Original Article

Utility of Visceral Adiposity Index and Lipid Accumulation Products to Define Metabolically-Unhealthy Polycystic Ovary Syndrome in Asian Indian Women - A Cross Sectional Study

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Abstract

Background: Polycystic ovary syndrome (PCOS) women are at risk of developing diabetes, cardiovascular disease and metabolic syndrome (MetS) due to insulin resistance (IR) and hyperandrogenism (HA). Both visceral adiposity index (VAI) and lipid accumulation product (LAP) are simple outpatient department-based metric tools that have been introduced to screen PCOS women who are metabolically unhealthy and are at risk of development of MetS. **Aims:** The aim of the study was to evaluate VAI and LAP in women with PCOS and to correlate them with metabolic and endocrine markers. The study also assessed these parameters amongst different PCOS phenotypes and determined their usefulness to define metabolically healthy PCOS (MH-PCOS) and metabolically unhealthy PCOS (MU-PCOS). **Settings and Design:** The design of the study was a cross-sectional study. **Materials and Methods:** Two hundred PCOS women were included in the study, and all the clinical, anthropometric, hormonal, biochemical and metabolic markers were assessed. The cohort was divided into MH-PCOS and MU-PCOS by the modified National Cholesterol Education Programme criteria. VAI and LAP were calculated and correlated with clinical, endocrine and metabolic parameters. **Statistical Analysis Used:** Univariate and multivariate logistic regression analysis was used to study the independent role of VAI and LAP to predict MetS. Adjusted and unadjusted odds ratios were calculated. Receiver-operating characteristic (ROC) analysis was done to define cut-offs in Asian Indian women. **Results:** VAI and LAP had good ability to correctly discriminate MU-PCOS from MH-PCOS (area under the curve [AUC] [95% confidence interval (CI)]: 0.89 [0.82–0.95]) and (AUC [95% CI [0.81–0.92] =0.86) using ROC, respectively. The sensitivity of VAI and LAP corresponding to the optimal cut-off of ≥2.76 and ≥48.06 (Youden) was 84.09% and 79.55%, respectively. Similarly, the specificity of VAI and LAP was 85.26% and 79.49%, respectively. VAI has a positive predictive value of 61.7% (95% CI [23.7%–40.3%]) and a negative predictive value of 95% (95% CI [88%–99.1%]). LAP has a positive predictive value of 53% (95% CI [40.3%–65.4%]) and a negative predictive value of 93.3% (95% CI [87.6%–96.9%]). PCOS women having VAI ≥ 2.76 had 19.3 times ([95% CI: 6.50–57.70]) more chance of developing

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MetS. PCOS women having LAP (≥48.06) have 3.7 times ([95% CI: 1.35–10.60]) more odds. There was no difference between ROC curves of VAI and LAP ($P = 0.32$). **Conclusion:** VAI cut-off ≥ 2.76 and LAP with a cut-off of ≥ 48.06 may be used as markers for predicting MetS amongst PCOS women.

Keywords: *Lipid accumulation product, metabolic syndrome, phenotype, polycystic ovary syndrome, risk factor, visceral adiposity index*

Introduction

Polycystic ovary syndrome (PCOS) is the most common endocrinologic disorder amongst reproductive-age women; its prevalence ranging from 6% to 26% depending on ethnicity and criteria used for diagnosis.[1] The Rotterdam ESHRE/ASRM-sponsored PCOS Consensus Workshop Group revised the diagnostic criteria of PCOS in 2003 (2 out of 3): (1) oligo- or anovulation (OA), (2) clinical and/or biochemical signs of hyperandrogenism (HA) and (3) polycystic ovarian morphology (PCOM) and exclusion of other aetiologies (congenital adrenal hyperplasia, androgen-secreting tumours and Cushing's syndrome).[2] Furthermore, different PCOS phenotypes have been defined according to the number and criteria present: A: HA + OA + PCOM; B: HA + OA; C: HA + PCOM; D: OA + PCOM.

Although not included in the diagnostic criteria, most of the PCOS women have associated insulin resistance (IR) and suffer from being overweight or obese. Almost 30%–70% of PCOS have associated IR.[3] High body mass index (BMI) and IR in PCOS women predispose to cardiovascular diseases, impaired glucose tolerance and type 2 diabetes mellitus. Due to androgen excess, PCOS women are more at risk of developing android obesity (visceral adiposity), which further puts these women at risk of cardiovascular disease and diabetes.[4] Although BMI is a simple and easily calculated marker of obesity, it calculates total obesity and does not provide any information about body adiposity and visceral obesity. BMI alone is not considered an accurate marker of risk of metabolic syndrome (MetS) and cardiovascular disease.[5]

The prevalence of MetS is variable amongst PCOS due to variable ethnicities with one study reporting around 12.6%, which is almost seven times higher than that in healthy women with a higher BMI.[6] In a recent study by Naghshband *et al*. on Indian women, the prevalence of MetS was found to be 59.3%.[7]

The visceral adiposity index (VAI) is a recently suggested mathematical model based on waist circumference (WC), BMI, high-density lipoprotein (HDL) and triglyceride (TG) levels, indirectly expressing visceral adiposity and insulin sensitivity. VAI is being considered an emerging marker of adipocyte dysfunction with reported efficacy comparable to computed tomography.[8] Similarly, lipid accumulation product (LAP), another easily obtainable index, is emerging as a reliable marker of IR amongst PCOS women. It may serve as a useful marker to screen for IR-related comorbidities like diabetes and also cardiovascular disease in PCOS women.[9]

The utility of VAI and LAP has been studied to define metabolically unhealthy PCOS (MU-PCOS) women, but different cut-offs have been given by studies from different geographical backgrounds. The cut-offs in Indian PCOS women have been defined by two authors to date; Agrawal *et al*., in 2019, reported a cut-off value of VAI as 1.55[10] and Naghshband *et al*., in 2021, reported cut-off values of VAI and LAP as 6.05 and 53, respectively.[7]

The present cross-sectional study was conducted to correlate VAI and LAP with metabolic and endocrine markers in PCOS women. The study also assessed VAI and LAP amongst different PCOS phenotypes and the usefulness of VAI and LAP to define MU-PCOS women.

Materials and Methods

This cross-sectional study was conducted in the outpatient department (OPD) of from 1 October 2020 to 30 June 2022. The ethical approval was taken from institutional (All India Institute of Medical Sciences, New Delhi) ethics approval committee. Participants were enrolled after taking written informed consent. The study was conducted in accordance with Helsinki Declaration.

Sample size calculation

Considering Anik Ilhan *et al*.'s[12] study as a reference study, they evaluated the impact of LAP and VAI on clinical, biochemical and metabolic parameters in lean PCOS women and reported a minimum correlation coefficient with LAP ($r = 0.3$) and VAI ($r = 0.4$) with clinical, biochemical and metabolic parameters. Therefore, a minimum correlation coefficient of 0.35 b/w LAP and VAI was expected in the present study. Accordingly, an adequate sample size for 80% power of the study for a 5% significance level was calculated to be 130. We were able to recruit a total of 200 subjects from our OPD. Study included 200 patients aged 18–38 years and diagnosed with PCOS by the

Rotterdam criteria. Exclusion criteria included patients with congenital adrenal hyperplasia, androgen-secreting tumours, Cushing's syndrome hyperprolactinemia, patients on antihypertensives, lipid-lowering agents, hypoglycaemics, insulin sensitisers, oral contraceptive pills or ovulation induction drugs (to be stopped 3 months before participation in the study), patients following a low-energy diet (800–1200 kcal/day), PCOS patients delivered within the last 1 year, with BMI >40 kg/m^2, uncontrolled thyroid/prolactin disorders, hypertensive women, renal/hepatic dysfunction, history of bariatric surgery or weight-reducing treatment. On enrolment, a detailed clinical history was taken and recorded in a pro forma for all the patients enrolled in the study. History was taken about menstrual cycle pattern, marital status, infertility (if present), hirsutism (modified Ferriman–Gallwey score ≥5), acne and weight gain. Details of all the treatments received for PCOS or other medical disorders in the past were documented and recorded. A thorough general, physical and clinical examination, including the presence of hirsutism and acanthosis nigricans, was done. Anthropometric measurements (height, weight, WC, hip circumference and neck circumference) were noted. Biochemical parameters including fasting lipid profile (HDL, LDL, TC and TG), fasting and post-prandial blood sugar, fasting serum insulin levels, serum total testosterone and free testosterone, LH/FSH, serum AMH, TSH and prolactin, serum progesterone (day 21–24 of cycle for PCOS women with regular cycles) (levels <3 ng/ml were taken as the cut-off to diagnose anovulation) and serum sex hormone-binding globulin (SHBG) were assayed.

VAI was calculated using the formula: (WC/36.58+ [1.89 × BMI]) × (TG/0.81) × (1.52/HDL-c) (where both TG and HDL levels are expressed in mmol/L), and LAP was calculated with the formula (WC – 58) × TG (where WC is expressed as cm and TG expressed in mmol/L). The waist-to-hip ratio (WHR): WC (cm) at the umbilical level/hip circumference (cm) at the anterior superior iliac spine level taken in the horizontal plane. A value of more than 0.85 indicates abdominal obesity. Waist-to-height ratio (WHtR): waist (cm)/height (cm). BMI: weight (in kg)/height (m^2). Homeostasis Model Assessment-IR (HOMA-IR): Fasting insulin (mU/L) × fasting glucose (mmol/L)/22.5. A HOMA-IR value of ≥2.5 was taken as suggestive of IR. Quantitative insulin-sensitivity check index (QUICKI): 1/(log fasting insulin [IU/mL] + log fasting glucose [mg/dL]). The QUICKI index below 0.35 corresponded to metabolic and clinical manifestations of IR. Fasting insulin glucose ratio (FGIR): Fasting glucose (mg/dL) divided by the fasting insulin (μU/mL). FGIR of <7 is associated with IR. Free Androgen Index (FAI): (Serum total testosterone level/Sex hormone binding globulin level) ×100. Ultrasound was performed for PCOM on days 2–5 of the menstrual cycle (as per the Rotterdam criteria).

Statistical analysis

The data were analysed by Stata 16 and presented in mean (standard deviation), median (minimum–maximum) and frequency (%). Categorical variables were compared by the Chi-square test and Fisher's exact test. Continuous variables were compared by the independent *t*-test (following normal distribution) or Wilcoxon rank-sum test (for non-normal distribution). The Spearman and Pearson's correlation were used to see the relation between continuous variables. Receiver-operating characteristic (ROC) analysis was carried out to see the discriminability of LAP and VAI for predicting MetS and to calculate their optimal cut-off in the Indian population. Univariate and multivariate logistic regression analysis after adjusting known confounders of MetS was used to see the independent role of VAI and LAP to predict MetS. The adjusted and unadjusted odds ratios were calculated.

Results

A total of 216 PCOS women diagnosed according to the Rotterdam criteria were screened from the OPD. After excluding 16 women according to the selection criteria, 200 women were finally analysed for the study. These patients were further divided into metabolically healthy PCOS (MH-PCOS) (n = 156) and MU-PCOS (n = 44) according to the diagnostic criteria given by the modified National Cholesterol Education Programme Adult Treatment Panel III (NCEP-ATP III) criteria.

Table 1 describes the baseline clinical and anthropometric characteristics of the study population. Out of the total 200 patients, 79.50% (n = 159) of women had irregular cycles, 54% (n = 108) had hirsutism and 28% (n = 56) had acanthosis nigricans.

The most common phenotype in our study was phenotype D followed by phenotype A. Although PCOS-A had the highest levels of VAI and LAP, the difference amongst different phenotypes was not statistically significant as depicted in Table 2.

Comparison of the visceral adiposity index and lipid accumulation product with anthropometric and hormonal parameters and lipid profile

VAI had a weak positive correlation with weight (r = 0.25) (P = 0.001), BMI (r = 0.27) (P = 0.001),

Table 1: Baseline clinical and anthropometric characteristics

Characteristics (*n*=200)	Mean±SD	Range
Age (years)	28.11±3.91	18–38
Age of menarche (years)	13.78±1.15	10–17
Cycle length (days)	60.6±29.15	25–150
BMI (kg/m^2)	26.44±4.65	23–40
Neck circumference (cm)	33.38±2.46	23–42
WHR	0.91±0.59	0.7–9.20
WHtR	0.84±3.63	0.41–5.19
Modified Ferriman–Gallwey score	5.55±5.55	0–22
Systolic blood pressure (mmHg)	111.4±9.21	90–140
Diastolic blood pressure (mmHg)	77.04±7.54	60–90

WHR=Waist-to-hip ratio, WHtR=Waist-to-height ratio, BMI=Body mass index, SD=Standard deviation, mFG=Modified Ferriman–Gallwey score

Table 2: Comparison of the visceral adiposity index and lipid accumulation product in polycystic ovary syndrome phenotypes

Phenotypes	VAI mean (range)	*P*	LAP mean (range)	*P*
PCOS A (*n*=77; 38%)	2.30 (0.486–12.06)	0.71	40.77 (6.55–92.13)	0.81
PCOS B (*n*=6; 3%)	2.10 (0.950–4.75)		28.77 (16.46–127.52)	
PCOS C (*n*=24; 12%)	1.57 (0.618–5.36)		32.57 (5.96–123.74)	
PCOS D (*n*=93; 47%)	2.12 (0.579–8.34)		36.58 (2.48–129.74)	

VAI=Visceral adiposity index, LAP=Lipid accumulation product, PCOS=Polycystic ovary syndrome

WC (r = 0.31) (P = 0.001), hip circumference (r = 0.23) (P = 0.001), WHR (r = 0.28) (P = 0.001), WHtR (r = 0.31) (P = 0.001) and neck circumference (r = 0.28) (P = 0.001). On the contrary, LAP in the present study had the strongest correlation with WC (r = 0.72) (P = 0.001). HOMA-IR was found to be positively correlated with LAP weakly (r = 0.23; P = 0.001). Serum testosterone too showed a weak positive correlation with LAP (r = 0.23) (P = 0.001). A strong positive correlation was seen between FAI and LAP (r = 0.80) (P = 0.001). All the parameters of the lipid profile were positively correlated with VAI and LAP except HDL [Table 3] which was negatively correlating with both indices as expected.

After dividing the study population into MH-PCOS and MU-PCOS by the modified NCEP criteria, it was found that 78% (n = 156) of the study population were MH-PCOS and 22% (n = 44) were MU-PCOS with the highest prevalence of MU-PCOS amongst phenotype A (43%) followed by phenotype D (36.3%) [Figure 1].

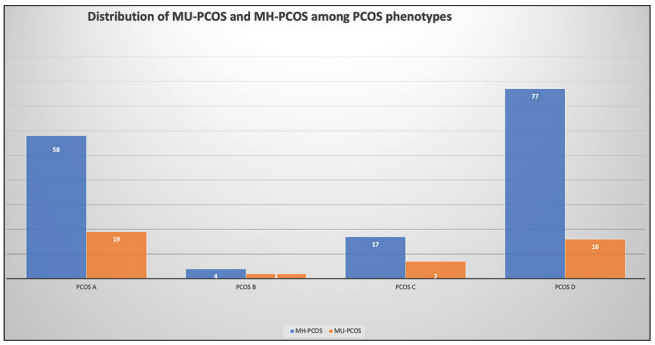


Figure 1: Distribution of metabolically unhealthy polycystic ovary syndrome and MH-PCOS amongst polycystic ovary syndrome phenotypes

Determining the ability of the visceral adiposity index and lipid accumulation product to differentiate metabolically unhealthy from metabolically healthy polycystic ovary syndrome

On ROC analysis, the present study revealed that VAI had a good ability to correctly discriminate MU-PCOS from MH PCOS (area under the curve [95% confidence interval (CI)]: 0.89 [0.82–0.95]). The sensitivity and specificity of the marker corresponding to the optimal cut-off (≥2.76) based on the Youden were 84.09% and 85.26%, respectively [Figure 2].

ROC analysis of LAP had an excellent ability to discriminate MU-PCOS from MH PCOS. The sensitivity and specificity of the marker corresponding to the optimal cut-off (≥48.06) based on the Youden were 79.55% and 79.49%, respectively [Figure 3].

After adjusting BMI, total cholesterol, LDL and VLDL on multivariate analysis, VAI and LAP emerged as significant predictors of MetS [Table 4]. PCOS women having VAI ≥2.76 have 9.42 times (95% CI: 3.25–27.26) chance of developing MetS and PCOS women having LAP (≥48.06) have 26.50 times (95% CI: 8.49–82.76) chance of developing MetS compared to the PCOS women having LAP <48.06.

Discussion

The present study evaluated the utility of VAI and LAP as OPD-based simple metric tools to define MU-PCOS women and their correlation of these markers with different PCOS phenotypes, endocrine and metabolic markers. The study concluded that VAI and LAP may be used as markers to differentiate MU-PCOS and MH-PCOS. VAI cut-off ≥2.767 and LAP ≥48.06 may be used for defining MU-PCOS for Asian Indian women.

Phenotypes A and B have been reported to be severe phenotypes, and previous studies by Amato *et al*.[11] and Agrawal *et al*.[10] have shown higher VAI and LAP in these phenotypes. The present study failed to show any significant difference of VAI and LA*P* values amongst

Table 3: Correlation of the visceral adiposity index and lipid accumulation product with anthropometric and hormonal parameters and lipid profile*

Variable	VAI *r*	*P*	LAP *r*	*P*
Anthropometric parameters				
Weight (kg)	0.25	0.001	0.60	0.001
BMI (kg/m²)	0.27	0.001	0.62	0.001
mFG score	−0.03	0.64	0.001	0.81
WC (cm)	0.31	0.001	0.72	0.001
Hip circumference (cm)	0.23	0.001	0.58	0.001
WHR	0.28	0.001	0.58	0.001
WHtR	0.31	0.001	0.69	0.001
Neck circumference (cm)	0.28	0.001	0.47	0.001
Hormonal parameters				
HOMA-IR	0.12	0.08	0.23	0.001
FGIR	−0.06	0.36	−0.14	0.03
LH (mIU/mL)	0.10	0.15	0.08	0.24
FSH (mIU/mL)	0.05	0.41	0.38	0.58
LH/FSH ratio	0.08	0.25	0.06	0.38
Serum testosterone levels (ng/mL)	0.12	0.08	0.23	0.001
Serum AMH levels (ng/mL)	−0.05	0.42	−0.12	0.08
SHBG (nmol/L) (*n*=97)	−0.18	0.18	−0.22	0.09
FAI (*n*=97)	0.16	0.88	0.80	0.001
QUICKI	−0.09	0.18	−0.21	0.002
Lipid profile				
TC (mmol/L)	0.30	0.001	0.37	0.001
HDL (mmol/L)	−0.62	0.001	−0.33	0.001
LDL (mg/dL)	0.35	0.001	0.38	0.001
TGL (mmol/L)	0.80	0.001	0.77	0.001
VLDL (mg/dL)	0.73	0.001	0.58	0.001

*Spearman's correlation was used for correlation. WHR=Waist-to-hip ratio, WHtR=Waist-to-height ratio, BMI=Body mass index, FGIR=Fasting glucose-to-insulin ratio, HOMA-IR=Homeostasis Model Assessment-Insulin Resistance, FSH=Follicle-stimulating hormone, LH=Luteinising hormone, AMH=Anti-Müllerian hormone, SHBG=Sex hormone-binding globulin, FAI=Free androgen index, QUICKI=Quantitative insulin-sensitivity check index, HDL=High-density lipoprotein, LDL=Low-density lipoprotein, VLDL=Very LDL, TGL=Triglyceride level, VAI=Visceral adiposity index, LAP=Lipid accumulation product, mFG=Modified Ferriman–Gallwey score, WC=Waist circumference, TC=Total cholesterol

different phenotypes which may be due to the small sample size and different geographical and ethnic variations in the severity of phenotypes from different populations.

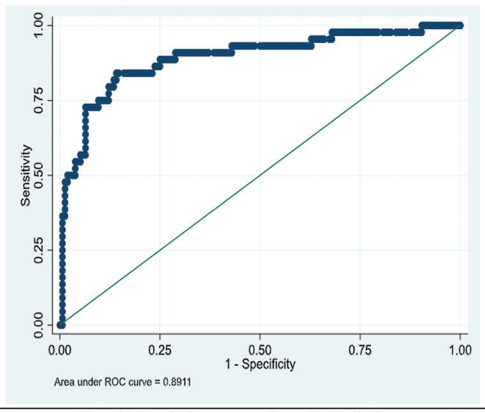
Studies have correlated VAI and LAP with different clinical, hormonal and lipid parameters amongst PCOS women. In the study by Anik Ilhan *et al*., in 2018, the authors reported a positive correlation of both LAP and VAI with WC in the insulin-resistant group, thus suggesting the use of VAI and LAP as promising screening tools in the early identification of IR and cardiometabolic risk in lean women with PCOS.[12] Kałużna *et al*. also reported a weak correlation of VAI with all parameters, while LAP significantly strongly correlated with BMI, WC and WHtR (r = 0.69–0.77).[13] The present study reported a weak positive correlation of VAI with blood pressure, BMI, WC and WHtR, while LAP showed a statistically significant strong positive correlation with BMI, WC and WHtR (r = 0.62–0.72).

IR and hyperandrogenaemia are the markers of the severity of PCOS and indicate associated metabolic dysfunction. VAI and LAP correlation has been studied with different hormonal and biochemical parameters. VAI and LAP have been shown to be positively correlated with insulin levels, HOMA-IR and FAI and negatively correlated with SHBG levels and HDL levels.[14,15] The present study showed a weak positive correlation of LAP with serum testosterone (r = 0.12). However, FAI showed a significant positive correlation with LAP in all the studies, including the present study (r = 0.80), thus favouring the utility of LAP as a future index to define hyperandrogenism and its severity in PCOS and thus consequently assessing their metabolic profile.

VAI and LAP have been positively correlated with HOMA-IR in previous studies by Mario *et al*.[16] and Banu *et al*.,[17] and LAP has been shown to have higher correlation than VAI. The present study showed similar results with a significant positive correlation of LAP with HOMA-IR (r = 0.23, P = 0.001). Hence, LAP may be used as a simple, cost-effective and reliable routine marker for assessing IR in PCOS women and an early screening tool for assessment of cardiometabolic health than other indices in PCOS women.

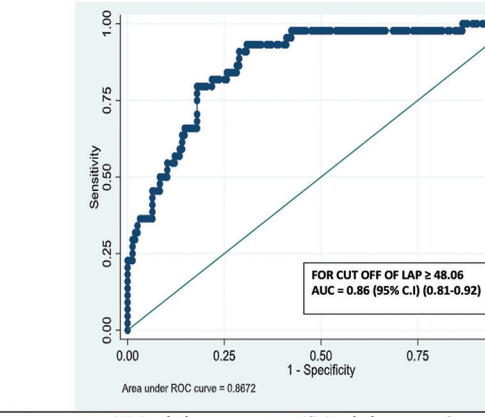
In contrast to studies by the above authors, the present study did not show any significant correlation between VAI and LAP with serum AMH levels or SHBG levels. Varied results with serum AMH levels may be due to different assay kits used amongst different studies. Similar to previous studies by Anik Ilhan *et al*.[12] and Ribeiro *et al*.,[15] we reported a strong positive correlation of both LAP and VAI with TGs and a significantly negative correlation with HDL.

Different authors have used different criteria to define MU-PCOS women in literature. Studies published by Kałużna *et al*., in 2022,[13] and Naghshband *et al*., in 2021,[7] used the IDF-AHA/NHLBI criteria (2009) mentioned below. Other studies by Amato *et al*., in 2011,[11] used NCEP-ATP III. In the present study, the modified NCEP-ATP III criteria were used for defining MU-PCOS women when three out of five parameters (described below) were present: (i) South Asian female WC ≥80 cm, (ii) elevated TGs ≥150 mg/dL, (iii) HDL <50 mg/dL, (iv) raised



Cut-off Point	Sensitivity (%)	Specificity (%)	Area under ROC curve	95% CI
2.767	84.09%	85.26%	0.89	0.82-0.95
Positive predictive value		**61.7%**		**95% CI (23.7%-40.3%)**
Negative predictive value		95%		95% CI (88%-99.1%)

Figure 2: Receiver-operating characteristic, visceral adiposity index. VAI = Visceral adiposity index, AUC = Area under the curve, CI: Confidence interval, ROC = Receiver-operating characteristic



Cut-off point	Sensitivity (%)	Specificity (%)	Area under ROC curve	95% CI
48.06	79.55%	79.49%	0.86	0.81-0.92
Positive predictive value		**53%**		**95% CI (40.3%-65.4%)**
Negative predictive value		93.3%		95% CI (87.6%-96.9%)

Figure 3: Receiver-operating characteristic, lipid accumulation product. LAP = Lipid accumulation product, ROC = Receiver-operating characteristic, AUC = Area under the curve, CI: Confidence interval

blood pressure (SBP ≥130 mmHg, DBP ≥85 mmHg) and (v) high fasting plasma glucose ≥100 mg/dL).

Different studies have given cut-offs of VAI and LAP to define MU-PCOS women. The varied values may be due to different anthropometric and metabolic profiles amongst PCOS women from different geographical backgrounds. The LAP value of the present study is comparable to Naghshband *et al.*,[7] the higher VAI may be due to different adipocyte dysfunction in the South Indian and North Indian populations. Other authors from different populations reported lower cut-off values for both indices than ours [Table 5] as South Asian women have more central obesity thus increasing WC, VAI and LA*P* values.

The limitations in the current study were that the study population was limited to PCOS women from a particular geographic area and most of the women were taken from the infertility clinic who were consulting for infertility. Due to this, it may be difficult to extrapolate the results and cut-offs to the general population. Another limitation was the lack of a control group. Further multi-centric and community-based studies may be planned to study the extent of metabolic dysfunction amongst PCOS women and the utility of these simple tools to differentiate MU-PCOS and MH-PCOS women in India. These parameters may also be used to assess response to

Table 4: Univariate and multivariate analysis: Odds ratio (after adjusting body mass index, total cholesterol, low-density lipoprotein and very low-density lipoprotein)

Variable	Unadjusted OR (95% CI)	*P*	AOR (95% CI)	*P*	Mean±SD	Range
LAP					40.82±23.47	2.48–129.74
<48.06	1	0.001	1	0.001		
≥48.06	15.6 (6.82–36.0)		9.42 (3.25–27.26)			
VAI					2.29±1.09	0.48–6.88
<2.767	1	0.001	1	0.001		
≥2.767	30.56 (12.16–76.78)		26.50 (8.49–82.76)			

VAI=Visceral adiposity index, LAP=Lipid accumulation product, OR=Odds ratio, AOR=Adjusted OR, CI=Confidence interval, SD=Standard deviation

Table 5: Cut-off values for the visceral adiposity index and lipid accumulation product in different studies

Study	Population	VAI cut-off	AUC	LAP cut-off	AUC
Guo *et al*., 2016[18]	Chinese	1.67	0.76	27.3	0.81
Bermúdez *et al*., 2021[19]	South American	1.7	0.56	37.7	0.50
Naghshband *et al*., 2021[7]	South Indian	6.05	0.91	53	0.81
Kałużna *et al*., 2022	Polish	1.38	0.84	22.04	0.87
Present study	North Indian	2.76	0.89	48.06	0.86

VAI=Visceral adiposity index, LAP=Lipid accumulation product, AUC=Area under the curve

treatment while studying the effect of lifestyle and medical interventions in PCOS women.

Conclusion

Both VAI and LAP may be used as OPD-based screening tools to differentiate MU-PCOS women at cut-off values of ≥2.76 and ≥48.06, respectively, acting as efficient and reliable predictors of MetS. Phenotype A women are at the highest risk of MetS. The study concluded a strong correlation of FAI and HOMA-IR with LAP than VAI so LAP may be used as an early screening tool to detect cardiometabolic complications in PCOS. Taking into consideration the ethnicity-dependent variability, independent cut-offs may be determined for different demographic populations.

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Author's contributions

SR, RM, MR and RC helped in the conception and design of the study. The literature search was done by SR, RM, MR and RC. Data acquisition was done by SR, MR and RC. Data analysis and interpretation was done by AU. The manuscript was prepared by SR, RM, MR and RC. Manuscript editing and review were done by all the authors (including GK, JBS and NB).

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Conflicts of interest

There are no conflicts of interest.

Data availability statement

The data are available with the corresponding author and willing to share it on request.

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