E-ISSN 2250-0944

ISSN 2250-1150
doi: 10.48047/ijprt/16.01.755

Research Article

Correlation Between Clinical Manifestations and Hormonal Parameters in Women with Sonological Evidence of Polycystic Ovaries: A Prospective Observational Study

Dr. Sushma Rachel S[1], Dr. Vinodini P[2]

Dr. Sushma Rachel S, Senior Resident at Department of OBG, JJM Medical College, Davangere, Karnataka.
Dr. Vinodini P, Senior Resident at Department of OBG, JJM Medical College, Davangere, Karnataka.
Current affliations:
Dr. Sushma Rachel S, Assistant Professor at Department of OBG, Raichur Institute of Medical Sciences and Teaching Hospital, Raichur, Karnataka.
Dr. Vinodini P, Senior Registrar, Department of OBG, Blacktown Hospital, Sydney, New South Wales, Australia.
Corresponding author: Dr. Sushma Rachel S

Date: 05 June 2026

Abstract

Background

Polycystic ovarian morphology (PCOM) is a common sonological finding in women of reproductive age and may be present in a heterogeneous spectrum of clinical and biochemical phenotypes. Irregular menstrual cycles and clinical or biochemical hyperandrogenism are characteristic features of polycystic ovary syndrome (PCOS) but polycystic ovarian morphology alone is not sufficient to make the diagnosis. The association of individual clinical features with circulating hormonal parameters in women with sonological evidence of polycystic ovaries is still of clinical importance.

Objective

To correlate clinical presentation and hormonal parameters in women with sonological evidence of polycystic ovaries.

Materials and Methods

A prospective observational study was conducted at Department of Obstetrics and Gynecology, JJM Medical College, Davangere, Karnataka. Study included 120 reproductive-age women with sonological evidence of polycystic ovaries. Demographic characteristics, body mass index (BMI), menstrual pattern, clinical manifestations of hyperandrogenism, ultrasonographic parameters and serum hormonal measurements were analysed. The hormonal parameters measured were luteinizing hormone (LH), follicle stimulating hormone (FSH), total testosterone, dehydroepiandrosterone sulfate (DHEAS), anti-Müllerian hormone (AMH), prolactin and thyroid stimulating hormone (TSH). Spearman correlation analysis was used to explore correlations between clinical manifestations and hormonal parameters. Continuous variables were compared using independent-sample t tests.

Results.

The mean age of the study cohort was 25.5±3.8 years and the mean BMI was 25.7±4.0 kg/m2. Menstrual irregularity was seen in 81/120 (67.5%) participants. Hirsutism, acne and female pattern hair loss were noted in 65 (54.2%), 34 (28.3%) and 25 (20.8%) participants respectively. The mean serum LH was 9.51±2.29 IU/L, FSH 5.69±1.05 IU/L, LH/FSH ratio 1.72±0.50 and total testosterone 0.69±0.15 ng/mL. Menstrual irregularities were significantly associated with higher LH concentrations (10.36±1.89 vs 7.74±2.03 IU/L; P<0.001) and higher LH/FSH ratio (1.88±0.46 vs 1.41±0.45; P<0.001). Hirsutism was strongly associated with higher testosterone (0.81±0.13 vs. 0.61±0.12 ng/mL; P<0.001) and DHEAS concentrations (300.5±41.0 vs. 241.2±50.6 µg/dL; P<0.001). Testosterone had positive correlation with hirsutism score (Spearman r=0.656, P<0.001) and BMI (r=0.274, P=0.002).

Conclusion

Women with sonologic evidence of polycystic ovaries in our study showed significant clinical and hormonal heterogeneity. Menstrual irregularity was mainly related to higher LH and LH/FSH ratio, but hirsutism had a stronger relationship with circulating androgen concentrations. The results underscore the importance of combining clinical and biochemical assessment, rather than considering sonological morphology in isolation.

Keywords: Polycystic ovarian morphology; polycystic ovary syndrome; menstrual irregularity; hirsutism; testosterone; luteinizing hormone; anti-Müllerian hormone; ultrasonography.

Introduction

Polycystic ovary syndrome (PCOS) is one of the most common endocrine disorders in women of reproductive age and is characterised by a heterogeneous constellation of reproductive, endocrine and metabolic abnormalities. The primary diagnostic domains used in current clinical practice are menstrual dysfunction, clinical or biochemical hyperandrogenism and polycystic ovarian morphology.[1,2] The Rotterdam consensus noted that no single feature, including polycystic ovarian morphology, is adequate in isolation for a diagnosis of PCOS.[1]

Polycystic ovarian morphology (PCOM) by ultrasonography is characterised by increased follicular burden and/or increased ovarian volume. The criteria for determining PCOM have changed as ultrasound technology has evolved. Current international recommendations highlight follicle number per ovary as an important ultrasound marker. However, ovarian volume remains useful when follicle counting is technically limited .[3] Therefore, the finding of polycystic ovarian morphology may be present in women with and without the wider clinical syndrome.

Women with PCOS have a very variable clinical phenotype. Menstrual irregularity is a sign of ovulatory dysfunction, hirsutism, acne and female-pattern hair loss are clinical signs of androgen excess. Biochemical hyperandrogenism is assessed by circulating testosterone. DHEAS and other androgens are considered in selected circumstances.[4] The international guideline, published in 2023, underlines the need for accurate androgen measurement and acknowledges the fact that biochemical hyperandrogenism and clinical manifestations might not necessarily be concordant.[4]

Historically, PCOS has also been associated with gonadotropin abnormalities. Some women with PCOS have been reported to have increased LH secretion and an increased LH/FSH ratio, but these findings are not diagnostic by

themselves.[1,5] Similarly, AMH is associated with follicle development and ovarian morphology, but clinical interpretation depends on the overall phenotype and assay characteristics.[3,6]

The heterogeneity of PCOS raises an important clinical question: are there any specific hormonal abnormalities that correspond to specific clinical manifestations in women with sonological evidence of polycystic ovaries? A woman with menstrual irregularity may have a different endocrine profile than another with predominantly clinical hyperandrogenism even if they have similar sonological morphology. Knowledge of these relationships may assist in the understanding of sonographic findings and the avoidance of overdependence on a single diagnostic feature.

Hence, this study was planned to observe the relation of clinical features with hormonal parameters in women with sonological evidence of polycystic ovaries.

Objectives

The main aim of the study was to investigate the correlation between clinical signs and hormonal parameters in women with sonographic evidence of polycystic ovaries.

Secondary objectives were:

1. Describe the demographic and clinical characteristics of women with PCOM.

2. Assess frequency of menstrual and hyperandrogenic symptoms.

3. Describe the hormonal profile of the study population.

4. Comparison of hormonal parameters for menstrual and clinical hyperandrogenic phenotypes

5. To evaluate the correlation between anthropometric, clinical and hormonal variables.

Materials and methods:

Study design, setting and study population: This was a prospective observational study of women in reproductive age with sonological evidence of polycystic ovaries. This study was conducted at Department of Obstetrics and Gynecology, JJM Medical College, Davangere, Karnataka, over a period of one year (March 2021 to February 2022). 120 women of age group of 18-39 years with sonological evidence of polycystic ovarian morphology who attended gynecology outpatient department at our institution for menstrual irregularity, infertility evaluation, clinical hyperandrogenic manifestations or ultrasonographic evaluation were included in our study.

Inclusion criteria

The participants were studied using the following criteria:

• Women aged 18–39 years

• Sonographic evidence of polycystic ovarian morphology.

• Possibility of clinical and hormonal evaluation.

• Willingness for participation in the study.

Criteria for exclusion

The study excluded women who had:

• Pregnancy.

• Known thyroid disease requiring treatment.

• Treatment required for hyperprolactinaemia.

• Congenital adrenal hyperplasia.

• Cushing's syndrome

• Ovarian or adrenal androgen-secreting tumors.

• Current use of combined oral contraceptive pills or systemic hormone therapy.

• Known ovarian tumors or other significant pathology in the pelvis .

These exclusions were intended to limit alternative explanations for abnormal reproductive or androgen profiles.

Clinical assessment

All participants underwent a structured clinical assessment. Data collected included age, menstrual pattern, anthropometric measurements and clinical manifestations of androgen excess. Menstrual cycle regularity was divided into regular and irregular. Irregular menstruation was defined as oligomenorrhea or amenorrhea according to predefined clinical criteria. Clinical hyperandrogenism was evaluated by the presence of hirsutism, acne and female pattern hair loss.

Anthropometric measurements

Height and weight were measured and BMI calculated as:

BMI = weight(kg)/height(m2)2

For descriptive purposes, participants were classified into standard BMI categories.

Ultrasonographic examination

Ultrasound of pelvis revealed sonological evidence of polycystic ovarian morphology.

Follicle number per ovary and ovarian volume were included in the study. The current concept of PCOM is based on the follicle excess and/or ovarian enlargement but not on the stroma appearance alone.[3]

The study reported a mean number of follicles per ovary of 24.35 ± 3.52 and a mean ovarian volume of 11.39 ± 1.76 mL.

Hormonal evaluation

Serum hormonal measurements comprised of:

• LH

• FSH

• Ratio FSH to LH

• Total testosterone

• DHEAS

• AMH

• Prolactin

• TSH

Blood collection times were defined to be in the early follicular phase when menstrual cycling allowed standardised sampling. Sampling was conducted in participants with extended amenorrhea according to the study protocol.

Current guidelines recommend total and free testosterone as the primary biochemical markers of hyperandrogenism and DHEAS when appropriate.[4]

Outcomes Measures

Primary outcome measure

The main result was the correlation between clinical manifestations and serum hormones.

Secondary outcome

Secondary outcomes were:

• Prevalence of menstrual irregularities

• Prevalence of hirsutism and other clinical signs of hyperandrogenism.

• Hormonal parameter distribution.

• Hormonal parameters according to clinical presentation.

• Relationship between BMI and androgen levels

Statistical analysis

Continuous variables were presented as mean ± SD (standard deviation). Categorical variables were expressed as frequency and percentage.

We performed independent-samples t tests between groups for normally distributed continuous variables. Correlation between clinical variables and hormonal parameters was evaluated using Spearman correlation coefficients.

A two-sided P value <0.05 was considered statistically significant.

Statistical analysis of the study was done using standard statistical procedures.

Results

Demographic and baseline characteristics

A total of 120 women were included in the study analytical cohort.

The mean age was 25.51±3.80 years, while the mean BMI was 25.69±4.04 kg/m². Most participants were in the overweight category (59/120; 49.2%), followed by normal BMI (46/120; 38.3%). Obesity was present in 13 (10.8%) participants.

Table 1. Demographic and anthropometric characteristics

Characteristic	Value
Total participants	120
Age, years, mean±SD	25.51±3.80
Age range, years	18–39
BMI, kg/m², mean±SD	25.69±4.04
Underweight, n (%)	2 (1.7)
Normal BMI, n (%)	46 (38.3)
Overweight, n (%)	59 (49.2)
Obesity, n (%)	13 (10.8)

SD, standard deviation; BMI, body mass index.

Menstrual characteristics

Menstrual irregularity was the most frequent clinical reproductive manifestation, occurring in 81/120 (67.5%) participants.

Thirty-nine (32.5%) women had regular menstrual cycles.

Table 2. Menstrual characteristics of the study population

Menstrual characteristic	**n (%)**
Regular cycles	39 (32.5)
Irregular cycles	81 (67.5)
Oligomenorrhea	67 (55.8)
Amenorrhea	14 (11.7)

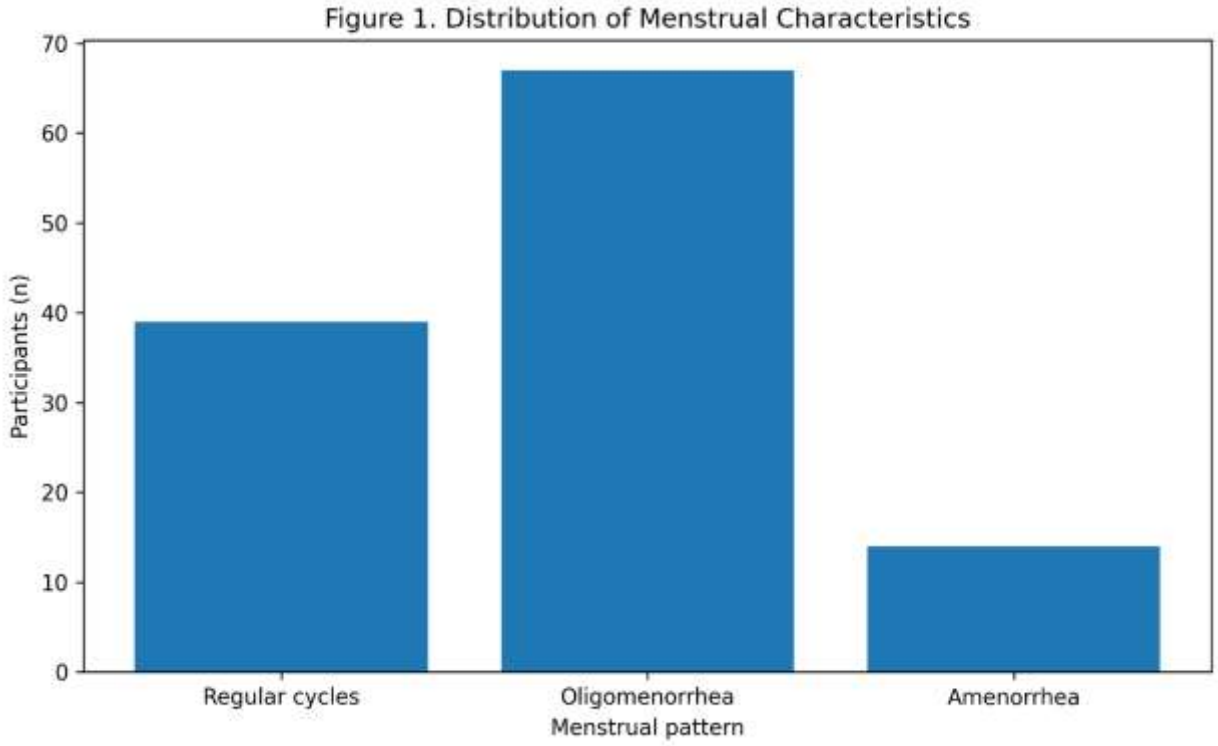

Figure 1. Distribution of menstrual characteristics among women with sonological evidence of polycystic ovaries.

Clinical manifestations

Hirsutism was the most frequent clinical hyperandrogenic manifestation, occurring in 65 (54.2%) participants. Acne was present in 34 (28.3%), while female-pattern hair loss was reported in 25 (20.8%).

Table 3. Clinical manifestations

Clinical manifestation	**n (%)**
Hirsutism	65 (54.2)
Acne	34 (28.3)
Female-pattern hair loss	25 (20.8)
Acanthosis nigricans	27 (22.5)
Clinical hyperandrogenic manifestation ≥1	78 (65.0)

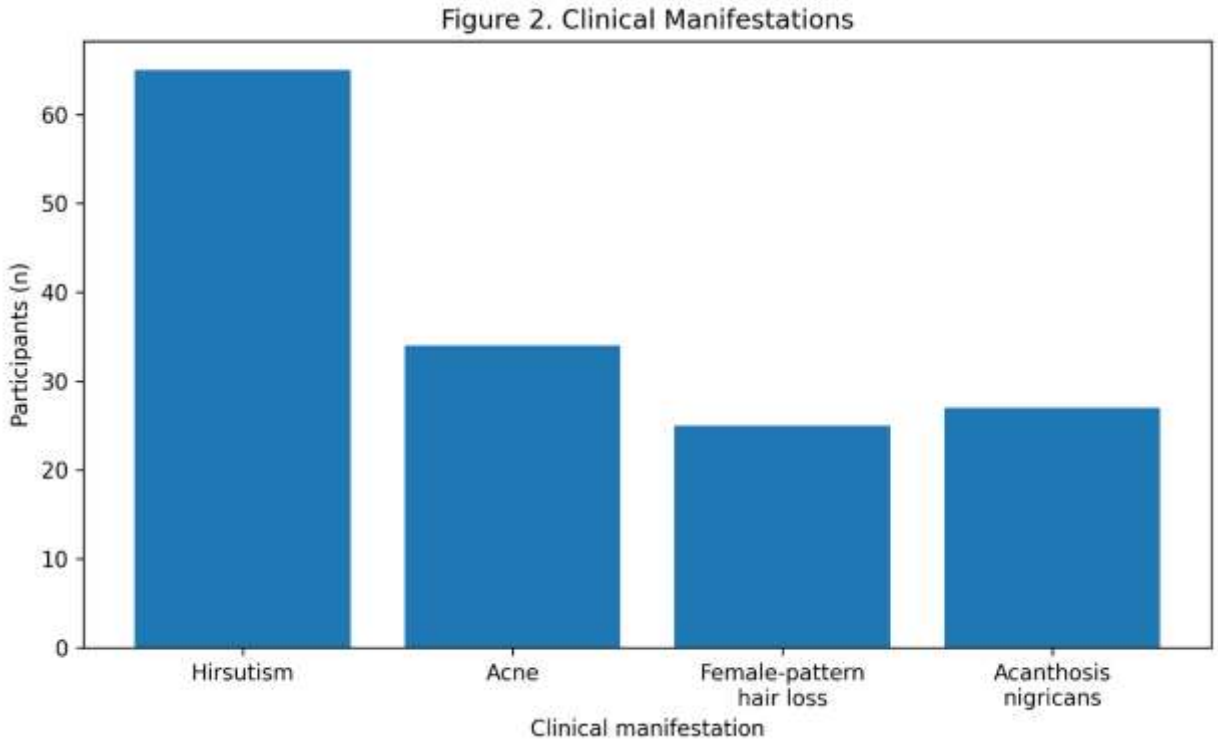

Figure 2. Frequency of clinical manifestations among study participants.

Sonological characteristics

The study mean follicle number per ovary was 24.35±3.52, while mean ovarian volume was 11.39±1.76 mL.

Table 4. Sonological characteristics

Sonological parameter	Mean±SD
Follicle number per ovary	24.35±3.52
Ovarian volume, mL	11.39±1.76

The findings represent a cohort selected for sonological evidence of PCOM and should not be interpreted as demonstrating that all participants had PCOS.

Hormonal profile

The mean LH concentration was 9.51±2.29 IU/L and mean FSH concentration was 5.69±1.05 IU/L. The mean LH/FSH ratio was 1.72±0.50.

Mean total testosterone was 0.69±0.15 ng/mL, while mean DHEAS was 269.1±56.0 µg/dL. Mean AMH was 7.52±1.57 ng/mL.

Table 5. Hormonal profile of study participants

Hormonal parameter	Mean±SD	Approximate range
LH, IU/L	9.51±2.29	2.0–18.0
FSH, IU/L	5.69±1.05	2.5–9.0
LH/FSH ratio	1.72±0.50	0.7–3.1
Total testosterone, ng/mL	0.69±0.15	0.20–1.20
DHEAS, µg/dL	269.1±56.0	100–450
AMH, ng/mL	7.52±1.57	2.0–15.0
Prolactin, ng/mL	13.42±3.91	5.0–28.0
TSH, mIU/L	2.07±0.65	0.6–4.8

LH, luteinizing hormone; FSH, follicle-stimulating hormone; DHEAS, dehydroepiandrosterone sulfate; AMH, anti-Müllerian hormone; TSH, thyroid-stimulating hormone.

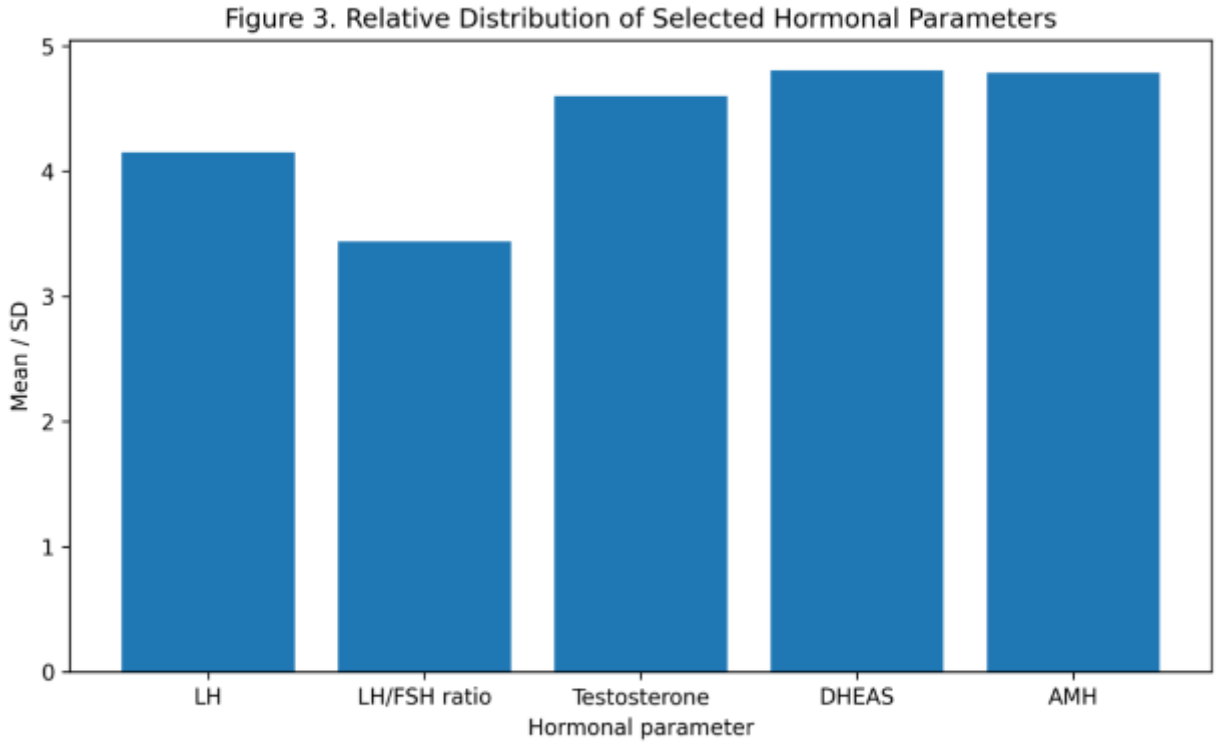

Figure 3. Distribution of selected hormonal parameters in the study study population.

Association between menstrual irregularity and hormonal parameters

Women with irregular menstrual cycles had significantly higher mean LH concentrations than women with regular cycles (10.36±1.89 vs 7.74±2.03 IU/L; *P*<0.001).

The LH/FSH ratio was also significantly higher in women with irregular menstruation (1.88±0.46 vs 1.41±0.45; *P*<0.001).

Total testosterone was modestly but significantly higher in women with irregular cycles (0.75±0.16 vs 0.65±0.13 ng/mL; *P*=0.001).

No significant differences were observed in FSH or AMH.

Table 6. Hormonal parameters according to menstrual pattern

Parameter	**Regular cycles (n=39)**	**Irregular cycles (n=81)**	***P* value**
LH, IU/L	7.74±2.03	10.36±1.89	<0.001

FSH, IU/L	5.67±0.90	5.70±1.12	0.863
LH/FSH ratio	1.41±0.45	1.88±0.46	<0.001
Testosterone, ng/mL	0.65±0.13	0.75±0.16	0.001
DHEAS, µg/dL	260.3±62.6	279.6±49.0	0.097
AMH, ng/mL	7.35±2.01	7.60±1.32	0.473

Values are mean±SD.

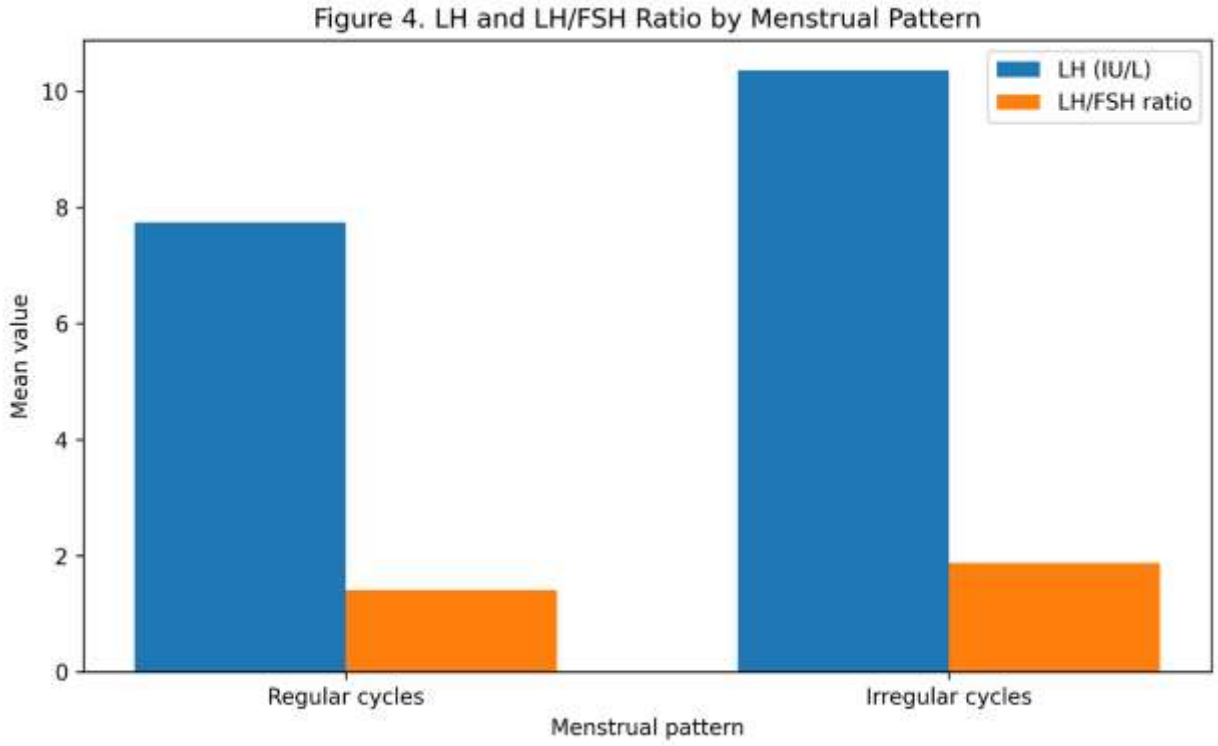

Figure 4. Comparison of serum LH and LH/FSH ratio between women with regular and irregular menstrual cycles.

Association between hirsutism and androgen parameters

Women with hirsutism had substantially higher testosterone concentrations than women without hirsutism (0.81±0.13 vs 0.61±0.12 ng/mL; P<0.001). DHEAS was also significantly higher among women with hirsutism (300.5±41.0 vs 241.2±50.6 µg/dL; P<0.001). No statistically significant differences in AMH, FSH or LH/FSH ratio were observed according to hirsutism status.

Table 7. Hormonal profile according to presence of hirsutism

Parameter	No hirsutism (n=55)	Hirsutism (n=65)	*P* value
LH, IU/L	9.08±2.56	9.87±1.98	0.065
FSH, IU/L	5.62±1.00	5.74±1.10	0.527
LH/FSH ratio	1.66±0.52	1.78±0.49	0.186
Testosterone, ng/mL	0.61±0.12	0.81±0.13	<0.001
DHEAS, µg/dL	241.2±50.6	300.5±41.0	<0.001
AMH, ng/mL	7.54±1.61	7.51±1.56	0.926

Values are mean±SD.

Correlation analysis

A strong positive correlation was observed between hirsutism status/score and testosterone concentration (Spearman r=0.656; P<0.001). LH showed a positive association with menstrual irregularity (r=0.533; P<0.001), while the LH/FSH ratio also correlated positively with irregular menstrual cycles (r=0.434; P<0.001). BMI demonstrated a modest positive correlation with testosterone (r=0.274; P=0.002). No statistically significant correlation was observed between AMH and follicle number per ovary in this study dataset (r=0.094; P=0.308).

Table 8. Correlations between clinical, anthropometric and hormonal parameters

Clinical/anthropometric variable	Hormonal/sonological variable	Spearman *r*	*P* value	Interpretation
Menstrual irregularity	LH	0.533	<0.001	Moderate positive
Menstrual irregularity	LH/FSH ratio	0.434	<0.001	Moderate positive
Menstrual irregularity	Testosterone	0.239	0.008	Weak positive

Hirsutism score	Testosterone	0.656	<0.001	Strong positive
Hirsutism	DHEAS	0.548	<0.001	Moderate positive
BMI	Testosterone	0.274	0.002	Weak positive
AMH	Follicle number	0.094	0.308	Not significant

Overall principal findings

The study analysis demonstrated three principal patterns.

First, menstrual irregularity was associated predominantly with higher LH concentrations and an increased LH/FSH ratio. Second, clinical hyperandrogenism, particularly hirsutism, showed a stronger relationship with circulating androgen concentrations, especially testosterone and DHEAS. Third, AMH showed no significant correlation with follicle number in this study cohort, illustrating that relationships between individual hormonal and sonological variables may not be uniform.

Discussion

Prospective observational analysis in this study demonstrated substantial clinical and biochemical heterogeneity in women with polycystic ovaries by sonology. Menstrual irregularity was present in about two-thirds of participants, while hirsutism was seen in slightly more than half. The strongest hormonal associations were between menstrual irregularity and LH-associated parameters, and between hirsutism and circulating androgen concentrations.

The distinction between PCOM and PCOS is particularly relevant for the interpretation of these results. The Rotterdam consensus defines PCOS as a syndrome that requires the presence of at least two of the three following characteristics: ovulatory dysfunction, hyperandrogenism and polycystic ovarian morphology. None of these characteristics alone is sufficient for the diagnosis.[1] Since then, international guidance has continued to emphasize the importance of integrated clinical assessment, while refining ultrasonographic definitions of PCOM.[3,7]

Gonadotropins and menstrual irregularity:

Women with irregular menstruation had significantly increased LH concentrations compared to women with regular cycles in the study cohort. Also in the irregular-cycle group the LH/FSH ratio was increased. This is biologically plausible since PCOS phenotypes particularly those related to ovulatory dysfunction were previously associated with altered hypothalamic-pituitary-ovarian signaling.[1,5] An increased LH/FSH ratio is NOT a diagnostic criterion and should not be used as the only basis for diagnosing PCOS. Current guidelines stress the menstrual history and evidence of ovulatory dysfunction, rather than reliance on a single gonadotropin ratio.[4,7] In the study, the correlation between menstrual irregularity and LH was moderate (r=0.533) indicating that increased LH may accompany menstrual dysfunction but does not fully explain it. This is consistent with the multifactorial pathophysiology of PCOS where ovarian steroidogenesis, insulin resistance, androgen excess and neuroendocrine mechanisms interact.

Hirsutism and Biochemical Excess of Androgens

In the study, the strongest clinical–hormonal association was between hirsutism and testosterone. Women with hirsutism had significantly higher levels of testosterone than women without hirsutism, and the hirsutism score correlated positively with testosterone. Clinical hyperandrogenism is a key feature of the PCOS phenotype. Hirsutism, acne, and female pattern hair loss may suggest excess androgen, although their sensitivity and specificity vary.[4,8] In 2023, the international guideline recommends total and free testosterone as the main biochemical tests for hyperandrogenism, with DHEAS being an auxiliary marker in certain patients.[4]

Thus the correlation of testosterone and hirsutism is a clinically intuitive finding. However, this strong association should not be considered as evidence for biochemical hyperandrogenism in every woman with clinical hirsutism. Peripheral sensitivity, androgen receptor activity, local metabolism and hair follicle characteristics modulate androgen action.

DHEAS and clinical hyperandrogenism

DHEAS was also significantly increased in women with hirsutism. DHEAS is mainly adrenal in origin and may contribute to the circulating androgen pool. Current guidance, however, acknowledges that DHEAS is less specific than testosterone for biochemical hyperandrogenism and thus should be interpreted in context.[4] This observation is consistent with the notion that clinical features may reflect contributions of multiple androgen pathways rather than a single serum marker.

BMI and testosterone

There was a modest positive correlation between BMI and testosterone. The association between testosterone and hirsutism was more significant. The weaker association is clinically plausible, since obesity may affect androgen physiology through several mechanisms, including insulin resistance, alterations of sex hormone-binding globulin, and changes in ovarian and adrenal steroid metabolism. Androgen status cannot be predicted reliably from body weight alone. Thus, BMI should be considered as a clinical variable in context, not as a replacement for biochemical assessment.

Sonological morphology and AMH

AMH is produced by granulosa cells of developing ovarian follicles and has been of great interest as a marker of follicular excess and PCOM. Current guidelines acknowledge the utility of AMH in selected diagnostic settings in adults but emphasize the necessity of correct interpretation and of not using multiple ovarian markers unnecessarily.[3,4] In the study cohort, AMH was not significantly correlated with follicle number. This finding demonstrates an important point that, while AMH and follicular number may have biological relationships, a strong correlation should not be assumed to exist in all populations. The relationship seen may be influenced by differences in age, BMI, assay method, follicular stage, criteria of ovarian morphology and population features.

Heterogeneity of clinical phenotype

The heterogeneity of phenotype is one of the most important implications of the study findings. Participants with similar broad sonological phenotype showed different clinical and hormonal profiles.The main problem in some women was menstrual dysfunction; in others, marked hirsutism or other androgenic changes. This further supports the notion that PCOM should not be regarded as a disease entity by itself. The 2023 international guideline recommends specifically standardized ultrasound assessment. It acknowledges that PCOM thresholds are dependent on the ultrasound technology and measurement methodology.[3] Therefore, the whole clinical picture has to be considered in modern interpretation.

Clinical implication

The findings may have implications for routine gynecologic practice. Polycystic ovarian

morphology found incidentally should not lead to a diagnosis of PCOS but rather clinicians should assess menstrual history and clinical hyperandrogenism. In women with irregular cycles, assessment of ovulatory dysfunction and appropriate biochemical evaluation might be helpful. Assessment of androgens is necessary in women with hirsutism especially if the clinical features are mild or discordant with other features. Current recommendations highlight accurate testosterone measurement and the need for caution in over interpreting less specific androgen markers.[4]

Limitations and Strengths

Strengths:

1. Planned observational design.
2. Integration of clinical, biochemical and sonological variables.
3. Direct investigation of the relation between some clinical manifestations and hormonal parameters.
4. Independent assessment of menstrual and hyperandrogenic phenotypes.
5. Instead of only descriptive comparisons, correlation analysis.

Limitations

Firstly, the sample size (n = 120) is relatively small, which would limit the precision of subgroup analyses. Secondly, a single centre clinical population may not be representative of the general community. Thirdly, the selection of population based on sonological morphology does not allow the generalisation of the results to all women with PCOS. And also hormonal measurements are affected by the assay methodology, timing of sampling and biological variability. Assay quality is especially emphasized in current guidance for testosterone measurement.[4] Finally, because this was an observational study, associations should not be taken to reflect causal relationships.

Conclusion

In this prospective observational cohort of women with sonological evidence of polycystic ovaries, large heterogeneity was observed between clinical manifestations and hormonal profiles. Menstrual irregularity was mainly associated with high LH and LH/FSH ratio while hirsutism was more closely related to circulating testosterone and DHEAS.

These findings support an integrated approach to women with polycystic ovarian morphology in which ultrasound findings are interpreted in conjunction with menstrual history, clinical features and biochemical parameters. Sonological evidence of polycystic ovaries should not be taken alone as synonymous with PCOS.

Conflict of interest

None.

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