

DECIPHERING THE INTRICATE NETWORK OF POLYCYSTIC OVARIAN SYNDROME: A THOROUGH EXAMINATION OF HORMONAL AND DEMOGRAPHIC INFLUENCES

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Abstract

One of the most prevalent hormonal disorders affecting women who are of reproductive age is polycystic ovarian syndrome, a serious public health concern. Insulin resistance is significantly more common together with hirsutism, polycystic ovaries, and oligo/anovulatory periods as typical symptoms and other multitude of chronic health issues that impact quality of life are linked to PCOS. PCOS patient and control group (non-PCOS) hormonal profiles are compared in this study. TSH, FSH, LH, and AMH are measured in this research. The results clarify the hormonal irregularities and consequences of PCOS. The data shows that women with PCOS had significantly greater AMH than controls, with a sensitivity and specificity of 93%. AMH has an NPV and PPV of 83% and 97%, respectively. The majority of PCOS patients reported higher LH levels than the control group, which had 86% sensitivity and 88% specificity. The LH level is impacted by PCOS, as seen by the 95% of PPV and 69%, of NPV. The FSH levels of controls and PCOS patients are comparable. Since FSH levels are comparable, the primary hormonal imbalance in PCOS is probably elevated LH and AMH. PCOS patients showed higher TSH levels than the control group, which may cause thyroid issues since 43% of PCOS patients had elevated TSH. These findings illuminate PCOS hormone abnormalities. Furthermore, people with PCOS are more prone than the general population to suffer from morbidity related to metabolic and cardiovascular diseases. Understanding the hormonal imbalances linked to PCOS makes future research easier, which is required to understand the etiology of PCOS and hormone-regulated PCOS treatment.

Keywords: Anti-Müllerian Hormone, hirsutism, hormonal disorders, insulin resistance, metabolic diseases, polycystic ovary syndrome

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Introduction

Ovulation induces the development of a proliferative cluster of unfinished follicles within the ovaries, which is related to increased ovarian androgen production. Clinical signs of PCOS include obesity, irregular or nonexistent menstruation, and androgen excess symptoms such as acne and seborrhea. Currently, a combination of clinical, biochemical, and ultrasonography criteria are used to diagnose PCOS. However, there is considerable interest in using biomarkers to enhance PCOS diagnosis. Biomarkers are quantitative indicators of a biological process or condition and their findings can help to improve diagnostic accuracy and efficiency (Robb *et al.*, 2016; Califf, 2018; Makoui *et al.*, 2023).

In addition to hyperandrogenism, dyslipidemia, and hyperinsulinemia, women diagnosed with Polycystic ovary syndrome (PCOS) exhibit elevated concentrations of anti-Müllerian hormone (AMH) and luteinizing hormone (LH). LH stimulates the growth of the corpus luteum following ovulation and speeds up the generation of progesterone. Patients with PCOS are unable to establish corpus luteum and produce low levels of progesterone, resulting in ovulation failure. Progesterone, an important pregnancy hormone that promotes embryo growth and endometrial receptivity (Taraborrelli, 2015; Hosseinzadeh *et al.*, 2021). Due to ovulation malfunction, low-dose progesterone causes infertility or abortion. However, for well-defined non-PCOS groups, there is a considerable disparity between hormone assays and a lack of precision (Rudnicka *et al.*, 2021; Malhotra *et al.*, 2023) because serological testing is non-invasive and non-traumatic, it is commonly employed in therapeutic settings. Furthermore, serum samples are quite easy to obtain. Six hormones, their metabolites, and inflammatory cytokines are measured by serological testing for PCOS: LH, FSH, progesterone, estrogen, androgen, and prolactin. Accuracy and specificity in the diagnosis of PCOS may be enhanced through the combination of serum indicators (Zheng *et al.*, 2018; Shirin *et al.*, 2021; Chauhan *et al.*, 2024; Kicińska *et al.*, 2023). Current research focuses on the discovery of novel biomarker profiles by comparing soluble inflammatory markers in the PCOS group to the control population and focusing on their link with obesity and insulin resistance measures. The AMH serum level is currently widely utilized as a prognostic indicator for fertility potential and as a marker for ovarian reserve due to its close connection with the number of antral follicles. We intend to measure AMH, LH, FSH, IN, TSH, and body weight in both cohorts (with PCOS and without PCOS as a control).

Materials and Methods

Subjects

A total of 140 people were recruited for the study, comprising 110 people with PCOS and 30 healthy people as a control group. The participants ranged in age from 14 to 40 years. Participants fulfill the Rotterdam criteria for PCOS to participate in the study. The participants were then requested to complete an HRQoL questionnaire. The information was gathered over a three to five-month period, from July 2021 to November 2021, through collaboration with the pathology lab and hospital.

Biomarker Assays

The data of biomarker profile (tests) of both the study group and the control group was collected from the pathology lab, which was performed using different biochemical assays specific to the PCOS biomarker by the same lab. The Chemiluminescent Microparticle Immunoassay method was employed to run the assays for each biomarker. Because of its great sensitivity and specificity for identifying low quantities of selected biomarkers in serum samples. The CLIA method was used to assess levels of insulin, anti-Müllerian hormone, TSH, LH, and FSH (Suresh and Vijayakumar, 2014; Carslake *et al.*, 2017; Morote *et al.*, 2017; He *et al.*, 2023).

The data obtained was afterward used to discern disparities in biomarker identification profiles between the study group and the control group. This analysis is aimed at getting a deeper understanding of the underlying mechanisms of the disease and contributes to the advancement of diagnostic and therapeutic approaches.

Statistical Analysis

The F-test and two-sample variance tests were used to examine descriptive statistics between the PCOS study group and the control group.

Means, standard deviations, sample variation, and other descriptive statistics were obtained for all variables. The results were provided as mean differences, 95% confidence intervals, and p-values.

Results and Discussion

Anti-Müllerian Hormone

The pathogenesis of polycystic ovarian syndrome (PCOS) is associated with Anti-Müllerian Hormone (AMH). AMH elevates androgen levels through the inhibition of aromatase expression and FSH-dependent follicle selection (Washington *et al.*, 2022). AMH is produced by the granulosa cells inside the ovarian follicles. The major function of

this entity inhibits the development of nascent follicles and facilitates the degradation of primordial follicles. Furthermore, research has shown that it has a significant impact on ovarian function, specifically in relation to the development of follicles. The discovery presented in this study has significantly expanded the potential uses of the Anti-Müllerian hormone (AMH) in the field of gynecology. These applications include a wide variety of areas, including in vitro fertilization (IVF), the diagnosis of different ovarian diseases and cancers, and the exploration of potential future applications (Dumont *et al.*, 2015; Washington *et al.*, 2022).

According to the findings of the present study, a significant majority (92%) of individuals diagnosed with Polycystic Ovary Syndrome (PCOS) exhibited elevated production of Anti-Müllerian Hormone (AMH), leading to higher concentrations of this hormone in their bloodstream. Table 1 presents the descriptive statistics and results for AMH, as illustrated in Figure 1. The data presented illustrates substantial variability in the individual concentrations of Anti-Müllerian hormone (AMH) among the study group and the control group. Certain results exhibit unusually high values, specifically 72.2, 22.42, and 18.21, whereas the remaining outcomes adhere to a more customary range. The observed elevation in mean Anti-Müllerian hormone (AMH) levels in the study group suggests a potential association between PCOS and increased AMH levels.

To compare the variability of variables in the study group and the control group, the F-test for two-sample variances was used. The F-test statistic was determined to be 141.8. The study group and the control group had 99 and 19, respectively, degrees of freedom. The one-tailed p-value obtained was 1.24237E-17, which is exceedingly small. The critical value for the one-tailed test was found to be 1.94 at a significance level of 0.05. The calculated F-test shows that the variances of the two groups differ significantly. The variable of the study group (53.07455354) is significantly more than the control group's variance (0.374105263). This shows that AMH readings in PCOS patients have greater variables than in the control group.

In conclusion, the F-test results show that there are substantial variations in the variances of AMH levels between the study group and the control group. This finding implies that the two groups exhibit distinct patterns of variability in AMH levels, which could indicate the presence of underlying physiological or hormonal abnormalities associated with PCOS.

While increased AMH levels are usually associated with PCOS, they are not the main cause

Table 1. Descriptive statistics of AMH in patients and control groups

Sr. No.	Description	PCOS	Without PCOS
1	Mean	9.33	3.06
2	Standard Error	0.73	0.14
3	Median	8.20	3.00
4	Mode	6.90	3.20
5	Standard Deviation	7.29	0.61
6	Sample Variance	53.07	0.37
7	Kurtosis	56.68	0.06
8	Skewness	6.67	-0.31
9	Range	69.45	2.20
10	Minimum	2.75	1.80
11	Maximum	72.20	4.00
12	Count	100.00	20.00
13	Confidence Level (95.0%)	1.45	0.29

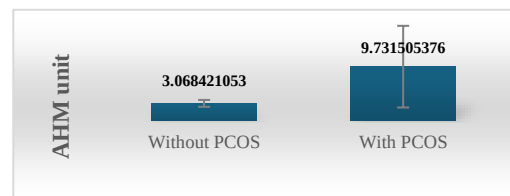


Figure 1. AMH level with PCOS and without PCOS group

of the disorder. It was also discovered that not all women with PCOS will have high AMH levels, with 8% being an exception in the current study.

Another study discovered that AMH levels were considerably greater in the study group than in the controls (Saxena *et al.*, 2017; Ran *et al.*, 2021; Vural *et al.*, 2022; Sivanandy and Ha, 2023). Patients with PCOS had a median AMH level of 4.32 ng/ml, which was significantly higher than the control group's 2.32 ng/ml ($p = 0.001$). At a cutoff of 3.44 ng/ml, AMH demonstrated the highest diagnostic potential for PCOS when used alone; its sensitivity and specificity were 93%, and it has NPV and PPV of 83% and 97%, respectively. Considering that the sensitivity of 93% was achieved with a three-out-of-four measure increase in antimalarial hormone with hyperandrogenism, oligomenorrhea, and polycystic ovarian morphology (the fourth increase), AMH was incorporated into the existing Rotterdam criteria. The sensitivity was enhanced to 71.11% and 86.67 percent, respectively, when the PCOM in Rotterdam criteria were substituted with AMH, OA+HA+AMH (any two out of three), or OA/HA+AMH. As an independent marker, AMH levels failed to detect PCOS adequately, according to the study. However, when used in conjunction with the established Rotterdam criteria for PCOS diagnosis, AMH levels had substantial diagnostic prospects (Wongwananuruk *et al.*, 2018; Tal *et al.*, 2020; Vural *et al.*, 2022). The

study also discovered that greater levels of serum Antimüllerian hormone (AMH) in women with PCOS using assisted reproductive technology (ART) were related to decreased live birth rates. A retrospective cohort analysis of 184 PCOS women who had their first fresh IVF/ICSI cycle was conducted. The 75th (high) percentile of serum AMH levels was used to classify the women into three groups. The parameters of cycle stimulation and reproductive outcomes were compared between groups. Females in the low serum AMH group exhibited a notable increase in live birth rates and a progressive trend toward higher clinical pregnancy rates when compared to those in the medium and high AMH groups (Tal *et al.*, 2020).

PCOS diagnosis and management should include a thorough examination of symptoms, medical history, and other hormonal markers, in addition to AMH values. Consultation with a healthcare professional is essential for accurate diagnosis and treatment.

Luteinizing Hormone

Elevated LH (luteinizing hormone) levels play a critical part in the pathogenesis of polycystic ovarian syndrome (Bozdogan *et al.*, 2019; Fu and Kuang, 2023). The pituitary gland in the brain produces LH, which has the main function of stimulating the ovaries to make and release mature eggs during the menstrual cycle (Jiang *et al.*, 2022). The LH level is divided into three categories: normal, below normal, and above normal. Out of 110 patients, 83% had above-normal LH levels, 4% had below-normal levels, 13% had normal LH enzyme levels, and which had 86% sensitivity and 88% specificity. The LH level is impacted by PCOS, as seen by the 95% of PPV and 69%, of NPV. Table 2 and Figure 2 show the statistics and outcomes.

The F-test two-sample for variances was used to examine the variability (variances) of LH levels between the study group and the control group. It was found to have 99 and 19 degrees of freedom, respectively. The F-statistic calculated was found to be 4.798621838. The test's one-tailed p-value was 0.000157284, and the critical value at a significance level of 0.05 was 1.940921063.

The calculated F-test of 4.798621838 indicates a significant difference in LH level variances between the study group and the control group. The extremely small one-tailed p-value (0.000157284) provides strong evidence against the null hypothesis of equal variances. The variance of LH levels in PCOS patients is significantly higher (25.37072281) than in the control group, which has a variance of 5.287085263.

This observation is consistent with the recognized hormonal deregulation associated with PCOS, in which elevated LH levels are frequently detected. The greater variability in LH levels emphasizes the PCOS condition's variety and complexity. This research emphasizes the necessity of taking individual variability in LH levels into account while diagnosing and managing PCOS, as well as the consequences of treatment options.

Fu and Kuang (2023) investigated the effect of elevated luteinizing hormone (LH) on the clinical outcomes of ovulation induction (OI) in infertile and ovulatory patients with polycystic ovarian syndrome (Vural *et al.*, 2022). The researchers did a retrospective cohort study in the same institutional ART facility from January 2013 to May 2019. 835 IUI cycles were collected for the study from PCOS patients who were treated with letrozole. During OI, cohorts were subdivided according to levels of LH after letrozole treatment (LHle) and basal LH (bLH). The OI response and fertility results of each cohort were evaluated. The chi-square test was employed to compare the distributions of categorical variables, while one-way ANOVA was utilized to analyze the distributions of continuous variables. Adjustments were made to the effect of the baseline variables and treatment regimens via a multivariate approach and 1:1 PS matching. For all

Table 2. Descriptive statistics of LH in patients and control group

Sr. No.	Description	With PCOS	Without PCOS
1	Mean	12.04	4.73
2	Standard Error	0.50	0.51
3	Median	11.85	4.70
4	Mode	12.30	3.00
5	Standard Deviation	5.04	2.30
6	Sample Variance	25.37	5.29
7	Kurtosis	0.98	0.38
8	Skewness	0.18	0.22
9	Range	27.90	9.91
10	Minimum	0.70	0.09
11	Maximum	28.60	10.00
12	Count	100.00	20.00
13	Confidence Level (95.0%)	1.00	1.08

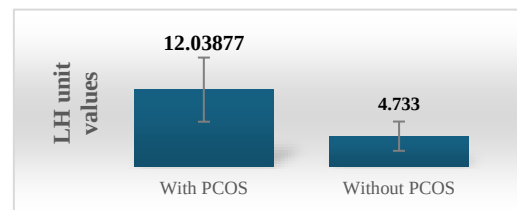


Figure 2. LH level with PCOS and without PCOS group

analysis, SPSS software (Version 22.0, SPSS Inc., Chicago, IL, USA) was utilized. High LH levels in PCOS are not definitive indicators of a poor prognosis for letrozole-induced ovulation, according to the study's findings; however, greater LHle may be a potential predictor of improved OI outcomes. It was determined by the researchers that pre-inhibition of LH secretion is superfluous (Conforti *et al.*, 2021).

The study also discovered that LH regulates ovulation of the dominant follicle in the late follicular phase of the menstrual cycle. The impact of other SNPs in the LHR gene on PCOS has also been postulated. However, the findings were in contrast to the LHR rs6168318 polymorphism, implying that this variation may be retained in the examined Chinese community (Bassiouny *et al.*, 2014; Deswal *et al.*, 2019).

Follicle-Stimulating Hormone

FSH levels are frequently changed in polycystic ovarian syndrome (PCOS) and play an important role in the disorder. FSH is a pituitary gland hormone that plays an important role in the regulation of the menstrual cycle and the development of ovarian follicles. Table 3 and Figure 3 show the statistics and outcomes.

The F-test for variances was used to assess the variability of FSH levels between the study group and the control group. The F-value calculated is 25.30859158. The F-value is the ratio of the variances of the two groups. In this scenario, there is a considerable difference in the variability of FSH levels between PCOS patients and non-PCOS individuals. The p-value of the F-value is very small, about 1.15518E-10 (a very small value near zero). This p-value indicates that there is a significant difference in the variability of FSH levels between the two groups, showing strong evidence against the null hypothesis. FSH had a sensitivity of 70% and a specificity of 66%. The 80% PPV and 54% NPV indicate that PCOS has an effect on the FSH level.

At a chosen significance level (one-tail), the crucial F-value is 1.940921063. Because the calculated F-value is substantially greater than the critical F-value, the null hypothesis is rejected and the difference in FSH variability between PCOS patients and persons without PCOS is statistically significant. FSH levels in PCOS patients are more variable, indicating an underlying hormonal imbalance linked with the illness. These findings add to our understanding and diagnosis of PCOS by providing vital insights into its hormonal features.

It is crucial to note that FSH levels might fluctuate depending on the menstrual cycle stage and individual circumstances. Furthermore, FSH

Table 3. Descriptive statistics of FHS in PCOS patients and control group

Sr. No.	Description	With PCOS	Without PCOS
1	Mean	4.81	4.27
2	Standard Error	0.48	0.21
3	Median	3.40	4.37
4	Mode	2.00	5.00
5	Standard Deviation	4.80	0.95
6	Sample Variance	22.99	0.91
7	Kurtosis	30.30	0.23
8	Skewness	4.77	-0.70
9	Range	38.43	3.64
10	Minimum	1.30	2.00
11	Maximum	39.73	5.64
12	Count	100.00	20.00
13	Confidence Level (95.0%)	0.95	0.45

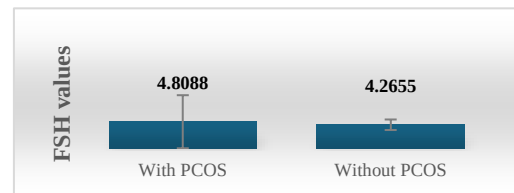


Figure 3. FSH level with PCOS and without PCOS group

levels in PCOS should be interpreted in conjunction with other hormonal markers and clinical examination.

In women with PCOS, FSH has a function in ovulation. Despite having a weak ovulation response, women with PCOS and an elevated LH/FSH ratio at baseline had a greater chance of achieving clinical pregnancy and live birth than women with normal LH/FSH. This shows that despite their unfavorable impact on ovulation, LH and FSH may have a role in successful conception in women with PCOS (Zhao *et al.*, 2018; Abdelghany *et al.*, 2023; Xia *et al.*, 2023).

A 33-year-old woman with primary infertility and an abnormally high (FSH) level is described in another study. In order to identify immunological complexes involving FSH, the authors employed the subsequent methodologies: a PEG precipitation test was utilized to identify autoimmune FSH immunoglobulin complex (macro-FSH), and gel filtration chromatography was employed to verify the existence of an FSH-immunoglobulin complex. The authors also analyzed sperm and evaluated LH levels before and after PEG precipitation. Magnetic resonance imaging (MRI) of the pituitary gland was also done. The study's findings revealed that the elevated FSH level was nearly entirely owing to the existence of an autoimmune FSH immunoglobulin complex (macro-FSH) (Catteau *et al.*, 2019; Jozkowiak *et al.*, 2023). The presence of an FSH-

immunoglobulin complex was confirmed by the gel filtration profile. The investigators also discovered that the anti-FSH auto-antibodies were most likely directed towards the FSH-sub-unit. The research emphasizes the significance of screening for anti-FSH auto-antibodies in instances of unexplained infertility and recurrent IVF failure (Recchia *et al.*, 2021).

Insulin

Insulin, a pancreatic hormone, plays an important function in PCOS (Polycystic Ovary Syndrome). PCOS is a complicated hormonal condition that affects women's reproductive and metabolic systems. Insulin, best known for its function in blood sugar regulation, also influences the development and progression of PCOS. Table 4 and Figure 4 show the statistics and outcomes.

As demonstrated in the graph, the level of insulin resistance and its impact on PCOS symptoms varies between individuals. The normal fasting insulin level commonly described is less than 25 mIU/L. The following insulin fasting value distribution was observed among the subjects evaluated:

31 patients had normal results (less than 25 mIU/L).

5 patients had results that were lower than usual.

64 patients had readings that were higher than usual.

The F-Test Two-Sample for Variances was used to compare fasting insulin variability between two groups: the study group and the control group. The F statistic, calculated as the variance ratio, was found to be 26.10244321.

This figure indicates the ratio of fasting insulin variability between the two groups. The probability (P) value for the F statistic was found to be 8.71994E-11, indicating the likelihood of attaining a ratio as extreme as the observed F statistic. This exceptionally low P value shows that the null hypothesis of equal variances between the two groups is strongly supported. For a one-tailed test, the crucial F value at the stated significance level is 1.940921063. We can conclude that the observed difference in variances between the two groups is statistically significant by comparing the estimated F statistic to the crucial F value. The considerable difference in fasting insulin level variations between PCOS patients and the control group could indicate underlying discrepancies in insulin regulation and metabolism. PCOS is frequently accompanied by insulin resistance, which can result in high insulin levels. The greater variability in fasting insulin levels found in PCOS individuals suggests more unpredictability and probable insulin deregulation

Table 4. Descriptive statistics of insulin in PCOS patient and control group

Sr. No.	Description	With PCOS	Without PCOS
1	Mean	33.54	23.10
2	Standard Error	3.59	1.57
3	Median	28.00	20.50
4	Mode	28.00	18.00
5	Standard Deviation	35.93	7.03
6	Sample Variance	1291.11	49.46
7	Kurtosis	47.81	0.24
8	Skewness	6.11	0.85
9	Range	328.70	28.00
10	Minimum	1.30	12.00
11	Maximum	330.00	40.00
12	Count	100.00	20.00
13	Confidence Level (95.0%)	7.13	3.29

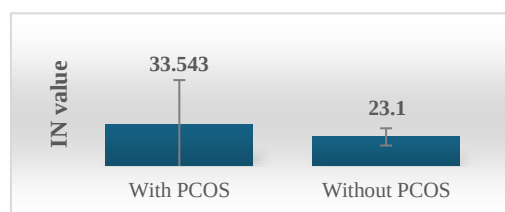


Figure 4. Insulin level with PCOS and without PCOS group

within this group. Elevated insulin levels and poor insulin signaling can compromise ovarian function, resulting in hormonal imbalances and PCOS symptoms. This study's findings show that a large number of patients with insulin levels beyond the normal range are consistent with the previously documented link between insulin resistance and PCOS. It implies that insulin resistance may play a role in the development or progression of PCOS in these people.

Detecting and treating insulin resistance in PCOS individuals is critical for both fertility and long-term health. A nutritious diet, regular exercise, weight control, and stress reduction can all assist in enhancing insulin sensitivity and lower insulin resistance. To regulate insulin levels and promote ovulation and menstrual regularity, pharmacological therapies such as insulin-sensitizing drugs (e.g., metformin) may be prescribed in some circumstances. Another group of scientists contends that not all women with PCOS should be treated for insulin resistance because the severity of insulin resistance varies among women with PCOS, and ISDs are not always the optimal treatment. Treatment should instead target specific metabolic or reproductive issues. According to the authors, the metabolic examination of women with PCOS should focus on recognizing abnormalities that may require intervention, such as impaired fasting glucose,

impaired glucose tolerance, metabolic syndrome, and LDL levels. The study also looks at the effectiveness of other ISDs, such as metformin and thiazolidinediones in treating PCOS-related symptoms such as monthly irregularity, ovulation rates, and hirsutism. The authors do warn, however, that ISDs are not a cure-all and should not be used as a first-line therapy for infertility or hirsutism. Overall, the authors believe that more study is needed to determine the effectiveness of ISDs in improving metabolic endpoints in women with PCOS (Unluhizarci *et al.*, 2021; Nguyen, 2023).

Thyroid-Stimulating Hormone

We investigated the association between TSH levels and PCOS in this study. TSH is a critical hormone involved in thyroid function regulation, and elevated levels can indicate thyroid malfunction. The distribution of TSH levels in women with PCOS was compared, and the relevance of deviations from the normal range was investigated. Table 5 contains the statistics. TSH levels in the normal range are normally between 0.5 and 5.0 mIU/L. In our study, TSH levels were classified as normal (within the normal range), below normal (less than 0.5 mIU/L), and above normal (more than 5.0 mIU/L). The distribution of TSH levels among research participants found that 55% had TSH levels within the normal range, 2% had values below normal, and 43% had values above normal. Elevated TSH levels may indicate hypothyroidism or sub-clinical hypothyroidism, both of which are common in women with PCOS.

These findings are consistent with a prior study that found a higher prevalence of thyroid problems in women with PCOS than in the general population. Thyroid dysfunction can have serious consequences for PCOS women. It might aggravate preexisting hormonal abnormalities, resulting in irregular menstrual periods, anovulation, and infertility. Furthermore, thyroid dysfunction and PCOS share characteristics such as insulin resistance, which can exacerbate metabolic and hormonal imbalances.

To assess the variability of TSH values between persons in the study group and the control group, the F-Test Two-Sample for Variances was used. The outcomes are as follows:

Variable 1 has 99 degrees of freedom (df), while Variable 2 has 19.

F-value: 26.10244321

8.71994E-11 P-value (one tail)

1.940921063 is the critical F-value (one tail).

The estimated F-test of 26.10244321 indicates the variation of TSH levels in the study group and the control group. A low p-value (8.71994E-11) suggests strong evidence against the null

hypothesis, implying that the difference in variances between the two groups is not attributable to random chance. The p-value is less than the threshold of significance (usually set at 0.05), confirming the conclusion that the variation of TSH levels changes considerably between patients with PCOS and the control group.

Table 5. Descriptive Statistics of TSH with PCOS and without PCOS group

Sr. No.	Description	With PCOS	Without PCOS
1	Mean	5.97	8.00
2	Standard Error	0.60	1.72
3	Median	4.26	4.00
4	Mode	2.80	4.00
5	Standard Deviation	5.99	7.68
6	Sample Variance	35.90	59.02
7	Kurtosis	8.08	-0.86
8	Skewness	2.58	0.90
9	Range	33.10	21.60
10	Minimum	0.40	0.90
11	Maximum	33.50	22.50
12	Count	100.00	20.00
13	Confidence Level (95.0%)	1.19	3.60

It was investigated how TSH affected the outcomes of in vitro fertilization in individuals with PCOS and normal thyroid function. 3190 individuals underwent IVF-ET (embryo transfer) at the Department of Human Reproductive Center, Renmin Hospital Hubei University of Medicine, between January 2017 and July 2021. 594 patients were categorized as having PCOS, while 2595 did not. Comparisons were made regarding the outcomes of IVF-ET in the two groups. Utilizing multi-factor linear regression analysis, the relationship between pertinent variables and oocyte maturation in PCOS patients was investigated. Oocyte maturation refers to the physiological transformation of an egg cell into a state suitable for fertilization. To assess TSH's effect on oocyte maturation in PCOS patients, the researchers additionally developed a receiver operating characteristic (ROC) curve. A ROC curve is a visual depiction that illustrates the performance of a binary classifier system as the discrimination threshold is modified. The PCOS patients were subsequently divided into two groups according to their TSH levels using the ROC criterion of TSH 2.98: TSH 2.98 group (n = 454) and TSH 2.98 group (n = 141). In order to determine whether TSH affected the outcomes of IVF-ET in patients with PCOS and normal thyroid function, we compared the results of IVF-ET in the two groups.

In each PCOS patient, TSH was found to be inversely associated with oocyte maturation, according to the study's results. Compared to the

general population, TSH levels are elevated in PCOS patients with normal thyroid function; furthermore, they exhibit an inverse correlation with egg maturation in in vitro fertilization.

The authors advise that in patients with PCOS and normal thyroid function when TSH levels exceed 2.98uIU/ml, pre-IVF intervention may be beneficial in facilitating egg maturation (Rushing and Santoro, 2021; Escobar-Morreale, 2022; Xu *et al.*, 2022;).

Body Weight

Identifying the pathogenic pathways may be challenging since obesity and PCOS frequently co-occur. The relationship between insulin resistance and cardiometabolic dysfunction with obesity and PCOS is intrinsically complicated. As a result, gaining weight and being obese promote PCOS development (Rushing and Santoro, 2021; Fan *et al.*, 2023). The metabolic condition of polycystic ovarian syndrome is a key illustration. It is linked to insulin resistance, has cardiometabolic risk as one of its symptoms, and is considerably exacerbated by obesity (Barber *et al.*, 2017; Barber *et al.*, 2019; Barber and Franks, 2021).

The following results were obtained from a comparison of body weight between the study group and the control group. Mean: The average body weight of those with PCOS was 63.72 kg, whereas those without PCOS weighed 61.00 kg. This implies that patients with PCOS had somewhat higher body weight on average than the control group. Standard Error: Individuals with PCOS had a standard error of 1.61 kg, while those without PCOS had a standard error of 3.33 kg. When compared to the control group, the PCOS group has a reduced standard error, indicating a more precise estimate of the mean body weight.

Median: The median weight for people with PCOS was 62.20 kg, while it was 57.50 kg for people without PCOS. The median reflects the data's midpoint, suggesting that 50% of people in each group had a weight less than this number and 50% had a weight greater than this value.

Mode: The mode represents the value that appears the most frequently in a dataset. The PCOS group had a weight mode of 60.00 kg, while the control group had a weight mode of 55.00 kg. This implies that more people in the PCOS group had weights around 60.00 kg than in the control group.

Standard Deviation: The standard deviation quantifies the data's dispersion or variability. The standard deviation for body weight in the PCOS group was 16.09 kg, and 14.91 kg in the control group. These results show that people with PCOS have slightly more fluctuation in body weight than the control group.

Kurtosis is a measure of the distribution's shape. A higher kurtosis number suggests a higher-peaked distribution, whereas a lower value indicates a flatter distribution. The kurtosis for body weight in this example was 1.13 in the PCOS group and 0.04 in the control group. Both groups had slightly positive kurtosis, indicating a peaked distribution.

Skewness: Skewness assesses the distribution's asymmetry. The skewness rating of 0 shows that the distribution is fully symmetrical. Body weight skewness was 0.84 in the PCOS group and 0.83 in the control group. Both groups had somewhat positive skewness, indicating a little tail to the right in the body weight distribution.

Range: The range represents the difference between the dataset's maximum and minimum values. body weight ranged between 89.70 kg in the PCOS group and 55.30 kg in the control group. This suggests that people with PCOS had a greater range of body weights than the control group.

Minimum and Maximum: The lowest and highest weights observed in each group are represented by the minimum and maximum numbers. The PCOS group's minimum weight was 30.30 kg, while the control group's was 42.00 kg. The greatest weight in the PCOS group was 120.00 kg, while it was 97.30 kg in the control group.

Sum: The sum is the sum of all the weights in each category. The PCOS group's total body weight was 6,371.80 kg, while the control group's total body weight was 1,219.90 kg. This means that the total weight of people with PCOS was considerably higher than the control group.

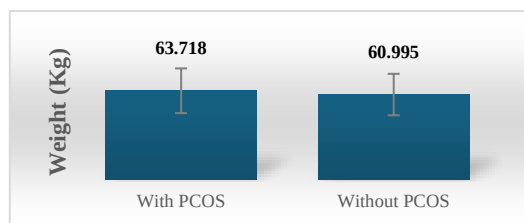
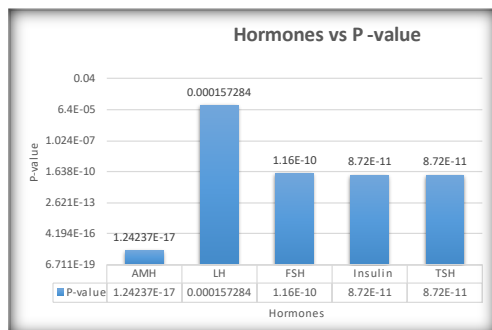
Confidence Level 95.0%: The confidence level specifies the range of possibilities for the genuine population meaning. The 95% confidence interval for body weight in the PCOS group was 3.19 kg, and 6.98 kg in the control group. These intervals indicate that, with 95% confidence, the true population means of body weight in the PCOS group is within 3.19 kg of the sample mean, while it is within 6.98 kg of the sample mean in the control group.

Individuals with PCOS have slightly higher body weight than those without PCOS, according to the findings. The PCOS group had somewhat higher mean, median, and mode body weight values. The PCOS group also had slightly higher variability and a wider range of body weights. Table 6 and Figure 5 illustrate the statistics.

38% to 88% of women with PCOS are overweight or obese (Wekker *et al.*, 2020; Dumesic *et al.*, 2015). According to data from the Northern Finland Birth Cohort (NFBC) 1966, body mass index (BMI) is significantly correlated with PCOS symptoms at all ages (Lizneva *et al.*, 2016).

Table 6. Descriptive statistics of body weight parameters

Sr. No.	Description	With PCOS	Without PCOS
1	Mean	63.72	61.00
2	Standard Error	1.61	3.33
3	Median	62.20	57.50
4	Mode	60.00	55.00
5	Standard Deviation	16.09	14.91
6	Sample Variance	258.89	222.44
7	Kurtosis	1.13	0.04
8	Skewness	0.84	0.83
9	Range	89.70	55.30
10	Minimum	30.30	42.00
11	Maximum	120.00	97.30
12	Sum	6371.80	1219.90
13	Count	100.00	20.00
14	Confidence Level (95.0%)	3.19	6.98

**Figure 5. Body weight of the patients and control group****Figure 6. Hormones p-value bar chart**

Cohort (NFBC) 1966, body mass index (BMI) is significantly correlated with PCOS symptoms at all ages (Lizneva *et al.*, 2016). Additionally, clinically significant improvements in the reproductive, hyperandrogenic, and metabolic characteristics of PCOS sometimes follow moderate weight loss of about 5% (Ollila *et al.*, 2016; Morley *et al.*, 2017; Silvestris *et al.*, 2018).

The combined P values for the hormone analysis in this inquiry range from 8.72E-11 (insulin and TSH) to 1.24237E-17 (AMH), consistently showing a high degree of statistical significance.

The low P values for LH and FSH, respectively, of 0.000157284 and 1.16E-10, significantly reject the null hypothesis. These findings demonstrate the validity of the study, providing strong evidence to counter the null hypothesis and emphasizing the crucial roles that LH, FSH, Insulin, TSH, and AMH play in triggering the observed hormonal alterations in PCOS.

Conclusions

The findings of this study shed light on the hormonal abnormalities linked with Polycystic Ovary Syndrome and their possible implications for those suffering from the disorder. The results show that there are substantial changes in the levels of Anti-Mullerian Hormone (AMH), Luteinizing Hormone (LH), Follicle-Stimulating Hormone (FSH), and Thyroid-Stimulating Hormone (TSH) between PCOS patients and the control group.

The majority of PCOS patients had elevated AMH levels, indicating increased synthesis of this hormone. AMH, which is known to limit follicle formation and promote follicular degeneration, could be involved in the Pathophysiology of PCOS. This data emphasizes the possibility of a link between PCOS and high AMH levels. The study emphasizes the importance of LH in PCOS, as the majority of PCOS patients had above-normal LH levels. In PCOS, the hormone LH, which stimulates the ovaries to create and release mature eggs, is deregulated. Higher LH levels in PCOS patients highlight the significance of this hormone in the development and expression of the condition. In contrast, there was no significant difference in FSH levels between PCOS patients and the control group. This shows that increased LH rather than FSH is the major hormonal imbalance in PCOS. FSH, which is involved in follicle growth, appears to be unaffected in PCOS individuals. The study also found that people with PCOS had a larger proportion of above-normal TSH levels, indicating a possible relationship between PCOS and thyroid dysfunction. TSH, which regulates thyroid function, may contribute to the metabolic abnormalities that are frequently linked with PCOS.

Overall, the study's findings contribute to a better knowledge of the hormonal profile of PCOS and emphasize the complexities of the hormonal abnormalities in this disorder. The findings highlight the need for more investigation into the underlying mechanisms and potential treatment techniques for PCOS's particular hormonal imbalance. Understanding the complicated interplay of hormones in PCOS can lead to the development

of tailored therapies and personalized methods to manage this complex illness.

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