Original Article

Variation in Clinical Presentation, Metabolic Profile, Hormonal Parameters and Inflammatory Markers in Polycystic Ovary Syndrome Women with and without Polycystic Ovary Morphology Appearance

Sweekruti Jena, Ipsita Mishra, Anoj Kumar Baliarsinha, Debarchan Jena, Madhumita Debata[1]

Departments of Endocrinology, and [1]Radiology, SCB Medical College and Hospital, Cuttack, Odisha, India

ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is a heterogeneous disorder with a spectrum of presentation. Studies have reported considerably different rates in terms of the incidence of polycystic ovary morphology (PCOM) in patients with PCOS with inconsistent results regarding the effects of PCOM in them. **Aims:** The aim of this study was to determine the differences in clinical presentation, metabolic profile, hormonal parameters and inflammatory markers in PCOS women with and without PCOM on ultrasonography (USG). **Settings and Design:** A total of 70 PCOS women were recruited. To analyse the differences between various parameters, the patients were divided into two groups based on the presence or absence of PCOM on USG of the pelvis as per the Rotterdam criteria. **Materials and Methods:** A total of 37 patients had PCOM as per the diagnostic criteria for PCOS (Group 1), while 33 patients did not have PCOM on USG and were designated as Group 2. All participants underwent a detailed clinical evaluation and biochemical investigations, including high-sensitivity C-reactive protein, serum adiponectin, luteinising hormone, follicle-stimulating hormone, total testosterone and serum anti-Mullerian hormone. The homeostasis model assessment of IR (HOMA-IR) was calculated using standard equations. **Statistical Analysis Used:** The mean and Standard deviation were computed for all continuous variables. Frequencies and proportions were calculated for categorical variables. Comparisons of the mean scores between the study groups were assessed using the Unpaired Student's *t*-test. The mean score of the subgroups was also compared using the unpaired Student's *t*-test. $P < 0.05$ was considered significant for all statistical inferences. **Results:** The mean LDL and mean triglyceride were higher in Group 2, which was statistically significant ($P = 0.004$ and $P \leq 0.001$, respectively). The mean hs-CRP was found to be higher in Group 2, which was statistically significant ($P = 0.005$). The mean AMH was higher in Group 1, which was statistically significant ($P = 0.002$). Group 1 had higher adiponectin levels, which was statistically significant ($P = 0.04$). **Conclusion:** The above findings suggest that patients without diagnostic PCO morphology have a worse metabolic profile

Address for correspondence: Dr. Ipsita Mishra, C/O Dr. H. N. Mishra, 344 Manavilas Lane, Ice Factory Road, College Square, Cuttack - 753 003, Odisha, India.
E-mail: ipsita.mishra1981@gmail.com

Received: 12-05-2023 **Revised:** 16-06-2023
Accepted: 19-06-2023 **Published:** 30-06-2023

Access this article online

Quick Response Code:

Website: www.jhrsonline.org

DOI: 10.4103/jhrs.jhrs_60_23

How to cite this article: Jena S, Mishra I, Baliarsinha AK, Jena D, Debata M. Variation in clinical presentation, metabolic profile, hormonal parameters and inflammatory markers in polycystic ovary syndrome women with and without polycystic ovary morphology appearance. J Hum Reprod Sci 2023;16:132-9.

compared to those with PCO morphology on USG. Obese patients without PCO morphology probably have a higher cardiovascular risk compared to obese patients with PCO morphology.

Keywords: *Adiponectin, high-sensitivity C-reactive protein, homeostasis model assessment of insulin resistance, polycystic ovarian morphology, polycystic ovary syndrome*

Introduction

Polycystic ovary syndrome (PCOS) is the most common form of chronic anovulation, which may be associated with androgen excess.[1] Hyperandrogenism, a clinical hallmark of PCOS, can further cause inhibition of follicular development, multiple small follicles in the ovaries, anovulation and menstrual changes.[2] The most common symptoms include irregular menstrual cycles, hirsutism and infertility.[3] PCOS has been associated with several metabolic abnormalities, including insulin resistance, type 2 diabetes mellitus, dyslipidaemia, hypertension, cardiovascular disease and non-alcoholic fatty liver disease.[4,5]

The pathophysiology of PCOS is multifaceted involving dysregulated ovarian steroidogenesis, aberrant insulin signalling, excessive oxidative stress and genetic/environmental factors. Many hypotheses describing ovarian dysfunction, neuroendocrine dysfunction and insulin-resistant hyperinsulinism emerged trying to explain the pathophysiology of PCOS. Dysregulation of ovarian steroidogenesis appears to result from resetting of the LH-steroidogenic dose-response curve, more due to 'escape from downregulation', rather than excessive LH stimulation.[6] In PCOS women, dysregulation in the neuroendocrine system leads to an imbalance in the hypothalamic-pituitary-ovarian axis leading to the overproduction of gonadotropins.[7] A modest rise in the androgen levels normally stimulates LH pulsatility rather than suppressing it. PCOS appears to be a state in which steroidogenic and adipose tissues are paradoxically sensitive to insulin in a state of overall resistance to the glucose metabolic effects of insulin.[8]

PCOS is a heterogeneous disorder with a spectrum of presentations. Polycystic ovary morphology (PCOM) can be seen in healthy women with regular menstrual cycles, and studies have reported considerably different rates in terms of the incidence of PCOM in patients with PCOS with inconsistent results regarding the effects of PCOM in PCOS patients.[9] Ovarian androgenic dysfunction can range from mild hyperandrogenism in regularly menstruating women with ultrasonographic PCOM to severe functional ovarian hyperandrogenism in PCOS. In a subset of PCOS women, hyperandrogenism may be attributed to adrenal source or obesity *per se*. Heightened ovarian sensitivity may be the explanation for some.[10] In women with PCOS, the implications of PCOM are not entirely clear. The effect of neuroendocrine dysfunction, ovarian hyperandrogenism and other factors such as obesity, hyperinsulinaemia and insulin resistance on ovarian morphology has not been studied in detail previously. On the other hand, whether ovarian morphology has any effect on the hormonal and metabolic parameters in PCOS women is also an area to be explored. In previous studies, statistically significant high levels of insulin resistance, triglyceride, total cholesterol and systolic and diastolic blood pressure values were observed in the PCOS group without PCO morphology, compared to the PCOS group with PCO morphology.[11] Therefore, patients with PCOS without PCOM may have more risk in terms of occurrence of type-2 diabetes, coronary artery disease and hypercholesterolemia. Understanding the metabolic and biochemical differences between the two groups can guide better management of the patients. Therefore, a careful follow-up of PCOS women without diagnostic PCOM can be considered with respect to the occurrence of future cardiovascular adverse events.

Materials and Methods

Study design and population

This cross-sectional study was conducted at an academic institute and was approved by the Institutional Ethics Committee (IEC Appln no. 920/03 August 2021). Ethical principles of the World Medical Association's Declaration of Helsinki (2013) were adhered to while conducting the study.

Sample size calculation

Based on a previous study by Inan and Karadag, the sample size was calculated with an expected frequency of 5% and a margin of error of 5%, and with a 95% confidence level, the required number of patients came out to be 64 for adequate statistical analysis. Hence, a total of 70 patients were included to accommodate for the lack of adequate venous blood samples if any.

Inclusion criteria

Female patients aged between 15 and 45 years, newly diagnosed with PCOS according to the Rotterdam criteria and attending the department of endocrinology were included after informed consent.[12] For participants who were <18 years of age (two participants), parental/guardian's informed consent was taken.

Rotterdam criteria of polycystic ovary syndrome

1. Oligo-ovulation or anovulation (amenorrhoea and irregular uterine bleeding)
2. Clinical and biochemical signs of hyperandrogenism (hirsutism, elevated serum total or free testosterone)
3. Polycystic ovaries documented by ultrasonography (USG) (ovarian volume of 10 ml and/or an Antral follicle count (AFC) of 12 follicles or more, measuring 2–9 mm in diameter).

Diagnosis in adolescent PCOS was done as per the accepted adolescent criteria of volume >10.8 cc (in the absence of a follicle >10 mm) or ≥10 follicles (2–9 mm) in the maximum ultrasonographic plane (the abdominal technique in virginal adolescents does not permit counting total antral follicles).[6]

Exclusion criteria

1. Patients with suspicion of androgen-secreting tumour
2. Hyperprolactinaemia
3. Cushing syndrome
4. Congenital adrenal hyperplasia
5. Patients who had received medical treatment (combined oestrogen + progesterone pills/ insulin sensitizers/myo-inositol) within the past 6 months
6. Patients with thyroid dysfunction/diabetes mellitus.

After applying the above criteria, a total of 70 PCOS women were enrolled. Thirty-seven patients had PCOM as per the diagnostic criteria for PCOS (Group 1), while 33 patients did not have PCOM on USG (Group 2). Group 1 included phenotypes A, C and D (as per the NIH Consensus Panel).[13] All participants were explained in detail about the purpose of the study. Valid consent was taken and detailed history, clinical evaluation and biochemical investigations, including high-sensitivity C-reactive protein (hsCRP), serum adiponectin, luteinising hormone (LH), follicle-stimulating hormone (FSH), total testosterone and serum AMH, were done. Homeostasis model assessment of IR (HOMA-IR) as a marker of IR was calculated as (FPG in mg/dl X fasting insulin in mIU/L)/405.[14]

Clinical assessment

A detailed history was taken, including a history of oligomenorrhoea/amenorrhoea, weight gain (weight gain of 5 kg or more over 3 months), acne and hirsutism. A history of all relevant diseases and medication use was obtained.

Physical examination included vitals, anthropometry, general examination and systemic examination. Height, weight, waist circumference and hip circumference were measured. The body mass index was calculated as weight in kg divided by the square of height in metres.

The cut-off point for HOMA-IR was considered 2, as per previous studies.[14] Hs-CRP <2.0 mg/L was considered low risk for cardiovascular disease based on recent guidelines.[15]

Laboratory tests

Blood samples were collected for fasting insulin, fasting glucose, 2-h PGPG, fasting lipid profile, liver function test and thyroid function test. Serum adiponectin, hsCRP, LH, FSH, total testosterone, DHEAS and serum AMH were also done. The hormonal evaluation was done on the 2nd or 3rd days of the menstrual cycle or *de novo* in the case of amenorrhoeic females. Serum insulin, LH, FSH, total testosterone and DHEAS assay were measured using the automated electrochemiluminescence immunoassay method (Cobas e 411 analyser, Roche Diagnostics International Ltd). hs-CRP was measured by a particle-enhanced immunoturbidimetric test (AU480 Chemistry Analyser, Beckman Coulter). AMH was measured using Serolisa Human AMH ELISA Kit (AU480 Chemistry Analyser, Beckman Coulter). Adiponectin was measured using BioVendor Human Adiponectin Kit (competitive ELISA, RD195023100).

Ultrasonography

Transabdominal USG (TAS) using high-resolution B-mode (Philips HD7) by a single experienced investigator was done on Day 2–4 (follicular phase) of the menstrual cycle or *de novo* in case of amenorrhoeic females. PCOM was detected using the Rotterdam criteria.[12]

Statistical analysis

The data were entered into Microsoft Excel Worksheet and analysed using the Statistical Package for the Social Sciences (SPSS, IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. IBM Corp., Armonk, NY, USA). Figures were generated using Microsoft Office 365. The normal distribution of data was checked using the Shapiro–Wilk test, and appropriate parametric tests were employed. The mean and standard deviation were computed for all continuous variables. Frequencies and proportions were calculated for categorical variables. Comparisons of the mean scores between the study groups were assessed using the unpaired Student's *t*-test. The mean score of the subgroups was compared using the unpaired Student's *t*-test. $P < 0.05$ was considered significant for all statistical inferences.

Results

A total of 70 PCOS women were included in the study. To analyse the differences between various

parameters, the patients were divided into two groups based on the presence or absence of PCOM on USG of the pelvis as per the Rotterdam criteria. A total of 37 patients had PCOM as per the diagnostic criteria for PCOS (Group 1), while 33 patients did not have PCOM on USG (Group 2).

On analysing the signs and symptoms, 91.8% of patients in Group 1 had oligomenorrhoea [Figure 1]. In Group 2, all patients had oligomenorrhoea as a chief complaint. The clinical profile of both groups is depicted in Figure 1. Hirsutism based on the modified Ferriman–Gallwey score is shown in Figure 2. Acanthosis nigricans grading is depicted in Figure 3.

The anthropometric parameters across both groups were comparable and did not reach statistical significance, as summarized in Table 1.

The mean FPG and the mean 2-h PGPG are depicted in Table 2. There was no statistically significant difference between the FPG and 2-h PGPG values of Groups 1 and 2. The prevalence of IFG (100–125 mg/dl) and IGT (140–199 mg/dl) across the two groups is described in Figures 4 and 5, respectively. Frank type 2 diabetes mellitus was newly detected in 9.09% of patients in Group 2. None of the patients in Group 1 had overt T2DM.

Although the mean fasting insulin levels and HOMA-IR were higher in Group 2, it was not statistically significant as observed in Table 2. Lipid profile analysis revealed that the difference between the mean LDL and mean triglyceride levels between both groups was statistically significant with higher levels in Group 2 as observed in Table 2. There was no statistically significant difference between total cholesterol, HDL and VLDL across both groups.

Table 1: Baseline anthropometric parameters of Groups 1 and 2

Variable	Mean±SD		*P*
	Group 1 PCOM (+)	Group 2 PCOM (−)	
Age (years)	23.62±3.98	22.91±4.81	0.480
Height (cm)	155.02±5.34	156.26±7.16	0.400
Weight (kg)	65.41±13.32	67.91±16.99	0.590
BMI (kg/m^2)	27.07±5.10	27.66±5.94	0.600
WC (cm)	92.01±16.13	95.68±15.45	0.330
HC (cm)	100.92±13.03	99.12±13.56	0.570
WHR	0.93±0.06	0.92±0.07	0.670
SBP (mm of Hg)	118.43±4.57	122.12±8.34	0.070
DBP (mm of Hg)	78.43±4.19	78.61±4.40	0.780

BMI=Body mass index, WC=Waist circumference, WHR=Waist-to-hip ratio, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, PCOM=Polycystic ovary morphology, SD=Standard deviation, HC=Hip circumference

On analysis of hormonal parameters, the mean LH/FSH ratio was >2 across both groups with no statistically significant difference. The mean Serum testosterone levels were higher in Group 2; however, this finding was not statistically significant. The other hormonal

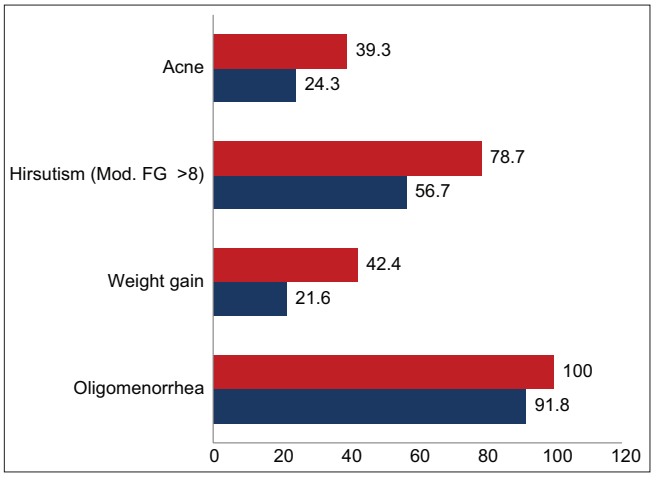

Figure 1: Clinical profile of both groups. (Legend: Blue: Group 1, Red: Group 2)

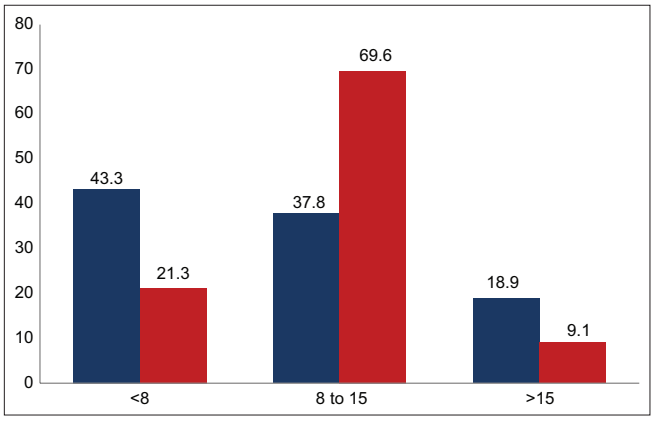

Figure 2: The modified Ferriman–Gallwey score of both groups. (Legend: Blue: Group 1, Red: Group 2)

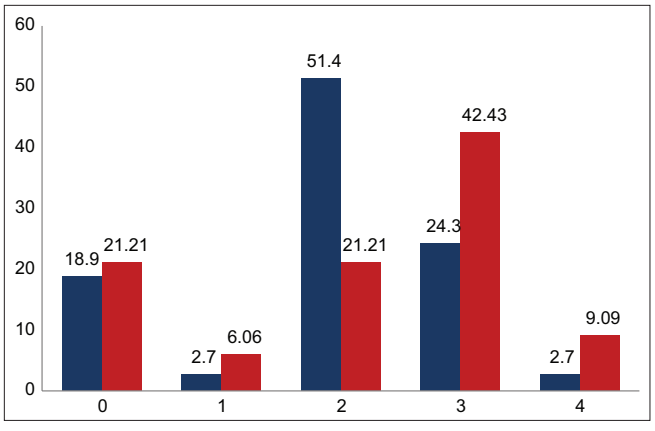

Figure 3: Acanthosis nigricans grading of both groups. (Legend: Blue: Group 1, Red: Group 2)

Table 2: Baseline biochemical parameters of Groups 1 and 2

Variable	Mean±SD		*P*
	Group 1 PCOM (+)	Group 2 PCOM (−)	
FPG (mg/dL)	82.32±13.39	84.12±10.66	0.540
2-h PGPG (mg/dL)	115.33±23.52	116.35±37.75	0.580
Fasting insulin (mIU/L)	14.82±6.76	15.11±5.56	0.430
HOMA-IR	2.87±1.16	3.07±1.23	0.400
Serum total cholesterol (mg/dL)	173.03±27.22	178.76±39.61	0.620
Serum TG (mg/dL)	119.24±36.55	170.32±45.92	<0.001
Serum HDL (mg/dL)	44±7.61	43.67±7.37	0.700
Serum LDL (mg/dL)	94.03±20.82	107.82±20.7	0.004
Serum VLDL (mg/dL)	42.59±12.34	41.12±12.53	0.570
LH (mIU/mL)	9.69±2.99	8.46±2.95	0.190
FSH (mIU/mL)	3.61±1.56	3.65±1.35	0.350
LH/FSH ratio	2.96±1.08	2.39±0.4	0.90
Serum testosterone (ng/dL)	60.81±20.04	68.71±22.07	0.120
Serum DHEAS (µg/dL)	220.32±122.75	262.01±101.93	0.130
Serum AMH (ng/mL)	6.85±1.74	5.56±1.32	0.002
Serum prolactin (ng/mL)	16.04±5.28	17.39±7.43	0.530
Serum 17-OHP (ng/mL)	0.94±0.44	1±0.38	0.430
ONDST 8 am serum cortisol (µg/dL)	0.8±0.25	0.76±0.35	0.320
hs-CRP (mg/L)	2.11±0.49	2.5±0.64	0.005
Serum adiponectin (µg/mL)	19.16±4.01	17.22±3.94	0.040

PCOM=Polycystic ovary morphology, FPG=Fasting plasma glucose, PGPG=Post-glucose plasma glucose, HOMA-IR=Homeostasis model assessment of insulin resistance, TG=Triglyceride, HDL=High-density lipoprotein, LDL=Low-density lipoprotein, VLDL=Very LDL, LH=Luteinising hormone, FSH=Follicle-stimulating hormone, DHEAS=Dehydroepiandrosterone sulphate, AMH=Anti-Mullerian hormone, 17-OHP=17-hydroxy progesterone, ONDST=Overnight dexamethasone suppression test, hs-CRP=High-sensitivity C-reactive protein, SD=Standard deviation

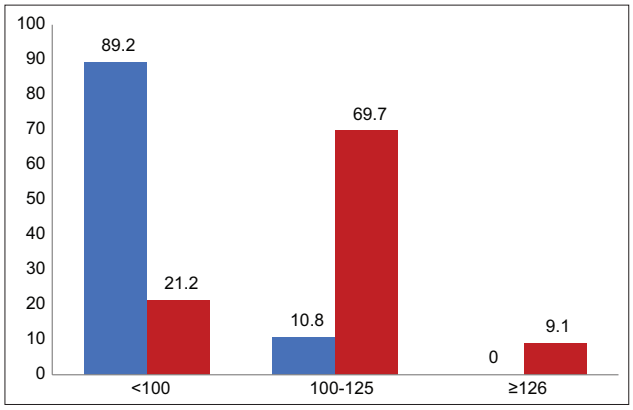

Figure 4: FPG of both groups. (Legend: Blue: Group 1, Red: Group 2)

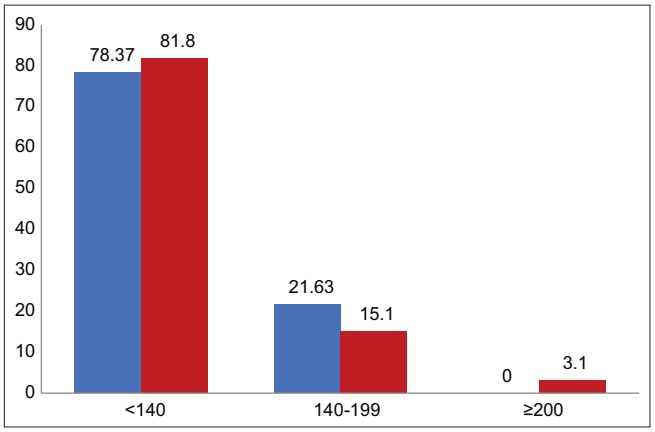

Figure 5: 2-h PGPG of both groups. (Legend: Blue: Group 1, Red: Group 2)

parameters analysis is depicted in Table 2. The mean hsCRP was found to be higher in Group 2, which was statistically significant (P = 0.005). The mean serum adiponectin was found to be higher in Group 1 compared to Group 2, and the difference was statistically significant (P = 0.040).

The obese PCOS patients of both Groups 1 and 2 were further compared to see if there was any difference in the anthropometric and metabolic parameters, which are markers of high cardiovascular risk as described in Table 3.

The mean age was comparable in both subgroups with no statistically significant difference. Other anthropometric parameters were comparable in both groups, and the differences were not statistically significant as summarised in Table 3.

The mean HOMA-IR, serum adiponectin and lipid profile analysis revealed no statistically significant difference between both subgroups. The difference between hs-CRP between both subgroups was statistically significant (P = 0.010) as denoted in Table 3.

Table 3: Obese of Group 1 versus Group 2

Variable	Mean±SD		*P*
	Group 1 PCOM (+)	Group 2 PCOM (−)	
Age (years)	24.00±4.22	23.75±5.19	0.600
BMI (kg/m^2)	30.17±4.10	30.63±4.66	0.730
WC (cm)	102.45±10.87	106.27±15.51	0.470
WHR	0.92±0.07	0.95±0.06	0.900
HOMA-IR	2.95±1.04	3.31±1.19	0.350
hs-CRP (mg/L)	2.08±0.52	2.69±0.64	0.010
Serum total cholesterol (mg/dL)	180.27±14.66	181.85±43.42	0.900
Serum TG (mg/dL)	133.55±35.51	162.07±29.43	0.060
Serum LDL (mg/dL)	96.91±16.92	107.05±21.49	0.760
Serum HDL (mg/dL)	43.27±10.16	42.65±7.73	0.240
Serum VLDL (mg/dL)	40.82±12.12	41.35±13.64	0.910
Serum adiponectin (µg/mL)	19.09±4.28	16.94±3.92	0.160

PCOM=Polycystic ovary morphology, BMI=Body mass index, WC=Waist circumference, WHR=Waist-to-hip ratio, HOMA-IR=Homeostasis model assessment of insulin resistance, TG=Triglyceride, HDL=High-density lipoprotein, LDL=Low-density lipoprotein, VLDL=Very LDL, hs-CRP=High-sensitivity C-reactive protein, SD=Standard deviation

Discussion

To the best of our knowledge, probably, this is the first Indian study to determine the differences in clinical presentation, metabolic profile, hormonal parameters and inflammatory markers in PCOS women with and without PCOM on USG. We found significantly higher levels of serum LDL, serum triglyceride and hs-CRP in Group 2 (PCOM absent) compared to Group 1 (PCOM present). Serum adiponectin was significantly higher in Group 1 compared to Group 2. The above findings suggest that patients without diagnostic PCOM have a worse metabolic profile compared to those with PCOM on USG. In the subgroup analysis of the obese PCOS patients of both Groups 1 and 2, our findings suggested that obese women without PCOM have a higher cardiovascular risk compared to obese women with PCOM.

In the present study, the baseline characteristics of patients in the two groups were comparable. A previous study by Inan and Karadag found no statistically significant difference in the baseline characteristics between PCOS women with or without PCOM.[11] In the current study, the percentage of obese was higher in Group 2; however, no statistically significant difference in BMI was seen in both groups.

The waist–hip ratio (WHR) >0.85 with WC is a risk factor for the development of the metabolic syndrome.[16] Few studies found that WC could predict IR in overweight and obese PCOS women but not in lean PCOS women.[17] Consequently, other reports found that it is not a good anthropometric marker for assessing IR in PCOS women.[17,18] However, we could not also predict the association of WC with IR in our study.

We found a prevalence of IFG and IGT higher in Group 2 compared to Group 1. The study by Inan and Karadag did not show any statistically significant difference in plasma glucose levels of both groups (PCOM present/absent).[11] Fasting glucose levels are poor predictors of type 2 diabetes risk in PCOS compared to impaired glucose tolerance. However, PCOS women who do not have IFG/IGT at the baseline should be followed up for the future development of diabetes due to associated metabolic risk factors.[19]

Fasting insulin concentration has been proposed as the simplest index for assessing IR and is also recommended in PCOS women to assess insulin resistance.[20] In the present study, although the mean level of fasting insulin was higher in Group 2, it was not statistically significant. In our study, the prevalence of insulin resistance (HOMA-IR >2) was >75% across individual groups. Previous studies have demonstrated the impact of hyperandrogenism on glucose and lipid metabolism pathways, leading to IR.[21] However, none of these studies took into account the variations in IR in different PCOS phenotypes. Therefore, a more differentiated view on the phenotype of PCOS is necessary to understand the underlying pathophysiology of the disorder.

Taking the cut-off of DHEAS as per Carmina and Longo, 28.5% of total patients had high DHEAS, which is in concordance with previous studies.[22] Dyslipidaemia may be present in up to 70% of women with PCOS.[23] A decrease in high-density lipid cholesterol (HDL-C) and an increase in triglyceride (TG) levels are well-known lipid profile changes in women with PCOS.[24] In the present study, we found significantly higher levels of serum LDL, serum triglyceride and hs-CRP in Group 2 compared to Group 1. Previous studies have reported increased LDL-C in women with PCOS; however, the cause for higher LDL-C levels in women with PCOS is not clearly elucidated yet, but postulated to be related to hyperandrogenism.[25]

High-sensitivity CRP is an independent predictor of diverse end points ranging from obesity, type 2 diabetes mellitus and metabolic syndrome, and previous studies have demonstrated significantly higher CRP levels in PCOS patients versus controls.[26] In the present study, the mean hs-CRP was found to be higher in Group 2, which was statistically significant.

The above findings suggest that patients without diagnostic PCOM have a worse metabolic profile compared to those with PCOM on USG. Obese

patients without PCOM have a higher cardiovascular risk compared to obese patients with PCOM. Hyperandrogenism and insulin resistance have been implicated in dyslipidaemia and worse metabolic profiles in PCOS. Although the mean serum testosterone and HOMA-IR were higher in the group without PCOM, which can explain the worse metabolic profile in this group, these were not statistically significant. Ovulatory women with PCOM have testosterone and androstenedione levels that are increased in comparison with women who have normal ovarian morphology, although levels are generally within the normal range.[27] Previous studies also demonstrated higher insulin levels in regularly cycling women with PCOM, compared with women who have normal ovarian morphology.[28] Women who do not fulfil the criteria for PCOM may not have completely normal appearing ovaries. These women represent variants in the spectrum of normal-appearing ovaries to PCOM as per the Rotterdam criteria. Whether peripheral hyperandrogenism is an accurate indicator of intraovarian hyperandrogenism is a matter to be delved into. It may be postulated that women with a higher degree of ovarian hyperandrogenism have subsequent follicular arrest giving rise to smaller and multiple number of follicles resulting in the characteristic polycystic appearance. The implication of non-PCOM on USG and how it translates to poor metabolic profile are still areas to be explored. Heterogeneity in PCOS is well-known, and PCO morphology does not always lead to PCOS. The phenotypic variation observed in PCOS is suggestive of an underlying genetic heterogeneity, which is beyond the currently defined biologically distinct subtypes. Future well-controlled, larger studies are required to prove these observations and find the causal mechanisms behind the above findings.

The study had some limitations; one being the absence of a control group for comparison. However, we were able to compare many key parameters with the established cut-off values available for the standard population. The sample size of the study may be considered small; however, our sample size was derived from a previously published study by Inan and Karadag of similar nature.[11] In addition, the free androgen index could have been used to better represent testosterone levels. The gold-standard test for insulin sensitivity, i.e. hyperinsulinaemic euglycaemic clamp, was not used in the study; instead, we relied on HOMA IR. However, many published studies have correlated well between the HOMA IR cut-off used in our study with metabolic derangements. Operator dependence, inability to perform transvaginal USG (TVS), constraints in obtaining clear images in obese girls and lack of normative data across the different phases of the menstrual cycle are the limitations of USG. Due to the high resolution of TVS, it is considered more accurate than TAS in detecting polycystic ovaries. However, in a conservative set-up like ours, with most patients being virgin females, TVS is not widely accepted. In a previous study, there was no difference in the prevalence of polycystic ovaries diagnosed by TAS or TVS in a group of randomly selected women.[29] Recent studies have shown ovarian morphology with PCOS using transabdominal USG to associate with the markers of reproductive dysfunction.[30] Despite these limitations, our study is the first of its kind in the Indian set-up to determine the differences in clinical profile, metabolic and hormonal parameters and inflammatory markers in PCOS women with and without PCOM.

Conclusion

The above findings suggest that patients without diagnostic PCOM have a worse metabolic profile compared to those with PCOM on USG. Obese patients without PCOM have a higher cardiovascular risk compared to obese patients with PCOM. Future well-controlled, larger studies are required to prove these observations and find the causal mechanisms behind the above findings. There are limited Indian data regarding the various metabolic and inflammatory components in relation to the expression of PCOM, which highlights the need for further research into the subject to delineate the contribution of these markers to find the best treatment options in future studies for Indian women with PCOS.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Data availability statement

The data that support the findings of the study are available from the author, upon reasonable request.

References

1. Melmed S, Auchus RJ, Goldfine AB, Koenig R, Rosen CJ, editors. Physiology and pathology of the female reproductive axis. In: Williams Textbook of Endocrinology. 14th ed., Vol. 2020. Philadelphia, PA: Elsevier; 2020. p. 612.
2. Ndefo UA, Eaton A, Green MR. Polycystic ovary syndrome: A review of treatment options with a focus on pharmacological approaches. P T 2013;38:336-55.
3. Azziz R, Woods KS, Reyna R, Key TJ, Knochenhauer ES, Yildiz BO. The prevalence and features of the polycystic ovary syndrome in an unselected population. J Clin Endocrinol Metab 2004;89:2745-9.
4. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third report of the national cholesterol education program (NCEP) expert panel

on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III) final report. Circulation 2002;106:3143-421.
5. Speroff L, Fritz MA. Clinical Gynaecologic Endocrinology and Infertility. 8th ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams and Wilkins; 2011.
6. De Groot LJ, Jameson JL. Hyperandrogenism, hirsutism and polycystic ovarian syndrome. In: Endocrinology: Adult and Pediatric. 7th ed. Elsevier, India; 2016. p. 2283-5.
7. van Santbrink EJ, Hop WC, Fauser BC. Classification of normogonadotropic infertility: Polycystic ovaries diagnosed by ultrasound versus endocrine characteristics of polycystic ovary syndrome. Fertil Steril 1997;67:452-8.
8. Rojas J, Chávez M, Olivar L, Rojas M, Morillo J, Mejías J, *et al.* Polycystic ovary syndrome, insulin resistance, and obesity: Navigating the pathophysiologic labyrinth. Int J Reprod Med 2014;2014:719050.
9. Esmaeilzadeh S, Andarieh MG, Ghadimi R, Delavar MA. Body mass index and gonadotropin hormones (LH and FSH) associate with clinical symptoms among women with polycystic ovary syndrome. Glob J Health Sci 2014;7:101-6.
10. Rosenfield RL. The polycystic ovary morphology-polycystic ovary syndrome spectrum. J Pediatr Adolesc Gynecol 2015;28:412-9.
11. Inan C, Karadag C. Correlation between ovarian morphology and biochemical and hormonal parameters in polycystic ovary syndrome. Pak J Med Sci 2016;32:742-5.
12. Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertil Steril 2004;81:19-25.
13. Lizneva D, Suturina L, Walker W, Brakta S, Gavrilova-Jordan L, Azziz R. Criteria, prevalence, and phenotypes of polycystic ovary syndrome. Fertil Steril 2016;106:6-15.
14. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: Insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 1985;28:412-9.
15. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, *et al.* Harmonizing the metabolic syndrome: A joint interim statement of the international diabetes federation task force on epidemiology and prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120:1640-5.
16. Talbott E, Clerici A, Berga SL, Kuller L, Guzick D, Detre K, *et al.* Adverse lipid and coronary heart disease risk profiles in young women with polycystic ovary syndrome: Results of a case-control study. J Clin Epidemiol 1998;51:415-22.
17. Dunaif A, Segal KR, Futterweit W, Dobrjansky A. Profound peripheral insulin resistance, independent of obesity, in polycystic ovary syndrome. Diabetes 1989;38:1165-74.
18. Faloia E, Canibus P, Gatti C, Frezza F, Santangelo M, Garrapa GG, *et al.* Body composition, fat distribution and metabolic characteristics in lean and obese women with polycystic ovary syndrome. J Endocrinol Invest 2004;27:424-9.
19. Livadas S, Anagnostis P, Bosdou JK, Bantouna D, Paparodis R. Polycystic ovary syndrome and type 2 diabetes mellitus: A state-of-the-art review. World J Diabetes 2022;13:5-26.
20. McAuley KA, Williams SM, Mann JI, Walker RJ, Lewis-Barned NJ, Temple LA, *et al.* Diagnosing insulin resistance in the general population. Diabetes Care 2001;24:460-4.
21. Sanchez-Garrido MA, Tena-Sempere M. Metabolic dysfunction in polycystic ovary syndrome: Pathogenic role of androgen excess and potential therapeutic strategies. Mol Metab 2020;35:100937.
22. Carmina E, Longo RA. Increased prevalence of elevated DHEAS in PCOS women with non-classic (B or C) phenotypes: A retrospective analysis in patients aged 20 to 29 years. Cells 2022;11:3255.
23. Legro RS, Kunselman AR, Dunaif A. Prevalence and predictors of dyslipidemia in women with polycystic ovary syndrome. Am J Med 2001;111:607-13.
24. Valkenburg O, Steegers-Theunissen RP, Smedts HP, Dallinga-Thie GM, Fauser BC, Westerveld EH, *et al*. A more atherogenic serum lipoprotein profile is present in women with polycystic ovary syndrome: A case-control study. J Clin Endocrinol Metab 2008;93:470-6.
25. Kim JJ, Choi YM. Dyslipidemia in women with polycystic ovary syndrome. Obstet Gynecol Sci 2013;56:137-42.
26. Boulman N, Levy Y, Leiba R, Shachar S, Linn R, Zinder O, *et al.* Increased C-reactive protein levels in the polycystic ovary syndrome: A marker of cardiovascular disease. J Clin Endocrinol Metab 2004;89:2160-5.
27. Bremer AA, Miller WL. The serine phosphorylation hypothesis of polycystic ovary syndrome: A unifying mechanism for hyperandrogenemia and insulin resistance. Fertil Steril 2008;89:1039-48.
28. Adams JM, Taylor AE, Crowley WF Jr., Hall JE. Polycystic ovarian morphology with regular ovulatory cycles: Insights into the pathophysiology of polycystic ovarian syndrome. J Clin Endocrinol Metab 2004;89:4343-50.
29. Farquhar CM, Birdsall M, Manning P, Mitchell JM. Transabdominal versus transvaginal ultrasound in the diagnosis of polycystic ovaries in a population of randomly selected women. Ultrasound Obstet Gynecol 1994;4:54-9.
30. Rackow BW, Vanden Brink H, Hammers L, Flannery CA, Lujan ME, Burgert TS. Ovarian morphology by transabdominal ultrasound correlates with reproductive and metabolic disturbance in adolescents with PCOS. J Adolesc Health 2018;62:288-93.