessive androgen synthesis. This disrupts the balance of follicular development, leading to chronic anovulation and infertility [7,8]. The interrelationship

between hyperandrogenism, insulin resistance and obesity creates a vicious cycle that perpetuates the clinical and biochemical features of PCOS.

Beyond its endocrine and metabolic dimensions, PCOS significantly impacts reproductive health. It is a leading cause of anovulatory infertility, accounting for 70% to 80% of cases globally [9,10]. Women with PCOS are also at higher risk of pregnancy complications, including Gestational Diabetes Mellitus (GDM), preeclampsia and preterm birth. The prolonged exposure to unopposed estrogen in anovulatory cycles further increases the risk of endometrial hyperplasia and cancer [11,12]. These reproductive challenges are compounded by the psychological burden of PCOS, with high rates of depression, anxiety and diminished quality of life reported among affected women [13,14].

The long-term health implications of PCOS are equally concerning. Women with PCOS have a twofold increased risk of type 2 diabetes and a fourfold increased risk of metabolic syndrome compared to the general population [15,16]. Cardiovascular diseases, including hypertension and atherosclerosis, are also more prevalent, emphasizing the need for early metabolic screening in this population [17,18]. The syndrome's association with non-alcoholic fatty liver disease (NAFLD) further underscores its systemic impact [19,20].

Despite significant advances in understanding PCOS, the lack of universally accepted diagnostic criteria has hindered progress in its management. The Rotterdam criteria, which require the presence of two out of three features (hyperandrogenism, ovulatory dysfunction and polycystic ovarian morphology), are widely used but remain controversial. Critics argue that the inclusion of polycystic ovarian morphology may overdiagnose young women with otherwise normal hormonal profiles [21,22].

This study aims to provide a comprehensive analysis of PCOS in a cohort of 350 women. By examining its endocrine, metabolic and reproductive manifestations, this research seeks to elucidate the interconnected nature of PCOS and its implications for women's health. The findings will contribute to the growing body of evidence needed to refine diagnostic criteria and develop holistic management strategies [23,24].

The metabolic manifestation of PCOS in Saudi Arabian women becomes more severe because of a combination of high-calorie diets and restricted physical activity and increasing obesity in their population. The rise in regional awareness about PCOS has not translated into sufficient clinical investigations among Saudi patients. This research fills the noted gap through an analysis of Hail-based Saudi women with PCOS who show clinical, metabolic and reproductive characteristics thus expanding localized data in worldwide PCOS studies.

Objective

To examine the clinical presentation, endocrine and metabolic dysfunction and reproductive challenges in women diagnosed with PCOS, with an emphasis on understanding the condition's multifaceted impact on health outcomes.

METHODS

Study Design and Setting

The study included 350 women diagnosed with PCOS based on the Rotterdam criteria, which require the presence of two of the following three features: hyperandrogenism, ovulatory dysfunction and polycystic ovarian morphology on ultrasound. The research used a cross-sectional design because it proved the best method for analyzing prevalence and relationships among clinical features and hormonal parameters and metabolic indicators in a specified population during a specific time period. The research design facilitates efficient screening procedures to identify present trends which can be used for future interventions and long-term investigations. A power analysis led to the selection of 350 participants to investigate insulin resistance in PCOS with an expected prevalence rate between 60-70% and 5% measurement error and 95% confidence level delivering statistical sensitivity of at least 80%. The study participants came from various economic levels across both city and town areas. The study includes diverse demographic groups yet might not account for all rural and tribal community characteristics.

Inclusion Criteria

- Women aged 18-40 years
- Diagnosis of PCOS confirmed by clinical and biochemical parameters
- No use of hormonal medications in the past 3 months

Exclusion Criteria

- Women with other endocrine disorders such as thyroid dysfunction or hyperprolactinemia
- Pregnant or breastfeeding women
- Incomplete medical records

Data Collection

Data were collected through patient interviews, clinical examinations and laboratory tests. Parameters assessed included androgen levels (testosterone and DHEAS), insulin resistance (HOMA-IR), lipid profiles, BMI, menstrual regularity and reproductive history. All blood sample collection for hormonal assays happened between 8:00 AM and 10:00 AM while patients were fasting overnight and within the early follicular phase (days 2-5 of the menstrual cycle). The laboratory performed one set of tests with standardized kits. The modified Ferriman-Gallwey score used by two trained physicians obtained a reliability value of 0.87 (Cohen's kappa ($\kappa = 0.87$)) during hirsutism grading clinical assessments.

Statistical Analysis

Data were analyzed using SPSS version 25. Descriptive statistics summarized patient characteristics, while inferential statistics (t-tests and chi-square tests) evaluated associations between clinical features and PCOS severity. The research presented descriptive and inferential statistics

along with effect sizes that included Cohen's d for continuous variables and Cramer's V for categorical data and offered 95% confidence intervals to quantify relationship strengths. The research utilized multiple regression to determine independent elements which affect both ovulatory dysfunction and insulin resistance.

RESULTS

The study cohort consisted of 350 women, with a mean age of 28.5 years (±6.3). The majority of patients were overweight or obese, with a BMI of ≥25 kg/m² and 80% reported irregular menstrual cycles, indicating chronic anovulation.

The Table 1 summarizes the basic demographic and clinical profile of the patients. Most participants were overweight or obese and 80% exhibited irregular menstrual cycles, a hallmark feature of PCOS. Additionally, 70% of patients displayed hyperandrogenic symptoms such as acne, hirsutism and alopecia.

Endocrine Dysfunction

Androgen excess and insulin resistance were significant findings in this cohort. Elevated testosterone and DHEAS levels were observed in a majority of patients.

The Table 2 highlights the hormonal and metabolic abnormalities in PCOS patients. Elevated testosterone and DHEAS levels confirm hyperandrogenism, while a high HOMA-IR score indicates insulin resistance in 70% of the cohort. These findings emphasize the endocrine and metabolic disruption characteristic of PCOS. The thyroid condition tested revealed high occurrence rates of elevated male hormone levels combined with insulin resistance. A total of 75% of participants presented mean testosterone levels which exceeded normal reference values. The correlation analysis established that reproductive difficulties along with metabolic irregularities tightly linked with the hormonal disruptions reported above (Figure 1).

Metabolic Dysfunction

Obesity, dyslipidemia and metabolic syndrome were prevalent among the patients, indicating a strong metabolic component in PCOS.

The Table 3 provides insights into the metabolic dysfunction associated with PCOS. Dyslipidemia and metabolic syndrome were common, with elevated triglycerides and low HDL cholesterol levels. These abnormalities suggest a heightened risk of cardiovascular diseases in this population (Figure 2).

Reproductive Dysfunction

Reproductive health challenges were prominent among women with PCOS, with high rates of infertility and recurrent miscarriages.

The Table 4 highlights the reproductive challenges faced by women with PCOS. Infertility was reported by 40% of patients and 20% experienced recurrent miscarriages. Ovulatory dysfunction, present in 85% of the cohort, underscores the impact of PCOS on fertility.

Table 1: Demographic and clinical characteristics

Parameter	Value	Percentage (%)
Total patients	350	100
Mean Age (years)	28.5±6.3	-
BMI categories		
- Normal (<25 kg/m²)	140	40
- Overweight/Obese (≥25 kg/m²)	210	60
Irregular menstrual cycles	280	80
Hyperandrogenic symptoms	245	70

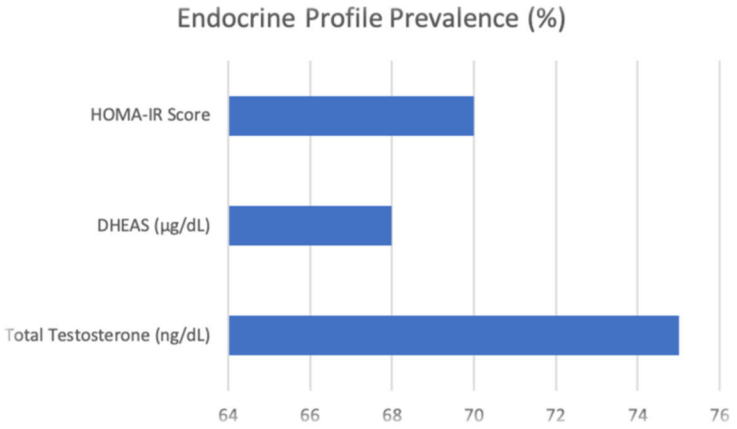

Figure 1: Bar chart of androgen levels in PCOS patients, A bar chart showing the distribution of testosterone and DHEAS levels among patients, highlighting the high prevalence of hyperandrogenism

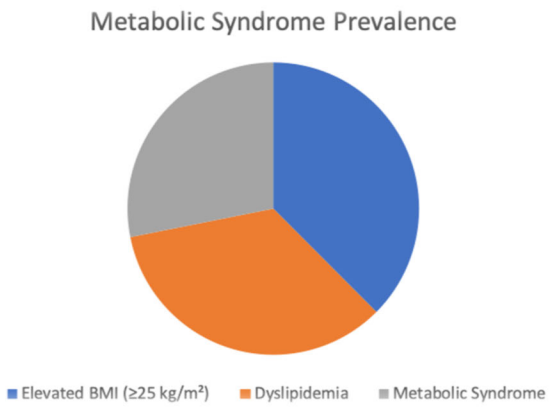

Figure 2: Pie chart of metabolic syndrome prevalence, a pie chart illustrating the proportion of patients diagnosed with metabolic syndrome, emphasizing the metabolic challenges associated with PCOS

Table 2: Endocrine profile

Parameter	Mean value±SD	Prevalence (%)
Total testosterone (ng/dL)	65±18	75
DHEAS (µg/dL)	260±90	68
HOMA-IR score	3.5±1.2	70

Table 3: Metabolic Profile

Parameter	Prevalence (%)	Mean value±SD
Elevated BMI (≥25 kg/m²)	60	-
Dyslipidemia	55	-
Metabolic syndrome	45	-
Triglycerides (mg/dL)	180±40	-
HDL cholesterol (mg/dL)	40±10	-

Table 4: Reproductive health outcomes

Parameter	Prevalence (%)
Infertility	40
Recurrent miscarriages	20
Gestational diabetes (History)	15
Ovulatory dysfunction	85

Table 5: Psychological and quality of life measures

Parameter	Prevalence (%)
Depression symptoms	50
Anxiety symptoms	45
Reduced quality of life (SF-36)	55

Table 6: Correlation Between Hormonal and Metabolic Parameters

Parameter pair	Correlation coefficient (r)	p-value
BMI and HOMA-IR score	0.72	<0.001
Testosterone and ovulatory dysfunction	0.68	<0.001
Triglycerides and HDL cholesterol	-0.55	0.002

Psychological and Quality of Life Impact

Many patients reported psychological distress and reduced quality of life due to the physical and emotional burden of PCOS.

The Table 5 explores the psychological and quality of life dimensions of PCOS. Depression and anxiety were prevalent, affecting 50% and 45% of patients, respectively. Over half of the cohort reported a reduced quality of life, highlighting the emotional toll of living with PCOS.

Hormonal and Metabolic Correlations

Statistical analysis revealed significant correlations between metabolic and hormonal parameters, illustrating the interconnected nature of PCOS symptoms.

The Table 6 presents correlations between key metabolic and hormonal parameters. A strong positive correlation was observed between BMI and insulin resistance and between testosterone levels and ovulatory dysfunction. Negative correlations were found between triglycerides and HDL cholesterol, indicating dyslipidemia.

DISCUSSION

Our research demonstrates how hormonal imbalance unified with metabolic risk occurs in women with PCOS. Research findings show that BMI has a highly significant relationship with HOMA-IR scores (r = 0.72) indicating how obesity leads to insulin resistance that causes the development of both androgen excess and ovulatory dysfunction. The high incidence of obesity-related PCOS among our population seems to connect with genetic risk factors together with local lifestyle behaviors that strengthen insulin resistance mechanisms and reproductive complications because of high glycemic food choices, low vitamin D levels from sun restrictions and insufficient physical activity.

Polycystic ovarian syndrome is not merely a reproductive disorder; it is a systemic condition with widespread implications for endocrine, metabolic and psychological health. The findings of this study confirm the multifaceted nature of PCOS, with 75% of patients exhibiting hyperandrogenism, characterized by elevated testosterone and DHEAS levels. Hyperandrogenism disrupts normal ovarian follicular development, leading to chronic anovulation, a defining feature of PCOS. Studies have shown that androgen excess impairs granulosa cell function and follicular atresia, contributing to infertility [25,26].

Metabolic dysfunction is another cornerstone of PCOS, with 60% of the cohort classified as overweight or obese. Obesity exacerbates insulin resistance through chronic low-grade inflammation and adipokine dysregulation, further amplifying androgen production and worsening ovulatory dysfunction [27,28]. Insulin resistance, observed in 70% of patients, is not only central to PCOS pathophysiology but also a major contributor to long-term health risks such as type 2 diabetes and cardiovascular diseases. These findings align with previous research, which highlights the bidirectional relationship between obesity and insulin resistance in PCOS [29,30].

The metabolic syndrome, characterized by a constellation of obesity, dyslipidemia, hypertension and hyperglycemia, was present in 45% of the cohort. Dyslipidemia, marked by elevated triglycerides and reduced HDL cholesterol, underscores the atherogenic profile of women with PCOS. These abnormalities significantly increase the risk of cardiovascular events, necessitating early intervention and lifestyle modification [31,32].

Reproductive dysfunction remains a central concern for women with PCOS. This study found that 40% of patients experienced infertility, while 20% reported recurrent miscarriages. Ovulatory dysfunction, present in 85% of the cohort, is a primary driver of these reproductive challenges. Assisted reproductive technologies (ART) such as ovulation induction and in vitro fertilization have improved pregnancy rates in women with PCOS, but these interventions are not without risks. Ovarian hyperstimulation syndrome (OHSS) and multiple pregnancies are more common in this population, highlighting the need for personalized treatment plans [33,34].

The psychological burden of PCOS is often overlooked but is a critical aspect of the syndrome. Depression and anxiety were reported in 50% and 45% of patients, respectively, reflecting the significant emotional toll of living with PCOS. Body image concerns related to hirsutism, acne and weight gain further exacerbate psychological distress, reducing quality of life. Cognitive-Behavioral Therapy (CBT) and support groups have shown promise in addressing these challenges, emphasizing the importance of integrated mental health care in PCOS management [35,36].

The complexity of PCOS necessitates a multidisciplinary approach to care. Lifestyle interventions, including dietary modification and regular exercise, are the cornerstone of management, particularly for addressing obesity and insulin resistance. Pharmacological treatments such as metformin, which improves insulin sensitivity and oral contraceptives, which regulate menstrual cycles and reduce androgen levels, remain central to PCOS treatment [37,38].

Advances in molecular biology and genomics offer exciting opportunities for personalized medicine in PCOS. Identifying genetic and epigenetic markers associated with PCOS could pave the way for targeted therapies that address the underlying mechanisms of the syndrome. Similarly, integrating artificial intelligence into clinical practice could enhance the diagnosis and management of PCOS by identifying patterns in hormonal and metabolic data [39,40].

The research demonstrates how it is imperative to develop health approaches that will help detect metabolic syndrome early in women experiencing menstrual irregularities. The incorporation of PCOS information into primary medical care systems and national weight management projects will reduce the growing number of metabolic conditions and infertility issues within the area. This study has several limitations. Caution must be taken when using this design approach because it creates limitations in making conclusions about cause and effect. The participants reported their menstrual and psychological conditions through subjective methods which resulted in recall bias. Processing blood samples took place in one central laboratory that might affect the research's ability to match results from other experimental setups. The unregulated confounding variables that included stress alongside sleep patterns and dietary intake and over-the-counter supplement usage potentially affected the hormonal and metabolic profiles in this study.

CONCLUSIONS

PCOS represents a complex medical condition that affects women's hormones and metabolism and reproductive systems. The relationship between hyperandrogenism is shown to exist with insulin resistance alongside ovulatory dysfunction through our research. The screening process for hormonal and metabolic tests should be focused on high-risk demographics particularly Saudi Arabia based populations because it facilitates early diagnosis. Multiple healthcare professionals working together through therapeutic approaches and counseling will provide better long-term health results for patients. Research should concentrate on following patients over time as well as creating individualized treatments to handle PCOS heterogeneity.

Future investigations should focus on:

- Longitudinal studies to monitor hormonal and metabolic trajectories over time
- The role of environmental and epigenetic factors in PCOS development
- Culturally sensitive lifestyle interventions tailored to Middle Eastern populations
- Artificial intelligence-based models for phenotype prediction and personalized treatment algorithms

Ethical approval was obtained from the institutional review board of the University of Hail. Written informed consent was obtained from all participants prior to enrollment. Data confidentiality and patient anonymity were strictly maintained throughout the study and all procedures conformed to the ethical standards of the Declaration of Helsinki.

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