Journal of Pioneering Medical Sciences
Received: April 25, 2026 | Accepted: August 28, 2026 | Published: September 05, 2026
Volume 15, Issue 08, Pages 154-163

DOI https://doi.org/10.47310/jpms2026150831

Ovarian Morphology and Doppler Vascular Patterns in Women with and Without Polycystic Ovarian syndrome: Associations with Body Mass Index

Shokhan Ahmed Hussein[1], Noor Sami Omar[2*], Lezan Jalal Ali Shah[3] and Nashwan Karkhi Abdulkareem[4]

[1,3]Department of Radiology, Ministry of Health-Erbil, Erbil, Kurdistan Region, Iraq
[2]Department of Radiological Imaging Technologies, College of Health Technology, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq
[4]Hawler Medical University, College of Medicine, Department of Pharmacology, Medical Physics, and Clinical Biochemistry, Erbil, Kurdistan Region, Iraq

*Corresponding author: Noor Sami Omar (e-mail: noor.sami@cihanuniversity.edu.iq).

Abstract: Polycystic ovarian syndrome (PCOS) is currently considered as being one of the most widespread endocrine and metabolic diseases in the reproductive age women across the world. It is approximated that about 116 million women worldwide with a proportion of some 3.4 of the total number of women is affected by PCOS. **Methods:** A total of 145 female participants took part in this case-control study, including 105 cases with PCOS and 40 controls, and they were recruited in a number of private clinical centers in Erbil Governorate within the Kurdistan Region of Iraq. The data gathering was done over a span of time, which is between June 2024 and November 2025. Measurements of height, body weight, hip circumference, waist circumference, and body mass index were taken during a comprehensive physical examination. **Results:** The statistically significant difference between the PCOS and non-PCOS groups was established based on the body mass index (BMI) ($p = 0.034$). There was also a significant difference in the anthropometric measures of various measurements used in the two groups. To be exact, the BMI in the PCOS group was considerably more than in the non-PCOS one ($p = 0.002$. Moreover, the volumes of both right and left ovaries were also found to be much higher in partakers of PCOS than those without the condition ($p = 0.001$). bilateral ovarian volume, bilateral FNPO, and FDP, none of the investigated variables demonstrated a statistically significant independent association with the outcome. RI and PI measurements were not statistically significant independent predictors of the outcome in this multivariable logistic regression model. Among the variables examined, PI left showed the strongest positive association (OR = 21.127, $p = 0.066$) **Conclusion:** This study demonstrated that women with PCOS had higher BMI values and were more likely to present with clinical features such as irregular menstrual cycles, acne, and hirsutism compared with non-PCOS women. Ultrasonographic assessment showed significant differences in ovarian morphology, including ovarian volume and follicle number, and in selected Doppler vascular parameters between the PCOS and non-PCOS groups. However, ovarian morphology and Doppler indices did not demonstrate significant independent associations in multivariable analyses.

Key Words: Polycystic Ovarian Syndrome, Body Mass Index, Ultrasonography, Follicle Numbers, Ovarian Volume

INTRODUCTION

Polycystic ovary syndrome (PCOS) has now been identified to be one of the most prevalent endocrinal and metabolic diseases among reproductively aged women in most parts of the world [1]. According to the epidemiological data, it is observed that there are around 116 million women in the world who have this condition (about 3.4 of the total female population in the world) [2]. In May 2003, the European Society of Human Reproduction and Embryology (ESHRE) and the American Society of Reproductive Medicine (ASRM) organized a joint consensus meeting to come up with standardized diagnostic criteria of PCOS [3]. The pathogenesis and development of PCOS is complicated with the relationships between numerous factors such as body weight and lifestyle practices. The occurrence of PCOS is different among

various BMI levels and various research has indicated PCOS to be linked to weight gain. Obesity is a common occurrence in women who have PCOS and fat distribution in such patients is usually androgenic in nature. Moreover, the hyperandrogenemia and insulin resistance (IR) are observed in many of the affected women. All in all, 30-75% of women with PCOS have been reported to be obese [4].

The clinical manifestation of PCOS is also highly diverse, with hyperandrogenism and insulin resistance being some of the numerous manifestations of this disorder. There is strong evidence supporting a significant role in the pathophysiology of PCOS of insulin resistance and compensatory hyperinsulinemia. The occurrence of this metabolic disturbance may be worsened by the fact that some of them have been found to be obese, with obesity being estimated to present in almost half of women with PCOS. Obesity, in these patients, is common in about 80 percent of obese women with PCOS and about 30-40 percent of lean women with the disorder [5-7].

The PCOS diagnostic standards have also been modified in a number of ways over the years. The first criteria were set in one of the consensus conferences held at National Institutes of Health (NIH). These criteria were further developed, which resulted in the detection of four significant phenotypic manifestations of PCOS [8]. Conventionally, diagnosis used to have two important characteristics, namely, hyperandrogenism and chronic oligo-anovulation, as long as other underlying disorders were ruled out [9].

Scientifically the definition of PCOS has been debated more than a long time. At the present, the condition does not have a certain diagnostic test. Rather the diagnosis relies on the existence of three main characteristics such as irregular menstruation (oligomenorrhoea), hyperandrogenism (either clinical or biochemical), and polycystic ovarian morphology observed on ultrasound (10). It is a combination of these criteria that are referred to as the Rotterdam criteria, and the presence of two out of these three features need to be present in order to diagnose PCOS when the rest of the associated disorders are ruled out such as thyroid disease. Age and ethnicity are some of the variation factors that might lead to difficulty in diagnostic issues. As an example, adolescent physiology, irregular menstrual cycles and multifollicular ovarian morphology, can be similar to the manifestations of PCOS, which threatens both underdiagnosis and overdiagnosis [10-11].

Ultrasonographic assessment provides important information about both ovarian morphology and ovarian vascularity in women with PCOS. The number of follicles and ovarian volume were chosen as were selected as key morphological parameters because they reflect structural changes associated with polycystic ovarian morphology, including ovarian enlargement and increased follicular development. In addition, assessment of follicular distribution may provide complementary morphological information by describing the spatial arrangement of follicles within the ovary. Doppler-derived resistance index (RI) and pulsatility index (PI) were included to characterize ovarian blood-flow patterns. RI provides an indirect measure of vascular resistance, whereas PI reflects the pulsatile characteristics of blood flow and may provide additional information regarding ovarian vascularity. Although the associations of PCOS with obesity, BMI, and conventional sonographic morphology have been widely investigated, the relationship between BMI and ovarian Doppler vascular patterns, particularly RI and PI, remains less clearly characterized. Furthermore, it is not fully established whether differences in ovarian morphology and vascularity observed between women with PCOS and non-PCOS women are associated with BMI. Therefore, the present study aimed to address this gap by simultaneously evaluating ovarian volume, follicle number, follicular distribution, RI, and PI in women with PCOS and control women and by examining their relationship with BMI.

METHODS

Study design

This investigation was a case-control study of both healthy and women with a clinically suspected PCOS. The sample was split into two categories (meaning healthy control group (non-PCO) and PCOS sample). The PCOS diagnosis was based on the Rotterdam 2003 diagnostic criteria. By these criteria PCOS is diagnosed in case of presence of at least two out of the following three: oligo- and/or anovulation; clinical and/or biochemical evidence of hyperandrogenism; and polycystic ovarian morphology (PCOM) as seen on ultrasound. Moreover, other possible reasons of such similar symptoms, such as congenital adrenal hyperplasia, androgen secreting tumors, and Cushing syndrome, were also meticulously considered and excluded [12-13].

The participants in the PCOS group demonstrated at least two of these criteria: irregular menstrual cycles, clinical features of hyperandrogenism (hirsutism and/or acne), and PCOM on ultrasound. The 40 control participants did not fulfill the diagnostic criteria for PCOS. After clinical classification, all participants underwent standardized pelvic ultrasound examination to assess ovarian morphology and Doppler vascular parameters. Of the 40 participants in the non-PCOS control group, eight were younger than 18 years. These participants were included as non-PCOS controls and did not have a clinical diagnosis of PCOS. Ultrasound ovarian morphology was assessed in these participants as part of the study imaging evaluation and was not used to establish a diagnosis of PCOS.

Participants

The sample comprised of 145 women volunteers, including 105 cases with PCOS and 40 controls, both married and unmarried, recruited in the case-control study in a number of private clinical centers in Erbil Governorate in the Kurdistan Region of Iraq. The participants were divided into the case group or control group based on predetermined clinical and diagnostic criteria. The PCOS group consisted of women with clinical suspicion of PCOS who had irregular menstrual cycles and clinical features of

hyperandrogenism, including hirsutism and/or acne, and who fulfilled the Rotterdam diagnostic criteria, including PCOM on ultrasound. For participants aged 16–17 years, PCOS diagnosis was established based on fulfillment of all three Rotterdam criteria. The control group consisted of healthy women without a previous diagnosis or clinical evidence of PCOS and without menstrual irregularity or clinical features of hyperandrogenism. Women in both groups underwent pelvic ultrasound examination for assessment of ovarian morphology and Doppler vascular parameters. The collection of data was carried out in the period between June 2024 and November 2025. A structured questionnaire was used to collect sociodemographic, clinical, and medical data by training the researchers to use them in their work. Ethical approval for the study was obtained from the relevant institutional ethics committee. Written informed consent was obtained from all adult participants. For participants younger than 18 years, Prior to enrollment, participant assent and a parent's written informed consent were obtained. All participants were informed about the study procedures, and participation was voluntary.

Inclusion Criteria

Age ranging from 16 to 42 years. Menstrual irregularity as oligomenorrhea, amenorrhea, and irregular cycles. Features of hyperandrogenism as hirsutism, acne, or androgenic alopecia.

Exclusion Criteria

Participants with known malignancies such as virilizing tumors and endocrinopathies such as Cushing's syndrome, thyroid disorders, and adrenal disorders.

Clinical Evaluation

Every participant had a thorough physical examination and history taken. Eligible subjects completed demographic and reproductive health surveys, including height, weight, age, acne presence, and hirsutism scoring. Ovulatory dysfunction was defined as oligomenorrhea (cycle interval >35 days) or amenorrhea (absence of menses for 3–6 months or more) [14]. Hirsutism was assessed using the Ferriman–Gallwey method [15] acne was scored separately (5). Anthropometric measures included height, weight, waist circumference (WC), hip circumference (HC), and body mass index BMI [16]. Waist was measured at the narrowest point between the costal margin and iliac crest, and BMI was calculated as (kg/m²) [17].

Ultrasonography Measurements

Participants underwent pelvic ultrasound examination using either a transabdominal or transvaginal approach according to participant suitability and acceptance of the examination. The examinations were performed by two specialist radiologists who followed the same standardized scanning and measurement protocol. using Philips 550 and Samsung R7 ultrasound systems with a transducer operating at a frequency range of 1–5 MHz. For participants with regular menstrual cycles, ultrasound assessment was performed during the early follicular phase (days 2–7 of the menstrual cycle). Participants with irregular menstrual cycles were examined without restriction to a specific cycle day because their menstrual timing was unpredictable and a specific cycle phase could not be reliably established. All participants were assessed using the same standardized ultrasound scanning and measurement protocol. Both ovaries were systematically assessed, and measurements were obtained from each ovary. To avoid overestimation of ovarian volume, when a dominant follicle measuring >10 mm or a corpus luteum cyst was present, ovarian measurements were obtained from the contralateral ovary. If both ovaries contained dominant follicles, the examination was repeated during the subsequent menstrual cycle. All visible follicles measuring 2–9 mm were counted. The follicle number per ovary (FNPO) was calculated as the mean number of 2–9 mm follicles in both ovaries and was additionally categorized into two follicle-size groups: 2–5 mm and 6–9 mm. Ovarian length, width, and anteroposterior diameter were measured, and ovarian volume was calculated using the standard ellipsoid formula: ovarian volume = length × width × anteroposterior diameter × 0.523. Ovarian morphology was assessed based on ovarian volume, follicle number, and follicular distribution. Doppler ultrasound was also performed to assess ovarian vascular parameters, including the resistive index (RI) and pulsatility index (PI).

Doppler Assessment

Ovarian vascularity was assessed bilaterally using color and spectral Doppler ultrasound. Representative stromal vessels within each ovary were identified, and pulsed-wave Doppler was used to obtain stable arterial waveforms. Doppler measurements were obtained three times from representative stromal vessels in each ovary. The resistive index (RI) and pulsatility index (PI) were recorded for each measurement, and the three measurements were averaged to obtain the final RI and PI values for each ovary. Both specialist radiologists followed the same standardized Doppler protocol. Each radiologist examined a separate group of participants, and the same participants were not independently assessed by both radiologists. The radiologists were aware of the participants' clinical information and group allocation during the examination; therefore, the Doppler assessment was not blinded.

Statistical Analysis

All the statistical tests were carried out using the SPSS software for statistical analysis. The software used was version 26, which was used for testing the data, calculating the mean, standard deviation, and the frequency of the participants. Continuous variables were assessed for normality using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots. The assumptions for parametric testing, including approximate normality and

homogeneity of variances, were evaluated before applying independent-samples *t*-tests. Independent-samples t-tests were used to compare continuous variables that satisfied these criteria between groups, while the chi-square test of independence was used to examine categorical data. Fisher's exact test was employed when the expected cell counts were not high enough for the chi-square test.

RESULTS

In this case-control study, 145 participants, including 105 cases with PCOS and 40 controls, aged 16 to 42 years were enrolled, with a mean age of 26.372±5.797 years. Among them, 61.4% were aged 21- 30 years, 24.8% were aged 31 years and more, while only 13.8% were aged 20 years and less (Figure 1).

In the present study, 63.4% of the participants were married, while 36.6% were single. The majority of participants were educated (97.2%) as shown in table 1, whereas only 2.8% were illiterate. Regarding occupation, 81 participants were housewives compared with 64 who were employed. Most participants were non-smokers (97.2%), while only 2.8% reported smoking. Concerning physical activity, 54.5% of participants engaged in exercise for less or more than one hour, whereas 45.5% did not perform any regular exercise.

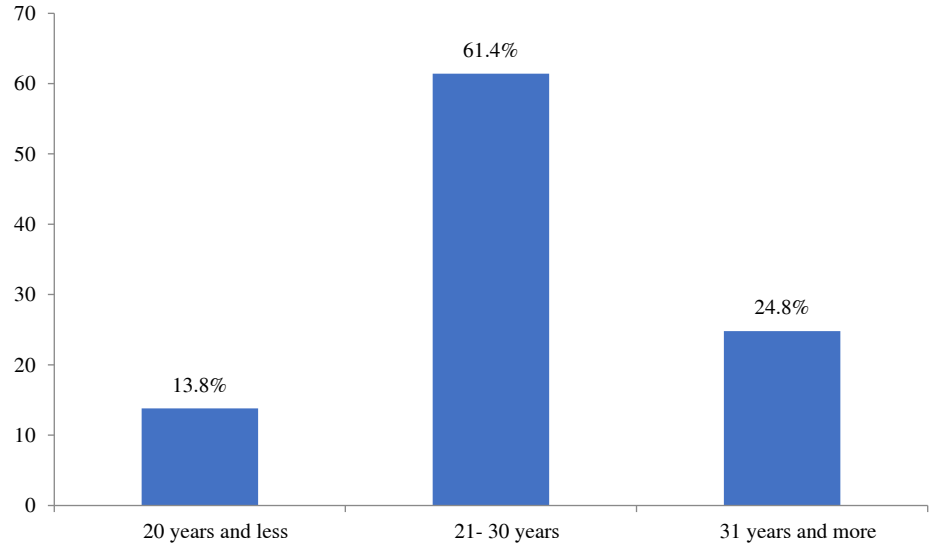

Figure 1: Age Groups of the Participants

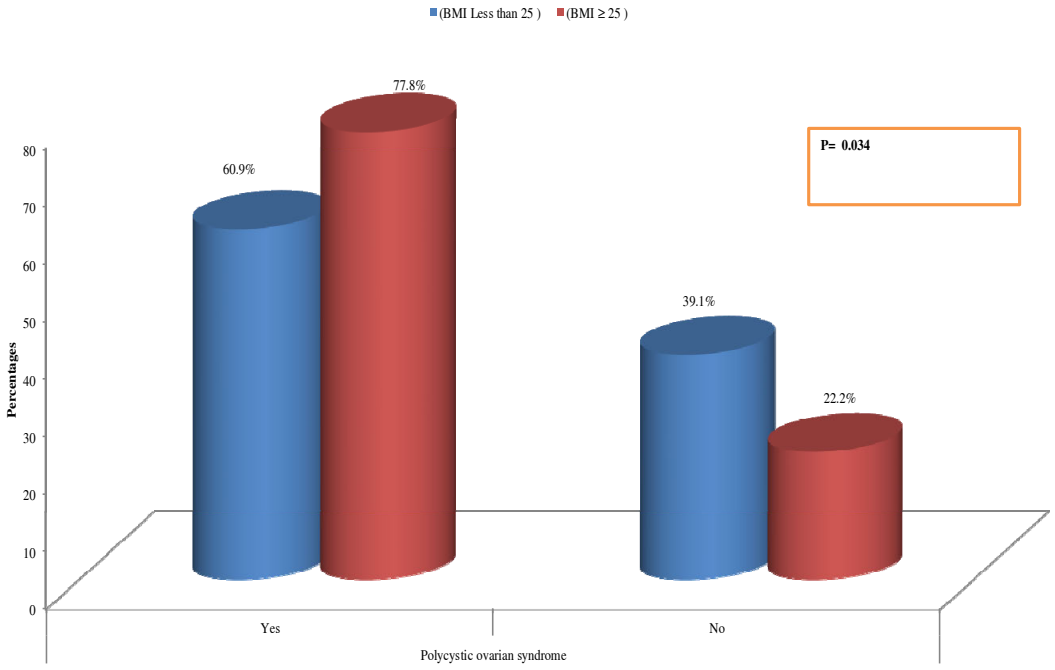

Figure 2: Body Mass Index Categories among PCOS and Non- PCOS Group

Table 1: Patients' Sociodemographic Details

Variables	Frequency	Percentage (%)
Marital status		
Single	53	(36.6)
Married	92	(63.4)
Educational level		
Illiterate	4	(2.8)
Primary educated	28	(19.3)
Secondary	44	(30.3)
Graduated	69	(47.6)
Occupation		
House wife	81	(55.9)
Worked	64	(44.1)
Smoking		
Yes	4	(2.8)
No	141	(97.2)
Exercise		
No	66	(45.5)
Less than 1 hour	71	(49.0)
More than 1 hour	8	(5.5)
Total	145	(100.0)

Table 2: Anthropometric measurements of PCOS and non-PCOS Patients Compared

Variables	Polycystic Ovarian Syndrome Mean± SD		95% Confidence Interval	p-value*
	Yes	No		
Weight in Kilograms	76.095±17.834	69.100±10.055	2.89 to 11.10	0.021
Height in Meters	1.607± 0.055	1.629± 0.053	- 0.042 to - 0.002	0.034
Body mass index	29.313± 6.059	26.035± 3.648	1.72 to 4.84	0.002
Waist circumference in Centimeters	97.733± 15.419	77.750± 7.860	15.70 to 24.27	0.001
Hip circumference in Centimeters	97.866± 15.818	104.800± 11.473	-11.85 to - 2.02	0.013
Waist/ hip ratio	1.021± 0.212	0.749± 0.106	0.210 to 0.334	0.001

*: Independent sample t-test

Table 3: Ultrasound Findings in PCOS and Non-PCOS Ovaries

Variables	Polycystic Ovarian Syndrome Mean± SD		95% Confidence Interval	p-value*
	Yes	No		
Volume of right ovary in ml	14.089± 4.262	7.445± 1.671	5.678 to 7.610	0.001
Volume of left ovary in ml	14.141± 4.298	7.540±1.600	5.641 to 7.561	0.001
Endometrial thickness in mm	5.132±1.754	6.915± 2.070	−2.507 to −1.059	0.001
Follicle numbers per ovary, right	15.971± 4.816	8.075± 3.049	6.576 to 9.216	0.001
Follicle numbers per ovary, left	15.285± 4.937	8.000± 3.202	5.915 to 8.655	0.001
Right Resistance index (RI)	0.503± 0.097	0.598± 0.051	−0.119 to −0.071	0.001
Left Resistance index (RI)	0.516±0.090	0.642± 0.108	−0.164 to −0.088	0.001
Right Pulsatility index (PI)	0.826± 0.212	0.877± 0.121	−0.106 to 0.004	0.158
Left Pulsatility index (PI)	0.814± 0.195	0.945± 0.013	−0.169 to −0.094	0.001
Follicle distribution pattern	1.076± 0.384	2.600± 0.545	−1.708 to −1.340	0.001

*: Independent sample t-test

The difference was statistically significant in the BMI distribution between the groups with and without PCOS (p = 0.034) as illustrated in Figure 2. In the normal BMI category, 60.9 percent were put under PCOS category, as opposed to 39.1 percent in non-PCOS category. Equally, a larger proportion of the respondents with BMI above 25 of the participants were in the PCOS group (77.8%), with only 22.2% in the non-PCOS group.

Significant differences in anthropometric measures were observed between PCOS-affected and non-affected women (Table 2). Women with PCOS had considerably higher BMIs. (29.31±6.06 kg/m²) compared with those without PCOS (26.04±3.65 kg/m²; 95% CI, 1.72–4.84; $p = 0.002$).

Waist circumference was markedly higher among women with PCOS (97.73±15.42 cm) compared with the non-PCOS group (77.75±7.86 cm; 95% CI, 15.70–24.27; $p = 0.001$). In contrast, hip circumference was significantly lower in the PCOS group (97.87±15.82 cm vs. 104.80±11.47 cm; 95% CI, −11.85 to −2.02; $p = 0.013$).

The waist-to-hip ratio was also significantly higher in women with PCOS than in the non-PCOS group (1.021±0.212 vs. 0.749±0.106; 95% CI, 0.210–0.334; $p = 0.001$). Overall, the PCOS group demonstrated significantly greater body weight, BMI, waist circumference, and waist-to-hip ratio, whereas height and hip circumference were significantly lower compared with the non-PCOS group.

Significant differences were observed between women with and without PCOS in several ovarian morphological and Doppler parameters (Table 3). The mean right ovarian volume was significantly higher in the PCOS group than in the non-PCOS group (14.09±4.26 mL vs. 7.45±1.67 mL; 95% CI for the mean difference, 5.678–7.610; $p = 0.001$). Similarly, the mean left

Table 4: Clinical Symptom Comparison Between PCOS and Non-PCOS Groups

Clinical symptoms	Polycystic Ovarian Syndrome No. and (%) *		p-value
	Yes	No	
Acne symptom			0.003
Present	60 (83.3)	12 (16.7)	
Absent	45 (61.6)	28 (38.4)	
Irregular cycle			0.001**
Oligomenorrhea	74 (98.7)	1 (1.3)	
Hypo menorrhea	10 (100.0)	0 (0.0)	
Polymenorrhea	10 (100.0)	0 (0.0)	
Secondary amenorrhea	10 (100.0)	0 (0.0)	
Regular cycle	1 (2.6)	38 (97.4)	
Irregular cycle	0 (0.0)	1 (100.0)	
Hirsutism			0.001**
Absent	10 (23.8)	32 (76.2)	
Mild	56 (91.8)	5 (8.2)	
Moderate	36 (92.3)	3 (7.7)	
Severe	3 (100.0)	0 (0.0)	
Total	105 (72.4)	40 (27.6)	100 (100.0)

*: Row percentages, **: Fischer's exact test

Table 5: The Binary Logistic Regression Analysis to Find Out the Associations of BMI to ovarian morphology and age

Variables	Regression coefficient (B)	95% Confidence Interval		p-value
		Lower	Upper	
Age in years	0.041	0.976	1.113	0.219
Volume of right ovary in ml	0.016	0.779	1.325	0.907
Volume of left ovary in ml	0.039	0.809	1.336	0.761
Follicle numbers per ovary, right	0.025	0.845	1.243	0.800
Follicle numbers per ovary, left	- 0.031	0.807	1.165	0.741
Follicle distribution pattern	- 0.354	0.410	1.200	0.196

Table 6: The Binary Logistic Regression Analysis to Find Out the Associations of BMI to ovarian Doppler vVscular parameters

Variables	Regression coefficient (B)	95% Confidence Interval		p-value
		Lower	Upper	
Right Resistance index (RI)	-3.469	0.000	74.350	0.382
Left Resistance index (RI)	-3.137	0.000	9.513	0.254
Right Pulsatility index (PI)	0.802	0.060	83.437	0.665
Left Pulsatility index (PI)	3.051	0.817	546.598	0.066

ovarian volume was significantly greater in the PCOS group (14.14±4.30 mL vs. 7.54±1.60 mL; 95% CI, 5.641–7.561; p = 0.001).

In contrast, endometrial thickness was significantly lower among women with PCOS compared with the non-PCOS group (5.13±1.75 mm vs. 6.92±2.07 mm; 95% CI, −2.507 to −1.059; p = 0.001). The number of follicles per ovary was also significantly higher in the PCOS group for both the right ovary (15.97±4.82 vs. 8.08±3.05; 95% CI, 6.576–9.216; p = 0.001) and the left ovary (15.29±4.94 vs. 8.00±3.20; 95% CI, 5.915–8.655; p = 0.001).

Regarding Doppler parameters, the right ovarian resistance index (RI) was significantly lower in the PCOS group than in the non-PCOS group (0.503±0.097 vs. 0.598±0.051; 95% CI, −0.119 to −0.071; p = 0.001). A similar difference was observed for the left ovarian RI (0.516±0.090 vs. 0.642±0.108; 95% CI, −0.164 to −0.088; p = 0.001). The left ovarian pulsatility index (PI) was also significantly lower in the PCOS group (0.814±0.195 vs. 0.945±0.013; 95% CI, −0.169 to −0.094; p = 0.001). However, no statistically significant difference was found in the right ovarian PI between the groups (0.826±0.212 vs. 0.877±0.121; 95% CI, −0.106 to 0.004; p = 0.158).

Finally, the follicle distribution pattern differed significantly between the groups, with mean values of 1.076±0.384 in the PCOS group and 2.600±0.545 in the non-PCOS group (95% CI for the mean difference, −1.708 to −1.340; p = 0.001). Overall, the findings demonstrate significant between-group differences in ovarian volume, follicle number, endometrial thickness, ovarian RI, left ovarian PI, and follicle distribution pattern, whereas right ovarian PI did not differ significantly.

These were further supported by the clinical characteristics. There was a significant difference in the prevalence of acnes between groups (p = 0.003) with women with PCOS (83.3) having a higher prevalence than the non-PCOS women (16.7). There was also a very significant difference (p =0.001) in patterns of menstrual cycles. Irregular cycles mostly women with the PCOS group (98.7% participants) were seen to have irregular cycles mostly oligomenorrhea as opposed to one participant in the non-PCOS group. Conversely, regular menstrual cycles were mostly observed in non-PCOS group (97.4%), and only one woman had a regular cycle in the PCOS group.

Hirsutism found a substantial difference between the groups (p = 0.001), with 95 participants in the PCOS group

exhibiting varying degrees of hirsutism (mild, moderate, or severe). Mild hirsutism was the most common presentation among women with PCOS (56 individual), while only eight participants in the non-PCOS group exhibited hirsutism. Furthermore, the absence of hirsutism was more frequent in the non-PCOS group (n = 32) compared with the PCOS group (n = 10).

After adjustment for age, bilateral ovarian volume, bilateral FNPO, and FDP, none of the investigated variables demonstrated a statistically significant independent association with the outcome. Age showed a weak positive association, while FDP showed the strongest apparent inverse association; however, neither reached statistical significance.

Overall, these findings suggest that age, ovarian volume, FNPO, and FDP do not independently predict the outcome in this multivariable model. The similarity of these results to the previous model without age also suggests that Age adjustment did not significantly change the associations of the ovarian parameters or FDP with the outcome (Table 5).

The multivariable logistic regression analysis examined the independent associations of right and left resistance indices (RI) and pulsatility indices (PI) with the outcome. None of the predictors reached conventional statistical significance at the 5% level ($p<0.05$).

Overall, RI and PI measurements were not statistically significant independent predictors of the outcome in this multivariable logistic regression model. Among the variables examined, PI left showed the strongest positive association (OR = 21.127, $p = 0.066$) (Table 6).

DISCUSSION

In the present study, BMI was significantly higher in women with PCOS than in healthy controls (p = 0.034), consistent with previous research reporting higher BMI among women with PCOS (18). BMI, waist circumference, and waist-to-hip ratio were higher among women with PCOS, consistent with previous evidence linking overall and central adiposity with PCOS [19-21].

Other researchers have also reported higher central adiposity in PCOS women, which is determined by high waist circumference, waist-to-hip ratio, and BMI [22]. It is interesting to note that, central fat build-up has been seen to be an important feature of PCOS in both lean and obese women irrespective of total body mass [23-26].

Menstrual cycle regularity varied considerably across the groups with and without PCOS (p = 0.001), with menstrual irregularities being substantially more common among women with PCOS. This finding is consistent with previous evidence identifying menstrual dysfunction as a common clinical manifestation of PCOS [27].

The high frequency of menstrual irregularities in the PCOS group is consistent with previous studies reporting menstrual dysfunction, particularly oligomenorrhea and amenorrhea, as common clinical manifestations of PCOS [28-34]. The variability in reported prevalence may reflect differences in diagnostic criteria and study populations, particularly among adolescents [28].

Acne was significantly more prevalent in the PCOS group than in controls (83.3% vs. 16.7%, p = 0.003), consistent with previous evidence linking cutaneous manifestations of hyperandrogenism with PCOS and metabolic abnormalities [35-37].

Hirsutism was noticeably more prevalent in the PCOS group (p = 0.001), consistent with the recognized association between hyperandrogenism and PCOS. Previous evidence also suggests that higher BMI may be associated with greater hirsutism severity, highlighting the potential interplay between adiposity and hyperandrogenic manifestations [38-39].

In the present study, both right and left ovarian volumes and follicle numbers per ovary were significantly higher in the PCOS group ($p<0.001$), consistent with previous studies in adolescents and adult women [40-46]. These findings support the recognized association of increased ovarian volume and follicle number with PCOS, while also indicating that ovarian morphology may vary according to patient characteristics, including adiposity.

Previous studies have similarly reported increased ovarian volume and follicle count in adolescents with PCOS [47-48]. Notably, follicle count may provide greater specificity than ovarian volume alone in adolescents, in whom physiological ovarian enlargement can limit the specificity of volume-based assessment [49].

In the multivariable analysis, none of the investigated ovarian parameters demonstrated a statistically significant independent association with the outcome after adjustment for age, bilateral ovarian volume, bilateral follicle number per ovary (FNPO), and follicular distribution pattern (FDP). Although age showed a weak positive association and FDP demonstrated the strongest apparent inverse association, neither association reached statistical significance. These findings suggest that the observed relationships between these ovarian characteristics and the outcome may not be independent when the other variables are considered simultaneously.

Notably, the overall pattern of findings was similar to that observed in the model without age adjustment, indicating that age did not materially alter the associations between the ovarian parameters, FDP, and the outcome. This consistency suggests that age was unlikely to be a major confounding factor in these associations within the current study population.

None of the ovarian Doppler indices, including right and left resistance indices (RI) and pulsatility indices (PI), demonstrated a statistically significant independent association with the outcome in the multivariable logistic regression model. This suggests that, after considering the Doppler parameters simultaneously, variations in ovarian vascular resistance and pulsatility were not independently associated with the studied outcome in this population.

Although the left ovarian PI showed the strongest apparent positive association, the statistical significance of this connection was not reached. The relatively wide

confidence interval and the fact that the confidence interval included the null value indicate substantial uncertainty around this estimate. Therefore, the elevated odds ratio should not be interpreted as evidence of a true association. The lack of statistically significant independent associations may indicate that ovarian Doppler characteristics alone have limited predictive value for the outcome or that their associations are influenced by other clinical, demographic, or ovarian factors.

These findings also highlight the importance of distinguishing between differences observed in univariable or group comparisons and independent associations identified after multivariable adjustment. Further studies with larger sample sizes and standardized Doppler assessment are warranted to determine whether specific ovarian vascular indices have clinically meaningful associations with the outcome, particularly across different PCOS phenotypes and patient characteristics.

CONCLUSION

This study demonstrated that women with PCOS had higher BMI values and were more likely to present with clinical features such as irregular menstrual cycles, acne, and hirsutism compared with non-PCOS women. Ultrasonographic assessment showed significant differences in ovarian morphology, including ovarian volume and follicle number, and in selected Doppler vascular parameters between the PCOS and non-PCOS groups. However, ovarian morphology and Doppler indices did not demonstrate significant independent associations in multivariable analyses. Further studies are warranted to clarify the complex relationship between BMI, ovarian morphology, and vascularity in PCOS.

Study Limitations

This study has several limitations. participants were recruited from private centers within a single region, which may limit the generalizability of the findings. Nine adolescent participants were included in the PCOS group, which may introduce variability in ovarian morphology. Hormonal and biochemical Not every participant had access to the data. limiting assessment of biochemical hyperandrogenism. Ultrasound measurements are operator-dependent; although two specialist radiologists followed the same protocol, they examined different participants, and formal interobserver reliability was not assessed. Finally, differences in menstrual-cycle timing between participants with regular and irregular cycles may have influenced ovarian morphology and Doppler measurements.

Ethics Approval and Consent to Participate

The study was approved by the Committee of the College of Medicine, Hawler Medical University (2-4/4.12.2025). Informed consent was obtained from each participant before completing the study questionnaire. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

REFERENCES

[1] Youngster M *et al.* "Utility of ultrasound in the diagnosis of polycystic ovary syndrome in adolescents." *Fertility and Sterility*, vol. 102, no. 5, 2014, pp. 1432-1438.

[2] Jabeen A *et al.* "Polycystic ovarian syndrome: prevalence, predisposing factors, and awareness among adolescent and young girls of South India." *Cureus*, vol. 14, no. 8, 2022.

[3] Fauser B. "Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome." *Fertility and Sterility*, vol. 81, no. 1, 2004, pp. 19-25.

[4] Essah P.A. and Nestler J.E. "The metabolic syndrome in polycystic ovary syndrome." *Journal of Endocrinological Investigation*, vol. 29, no. 3, 2006, pp. 270-280.

[5] Laganà A.S. *et al.* "Metabolism and ovarian function in PCOS women: a therapeutic approach with inositols." *International Journal of Endocrinology*, vol. 2016, 2016, pp. 1-9.

[6] Laganà A.S. *et al.* "Inositol in polycystic ovary syndrome: restoring fertility through a pathophysiology-based approach." *Trends in Endocrinology and Metabolism*, vol. 29, no. 11, 2018, pp. 768-780.

[7] Paul C. *et al.* "Inositol's and other nutraceuticals' synergistic actions counteract insulin resistance in polycystic ovarian syndrome and metabolic syndrome: state-of-the-art and future perspectives." *Gynecological Endocrinology*, vol. 32, no. 6, 2016, pp. 431-438.

[8] Lizneva D. *et al.* "Criteria, prevalence, and phenotypes of polycystic ovary syndrome." *Fertility and Sterility*, vol. 106, no. 1, 2016, pp. 6-15.

[9] Roe A.H. and Dokras A. "The diagnosis of polycystic ovary syndrome in adolescents." *Reviews in Obstetrics and Gynecology*, vol. 4, no. 2, 2011, pp. 45.

[10] Hoeger K.M. *et al.* "Update on PCOS: consequences, challenges, and guiding treatment." *The Journal of Clinical Endocrinology & Metabolism*, vol. 106, no. 3, 2021, pp. e1071-e1083.

[11] Gibson-Helm M. *et al.* "Delayed diagnosis and a lack of information associated with dissatisfaction in women with polycystic ovary syndrome." *The Journal of Clinical Endocrinology & Metabolism*, vol. 102, no. 2, 2017, pp. 604-612.

[12] Escobar-Morreale H.F. "Polycystic ovary syndrome: definition, aetiology, diagnosis and treatment." *Nature Reviews Endocrinology*, vol. 14, no. 5, 2018, pp. 270-284.

[13] The Rotterdam ESHRE/ASRM-sponsored PCOS Consensus Workshop Group. "Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome (PCOS)." *Human Reproduction*, vol. 19, no. 1, 2004, pp. 41-47.

[14] Arentz S. *et al.* "Herbal medicine for the management of polycystic ovary syndrome (PCOS) and associated oligo/amenorrhoea and hyperandrogenism: a review of the laboratory evidence for effects with corroborative clinical findings." *BMC Complementary and Alternative Medicine*, vol. 14, no. 1, 2014, pp. 511.

[15] Al Kindi M.K. *et al.* "Validity of serum testosterone, free androgen index, and calculated free testosterone in women with suspected hyperandrogenism." *Oman Medical Journal*, vol. 27, no. 6, 2012, pp. 471.

[16] Dou P. *et al.* "Application of receiver operating characteristic curve in the assessment of the value of body mass index, waist circumference and percentage of body fat in the diagnosis of polycystic ovary syndrome in childbearing women." *Journal of Ovarian Research*, vol. 9, no. 1, 2016, pp. 51.

[17] Ahmed Hussein S. *et al.* "The impact of body mass index on clinical and sonographic features of polycystic ovary syndrome (PCOS): a cross-sectional study." *Journal of Obstetrics and Gynecology and Cancer Research*, vol. 11, no. 3, 2026, pp. 261-269.

[18] Memon T.F. *et al.* "Clinical, hormonal and metabolic factors associated with polycystic ovary syndrome among Pakistani women." *Rawal Medical Journal*, vol. 45, no. 4, 2020, pp. 817-821.

[19] Thangavelu M. *et al.* "A case-controlled comparative hospital-based study on the clinical, biochemical, hormonal, and gynecological parameters in polycystic ovary syndrome." *Indian Journal of Pharmaceutical Sciences*, vol. 79, no. 4, 2017, pp. 608-616.

[20] Folsom A.R. *et al.* "Associations of general and abdominal obesity with multiple health outcomes in older women: the Iowa Women's Health Study." *Archives of Internal Medicine*, vol. 160, no. 14, 2000, pp. 2117-2128.

[21] Kumar N. and Agarwal H. "Early clinical, biochemical and radiological features in obese and non-obese young women with polycystic ovarian syndrome: a comparative study." *Hormone and Metabolic Research*, vol. 54, no. 9, 2022, pp. 620-624.

[22] Glintborg D. *et al.* "Comparison of regional fat mass measurement by whole body DXA scans and anthropometric measures to predict insulin resistance in women with polycystic ovary syndrome and controls." *Acta Obstetricia et Gynecologica Scandinavica*, vol. 95, no. 11, 2016, pp. 1235-1243.

[23] Taponen S. *et al.* "Metabolic cardiovascular disease risk factors in women with self-reported symptoms of oligomenorrhea and/or hirsutism: Northern Finland Birth Cohort 1966 Study." *The Journal of Clinical Endocrinology & Metabolism*, vol. 89, no. 5, 2004, pp. 2114-2118.

[24] Lim S.S. *et al.* "Overweight, obesity and central obesity in women with polycystic ovary syndrome: a systematic review and meta-analysis." *Human Reproduction Update*, vol. 18, no. 6, 2012, pp. 618-637.

[25] Dutt S. *et al.* "Comparison of clinical, biochemical, and sonological parameters in adolescents with and without polycystic ovarian syndrome." *Annals of the National Academy of Medical Sciences (India)*, vol. 58, 2022, pp. 197-203.

[26] Kamrul-Hasan A.B.M. *et al.* "Clinical, metabolic and hormonal profiles of Bangladeshi adolescents with polycystic ovary syndrome." *TouchREVIEWS in Endocrinology*, vol. 17, no. 1, 2021, pp. 54.

[27] Siam S.G. *et al.* "Prevalence of polycystic ovarian syndrome in young adult unmarried females attending Zagazig University Hospital outpatient clinic." *The Egyptian Journal of Hospital Medicine*, vol. 81, no. 6, 2020, pp. 2152-2159.

[28] Milczarek M. *et al.* "Difficulties in diagnostics of polycystic ovary syndrome in adolescents: a preliminary study." *Pediatric Endocrinology, Diabetes and Metabolism*, vol. 25, no. 3, 2019, pp. 122-126.

[29] Thathapudi S. *et al.* "Anthropometric and biochemical characteristics of polycystic ovarian syndrome in South Indian women using AES-2006 criteria." *International Journal of Endocrinology and Metabolism*, vol. 12, no. 1, 2014, pp. e12470.

[30] Yetim A. *et al.* "Anti-müllerian hormone and inhibin-A, but not Inhibin-B or insulin-like peptide-3, may be used as surrogates in the diagnosis of polycystic ovary syndrome in adolescents: preliminary results." *Journal of Clinical Research in Pediatric Endocrinology*, vol. 8, no. 3, 2016, pp. 288.

[31] Vrbikova J. *et al.* "Insulin sensitivity and β-cell function in women with polycystic ovary syndrome." *Diabetes Care*, vol. 25, no. 7, 2002, pp. 1217-1222.

[32] Taponen S. *et al.* "Hormonal profile of women with self-reported symptoms of oligomenorrhea and/or hirsutism: Northern Finland birth cohort 1966 study." *The Journal of Clinical Endocrinology & Metabolism*, vol. 88, no. 1, 2003, pp. 141-147.

[33] Alili A. and Idrizi E.A. "Clinical and biochemical characteristics in women with polycystic ovarian syndrome in the region of Pollog, Republic of Macedonia." *European Scientific Journal*, vol. 10, no. 12, 2014.

[34] Gupta N. *et al.* "Comparison of metabolic and endocrinal parameters in obese and nonobese women of polycystic ovary syndrome with normal controls." *Fertility Science and Research*, vol. 2, no. 1, 2015, pp. 19-23.

[35] Lucky A.W. *et al.* "The prevalence of upper lip hair in black and white girls during puberty: a new standard." *The Journal of Pediatrics*, vol. 138, no. 1, 2001, pp. 134-136.

[36] Gowri B.V. *et al.* "Correlation of skin changes with hormonal changes in polycystic ovarian syndrome: a cross-sectional study clinical study." *Indian Journal of Dermatology*, vol. 60, no. 4, 2015, pp. 419.

[37] Gholinezhad M. *et al.* "Insulin resistance and adverse metabolic profile in overweight/obese and normal weight of young women with polycystic ovary syndrome." *Caspian Journal of Internal Medicine*, vol. 9, no. 3, 2018, pp. 260.

[38] Neubronner S.A. *et al.* "Effect of body mass index (BMI) on phenotypic features of polycystic ovary syndrome (PCOS) in Singapore women: a prospective cross-sectional study." *BMC Women's Health*, vol. 21, no. 1, 2021, pp. 135.

[39] Legro R.S. *et al.* "Diagnosis and treatment of polycystic ovary syndrome: an Endocrine Society clinical practice guideline." *The Journal of Clinical Endocrinology & Metabolism*, vol. 98, no. 12, 2013, pp. 4565-4592.

[40] Chen Y. *et al.* "Ovarian volume and follicle number in the diagnosis of polycystic ovary syndrome in Chinese women." *Ultrasound in Obstetrics & Gynecology*, vol. 32, no. 5, 2008, pp. 700-703.

[41] Sujata K. and Swoyam S. "2D and 3D trans-vaginal sonography to determine cut-offs for ovarian volume and follicle number per ovary for diagnosis of polycystic ovary syndrome in Indian women." *Journal of Reproduction and Infertility*, vol. 19, no. 3, 2018, pp. 146.

[42] Şentürk Ş. *et al.* "Serum preptin and amylin levels with respect to body mass index in polycystic ovary syndrome patients." *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, vol. 24, 2018, pp. 7517.

[43] Pambou A. *et al.* "Polycystic ovary syndrome: pelvic MRI as alternative to pelvic ultrasound for the diagnosis in overweight and obese adolescent girls." *International Journal of Pediatrics and Adolescent Medicine*, vol. 4, no. 4, 2017, pp. 147-152.

[44] Ahmed A.A. *et al.* "Ultrasonographic and biochemical assessments as early prediction of polycystic ovarian syndrome in obese women." *African Health Sciences*, vol. 20, no. 2, 2020, pp. 676-681.

[45] Chen Y. *et al.* "The role of ovarian volume as a diagnostic criterion for Chinese adolescents with polycystic ovary syndrome." *Journal of Pediatric and Adolescent Gynecology*, vol. 21, no. 6, 2008, pp. 347-350.

[46] Chun S. "Inter-ovarian differences in ultrasound markers of ovarian size in women with polycystic ovary syndrome." *Clinical and Experimental Reproductive Medicine*, vol. 46, no. 4, 2019, pp. 197.

[47] Silfen M.E. *et al.* "Early endocrine, metabolic, and sonographic characteristics of polycystic ovary syndrome (PCOS): comparison between nonobese and obese adolescents." *The Journal of Clinical Endocrinology & Metabolism*, vol. 88, no. 10, 2003, pp. 4682-4688.

[48] Battaglia C. *et al.* "Two- and three-dimensional sonographic and color Doppler techniques for diagnosis of polycystic ovary syndrome: the stromal/ovarian volume ratio as a new diagnostic criterion." *Journal of Ultrasound in Medicine*, vol. 31, no. 7, 2012, pp. 1015-1024.

[49] Asanidze E. *et al.* "Challenges in diagnosis of polycystic ovary syndrome in adolescence." *Gynecological Endocrinology*, vol. 37, no. 9, 2021, pp. 819-822.