

ASSESSMENT OF OVARIAN VOLUME IN APPARENTLY HEALTH WOMEN OF CHILDBEARING AGE IN NNEWI METROPOLIS AND THEIR ANTHROPOMETRIC PARAMETERS

Authors Details

Oluchi Perpetua Onuchukwu^{1*}

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Victor Kelechi Nwodo²

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Joseph C. Eze³

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Daniel C. Ugwuanyi⁴

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Sharonrose Ogochukwu Nwadike⁵ 

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Maryrose Chicheokwu Nwodo⁶

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Ifeoma Glory Ezeugwu⁷

Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University,
Awka, Nigeria.

Corresponding Author: Oluchi Perpetua Onuchukwu

ABSTRACT:

Background: Ovarian volume is an important parameter in reproductive health, relevant to fertility assessment and gynecological diagnosis. Its relationship with anthropometric measures such as BMI, weight, height, and waist–hip ratio, as well as menstrual cycle phases, remains underexplored, particularly in African populations. Establishing these associations is crucial for improving diagnostic accuracy and developing region-specific reference values. This study assessed ovarian volume characteristics in apparently healthy women of reproductive age (15–49 years) residing in the Nnewi metropolis, alongside their anthropometric indices.

Materials and methods: A cross-sectional study was conducted among 152 women aged 21–40 years. Anthropometric measurements including height, weight, BMI, waist circumference, hip circumference, and WHR were obtained. Ovarian volume was measured by transvaginal ultrasound. Data analysis employed descriptive statistics, Spearman’s correlation, ANOVA with post hoc tests, normality assessments, and multiple regression modeling to identify predictors of ovarian volume.

Results: The mean ovarian volume was 7.64 cm³. Strong positive correlations were observed between ovarian volume and weight ($r = 0.527$, $p < 0.001$), BMI ($r = 0.743$, $p < 0.001$), and WHR ($r = 0.405$, $p < 0.001$), while height showed no significant correlation. Age group comparisons revealed significantly higher ovarian volumes in women aged 31–35 and 36–40 years compared to younger groups. Menstrual cycle phase demonstrated no significant correlation ($r = 0.003$, $p = 0.966$). Regression analysis identified height, weight, BMI, and age as significant determinants, explaining 71.7% of the variance, while WHR and menstrual phase were not predictive.

Conclusion: This study demonstrates that ovarian volume is strongly influenced by age and body composition, particularly BMI and weight, but not by menstrual cycle phase. The findings provide region specific data and a predictive model for ovarian volume, contributing to reproductive health knowledge and offering practical implications for fertility assessment, gynecological evaluation, and public health interventions.

Keywords: *Body mass index, ovarian volume, PCOS, Ultrasound*

INTRODUCTION

Reproductive health disorders such as infertility, polycystic ovarian syndrome and metabolic syndrome are increasingly prevalent among women of childbearing age globally. Polycystic ovarian syndrome (PCOS) is a complex endocrine disorder characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology. Among its diagnostic features, ovarian volume has emerged as a critical parameter. An enlarged ovarian volume (≥ 10 mL) is strongly associated with increased follicle number, altered stromal density, and disrupted folliculogenesis. These changes reflect the underlying pathophysiology of the syndrome [1,2], which can result in female infertility.

The clinical relevance of ovarian volume lies not only in its role as an imaging marker but also in its correlation with hormonal imbalance, as women with higher ovarian volume often exhibit elevated luteinizing hormone levels, increased testosterone concentrations, and greater insulin resistance, which collectively exacerbate reproductive and metabolic complications[3]. Despite its diagnostic utility, ovarian volume alone cannot define PCOS, yet its enlargement remains a consistent morphological hallmark that links the structural changes of the ovary to the systemic manifestations of the disorder, underscoring the need for further investigation into how ovarian volume contributes to disease severity, fertility outcomes, and long-term metabolic risk [4].

Ultrasound technology now enables clinicians to quantify the relative proportion of stromal tissue within the ovary compared to the total ovarian area[5]. This ratio reflects ovarian physiology and morphology, serving as a potential diagnostic marker for abnormal reproductive conditions. For instance, women with PCOS typically present with an increased stromal component, which correlates with hyperandrogenism and other endocrine features [6]. Evaluating the ovarian stroma in apparently healthy women is therefore vital in establishing baseline reference values that can distinguish between normal physiology and pathology.

Anthropometric parameters are measurable indicators of the size, shape, and composition of the human body. They include body mass index (BMI), height, weight, and waist-to-hip ratio. These indices are widely used to assess nutritional status and predict the risk of chronic illnesses such as diabetes, hypertension, and cardiovascular diseases[7].

Importantly, they also influence reproductive outcomes. Obesity, as defined by elevated BMI, is strongly linked to menstrual irregularities, anovulation, infertility, and abnormal ovarian morphology. Studies have shown that women with higher BMI values often exhibit altered ovarian stromal characteristics and higher risks of developing PCOS[8]. Furthermore, abdominal obesity, often assessed by waist-to-hip ratio, is a key indicator of metabolic syndrome. Central obesity disrupts normal hormonal balance, leading to hyperinsulinemia and hyperandrogenism, which further influence ovarian function. Anthropometric parameters therefore serve not only as measures of general health but also as indirect predictors of ovarian health and reproductive potential.

Observation from the researchers' working place in Nnewi reveals that majority of women were diagnosed with polycystic ovaries when their ovarian volume was compared with Caucasian volume as a bases for diagnosis, thus, there is need for local reference value. Despite the potential of ovarian volume as a useful marker in assessing ovarian function and reproductive health, there is limited data on its correlation with anthropometric parameters in Nigerian women. This gap in knowledge hinders the ability to develop locally relevant diagnostic criteria and preventive strategies. Most available studies are from International and Nigeria populations did not correlate with the anthropometric parameters, which are possible potential markers for diagnosis of ovarian pathologies. Without such data, clinicians and researchers may face challenges in early detection and management of reproductive disorders. This study was therefore aimed to assess the ovarian volume in apparently healthy women of childbearing age and their anthropometric parameters in Nnewi Metropolis, Anambra State, Nigeria.

MATERIALS AND METHODS

1.0 Research Design

This was a cross-sectional descriptive design study, which was used to assess ovarian volume and anthropometric parameters at a single point in time among apparently healthy women of childbearing age.

2.0 Study Area

The study was conducted in Nnewi Metropolis, Anambra State, Nigeria. Nnewi is a major urban and commercial hub located in Anambra. It comprises Nnewi North and Nnewi

South Local Government Areas and hosts numerous public and private healthcare facilities equipped with diagnostic imaging services, including TVUS. These facilities provide a broad patient base that includes women of diverse socio-economic backgrounds, making it ideal for generating representative sonographic reference values for the locality[9].

3.0 Study Population

The study population consisted of apparently 300 healthy women of childbearing age (15–49 years) residing in Nnewi metropolis who consent to participate. Participants were recruited from selected diagnostic centers (Breeze Diagnostic Centers, Nnewi) and hospitals (Nnamdi Azikiwe University teaching Hospital, NAUTH, Nnewi) where routine gynecological and abdominal ultrasound examinations are conducted.

4.0 Study Criteria

4.1 Inclusion Criteria

1. Women aged 15–49 years.
2. Not pregnant at the time of examination (confirmed by history and/or urine pregnancy test if necessary).
3. No history or sonographic evidence of ovarian or pelvic pathology (e.g., cysts >3 cm, tumors, endometriomas).
4. Not currently on ovulation induction or hormonal therapy.
5. Willing to provide informed consent and undergo transvaginal ultrasound.

5.0 Sample Size Determination

A sample size of 171 apparently healthy women of childbearing was used in the study. The sample size was obtained using the Yamane's[10] formula as described below.

$$n = \frac{N}{1 + N (e)^2}$$

Where : n= sample size required

N = 300 Apparently Healthy women of child bearing age.

e = allowable error (%)

1 = Constant

$$n = \frac{300}{1 + 300 (0.05)^2}$$

$$n = \frac{300}{1 + 300 (0.0025)}$$

$$n = \frac{300}{1 + 0.75}$$

$$n = \frac{300}{1.75}$$

$$n = 171$$

6.0 Sampling Technique

A Random sampling technique was employed to recruit participants, as the study concentrated on ostensibly healthy women undergoing ultrasound examinations for non-pathological purposes, such as routine checkups.

7.0 Ethical Considerations

Ethical approval was obtained from the Ethics Committee of Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi Campus. Participation in the study was based on voluntary participation with written informed consent duly obtained. To ensure confidentiality, data were coded and stored securely. Participants received information about any incidental findings for appropriate clinical follow-up.

8.0 Instrument for data collection

8.1 Ultrasound assessment of ovarian volume

Transvaginal ultrasound (TVS) is the gold standard imaging technique for assessing ovarian morphology and calculating ovarian volume. It provides high resolution images by placing the probe close to the ovaries, thereby overcoming limitations of transabdominal ultrasound such as poor visualization in obese patients or interference from bowel gas. The

patient is positioned in the lithotomy position with an empty bladder to optimize pelvic visualization. A high frequency transvaginal probe (5–7.5 MHz) is covered with a sterile sheath and lubricated before insertion into the vagina. The probe is gently advanced to visualize the uterus and adnexa, then angled laterally to locate each ovary. Once the ovary is identified, three orthogonal diameters are measured: length (longitudinal axis), width (transverse axis), and thickness (antero-posterior axis).

Ovarian volume is calculated using the ellipsoid formula:

Volume = $\frac{\pi}{6}$ X Length X Width X Thickness. It is measured in cm³ Measurements are taken for both ovaries, and the total ovarian volume is derived by averaging or summing the values. Measurements were performed independently by two trained sonographers, and the mean value was recorded to minimize inter-observer variability[11].

8.2 Anthropometric measurements

Anthropometric parameters included:

Height: Measured in meters using a stadiometer, with participants standing erect without shoes.

Weight: Measured in kilograms using a calibrated weighing scale.

Body Mass Index (BMI): Calculated as weight (kg) divided by height squared (m²).

Waist Circumference (WC): Measured at the midpoint between the lower rib and iliac crest using a flexible tape.

Hip Circumference (HC): Measured at the widest point over the buttocks.

Waist–Hip Ratio (WHR): Calculated as WC/HC.

All measurements followed WHO [12] standardized protocols to ensure accuracy.

9.0 Data collection procedure

Participants first underwent anthropometric measurements, after which ultrasound scans was performed. Data was recorded in a structured proforma capturing socio-demographic

details, anthropometric indices, and ovarian sonographic parameters. Data collection was conducted over a period of three months.

10.0 Data analysis

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics. Mean ovarian volume, and anthropometric variables were analyzed using descriptive statistics (mean standard deviation, and range). Correlation and regression analysis was used for relationship with anthropometric parameters (height, weight, BMI, WHR). Comparison of ovarian volume among different age groups was analyzed using ANOVA followed by post Turkey's comparison. Normality test using Shapiro-Wilk and Kolmogorov-Smirnov. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Table 1: Descriptive characteristics of participants

Variables (N=152)	Minimum	Maximum	Mean $\pm$ STD
Age (Years)	21.00	40.00	27.55 $\pm$ 5.13
Height (meters)	1.46	1.83	1.62 $\pm$ 0.09
Weight (Kg)	50.00	99.00	63.90 $\pm$ 9.94
Body mass Index (Kg/m ²)	18.40	32.03	24.16 $\pm$ 2.96
Waist circumference	36.00	106.00	73.05 $\pm$ 14.19
Hip circumference	39.00	116.00	85.90 $\pm$ 16.54
Waist Hip Ratio	0.72	0.98	0.85 $\pm$ 0.06
Right ovarian volume (cm ³)	2.93	27.20	7.13 $\pm$ 4.58
Left ovarian volume (cm ³)	1.49	30.10	8.15 $\pm$ 4.98
Total ovarian volume (cm ³)	2.27	22.58	7.64 $\pm$ 4.41

Table 1 above, showed the mean age (27.55), height (1.62), weight (63.90), BMI (24.16), waist circumference (73.05), Hip circumference (85.90), WHR (0.85), right ovarian volume (7.13), left ovarian volume (8.15), and the total ovarian volume (7.64).

Table 2: Correlation between ovarian volume and anthropometric parameters

Spearman's rho		Total ovarian volume (cm3)
Height (meters)	Correlation Coefficient	-0.044
	Sig. (2-tailed)	0.588
	N	152
Weight (Kg)	Correlation Coefficient	0.527**
	Sig. (2-tailed)	0.000
	N	152
Body mass Index (Kg/m2)	Correlation Coefficient	0.743**
	Sig. (2-tailed)	0.000
	N	152
Waist Hip Ratio	Correlation Coefficient	0.405**
	Sig. (2-tailed)	0.000
	N	152

Table 2 above, showed a very weak negative correlation with total ovarian volume ($\rho = -0.044$, $p = 0.588$), weight, BMI, and WHR ($\rho = 0.527$, $p = 0.000$; $\rho = 0.743$, $p = 0.000$; $\rho = 0.405$, $p = 0.000$) had a strong positive correlation with total ovarian volume, respectively with BMI demonstrating a very strong positive correlation.

Table 3: comparison of ovarian volume among the different age groups

	Total ovarian volume (cm3)
	Mean $\pm$ SEM
21-25 years	5.54 $\pm$ 0.20
26-30 years	5.98 $\pm$ 0.36
31-35 years	11.99 $\pm$ 1.25*
36-40 years	12.95 $\pm$ 0.74*
<i>F-ratio</i>	42.61

Data was analysed using ANOVA followed by post Hoc Turkey HSD comparison, *: significant difference.

From table 3 above, an increase in the ovarian volume as the age increases was noted, which had a statistical significance in age 31-35 years and 36-40 years, while 26-30 years had no significance when compared to age 21-25 years.

Table 4: Relationship between ovarian volume and menstrual cycle phases

Spearman's rho		Total ovarian volume (cm3)
Menstrual Phase	Correlation Coefficient	0.003
	Sig. (2-tailed)	0.966
	N	152

Table 4 above, revealed a very weak positive correlation ($\rho=0.003$, $p=0.966$) between menstrual phase and total volume, which had no significance.

Table 5: Test of normality of data on total ovarian volume

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Total ovarian volume (cm3)	0.221	152	0.000	0.815	152	0.000

Table 5 result reported a normality of the data of total ovarian volume had mild deviation from the normal, which is statistically significance.

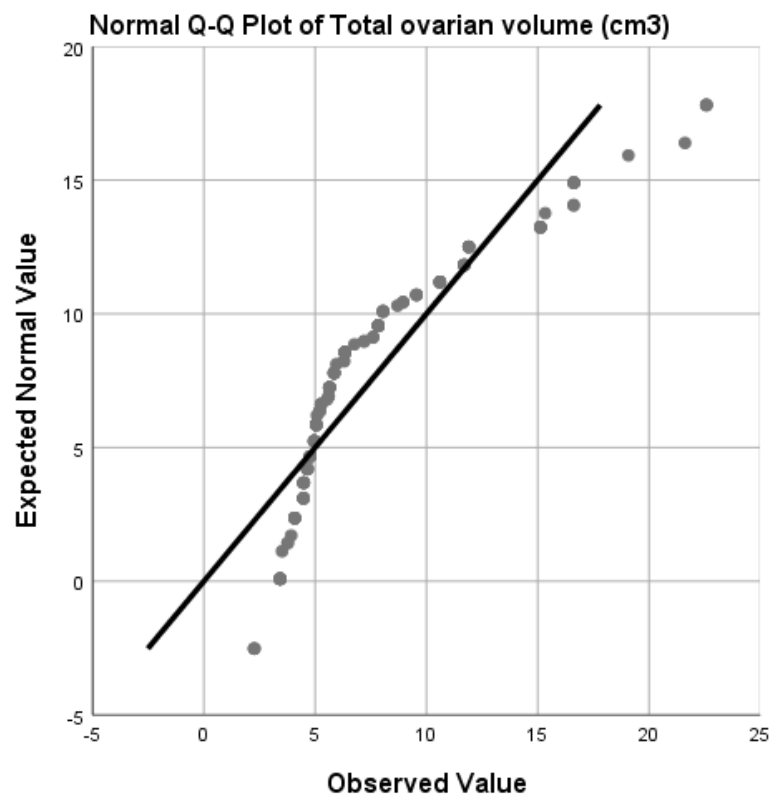


Figure 1 shows the normal Q-Q plot of total ovarian volume revealing the data was normally distributed.

Table 6 shows the regression model between total ovarian volume and anthropometric variables

Table 6a Regression model summary

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.847 ^a	0.717	0.706	2.39520	0.717	61.342	6	145	0.000
a. Predictors: (Constant), Menstrual Phase, Age (Years), Height (meters), Waist Hip Ratio, Body mass Index (Kg/m2), Weight (Kg)									

Table 6a result shows the regression model summary, revealing that 84.7% predictors were reliable to estimate the ovarian volume, and 15.3% were not reliable.

Table 6b Regression co-efficient determinant

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	80.155	29.067		2.758	0.007
	Height (meters)	-63.031	17.707	-1.263	-3.560	0.001
	Weight (Kg)	.912	.223	2.055	4.099	0.000
	Body mass Index (Kg/m2)	-1.575	.615	-1.056	-2.560	0.011
	Waist Hip Ratio	2.111	3.274	.031	.645	0.520
	Age (Years)	.293	.049	.341	6.005	0.000
	Menstrual Phase	-.101	.233	-.019	-.433	0.666
a. Dependent Variable: Total ovarian volume (cm3)						

Table 6b result revealed that height, weight, BMI, and age are determinant of ovarian volume, and WHR and menstrual phase are not determinant of ovarian volume.

DISCUSSIONS

Findings from this study revealed the participants had a mean age of 27.55 years and a mean BMI of 24.16 kg/m², which falls within the normal range. The mean total ovarian volume for apparently healthy women of childbearing age was 7.64 cm³, with the left ovary slightly larger (8.15 cm³) than the right (7.13 cm³). These baseline values provide reference points for ovarian morphology in this population. Thus, the reason for the range of ovarian volume documented in this study could possibly result from morphological changes with respect to age differences. Furthermore, the higher mean ovarian volume indicated in the left ovary than the right ovary, results from anatomical variation. This study showed similarities to the reports of Eze *et al*[12], Danjem *et al.* [14], and Mohammad *et al.* [15] revealing a reference point range of ovarian volume (5.3cm³ to 13.9cm³) in a Nigeria populace; thereby contributing to local reference data. However, their studies demonstrated geographical and environmental factor, which affects morphological variations of the ovarian function among women of childbearing age.

Further, the study findings showed strong positive correlation between ovarian volume and body composition measures. Weight, BMI, and waist-hip ratio all showed significant associations, with BMI demonstrating the strongest correlation ($r = 0.743$, $p < 0.001$). Height, however, showed no significant relationship. This suggests that adiposity and somatic growth are major determinants of ovarian size, reinforcing the metabolic-reproductive link highlighted in earlier studies [14]. This study is in line with the findings of Eze *et al.* (2009), revealing a significant relationship between ovarian volume and body weight. Danjem *et al.* (2016) showed disagreement to the study findings demonstrating BMI had no significant correlation with ovarian volume. Fulghesu *et al*[11] and Fulghesu *et al*[16], demonstrated that stromal hypertrophy and increased S/A ratio were strongly associated with hyperandrogenism, while Armeni *et al*[17] highlighted the role of central obesity and insulin resistance in driving ovarian morphological changes. Zakaria[18], confirmed that BMI and WHR are reliable predictors of PCOS morphology, emphasizing their clinical utility. Similarly, Kotori *et al*[19] found BMI significantly associated with PCOS features and endocrine alterations. Within Nigeria, Chukwuonye *et al*[20] reported a high prevalence of polycystic ovarian morphology among obese women, underscoring the influence of body composition on reproductive health.

Also, our study findings showed that the ovarian volume increased significantly in women aged 31–35 and 36–40 years compared to younger groups. This age-related rise indicates that ovarian morphology undergoes structural changes after the age of 30, possibly reflecting cumulative stromal hypertrophy or altered follicular dynamics. The finding is consistent with global evidence showing age as a strong predictor of ovarian volume. The finding is consistent with global evidence showing age as a strong predictor of ovarian volume [21,22]. Nigerian studies also support this trend, with Eze *et al.*[13] reporting significant correlations between ovarian volume and age, while Danjem *et al.*[14] observed a decline after the second decade of life, highlighting regional variations in ovarian morphology.

In addition, our study reveals no significant correlation was observed between ovarian volume and menstrual cycle phase ($r = 0.003$, $p = 0.966$). This result challenges the assumption that cyclical hormonal changes substantially influence ovarian size, instead suggesting that ovarian volume is more stable across the cycle and primarily shaped by age and body composition [21]. Similar findings have been reported by Pavlik *et al.*[22], who demonstrated that ovarian volume is largely age-dependent and not significantly altered by cycle phase. Kelsey *et al.*[21] also confirmed that age accounts for the majority of variation in ovarian volume, with minimal influence from cyclical changes. Conversely, some studies have noted subtle variations: Moro *et al.*[23], described follicular phase changes in follicle size and distribution, while Christ, Legro, and Chen [24] observed that ovulation and luteal phase morphology may alter sonographic appearance without significantly affecting overall ovarian volume.

Our study report showed that the normality tests indicated mild deviation from a perfect normal distribution, while Q–Q plots confirmed approximate normality, thereby validating the use of parametric analyses. This methodological approach is consistent with recommendations in statistical literature, where mild deviations from normality are considered acceptable for regression modeling provided sample sizes are adequate [25]. Regression analysis further demonstrated that height, weight, BMI, and age were significant predictors of ovarian volume, while waist–hip ratio and menstrual phase were not. The regression model explained 71.7% of the variance in ovarian volume, underscoring the robustness of anthropometric and age related determinants. These

findings align with previous Nigerian studies such as Eze *et al*[13], who reported strong associations between ovarian volume and body weight, and contrast with Danjem *et al*[14], who found no significant correlation with BMI. Globally, Kelsey *et al*[21], validated age as the strongest determinant of ovarian volume, while Fulghesu *et al*[11] and Fulghesu *et al*[16], highlighted the role of adiposity and stromal hypertrophy in ovarian morphology. Taken together, our regression model reinforces the evidence that ovarian volume is primarily shaped by somatic growth and adiposity rather than cyclical hormonal changes, providing a predictive framework that is both statistically robust and clinically relevant.

CONCLUSION

This study establishes that anthropometric parameters, particularly BMI, weight, and age, are strong determinants of ovarian volume, while menstrual cycle phase and WHR have negligible influence. The findings highlight a clear age-related increase in ovarian volume, especially after age 30, and demonstrate that body composition plays a critical role in ovarian morphology. These results provide evidence that ovarian volume is more closely linked to somatic growth and adiposity than to cyclical hormonal changes.

Conflict of interest: None declared among the authors

REFERENCES

1. Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group. (2004). Revised 2003 consensus on diagnostic criteria and long-term health risks related to PCOS. *Fertility and Sterility*, 81(1), 19–25.
2. Dewailly, D., Lujan, M. E., Carmina, E., Cedars, M. I., Laven, J., Norman, R. J., and Escobar-Morreale, H. F. (2014). Definition and significance of polycystic ovarian morphology: A task force report. *Human Reproduction Update*, 20(3), 334–352.
3. Costello, M. F., Misso, M. L., Balen, A., Boyle, J., Devoto, L., Garad, R. M., Hart, R., Johnson, L., Jordan, C., Legro, R. S., Norman, R. J., Qiao, J., Rodgers, R. J., and Teede, H. J. (2019). *Evidence summaries and recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome: Assessment and treatment of infertility*. Human Reproduction Open, 2019(1), hoy021. <https://doi.org/10.1093/hropen/hoy021>

4. Azziz, R., Carmina, E., Chen, Z., Dunaif, A., Laven, J. S. E., Legro, R. S., Lizneva, D., Natterson-Horowitz, B., Teede, H. J., and Yildiz, B. O. (2016). *Polycystic ovary syndrome*. *Nature Reviews Disease Primers*, 2, 16057. <https://doi.org/10.1038/nrdp.2016.57>
5. Feleppa, E.J. (2023). Quantitative Ultrasound: An Emerging Technology for Detecting, Diagnosing, Imaging, Evaluating, and Monitoring Disease. In: Mamou, J., Oelze, M.L. (eds) *Quantitative Ultrasound in Soft Tissues. Advances in Experimental Medicine and Biology*, 1403. 3-17, Springer, Cham. https://doi.org/10.1007/978-3-031-21987-0_1
6. Balen, A. H., and Michelmores, K. (2019). What is polycystic ovary syndrome? Are national views important? *Human Reproduction*, 17(9), 2219–2227. <https://doi.org/10.1093/humrep/17.9.2219>
7. World Health Organization (WHO). (2021). Obesity and overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
8. Zawadzki, J. K., and Dunaif, A. (2017). Diagnostic criteria for polycystic ovary syndrome: Towards a rational approach. In A. Dunaif *et al.*, (Eds.), *Polycystic ovary syndrome* (pp. 377–384). Springer.
9. Anambra State Ministry of Health. (2024). Anambra State health facilities directory. Awka: Ministry of Health.
10. Yamane, T. (1967). *Statistics: An Introductory Analysis* (2nd ed.). New York: Harper and Row.
11. Fulghesu, A. M., Angioni, S., Portoghese, E., Belosi, C., Apa, R., and Lanzone, A. (2007). Sonographic ovarian stroma/total area ratio in PCOS diagnosis. *Human Reproduction*, 22(5), 1178–1183. <https://doi.org/10.1093/humrep/del494>
12. World Health Organization. (2008). Waist circumference and waist–hip ratio: Report of a WHO expert consultation. WHO Press
13. Eze, J., Ugwu, A., and Nzotta, C. (2009). Sonographic Quantification of Ovarian Volumes in an adult Nigeria population. *Internet Journal of Medical Update - EJOURNAL*, 4(1), 15-18. <https://doi.org/10.4314/ijmu.v4i1.39868>
14. Danjem, S. M., Ibinaiye, P. O., and Salaam, A. J. (2016). Transvaginal ultrasound assessment of normal ovarian volume among women of reproductive age in Jos,

- Nigeria. *Journal of Advances in Medicine and Medical Research*, 14(11), 1–6. <https://doi.org/10.9734/BJMMR/2016/24679>
15. Mohammad, H., Ngwan, S. D., Utoo, B. T., and Swende, T. Z. (2013). Transvaginal ultrasound evaluation of ovarian volume among normal adults in Makurdi, North-Central Nigeria. *Journal of Reproductive Biology and Health*, 6(2), 45–52. <http://dx.doi.org/10.7243/2054-0841-1-1>
 16. Fulghesu, A. M., Ciampelli, M., Belosi, C., Apa, R., Pavone, V., and Lanzone, A. (2001). Ovarian stromal hypertrophy in PCOS: Correlation with androgen and insulin levels. *Fertility and Sterility*, 76(5), 999–1005. [https://doi.org/10.1016/S0015-0282\(01\)02862-9](https://doi.org/10.1016/S0015-0282(01)02862-9)
 17. Armeni, E., Lambrinoudaki, I., Ceausu, I., Depypere, H., Mueck, A., Pérez-López, F. R., and Simoncini, T. (2018). Ovarian volume and anthropometric measures: Association with BMI and WHR. *Climacteric*, 21(2), 150–156. <https://doi.org/10.1080/13697137.2017.1421925>
 18. Zakaria, R. (2024). Comparative analysis of BMI and WHR in predicting PCOS morphology. *Journal of Reproductive Medicine*, 69(4), 312–320.
 19. Kotori, M., Ferizi-Shabani, L., Koçinaj, A., Ferizi, V., and Kotori, J. (2024). Clinical and endocrine alterations in women with polycystic ovary syndrome. *Georgian Medical News*, 1(346), 45–52.
 20. Chukwuonye, I. I., Ohagwu, K. A., Ogah, O. S., John, C., Oviasu, E., Anyabolu, E. N., Ezeani, I. U., Iloh, G. U. P., Chukwuonye, M. E., Raphael, C. O., Onwuchekwa, U., Okafor, U. H., Oladele, C., Obi, E. C., Okwuonu, C. G., Iheji, O., Nwabuko, O. C., Nnoli, M. A., and Okpechi, I. G. (2022). Prevalence of overweight and obesity in Nigeria: Systematic review and meta-analysis of population-based studies. *PLOS Global Public Health*, 2(6), e0000515. <https://doi.org/10.1371/journal.pgph.0000515>
 21. Kelsey, T. W., Dodwell, S. K., Wilkinson, A. G., Greve, T., Andersen, C. Y., Anderson, R. A., and B Wallace, W. H. (2013). Ovarian Volume throughout Life: A Validated Normative Model. *PLoS ONE*, 8(9), e71465. <https://doi.org/10.1371/journal.pone.0071465>
 22. Pavlik, E. J., DePriest, P. D., Gallion, H. H., Ueland, F. R., Reedy, M. B., Kryscio, R. J., and van Nagell, J. R. (2000). Ovarian volume related to age. *Gynecologic Oncology*, 77(3), 410–412. <https://doi.org/10.1006/gyno.2000.5783>

23. Moro, F., Cicinelli, E., Scioscia, M., Scardapane, A., Lorusso, F., and Resta, L. (2022). Sonographic anatomy of the ovary in reproductive-age women. *Ultrasound in Obstetrics and Gynecology*, 59(4), 512–520. <https://doi.org/10.1002/uog.24891>
24. Christ, J., Legro, R. S., and Chen, Z. (2023). Sonographic features of polycystic ovary morphology across menstrual phases. *Reproductive Biology and Endocrinology*, 21(1), 45–53.
25. Ghasemi, A., and Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 10(2), 486–489.

