

Menstrual Phase–Classified Ovarian Morphometry and Ultrasound Findings Among Nigerian University Students: A Cross-Sectional Study

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Abstract

Background

Ovarian morphometry and ultrasound-detected ovarian findings are relevant to reproductive health assessment, but data from young women in sub-Saharan Africa remain limited. This study assessed ovarian volume, ovarian asymmetry, and selected ultrasound-detected ovarian findings across calendar-estimated menstrual phases among reproductive-aged female Nigerian University Students.

Methods

This cross-sectional analytical study included reproductive-aged female students who reported menstruation within the preceding 12 months, had a valid menstrual phase assigned at ultrasound assessment, and had ovarian ultrasound information available. Transabdominal ultrasonography was used to assess ovarian volume and selected ovarian findings, including ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, follicles, and dominant follicles. Menstrual phase was classified using self-reported last menstrual period and a single ultrasound scan. Ovarian morphometric parameters were compared across menstrual phases using Kruskal–Wallis tests, with pairwise Mann–Whitney U tests and Holm correction. Prevalence estimates were calculated using Wilson 95% confidence intervals. Log-linear regression models estimated percentage differences in mean ovarian volume.

Results

A total of 235 participants were included in the ovarian ultrasound analytic cohort. Among these, 193 had at least one valid ovarian volume measurement, and 152 had valid bilateral ovarian volume measurements. Mean ovarian volume was $13.19 \pm 6.76 \text{ cm}^3$. Right ovarian volume differed across menstrual phases ($p = 0.043$), while left ovarian volume did not ($p = 0.181$). The Kruskal–Wallis test for mean ovarian volume yielded $p = 0.068$. In the primary adjusted model, follicular-phase assessment was associated with higher mean ovarian volume compared with luteal-phase assessment (95% CI: 1.2 to 76.6; $p = 0.041$). Ovarian cysts were identified in 25/153 participants (16.3%; 95% CI: 11.3–23.0), PCOS-related ultrasound features in 17/159 participants (10.7%; 95% CI: 6.8–16.5), and pouch of Douglas fluid in 148/235 participants (63.0%; 95% CI: 56.6–68.9). Most exploratory associations between ovarian findings and participant characteristics were not statistically significant.

Conclusions

Among reproductive-aged female university students in Nigeria, ovarian volume showed modest variation across calendar-estimated menstrual phases, while several ultrasound-detected ovarian

findings were common. These findings provide descriptive ovarian ultrasound data from an understudied population and support further longitudinal studies using hormonally confirmed menstrual phase classification.

Introduction

The menstrual cycle is increasingly recognized as an informative marker of reproductive and general health across the life course. Contemporary reviews describe menstrual cycle characteristics as clinically relevant indicators that may reflect gynecological, endocrine, metabolic, environmental, and psychosocial influences on health [1]. In reproductive-aged women, menstrual regularity and ovulatory function are also central to the clinical interpretation of reproductive health, with the FIGO ovulatory disorders classification system providing a contemporary framework for describing ovulatory dysfunction and its diverse causes [2]. For young women, however, menstrual cycle variation may coexist with physiological ovarian events, including follicular recruitment, dominant follicle development, ovulation, and corpus luteum formation. Distinguishing physiological sonographic findings from potentially clinically relevant abnormalities is therefore important, particularly in settings where ultrasound-based ovarian data are limited.

Ovarian morphometry is widely used in gynecological imaging and reproductive assessment. Ovarian volume varies across the life course, increasing through childhood and adolescence, reaching its highest values in early adulthood, and declining with advancing reproductive age [3]. It may also vary across the menstrual cycle in relation to dominant follicle growth, follicular rupture, and corpus luteum development [4]. Contemporary systematic review evidence on physiological ovarian ultrasound features further demonstrates that ovarian volume and follicle-related parameters are influenced by age, imaging approach, and study population characteristics [5]. These considerations are important when interpreting ovarian measurements among young reproductive-aged women.

Ultrasound may also detect ovarian and pelvic findings such as follicles, dominant follicles, ovarian cysts, polycystic ovarian morphology, and free fluid in the pouch of Douglas. Many of these findings may be physiological or incidental in premenopausal women. The Society of Radiologists in Ultrasound consensus update emphasizes that many small, well-characterized simple adnexal cysts in premenopausal women are clinically inconsequential and do not require follow-up imaging unless size or imaging features justify surveillance [6]. Similarly, small-volume free fluid in the pouch of Douglas may occur in healthy reproductive-aged women, although the evidence base for normal cyclic pelvic fluid remains limited and includes older ultrasound studies [7]. Conversely, polycystic ovarian morphology requires careful interpretation. The 2023 International Evidence-based Guideline for the Assessment and Management of Polycystic Ovary Syndrome emphasize structured diagnostic assessment and cautions against equating isolated ultrasound morphology with a clinical diagnosis of PCOS when ovulatory and androgen-status data are incomplete [8].

Despite the clinical relevance of ovarian morphometry and ultrasound-detected ovarian findings, context-specific data from young women in sub-Saharan Africa remain limited. Available Nigerian data on ovarian volume are largely derived from hospital-based or clinically selected populations rather than community-based student cohorts [9]. University students constitute an important population for reproductive health research because they are generally in early reproductive life and may experience menstrual symptoms, cycle irregularity, stress exposure, and changing lifestyle patterns. Generating ultrasound-based ovarian data from this population may improve understanding of the distribution of ovarian morphometry and common ovarian findings in young African women.

This study aimed to characterize ovarian morphometry and ultrasound-detected ovarian findings among reproductive-aged female university students in Nigeria. Specifically, it assessed right, left, and mean ovarian volume across menstrual phases; quantified right–left ovarian volume correlation and ovarian asymmetry; estimated the prevalence of ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, dominant follicles, and follicles; and explored associations between selected ovarian findings and menstrual, biodemographic, and reproductive-health characteristics. We hypothesized that ovarian morphometric parameters would differ modestly across calendar-estimated menstrual phases, while ultrasound-detected ovarian findings would show limited associations with menstrual or biodemographic characteristics in this young community-based cohort.

Methods

Study design and setting

This study was a cross-sectional analytical study with an exploratory component, conducted among reproductive-aged female students at the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria. The present study was derived from a larger ultrasound and menstrual health assessment project designed to evaluate menstrual characteristics and abdominopelvic ultrasound parameters among female students [10]. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.

Study population and eligibility criteria

The source population comprised female students aged 15–49 years who had attained menarche and were enrolled within the College of Health Sciences. Participants were recruited across academic programmes within the College and were eligible for the study if they provided informed consent and were willing to complete the study questionnaire and undergo ultrasound assessment.

For the present ovarian ultrasound analysis, a population-based analytical framework was adopted rather than a restricted healthy-volunteer framework. Participants were eligible for inclusion in the full ovarian analytic cohort if they had consented to participate, reported menstruation within the preceding

12 months, had a valid menstrual phase assigned at the time of ultrasound assessment, and had ovarian ultrasound information available. Participants without a valid menstrual phase classification or without ovarian ultrasound evidence were excluded from the present analysis.

A total of 347 participants were enrolled in the parent project. Of these, 330 reported menstruations within the preceding 12 months. After exclusion of participants without a valid menstrual phase assignment, 235 participants were included in the full ovarian ultrasound analytic cohort. Among these, 193 participants had at least one valid ovarian volume measurement and were included in the ovarian morphometry subcohort. Participants with valid right and left ovarian volume measurements were included in the bilateral morphometry subcohort for ovarian asymmetry analysis. A reference morphometry subcohort was also defined for sensitivity analysis and comprised participants in the morphometry subcohort who reported no contraceptive use in the preceding year, no previous pregnancy, no reproductive surgery, no prior diagnosis of polycystic ovary syndrome, and no prior diagnosis of ovarian cyst.

Data collection and study variables

Data were collected using a structured, pretested online questionnaire administered through Google Forms (<https://forms.gle/cgmumPbWtmNdxmjk9>). The questionnaire captured sociodemographic characteristics, menstrual history, menstrual symptoms, lifestyle factors, reproductive history, and prior gynecological diagnoses. Variables extracted for the present analysis included age group, age at menarche, menstrual cycle regularity, menstrual cycle length, menstrual flow duration, menstrual symptoms, contraceptive use in the preceding year, smoking, alcohol consumption, exercise level, perceived stress level, history of pregnancy, history of reproductive surgery, prior diagnosis of polycystic ovary syndrome, and prior diagnosis of ovarian cyst.

Menstrual cycle regularity was based on participants' self-reported consistency of menstrual cycles over the preceding 12 months and categorized as regular or irregular. Menarcheal age was analyzed as a continuous variable and categorized into normative and non-normative menarcheal timing. Normative menarcheal timing was defined as menarche between 11 and 15 years, while early menarche (≤ 10 years) and later menarche (≥ 16 years) were combined as non-normative menarcheal timing for exploratory analyses because of the small number of participants in these categories.

Menstrual symptoms were recorded as binary symptom indicators and summarized as a symptom burden count by summing the number of reported symptoms. Lifestyle variables included smoking status, alcohol use, exercise level, and stress level. Exercise level was categorized as low exercise for participants reporting never or rarely exercising, and higher exercise for those reporting occasional or regular exercise. Stress level was categorized as low, moderate, or high based on self-report.

Anthropometric measurements

Height and weight were measured using standardized procedures. Height was measured to the nearest 0.1 cm using a stadiometer, with participants standing upright without footwear. Weight was measured to the nearest 0.1 kg using a calibrated digital scale. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. BMI was classified according to World Health Organization categories as underweight ($< 18.5 \text{ kg/m}^2$), normal weight ($18.5\text{--}24.9 \text{ kg/m}^2$), overweight ($25.0\text{--}29.9 \text{ kg/m}^2$), or obese ($\geq 30.0 \text{ kg/m}^2$).

Menstrual phase classification

Menstrual phase at the time of ultrasound assessment was primarily estimated using each participant's self-reported last menstrual period (LMP) and expected cycle timing. Where available, the assigned phase was assessed for consistency with corresponding uterine and ovarian ultrasound features, including endometrial appearance, follicular development, dominant follicle or corpus luteum features, and pouch of Douglas fluid. Participants were classified into four calendar-estimated menstrual phases based on self-reported LMP: menstruation, follicular phase, ovulation, and luteal phase. Menstruation corresponded to cycle days 1–5, the follicular phase to days 6–12, ovulation to days 13–15, and the luteal phase to days 16–28. Records with missing, invalid, or non-informative menstrual phase entries were excluded from the present analysis. Because menstrual phase was not confirmed by serial ultrasonography or hormonal assays, phase classification was treated as calendar estimated. This calendar-based approach provides an approximation of menstrual phase and does not account for inter-individual variation in ovulation timing; therefore, misclassification of the ovulatory window is likely.

Ultrasound assessment and ovarian outcome measures

Abdominopelvic ultrasonography was performed using a transabdominal approach with a 3.5–5.0 MHz curvilinear transducer on a GE Logiq V2 ultrasound machine. Participants were examined in the supine position. A full bladder was required to optimize the acoustic window for pelvic visualization, and participants were supported with on-site water intake when necessary. Ultrasound examinations were performed by a trained and experienced sonographer using a standardized scanning approach to reduce measurement variability.

Ovarian assessment included documentation of ovarian visualization status, right and left ovarian volume where measurable, follicles, dominant follicle, ovarian cysts, PCOS-related ultrasound features, and pouch of Douglas fluid. Ovarian volume was recorded in cubic centimetres as documented during ultrasound assessment. Mean ovarian volume was calculated as the average of available valid right and left ovarian volume measurements; participants with at least one valid ovarian volume measurement contributed to mean ovarian volume analyses. Absolute ovarian asymmetry was calculated as the absolute difference between right and left ovarian volume and was restricted to participants with valid bilateral ovarian volume measurements.

Ovarian cysts were analyzed as binary sonographer-recorded ultrasound findings. Entries describing simple cysts, complex cysts, side-specific cysts, or equivalent positive cyst descriptions were coded as ovarian cyst present. Dominant follicle and follicles were analyzed as sonographer-recorded binary findings based on the ultrasound record. PCOS-related ultrasound feature was coded as present when the ultrasound record indicated PCOS-related or polycystic ovarian morphology. This variable was treated strictly as an ultrasound feature and not as a clinical diagnosis of polycystic ovary syndrome, because biochemical hyperandrogenism, clinical hyperandrogenism, and formal ovulatory dysfunction criteria were not comprehensively assessed. Pouch of Douglas fluid was coded as present when the ultrasound record indicated fluid, minimal fluid, or equivalent positive documentation.

Data cleaning and quality control

The dataset was reviewed and cleaned before statistical analysis. Menstrual phase entries were standardized into menstruation, follicular, ovulation, and luteal phase categories. Non-informative entries such as blank responses or “no” were treated as missing for menstrual phase. Ovarian visualization entries were standardized to indicate both ovaries visualized, right ovary only, left ovary only, or no ovary visualized.

Ovarian volume variables were cleaned by converting numeric entries to continuous values and treating text entries such as “no,” “not visualized,” “not seen,” or similar non-numeric entries as missing for morphometric analysis. Non-visualized ovaries were treated as missing for ovarian volume rather than assigned a value of zero. Grossly implausible ovarian volume values were removed before analysis. Specifically, non-positive values and values greater than 60 cm³ were considered physiologically implausible for this study population and set to missing. High but plausible ovarian volume values were retained in the primary analysis and flagged for sensitivity review.

Categorical ovarian findings were harmonized by recoding synonymous or side-specific entries into binary variables. For prevalence analyses, variable-specific denominators were used because not all ultrasound findings were assessable in every participant. Missing or non-assessable entries were not counted as negative findings unless the source record clearly indicated absence of the finding.

Statistical analysis

All statistical analyses were conducted using Python version 3.10. Data preprocessing and management were performed using pandas and numpy. Descriptive and inferential analyses were conducted using scipy and statsmodels, while figures were generated using matplotlib.

Participant characteristics were summarized using frequencies and percentages for categorical variables and mean $\pm$ standard deviation for continuous variables. Baseline characteristics were presented overall and by menstrual phase. Denominators were reported as valid denominators where data were missing or non-classifiable.

Ovarian morphometric variables, including right ovarian volume, left ovarian volume, mean ovarian volume, and absolute ovarian asymmetry, were summarized using mean $\pm$ standard deviation and median with interquartile range. Because ovarian volume distributions were non-normal and group sizes were unequal across menstrual phases, Kruskal–Wallis tests were used to compare ovarian morphometric parameters across menstrual phases. When omnibus tests were performed, pairwise Mann–Whitney U tests were used for phase comparisons, with Holm correction applied to account for multiple testing. Effect sizes for non-parametric comparisons were summarized using rank-based measures where appropriate.

Right–left ovarian volume relationships were evaluated among participants with valid bilateral ovarian measurements. Pearson correlation was used to assess linear correlation, while Spearman correlation was used to assess monotonic correlation.

The prevalence of ultrasound-detected ovarian findings was estimated using variable-specific valid denominators. Prevalence estimates were reported as percentages with Wilson 95% confidence intervals. Ovarian findings included ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, dominant follicles, and follicles.

Exploratory associations between ovarian ultrasound findings and participant characteristics were assessed using Fisher’s exact test for two-level categorical comparisons and chi-square tests for comparisons involving more than two categories. Exposures examined included menstrual phase, menstrual cycle regularity, BMI category, menarcheal timing, and contraceptive use. Because several ovarian findings had sparse cell counts, these analyses were interpreted as exploratory.

An exploratory logistic regression model was fitted to evaluate the association between menstrual cycle regularity and PCOS-related ultrasound features, with adjustment for age and BMI. Results were reported as odds ratios with 95% confidence intervals and p-values.

Mean ovarian volume was right-skewed and was therefore analyzed using log-linear regression models. The luteal phase was used as the reference category for menstrual phase comparisons. An unadjusted phase model estimated the percentage difference in mean ovarian volume by menstrual phase. The primary adjusted model included menstrual phase, age, BMI, menstrual cycle regularity, contraceptive use in the preceding year, and menarcheal age. Model coefficients were exponentiated and presented as percentage differences in mean ovarian volume with 95% confidence intervals. Robust standard errors were used for regression estimates. A sensitivity analysis was conducted in the reference morphometry subcohort to evaluate the consistency of phase-related findings in participants without prior pregnancy, contraceptive use, reproductive surgery, prior PCOS diagnosis, or prior ovarian cyst diagnosis.

All statistical tests were two-sided. A p-value less than 0.05 was considered statistically significant, although emphasis was placed on effect sizes, confidence intervals, and consistency across analyses rather than p-values alone.

Results

Analytic cohort and participant characteristics

A total of 235 participants were included in the ovarian ultrasound analytic cohort. Among these, 193 participants had at least one valid ovarian volume measurement and were included in the ovarian morphometry subcohort, while 152 participants had valid bilateral ovarian volume measurements and were included in analyses of ovarian asymmetry. The menstrual phase distribution in the analytic cohort was as follows: luteal phase, 136/235 (57.9%); menstruation, 51/235 (21.7%); ovulation, 34/235 (14.5%); and follicular phase, 14/235 (6.0%).

Baseline characteristics of participants by menstrual phase are presented in Table 1. Overall, 111/235 (47.2%) participants were aged 16–20 years, 112/235 (47.7%) were aged 21–25 years, and 12/235 (5.1%) were aged 26–30 years. Among participants with valid BMI classification, 159/226 (70.4%) had normal BMI, 34/226 (15.0%) were overweight, and 16/226 (7.1%) were obese. Regular menstrual cycles were reported by 139/235 (59.1%) participants, while 96/235 (40.9%) reported irregular cycles. Normative menarcheal timing was reported by 191/225 (84.9%) participants, while 34/225 (15.1%) had non-normative menarcheal timing. Contraceptive use within the preceding year was reported by 57/235 (24.3%) participants. The overall mean age was 20.89 ± 2.95 years, while the mean menarcheal age was 13.22 ± 1.79 years.

Table 1
Baseline characteristics of participants by menstrual phase

Characteristic	Overall	Menstruation	Follicular	Ovulation	Luteal
Participants, n	235	51	14	34	136
Age 16–20 years	111/235 (47.2)	21/51 (41.2)	8/14 (57.1)	18/34 (52.9)	64/136 (47.1)
Age 21–25 years	112/235 (47.7)	27/51 (52.9)	6/14 (42.9)	14/34 (41.2)	65/136 (47.8)
Age 26–30 years	12/235 (5.1)	3/51 (5.9)	0/14 (0.0)	2/34 (5.9)	7/136 (5.1)
Normal BMI	159/226 (70.4)	35/46 (76.1)	10/14 (71.4)	18/31 (58.1)	96/135 (71.1)
Overweight	34/226 (15.0)	6/46 (13.0)	2/14 (14.3)	6/31 (19.4)	20/135 (14.8)
Obese	16/226 (7.1)	2/46 (4.3)	1/14 (7.1)	3/31 (9.7)	10/135 (7.4)
Regular menstrual cycle	139/235 (59.1)	29/51 (56.9)	8/14 (57.1)	20/34 (58.8)	82/136 (60.3)
Non-normative menarcheal timing	34/225 (15.1)	10/49 (20.4)	1/13 (7.7)	6/32 (18.8)	17/131 (13.0)
Contraceptive use in last year	57/235 (24.3)	13/51 (25.5)	1/14 (7.1)	11/34 (32.4)	32/136 (23.5)
Low exercise level	130/235 (55.3)	34/51 (66.7)	4/14 (28.6)	20/34 (58.8)	72/136 (52.9)
High stress level	48/235 (20.4)	12/51 (23.5)	4/14 (28.6)	8/34 (23.5)	24/136 (17.6)
Age, years, mean $\pm$ SD	20.89 $\pm$ 2.95	21.24 $\pm$ 2.97	20.14 $\pm$ 2.57	20.65 $\pm$ 3.07	20.90 $\pm$ 2.95
Menarcheal age, years, mean $\pm$ SD	13.22 $\pm$ 1.79	12.76 $\pm$ 2.07	13.15 $\pm$ 1.52	13.59 $\pm$ 1.66	13.31 $\pm$ 1.72
Symptom burden, mean $\pm$ SD	8.50 $\pm$ 3.54	8.53 $\pm$ 3.80	8.86 $\pm$ 3.13	8.29 $\pm$ 3.25	8.51 $\pm$ 3.57

Data are presented as n/valid denominator (%) for categorical variables and mean $\pm$ standard deviation for continuous variables. Menstrual phase was classified as menstruation, follicular, ovulation, or luteal phase based on self-reported last menstrual period. Denominators vary across variables because of missing or non-classifiable responses. BMI, body mass index.

Ovarian morphometry by menstrual phase

Ovarian morphometric parameters by menstrual phase are shown in Fig. 1. The mean right ovarian volume was $12.83 \pm 6.80 \text{ cm}^3$, with a median of 11.20 cm^3 [interquartile range (IQR): 8.23–15.62]. The mean left ovarian volume was $12.35 \pm 6.91 \text{ cm}^3$, with a median of 10.10 cm^3 [IQR: 7.80–15.00]. The mean ovarian volume was $13.19 \pm 6.76 \text{ cm}^3$, with a median of 11.55 cm^3 [IQR: 8.40–16.50]. Among participants with bilateral ovarian volume measurements, the median absolute ovarian asymmetry was 1.30 cm^3 [IQR: 0.90–3.00].

Right ovarian volume differed across menstrual phases on Kruskal–Wallis testing ($H = 8.137$, $p = 0.043$). The median right ovarian volume was 11.20 cm^3 [IQR: 7.50–14.93] during menstruation, 17.75 cm^3 [IQR: 10.00–20.62] in the follicular phase, 8.55 cm^3 [IQR: 6.58–14.00] during ovulation, and 11.55 cm^3 [IQR: 8.50–16.00] in the luteal phase. Left ovarian volume did not differ significantly across menstrual phases ($H = 4.874$, $p = 0.181$). Median left ovarian volume was 10.00 cm^3 [IQR: 7.30–12.80] during menstruation, 13.00 cm^3 [IQR: 9.10–17.00] in the follicular phase, 9.10 cm^3 [IQR: 7.40–13.50] during ovulation, and 11.05 cm^3 [IQR: 8.20–15.25] in the luteal phase.

Mean ovarian volume showed a borderline difference across menstrual phases ($H = 7.127$, $p = 0.068$). Median mean ovarian volume was 11.55 cm^3 [IQR: 7.80–15.00] during menstruation, 17.00 cm^3 [IQR: 10.70–20.50] in the follicular phase, 9.70 cm^3 [IQR: 7.35–14.81] during ovulation, and 11.75 cm^3 [IQR: 8.70–16.50] in the luteal phase. Absolute ovarian asymmetry also showed a borderline difference across menstrual phases ($H = 7.706$, $p = 0.053$). Pairwise phase comparisons using Mann–Whitney U tests did not remain statistically significant after Holm correction for multiple comparisons.

Right–left ovarian volume correlation and ovarian asymmetry

Among participants with valid bilateral ovarian volume measurements ($n = 152$), right and left ovarian volumes were positively correlated. The Spearman correlation coefficient was 0.721 ($p < 0.001$), while the Pearson correlation coefficient was 0.423 ($p < 0.001$). The mean absolute ovarian asymmetry was $3.35 \pm 5.74 \text{ cm}^3$, and the median absolute ovarian asymmetry was 1.30 cm^3 [IQR: 0.90–3.00].

Boxplots showing the distribution of ovarian morphometric parameters across menstrual phases. Panel A shows right ovarian volume, Panel B shows left ovarian volume, Panel C shows mean ovarian volume, and Panel D shows absolute ovarian asymmetry. Boxes represent the interquartile range, horizontal lines indicate medians, whiskers extend to values within 1.5 times the interquartile range, and points represent participant-level observations. Mean values are indicated by marker symbols within each boxplot. Menstrual phase was classified using self-reported LMP and a single ultrasound scan. Sample sizes differ between panels because of missing or non-visualized ovarian measurements.

Prevalence of ultrasound-detected ovarian findings

The prevalence of ultrasound-detected ovarian findings is presented in Fig. 2. Ovarian cysts were identified in 25/153 participants with valid cyst assessment, corresponding to a prevalence of 16.3% (95% CI: 11.3–23.0). PCOS-related ultrasound features were present in 17/159 participants with valid

assessment, corresponding to a prevalence of 10.7% (95% CI: 6.8–16.5). Pouch of Douglas fluid was observed in 148/235 participants, corresponding to a prevalence of 63.0% (95% CI: 56.6–68.9). Dominant follicles were documented in 185/216 participants, corresponding to a prevalence of 85.6% (95% CI: 80.3–89.7), while follicles were present in 196/216 participants, corresponding to a prevalence of 90.7% (95% CI: 86.1–93.9).

When stratified by menstrual phase, ovarian cysts were observed in 5/30 (16.7%) participants assessed during menstruation, 0/11 (0.0%) in the follicular phase, 5/20 (25.0%) during ovulation, and 15/92 (16.3%) in the luteal phase. PCOS-related ultrasound features were observed in 4/32 (12.5%) participants assessed during menstruation, 0/11 (0.0%) in the follicular phase, 2/18 (11.1%) during ovulation, and 11/98 (11.2%) in the luteal phase. Pouch of Douglas fluid was observed in 32/51 (62.7%) participants during menstruation, 9/14 (64.3%) in the follicular phase, 22/34 (64.7%) during ovulation, and 85/136 (62.5%) in the luteal phase.

Bar chart showing the prevalence of ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, dominant follicles, and follicles among participants with valid ultrasound assessments. Error bars represent Wilson 95% confidence intervals. Prevalence estimates were calculated using variable-specific denominators because not all ovarian findings were assessable in every participant. Valid denominators were 153 for ovarian cysts, 159 for PCOS-related ultrasound features, 235 for pouch of Douglas fluid, and 216 for dominant follicle and follicles. PCOS, polycystic ovary syndrome.

Exploratory associations between ovarian findings and participant characteristics

Exploratory associations between selected ovarian findings and participant characteristics are presented in Supplementary Table 1. Ovarian cyst prevalence did not differ significantly by menstrual phase ($p = 0.355$), cycle regularity ($p = 0.505$), BMI category ($p = 0.197$), menarcheal timing ($p = 0.543$), or contraceptive use ($p = 0.117$). PCOS-related ultrasound features did not differ significantly by menstrual phase ($p = 0.692$), BMI category ($p = 0.279$), menarcheal timing ($p = 0.500$), or contraceptive use ($p = 1.000$). The association between PCOS-related ultrasound features and cycle regularity had a p -value of 0.077. Pouch of Douglas fluid did not differ significantly by menstrual phase ($p = 0.995$), cycle regularity ($p = 0.683$), BMI category ($p = 0.625$), menarcheal timing ($p = 0.700$), or contraceptive use ($p = 1.000$). Dominant follicle detection did not differ significantly by menstrual phase ($p = 0.326$), cycle regularity ($p = 0.480$), BMI category ($p = 0.228$), menarcheal timing ($p = 0.396$), or contraceptive use ($p = 0.309$).

In an exploratory logistic regression model adjusted for age and BMI, the estimated odds ratio for PCOS-related ultrasound features among participants with irregular compared with regular menstrual cycles was 2.82 (95% CI: 0.93–8.49; $p = 0.066$).

Adjusted models for mean ovarian volume

Adjusted percentage differences in mean ovarian volume are shown in Fig. 3. In the unadjusted phase model, follicular-phase assessment was associated with a 31.3% higher mean ovarian volume compared

with luteal-phase assessment (95% CI: -0.9 to 73.8; $p = 0.058$). Menstruation was associated with a - 3.1% difference compared with the luteal phase (95% CI: -17.7 to 14.1; $p = 0.706$), while ovulation was associated with a - 12.6% difference compared with the luteal phase (95% CI: -28.1 to 6.4; $p = 0.179$).

In the primary adjusted model, follicular-phase assessment was associated with a 33.7% higher mean ovarian volume compared with luteal-phase assessment (95% CI: 1.2 to 76.6; $p = 0.041$). Menstruation was associated with a - 0.6% difference compared with the luteal phase (95% CI: -16.4 to 18.2; $p = 0.945$), while ovulation was associated with a - 15.5% difference compared with the luteal phase (95% CI: -32.3 to 5.5; $p = 0.137$). Irregular cycle was associated with a - 6.8% difference compared with regular cycle (95% CI: -20.7 to 9.5; $p = 0.392$), contraceptive use was associated with an 8.2% difference compared with no contraceptive use (95% CI: -11.4 to 32.0; $p = 0.442$), and each one-year increase in menarcheal age was associated with a - 1.6% difference in mean ovarian volume (95% CI: -5.7 to 2.7; $p = 0.466$).

In the reference morphometry sensitivity model, follicular-phase assessment was associated with a 47.0% higher mean ovarian volume compared with luteal-phase assessment (95% CI: 10.0 to 96.5; $p = 0.009$). Menstruation was associated with a - 8.3% difference compared with the luteal phase (95% CI: -26.8 to 14.9; $p = 0.453$), while ovulation was associated with a - 6.8% difference compared with the luteal phase (95% CI: -27.7 to 20.1; $p = 0.586$). In the same model, each 1 kg/m² increase in BMI was associated with a 2.8% higher mean ovarian volume (95% CI: 0.3 to 5.4; $p = 0.026$).

Forest plot shows percentage differences in mean ovarian volume and corresponding 95% confidence intervals from log-linear regression models. The primary adjusted model included menstrual phase, age, body mass index, menstrual cycle regularity, contraceptive use, and menarcheal age. The sensitivity model was restricted to the reference morphometry subcohort. The luteal phase was used as the reference category for menstrual phase comparisons. Estimates to the right of zero indicate higher mean ovarian volume, while estimates to the left of zero indicate lower mean ovarian volume. Model sections are labelled on the y-axis. BMI, body mass index; CI, confidence interval.

Discussion

Principal findings

This study evaluated ovarian morphometry and ultrasound-detected ovarian findings among reproductive-aged female university students in Nigeria. In the full ovarian ultrasound analytic cohort of 235 participants, 193 had at least one valid ovarian volume measurement and 152 had valid bilateral ovarian volume measurements. The mean right and left ovarian volumes were 12.83 cm³ and 12.35 cm³, respectively, while the mean ovarian volume was 13.19 cm³. Right ovarian volume differed across menstrual phases, whereas left ovarian volume did not. Mean ovarian volume and absolute ovarian asymmetry showed borderline phase-related differences. In the primary adjusted model, follicular-phase

assessment was associated with higher mean ovarian volume compared with luteal-phase assessment, and this pattern was also observed in the reference morphometry sensitivity model.

Ovarian ultrasound findings were common, although valid denominators differed across findings. Follicles and dominant follicles were documented in most participants with valid assessments. Ovarian cysts were identified in 16.3% of participants with valid cyst assessment, while PCOS-related ultrasound features were observed in 10.7% of participants with valid assessment. Pouch of Douglas fluid was present in 63.0% of the cohort and showed no statistically significant variation across menstrual phases. Exploratory categorical analyses did not demonstrate statistically significant associations between ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, or dominant follicle detection and most examined participant characteristics. The association between irregular menstrual cycles and PCOS-related ultrasound features did not reach conventional statistical significance in either categorical testing or age- and BMI-adjusted logistic regression.

Ovarian morphometry and menstrual phase

The ovarian volumes observed in this study were higher than those reported in a Nigerian hospital-based transvaginal ultrasound study, in which the mean ovarian volume among reproductive-aged women was 7.9 cm³ [9]. Differences in study population, age distribution, imaging route, ovarian-volume recording practices, cycle-phase composition, and inclusion of participants with ovarian findings may partly explain this discrepancy. Participants in the present study were predominantly young adults, and normative modelling shows that ovarian volume reaches its highest values around early adulthood before declining with age [3]. Contemporary meta-analytic evidence also indicates that physiological ovarian ultrasound features vary across populations and imaging contexts [5].

The phase-specific ovarian volume pattern observed in this study is compatible with known ovarian physiology, but it should be interpreted cautiously. Serial three-dimensional ultrasound studies have demonstrated ovarian volume and vascularity changes across the menstrual cycle, especially in relation to dominant follicle development and corpus luteum formation [4]. In the present study, mean ovarian volume was highest in the follicular phase, and follicular-phase assessment remained associated with higher mean ovarian volume in adjusted and sensitivity models. However, this finding was based on a small follicular-phase subgroup and cross-sectional phase classification rather than repeated within-person ultrasound measurements. It should therefore be interpreted as an exploratory phase-related association rather than definitive evidence of within-cycle ovarian volume change.

Right and left ovarian volumes were positively correlated among participants with bilateral ovarian measurements, while ovarian asymmetry varied across individuals. Such asymmetry is expected in reproductive-aged women because follicular recruitment, dominant follicle development, and corpus luteum formation do not occur symmetrically between ovaries in a given cycle. The present study quantified this asymmetry but did not determine ovulatory side or confirm cycle phase biochemically. Future repeated-measures studies incorporating serial ultrasound and hormonal confirmation would better characterize ovarian asymmetry as a dynamic feature of the menstrual cycle.

Ultrasound-detected ovarian findings

Ovarian cysts were identified in 16.3% of participants with valid cyst assessment. The clinical significance of these cystic findings cannot be inferred because cyst size, morphology, persistence, and follow-up data were not available in this analysis. Current Society of Radiologists in Ultrasound (SRU) consensus guidance emphasizes that simple adnexal cysts are commonly encountered and that many small, well-characterized simple cysts in premenopausal women do not require follow-up imaging [6]. In the present study, cyst prevalence did not differ significantly by menstrual phase, cycle regularity, BMI category, menarcheal timing, or contraceptive use. These findings should be interpreted descriptively because cyst assessment had a variable-specific denominator and relatively small event counts.

PCOS-related ultrasound features were observed in 10.7% of participants with valid assessment. This estimate should not be interpreted as the prevalence of PCOS. The 2023 International Evidence-based Guideline for PCOS emphasizes that PCOS diagnosis requires structured assessment using diagnostic criteria, including ovulatory dysfunction, clinical or biochemical hyperandrogenism, and/or polycystic ovarian morphology, with exclusion of relevant differential diagnoses [8]. In this study, ultrasound morphology was available, but comprehensive biochemical androgen data and formal clinical diagnostic evaluation were not included. The non-significant trend toward higher odds of PCOS-related ultrasound features among participants with irregular cycles is consistent with the clinical relevance of ovulatory dysfunction, but the confidence interval was wide and included the null value. This result should therefore be considered exploratory.

Pouch of Douglas fluid was frequently recorded, being documented in nearly two-thirds of participants. Small-volume free pelvic fluid may be physiological in reproductive-aged women, although direct evidence on normal cyclic fluid patterns remains limited and includes older ultrasound work [7]. In the present study, pouch of Douglas fluid was not associated with menstrual phase and showed similar prevalence across menstruation, follicular, ovulatory, and luteal phases. Differences in ultrasound timing, transabdominal imaging conditions, bladder filling, documentation practices, and the threshold used to code fluid as present may have influenced this finding. In the absence of linked clinical signs, inflammatory markers, pregnancy-related assessment, or follow-up imaging, this result should be interpreted as a descriptive sonographic observation.

Menstrual and biodemographic correlates

Most ovarian findings were not significantly associated with menstrual phase, menstrual cycle regularity, BMI category, menarcheal timing, or contraceptive use. These largely null findings may reflect the relatively young age of the cohort, the low frequency of some ultrasound outcomes, the use of variable-specific denominators, and the cross-sectional design. They may also reflect the possibility that several ultrasound-detected ovarian findings in young women are physiological or incidental when assessed in a community-based student population. However, the absence of statistically significant associations should not be interpreted as evidence of no association, particularly for outcomes with sparse event counts.

BMI showed a positive association with mean ovarian volume only in the reference morphometry sensitivity model. Because this was not the primary exposure and was observed in a restricted analytic subgroup, this finding should be interpreted as exploratory. Prior evidence on BMI and ovarian volume is inconsistent, and the Nigerian comparator study by Danjem et al. reported no statistically significant BMI-related difference in ovarian volume [9]. Given that the BMI association in the present analysis was observed in a restricted sensitivity model, it requires confirmation in larger studies with more detailed assessment of body composition, metabolic status, and reproductive endocrine parameters.

Strengths and limitations

This study provides ultrasound-based ovarian data from a relatively understudied population of young reproductive-aged women in Nigeria. It integrates ovarian morphometry, menstrual phase, menstrual characteristics, biodemographic variables, and sonographic ovarian findings within a single analytical framework. The analysis also used prespecified data-cleaning procedures, variable-specific denominators, non-parametric tests for skewed morphometric outcomes, Wilson confidence intervals for prevalence estimates, and sensitivity modelling to assess the consistency of phase-related morphometry findings.

Several limitations should be considered. First, the cross-sectional design prevents inference about within-person ovarian changes across the menstrual cycle. Menstrual phase was estimated using self-reported LMP and a single ultrasound scan rather than confirmed by serial ultrasound, luteinizing hormone testing, progesterone measurement, or estradiol profiling. Phase misclassification is therefore possible. Second, the follicular-phase subgroup was small, which limits precision and increases uncertainty around phase-specific estimates. Third, ultrasonography was performed transabdominally; this approach is non-invasive and appropriate in the study context but may be less sensitive than transvaginal ultrasonography for detailed ovarian morphology, small cysts, and follicle counts. This may have affected detection of small cysts, follicle counts, and subtle polycystic ovarian morphology, and may partly explain variable denominators for ovarian findings. Fourth, some ovarian findings had substantial missingness, requiring variable-specific denominators and limiting power for association testing. Fifth, PCOS-related ultrasound features were not equivalent to a clinical diagnosis of PCOS because comprehensive biochemical and clinical diagnostic criteria were not available. Sixth, the study was conducted in a single university population, which may limit generalizability to non-student populations, older reproductive-aged women, clinical populations, or women from other regions.

Implications for research and practice

The findings support the value of context-specific ovarian ultrasound data from young women in sub-Saharan Africa. For clinical interpretation, the study reinforces the need to distinguish descriptive ultrasound findings from clinical diagnoses. Ovarian cysts, pouch of Douglas fluid, dominant follicles, and PCOS-related ultrasound features may occur in reproductive-aged women without necessarily indicating clinically significant pathology. For research, these findings highlight the importance of standardized definitions, complete ovarian visualization data, cyst size and morphology documentation,

biochemical confirmation of cycle phase, and follow-up imaging when investigating ovarian findings in community-based cohorts.

Future studies should prioritize longitudinal or repeated-measure designs that follow participants across multiple cycle phases, ideally with hormonal confirmation of ovulation and standardized ultrasound protocols. Larger multi-institutional studies would improve precision for less frequent findings such as ovarian cysts and PCOS-related morphology and allow more robust evaluation of menstrual, metabolic, and lifestyle correlates.

Conclusion

In this cohort of reproductive-aged female university students in Nigeria, ovarian volume showed modest variation across calendar-estimated menstrual phase groups, with higher mean ovarian volume observed in the follicular phase in adjusted and sensitivity analyses. Ovarian cysts and PCOS-related ultrasound features were detected in a minority of participants with valid assessments, while pouch of Douglas fluid, follicles, and dominant follicles were common. Most ovarian findings were not significantly associated with menstrual phase, menstrual cycle regularity, BMI category, menarcheal timing, or contraceptive use. These findings provide descriptive ovarian ultrasound data from an understudied population and support further longitudinal, hormonally confirmed studies of ovarian morphometry and incidental ovarian findings in young African women.

Abbreviations

BMI

Body Mass Index

CI

Confidence Interval

FIGO

International Federation of Gynecology and Obstetrics

H

Kruskal–Wallis Test Statistic

IQR

Interquartile Range

LMP

Last Menstrual Period

PCOS

Polycystic Ovary Syndrome

SIE

Italian Society of Endocrinology

SIGO

Italian Society of Gynecology and Obstetrics

SRU

Society of Radiologists in Ultrasound

STROBE

Strengthening the Reporting of Observational Studies in Epidemiology

WHO

World Health Organization

Declarations

Ethics approval and consent to participate

Ethical approval for the study was obtained from the Nnamdi Azikiwe University Teaching Hospital Health Research Ethics Committee (Protocol No. NAUTH/CS/66/VOL.17/VER.3/117/2024/262). All procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before data collection and ultrasound assessment.

Consent for publication

Not applicable.

Availability of data and materials

The dataset analyzed during the current study is available in an online data repository (<https://doi.org/10.5281/zenodo.19008084>).

Competing interests

The authors declare no competing interests.

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Author's contributions

IAO designed the study with contributions from ACE and KCI. IAO, ACE, KCI, KOA, ECN and KMU collected the data while IAO, KCI, KMC and FCA performed the data analysis. All the authors reviewed the analysis, interpreted the data, and contributed to the writing of the first draft. All the authors contributed to the revision of the first draft and approved the final manuscript.

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Figures

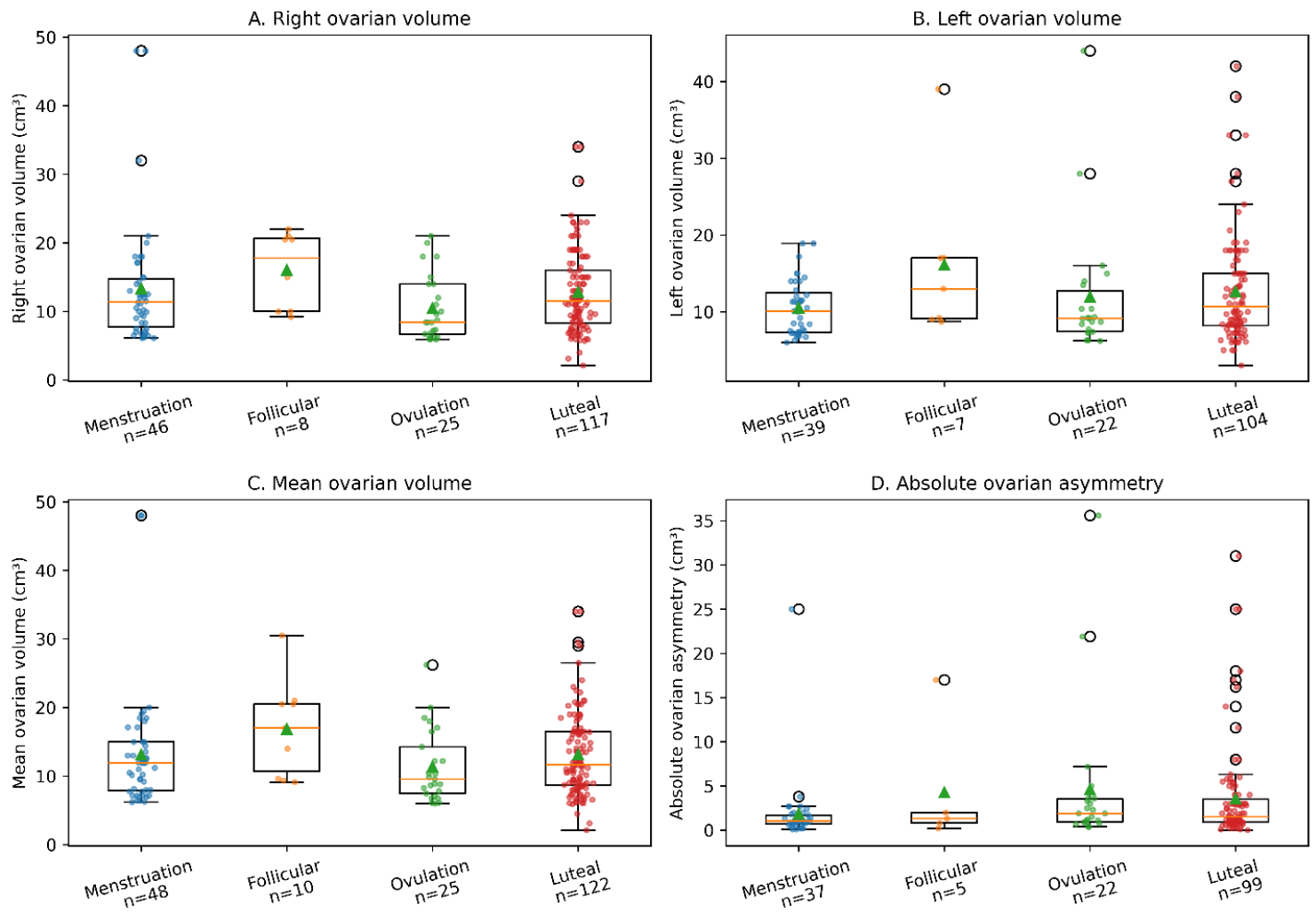


Figure 1

Ovarian morphometry by menstrual phase among reproductive-aged female students

Boxplots showing the distribution of ovarian morphometric parameters across menstrual phases. Panel A shows right ovarian volume, Panel B shows left ovarian volume, Panel C shows mean ovarian volume, and Panel D shows absolute ovarian asymmetry. Boxes represent the interquartile range, horizontal lines indicate medians, whiskers extend to values within 1.5 times the interquartile range, and points represent participant-level observations. Mean values are indicated by marker symbols within each boxplot. Menstrual phase was classified using self-reported LMP and a single ultrasound scan. Sample sizes differ between panels because of missing or non-visualized ovarian measurements.

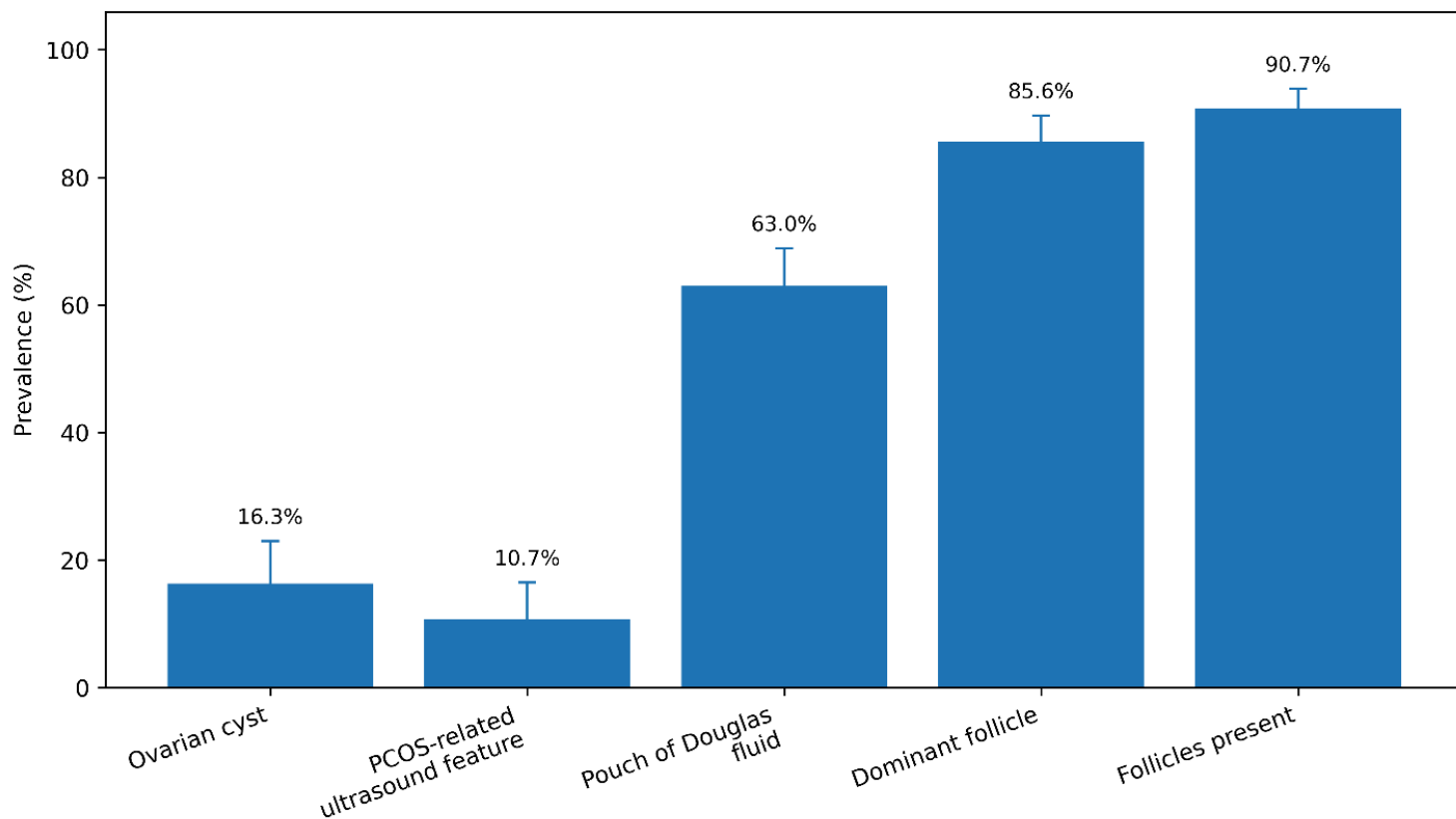


Figure 2

Prevalence of ultrasound-detected ovarian findings

Bar chart showing the prevalence of ovarian cysts, PCOS-related ultrasound features, pouch of Douglas fluid, dominant follicles, and follicles among participants with valid ultrasound assessments. Error bars represent Wilson 95% confidence intervals. Prevalence estimates were calculated using variable-specific denominators because not all ovarian findings were assessable in every participant. Valid denominators were 153 for ovarian cysts, 159 for PCOS-related ultrasound features, 235 for pouch of Douglas fluid, and 216 for dominant follicle and follicles. PCOS, polycystic ovary syndrome.

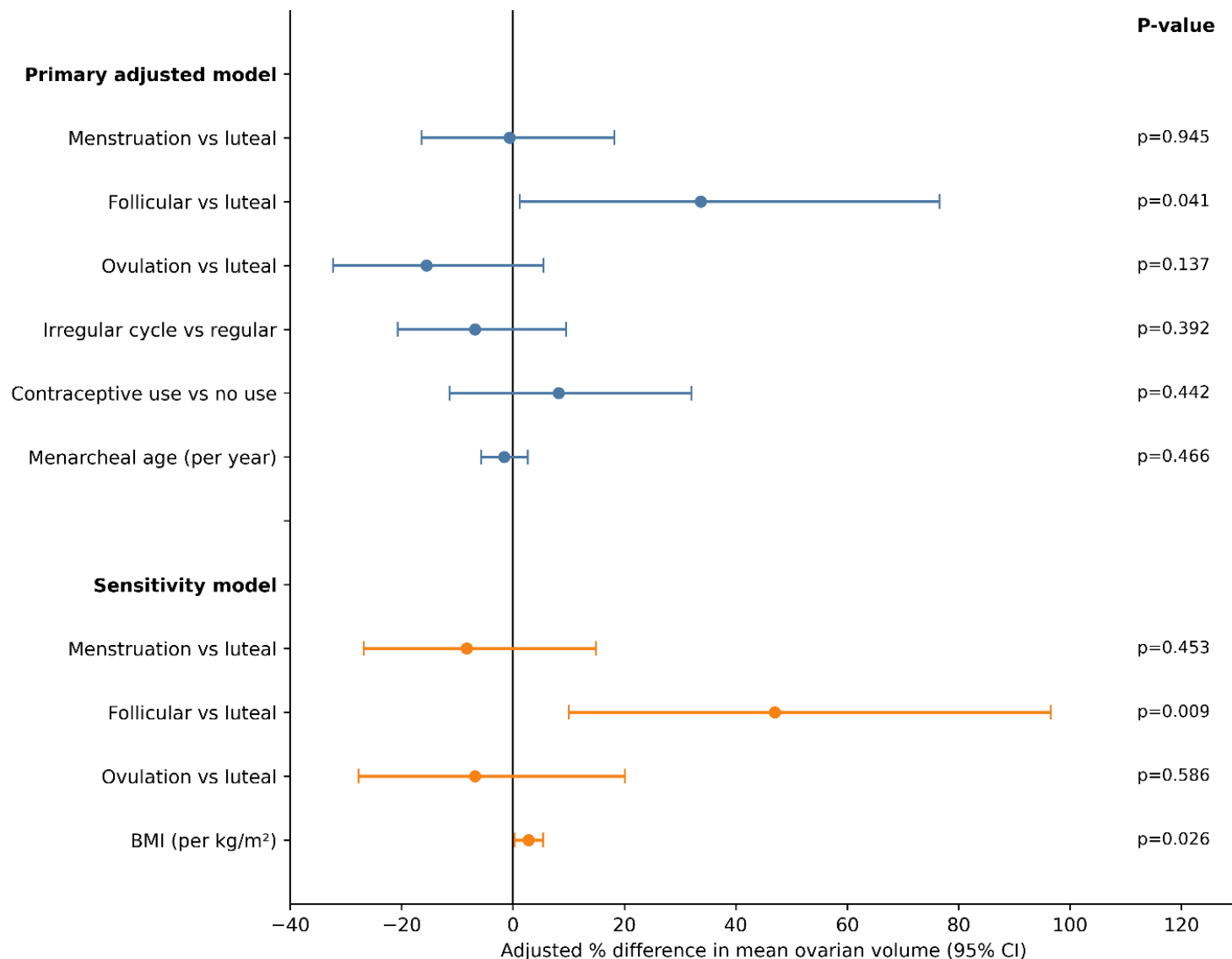


Figure 3

Adjusted associations with mean ovarian volume

Forest plot shows percentage differences in mean ovarian volume and corresponding 95% confidence intervals from log-linear regression models. The primary adjusted model included menstrual phase, age, body mass index, menstrual cycle regularity, contraceptive use, and menarcheal age. The sensitivity model was restricted to the reference morphometry subcohort. The luteal phase was used as the reference category for menstrual phase comparisons. Estimates to the right of zero indicate higher mean ovarian volume, while estimates to the left of zero indicate lower mean ovarian volume. Model sections are labelled on the y-axis. BMI, body mass index; CI, confidence interval.

Supplementary Files

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