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Association between body mass index and ovarian morphology in Nigerian women with polycystic ovary syndrome: A comparative transvaginal sonographic study

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Abstract

Background: Polycystic ovary syndrome (PCOS) is a common endocrine disorder affecting women of reproductive age and is frequently associated with obesity and metabolic complications. However, the relationship between body mass index (BMI) and ovarian morphological abnormalities remains unclear, particularly among African women. This study assessed the association between BMI and ovarian morphology among Nigerian women with PCOS using transvaginal ultrasonography.

Methods: A prospective comparative cross-sectional study was conducted among 205 women attending the Fertility Clinic of the Federal Medical Centre, Onitsha, Nigeria. Participants comprised 105 women with PCOS and 100 apparently healthy controls. Anthropometric measurements were obtained, and BMI was calculated. Transvaginal ultrasonography was used to assess ovarian volume, antral follicle count, and stromal thickness. Data were analysed using independent samples *t*-test, chi-square test, and Pearson's correlation coefficient, with statistical significance set at $p < 0.05$.

Results: Women with PCOS had significantly higher mean BMI than controls (25.56 ± 4.87 vs 23.15 ± 3.37 kg/m^2; $t(203) = -4.10$, $p < 0.001$). Overweight and obesity were more common among women with PCOS (20.0% and 21.9%, respectively) compared with controls (17.0% and 4.0%). Ovarian volume, antral follicle count, and stromal thickness were significantly greater among women with PCOS than controls (all $p < 0.001$). However, BMI was not significantly correlated with ovarian volume, antral follicle count, or stromal thickness in either group (all $p > 0.05$).

Conclusion: Women with PCOS had higher BMI and more pronounced ovarian morphological abnormalities than healthy controls. Nevertheless, BMI was not associated with ovarian structural parameters, suggesting that obesity may contribute more to the metabolic phenotype of PCOS than to ovarian morphology. Transvaginal ultrasonography, integrated with clinical and biochemical assessment, remains essential for PCOS evaluation.

Keywords: Polycystic ovary syndrome; Body mass index; Ovarian morphology; Transvaginal ultrasonography; Obesity.

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1. Introduction

Polycystic ovary syndrome (PCOS) is the most common endocrine disorder affecting women of reproductive age and is recognized as a complex reproductive, metabolic, and psychological condition with substantial implications for women's health worldwide [1; 2]. Depending on the diagnostic criteria applied and the population studied, the prevalence of PCOS is estimated to range between 8% and 13% among reproductive-aged women, although many affected individuals remain undiagnosed due to variations in clinical presentation and diagnostic approaches [3; 4].

Polycystic ovary syndrome is characterized by a heterogeneous combination of hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology (PCOM), with considerable variation in how these features are expressed among affected women [1; 2]. Beyond reproductive abnormalities, PCOS is associated with significant metabolic and psychological consequences. These include insulin resistance, obesity, impaired glucose tolerance, type 2 diabetes mellitus, dyslipidaemia, hypertension, infertility, anxiety, depression, reduced quality of life, and increased long-term cardiometabolic risk [4; 5; 6;].

The diagnostic framework for PCOS has evolved substantially over recent years. According to the 2023 International Evidence-based Guideline for the Assessment and Management of Polycystic Ovary Syndrome, after excluding other disorders with similar clinical features, diagnosis in adults should be based on the presence of at least two of the following: (1) clinical or biochemical hyperandrogenism, (2) ovulatory dysfunction, and (3) polycystic ovarian morphology identified by ultrasonography or elevated anti-Müllerian hormone (AMH) levels [4]) While AMH, a hormone produced by ovarian follicles, has become an increasingly important adjunct diagnostic marker, ultrasonography remains essential for evaluating ovarian morphology, particularly ovarian volume, follicle number, and structural ovarian characteristics [4; 7].

Transvaginal ultrasonography provides superior visualization of ovarian structures compared with transabdominal approaches and is the preferred imaging modality for detailed assessment of ovarian morphology in suitable patients [8]. Sonographic parameters such as ovarian volume, antral follicle count (AFC, the number of small follicles within the ovary), and follicle distribution are valuable markers for identifying polycystic ovarian morphology and enhancing the diagnostic characterization of PCOS [9; 4].

Obesity is one of the most common metabolic abnormalities associated with PCOS, although its prevalence varies considerably across different populations, ethnic groups, and geographical regions [6; 4]. Excess adiposity, especially visceral obesity, contributes to insulin resistance, compensatory hyperinsulinaemia, chronic inflammation, and increased androgen activity. These factors may worsen ovulatory dysfunction, reproductive abnormalities, and cardiometabolic complications in affected women [2; 6]. Body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, remains the most widely used anthropometric indicator for classifying overweight and obesity due to its simplicity, reproducibility, and established association with metabolic risk [10].

Despite the well-established relationship between obesity and metabolic complications in PCOS, the influence of BMI on ovarian morphology remains uncertain. Some studies have reported associations between increased adiposity and altered ovarian volume, stromal enlargement, and follicular abnormalities, whereas others have demonstrated weak or absent relationships after consideration of hormonal and metabolic factors [2; 4; 11]. These inconsistencies suggest that ovarian morphology may reflect a complex interaction between intrinsic ovarian dysfunction, endocrine abnormalities, genetic predisposition, and metabolic factors rather than adiposity alone.

Evidence regarding the relationship between BMI and ovarian morphology among African women remains limited. Available studies from Nigeria and other sub-Saharan African populations have predominantly focused on infertility, hormonal abnormalities, metabolic disturbances, and clinical manifestations of PCOS, with fewer investigations examining detailed ultrasonographic parameters such as ovarian volume, antral follicle count, and stromal thickness [12]. Considering the increasing burden of overweight and obesity among African women and potential ethnic variations in PCOS phenotype, locally generated evidence is essential for improving diagnosis, risk assessment, and individualized management strategies.

Therefore, this study aimed to evaluate the association between body mass index and ovarian morphology among Nigerian women with polycystic ovary syndrome using Transvaginal ultrasonography. Specifically, the study compared ovarian volume, antral follicle count, and stromal thickness between women with PCOS and healthy controls and assessed whether BMI was associated with these sonographic ovarian morphological parameters. The findings provide additional evidence on the relationship between obesity and ovarian structural characteristics in PCOS and may contribute to improved clinical assessment and management of the disorder among women in sub-Saharan Africa.

2. Materials and methods

2.1. Study Design and Setting

This was a prospective comparative cross-sectional study conducted at the Fertility Clinic of the Department of Obstetrics and Gynaecology, Federal Medical Centre (FMC), Onitsha, Anambra State, Nigeria, between June 2025 and May 2026. The study was designed to evaluate the association between body mass index (BMI) and ovarian morphological characteristics among women diagnosed with polycystic ovary syndrome (PCOS) compared with apparently healthy women.

2.2. Study Population

The study population comprised women of reproductive age (18–45 years) attending the Fertility Clinic during the study period. Participants were divided into two groups:

- PCOS group (Cases): Women diagnosed with PCOS according to the 2023 International Evidence-based Guideline for the Assessment and Management of Polycystic Ovary Syndrome, which requires the presence of at least two of the following after exclusion of other related disorders:
    - Clinical and/or biochemical hyperandrogenism;
    - Ovulatory dysfunction; and
    - Polycystic ovarian morphology on ultrasonography or elevated anti-Müllerian hormone (AMH) levels [4].
- Control group: Apparently healthy women without clinical, biochemical, or sonographic evidence of PCOS or other ovarian pathology.

2.3. Sample Size Determination

A total of 205 women participated in the study, comprising 105 women with PCOS and 100 healthy controls. The sample size was estimated using the Taro Yamane sample size determination formula for finite populations with a 95% confidence level and a precision level of 5% [13]. The calculated sample size was increased slightly to improve statistical power and compensate for possible incomplete data.

2.4. Sampling Technique

Participants were recruited using a consecutive sampling technique, whereby all eligible women attending the fertility clinic during the study period who met the inclusion criteria and consented to participate were enrolled until the desired sample size was achieved.

2.5. Inclusion Criteria

Women were eligible if they:

- were aged between 18 and 45 years;
- provided written informed consent;
- had a confirmed diagnosis of PCOS based on the 2023 International PCOS Guideline (case group); or
- had normal menstrual cycles with no clinical or sonographic evidence of PCOS (control group).

2.6. Exclusion Criteria

Women were excluded if they:

- were pregnant;
- had undergone previous oophorectomy or ovarian surgery;
- had ovarian cysts or pelvic masses unrelated to PCOS;
- had endocrine disorders that could mimic PCOS, including thyroid disease, congenital adrenal hyperplasia, Cushing syndrome, hyperprolactinaemia, or androgen-secreting tumours;
- were receiving hormonal therapy within the preceding three months; or
- declined participation.

2.7. Anthropometric Measurements

Body weight was measured to the nearest 0.1 kg using a calibrated Hana® digital weighing scale with participants wearing light clothing and no footwear. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer while participants stood erect in the Frankfurt plane without shoes.

Body mass index (BMI) was calculated using the World Health Organization (WHO) standard equation: BMI (kg/m^2) = Weight (kg) ÷ Height^2 (m^2)

Participants were classified according to the WHO BMI classification:

- Underweight: <18.5 kg/m^2
- Normal weight: 18.5–24.9 kg/m^2
- Overweight: 25.0–29.9 kg/m^2
- Obesity: ≥30.0 kg/m^2 (World Health Organization, 2000).

2.8. Ultrasonographic Assessment

Transvaginal ultrasonography was performed using a Mindray ultrasound system (Mindray Biomedical Electronics Co., Shenzhen, China) equipped with a 6–12 MHz endovaginal transducer. All examinations were conducted by an experienced sonographer following standardized scanning procedures to minimize inter-observer variability. Both ovaries were evaluated in longitudinal and transverse planes.

2.9. Ovarian Volume

Ovarian volume was calculated using the prolate ellipsoid formula:
Ovarian Volume = Length × Width × Thickness × 0.523
Measurements were obtained from three orthogonal diameters, and the average value of both ovaries was used for statistical analysis.

2.10. Stromal Thickness

Ovarian stromal thickness was measured at the widest stromal region on the longitudinal ovarian section using electronic callipers. Measurements were obtained twice for each ovary, and the average value was recorded.

2.11. Antral Follicle Count

The antral follicle count (AFC) was determined by counting all follicles measuring 2–9 mm in diameter within each ovary, in accordance with current international recommendations. The total AFC for both ovaries was recorded for analysis.

2.12. Quality Control

To ensure measurement reliability, the ultrasound machine was calibrated before commencement of the study. Anthropometric instruments were also calibrated periodically throughout the study period. All ultrasonographic examinations were performed by the same experienced operator using a standardized protocol to minimize measurement bias and improve reproducibility.

2.13. Data Management and Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Shapiro–Wilk test and expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

Comparisons between the PCOS and control groups were performed using the Independent Samples t-test for normally distributed continuous variables and the Chi-square test for categorical variables.

Pearson's correlation coefficient was used to determine the relationship between BMI and ovarian morphological parameters (ovarian volume, stromal thickness, and antral follicle count).

A two-tailed p-value <0.05 was considered statistically significant.

2.14. Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of the Anambra State Ministry of Health, Awka (Approval No.: MH/PRS/1244/VOL.248). Permission to conduct the study was also obtained from the management of Federal Medical Centre, Onitsha. All participants provided written informed consent before enrolment. Confidentiality was maintained by anonymizing participant information, and the study complied with the ethical principles of the Declaration of Helsinki.

3. Results

Table 1 Comparison of BMI Categories Between the Control and Test Groups

Variables	Control group, N(%)	Test group, N(%)
BMI Categories		
18-24.9(Healthy)	79(79.0)	61(58.1)
25-29.9(Overweight)	17(17.0)	21(20.0)
>30.0 (Obese)	4(4.0)	23(21.9)
Mean ± SD	23.10±3.37	25.55±3.37
Total	100(100.0)	105(100.)

The control group had a higher proportion of participants with a healthy BMI (79.0%) than the test group (58.1%). In contrast, overweight and obesity were more prevalent in the test group (20.0% and 21.9%, respectively) than in the control group (17.0% and 4.0%). Accordingly, the test group had a higher mean BMI (25.55 ± 3.37) than the control group (23.10 ± 3.37).

Table 2 Independent Samples t-Test Comparing Mean Body Mass Index (BMI) Between the Control and Test Groups

Subjects	N	Mean±SD	t-test	Df	p-value	Remark
Control group	100	23.15±3.37	-4.095	203	< .001	Sig
Cases(BMI)	105	25.56±4.87				

BMI was significantly higher in the test group (25.56 ± 4.87) than in the control group (23.15 ± 3.37), $t(203) = -4.10$, $p < .001$.

Table 3 Independent Samples t-Test Comparing Ovarian Volume, Follicle Count, and Stromal Thickness Between the Control and Test Groups

Subjects	N	Mean±SD	t-test	df	p-value	Remark
Control group	100	17.25±13.84	7.674	203	< .001	Sig
Cases(Ovarian volume)	105	6.55±3.49				
Control group	100	0.82±0.69	-8.346	203	< .001	Sig
Cases(Follicle count)	105	4.35±4.17				
Control group	100	0.71±0.26	-29.899	203	< .001	Sig
Cases(Stromal Thickness)	105	7.41±2.22				

BMI was not significantly associated with ovarian volume, follicle count, or stromal thickness in either the control group or women with PCOS (all $p > .05$).

Table 4 Correlation of BMI with Ovarian Morphological Parameters in Women with PCOS and Controls

Subjects	N	R	p-value	Remark
Control group	100	0.05	0.62	N/S
Cases(Ovarian volume)	105	-0.00	0.99	N/S
Control group	100	-0.07	0.47	N/S
Cases(Follicle count)	105	-0.01	0.92	N/S
Control group	100	-0.04	0.67	N/S
Cases(Stromal Thickness)	105	0.09	0.33	N/S

BMI was not significantly associated with ovarian morphological parameters in either the control or PCOS group (all $p > .05$).

4. Discussion

This study evaluated the association between body mass index (BMI) and ovarian morphological characteristics among Nigerian women with polycystic ovary syndrome (PCOS) using transvaginal ultrasonography. The principal findings were that women with PCOS had significantly higher BMI than healthy controls and demonstrated significantly greater ovarian volume, antral follicle count, and stromal thickness. However, BMI was not significantly correlated with any of the assessed ovarian morphological parameters among either women with PCOS or healthy controls. These findings suggest that although excess body weight is frequently observed among women with PCOS, BMI was not significantly associated with ovarian structural abnormalities in this study.

Women with PCOS in the present study had significantly higher mean BMI than healthy controls, with a greater proportion classified as overweight or obese. This observation agrees with recent evidence showing that overweight and obesity are common among women with PCOS, although prevalence varies according to ethnicity, geographical location, lifestyle factors, and diagnostic criteria applied [6; 14]. Excess adiposity contributes to the pathophysiology of PCOS through mechanisms involving insulin resistance, compensatory hyperinsulinaemia, chronic inflammation, altered adipokine activity, and increased androgen biosynthesis, which collectively worsen ovulatory dysfunction and cardiometabolic risk [15; 16]. Although obesity is not included among the diagnostic criteria for PCOS, routine assessment of anthropometric and metabolic parameters is recommended because excess adiposity influences disease severity and long-term health outcomes [4].

Women with normal BMI may present with classical PCOS-related ovarian changes, while obese women may not necessarily demonstrate more severe ovarian structural abnormalities [4]; 8]. Increased ovarian size in PCOS reflects underlying alterations in follicular development, stromal expansion, and abnormal ovarian steroidogenesis associated with disrupted folliculogenesis [2]. The present findings therefore reinforce the clinical value of standardized transvaginal ultrasonography in identifying ovarian morphological abnormalities among women undergoing evaluation for PCOS.

The significantly higher antral follicle count observed among women with PCOS is consistent with contemporary evidence identifying increased follicle number as a major sonographic feature of polycystic ovarian morphology [17; 4]. Excess accumulation of small antral follicles in PCOS results from impaired follicular maturation caused by abnormalities in androgen signalling, gonadotropin regulation, and metabolic disturbances such as insulin resistance [14; 2]. Consequently, antral follicle count remains an important marker for improving diagnostic characterization and assessing ovarian morphology among reproductive-aged women with PCOS [17].

Similarly, ovarian stromal thickness was significantly greater among women with PCOS compared with controls. Increased stromal tissue in PCOS has been linked to stromal hypertrophy, enhanced theca cell activity, and increased androgen production, which contribute to the endocrine abnormalities characteristic of the syndrome [2; 16]. Recent studies indicate that stromal morphology may provide additional information regarding ovarian dysfunction and hyperandrogenic features among affected women, although its clinical application remains dependent on standardized imaging protocols [18]. The findings of this study therefore support the inclusion of ovarian stromal assessment as part of comprehensive ultrasonographic evaluation in women with PCOS.

Despite significant differences in ovarian morphology between women with PCOS and healthy controls, BMI was not significantly correlated with ovarian volume, antral follicle count, or stromal thickness in either group. This finding

suggests that generalized adiposity alone was not associated with ovarian structural abnormalities in this study. Instead, ovarian morphology in PCOS likely reflects complex interactions involving intrinsic ovarian dysfunction, genetic predisposition, hormonal abnormalities, and local ovarian regulatory pathways [2; 15]. Previous studies have similarly reported inconsistent associations between BMI and ovarian morphology, suggesting that obesity may influence the metabolic phenotype of PCOS more strongly than its structural ovarian characteristics [6; 15]. Therefore, BMI was not found to be a surrogate marker for predicting ovarian morphological severity in women with PCOS in this study.

From a clinical perspective, these findings emphasize the importance of comprehensive assessment of women with suspected PCOS. Although BMI remains useful for identifying metabolic and cardiovascular risks, it cannot replace detailed ultrasonographic evaluation of ovarian morphology. Women with normal BMI may present with classical PCOS-related ovarian changes, while obese women may not necessarily demonstrate more severe ovarian structural abnormalities [4]. Therefore, accurate diagnosis and management should integrate clinical features, biochemical evaluation, anthropometric assessment, and standardized transvaginal ultrasonography.

The findings also have important environmental health implications. The increasing global prevalence of overweight and obesity has been associated with obesogenic environments characterized by increased consumption of energy-dense processed foods, reduced physical activity opportunities, sedentary behaviour, urbanization, and socioeconomic transitions [19; 20]. These environmental determinants contribute substantially to obesity among women of reproductive age and may indirectly worsen metabolic complications associated with PCOS, even when they do not directly influence ovarian morphology [15]. Consequently, environmental health strategies promoting healthier food systems, active transportation, supportive urban environments, workplace wellness programmes, and community-based obesity prevention initiatives may help address obesity-related metabolic complications associated with PCOS

Emerging evidence further suggests that exposure to endocrine-disrupting chemicals (EDCs), including bisphenol A (BPA), phthalates, per- and polyfluoroalkyl substances (PFAS), and other persistent environmental contaminants, may contribute to reproductive endocrine disruption, altered insulin sensitivity, obesity, and metabolic dysfunction [21]. Although environmental chemical exposures were not evaluated in this study, future research should investigate potential interactions between environmental exposures, obesity, endocrine abnormalities, and ovarian morphology among African women with PCOS. Such multidisciplinary investigations may improve understanding of environmental determinants of PCOS and support preventive environmental health strategies.

The strengths of this study include the use of high-resolution transvaginal ultrasonography, inclusion of a healthy comparison group, standardized anthropometric measurements, and assessment of ovarian characteristics using contemporary diagnostic principles [4; 17]. However, the study has some limitations. The single-centre design may limit generalizability, while the cross-sectional nature prevents determination of causal relationships between BMI and ovarian morphology [22]. Additionally, biochemical parameters such as insulin resistance indices, androgen profiles, anti-Müllerian hormone levels, body composition measurements, dietary factors, physical activity patterns, and environmental exposure markers were not assessed. Future multicentre longitudinal studies incorporating metabolic, endocrine, environmental, and genetic determinants are recommended.

Overall, this study demonstrates that Nigerian women with PCOS have significantly higher BMI and more pronounced ovarian morphological abnormalities compared with healthy women. However, BMI was not independently associated with ovarian volume, antral follicle count, or stromal thickness, suggesting that obesity contributes more strongly to the metabolic phenotype of PCOS than to structural ovarian changes. These findings support the continued integration of anthropometric assessment, biochemical evaluation, and high-quality transvaginal ultrasonography in PCOS diagnosis and management while emphasizing lifestyle modification and environmental health interventions to reduce obesity-related reproductive and metabolic complications.

5. Conclusion

This study demonstrated that Nigerian women with polycystic ovary syndrome (PCOS) had significantly higher body mass index (BMI), ovarian volume, antral follicle count, and stromal thickness than apparently healthy women. These findings indicate that excess weight is frequently associated with PCOS and that ovarian morphological abnormalities identified through ultrasonography remain important features in characterizing the syndrome. However, despite the significantly higher BMI observed among women with PCOS, no statistically significant association was found between BMI and ovarian volume, antral follicle count, or stromal thickness. This suggests that although obesity contributes substantially to the metabolic and cardiometabolic burden associated with PCOS, generalized adiposity alone may not reliably predict ovarian structural changes. Therefore, evaluation of ovarian morphology should continue to rely on

standardized transvaginal ultrasonography integrated with clinical and biochemical assessment rather than anthropometric indices alone, as recommended in current international PCOS diagnostic guidelines.

The findings highlight the importance of routine anthropometric assessment and comprehensive metabolic evaluation among women with PCOS, given the high prevalence of overweight and obesity and their association with insulin resistance, dyslipidaemia, impaired glucose metabolism, cardiovascular risk, and adverse reproductive outcomes. Lifestyle interventions involving improved dietary quality, increased physical activity, weight management, and behavioural modification should remain central components of PCOS management because they improve metabolic health and overall wellbeing, even when changes in ovarian morphology are limited [24]. International PCOS Network, 2023). Furthermore, multidisciplinary care involving gynaecologists, endocrinologists, radiologists, nutritionists, physiotherapists, and public health professionals is essential for addressing the complex reproductive, metabolic, and psychosocial consequences of PCOS.

From an environmental health perspective, these findings emphasize the need for population-based interventions that address environmental drivers of obesity, including unhealthy food environments, sedentary lifestyles, reduced opportunities for physical activity, and urban environments that discourage active living. Such interventions are increasingly recognized as important strategies for preventing obesity and related non-communicable diseases among women of reproductive age. In addition, emerging evidence indicates that environmental exposures, particularly endocrine-disrupting chemicals (EDCs), may influence reproductive hormone regulation, insulin sensitivity, adiposity, and metabolic dysfunction, potentially contributing to the complex pathophysiology of disorders such as PCOS. Future multicentre longitudinal studies incorporating hormonal profiles, metabolic biomarkers, body composition measurements, lifestyle factors, and environmental exposure assessments are therefore needed to better elucidate the interactions between obesity, ovarian morphology, endocrine dysfunction, and environmental determinants among African women with PCOS.

Overall, this study provides important evidence on the relationship between BMI and ovarian morphology among Nigerian women with PCOS. Although obesity was more common among women with PCOS and was associated with increased metabolic risk, ovarian morphological abnormalities were not significantly associated with BMI in this study. These findings support the continued use of standardized transvaginal ultrasonography as an essential diagnostic tool while emphasizing integrated clinical management, lifestyle modification, and environmental health interventions to reduce the long-term reproductive and metabolic consequences of PCOS.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest whatsoever in the course of this research.

Statement of Ethical approval

Ethical approval was obtained from the Health Research Ethics Committee of the Anambra State Ministry of Health, Awka (Approval No.: MH/PRS/1244/VOL.248)

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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