

Prevalence of Polycystic Ovarian Syndrome Among Adolescents and Young Women in India

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Abstract

Background: There is little epidemiological data from India on the prevalence of polycystic ovarian syndrome (PCOS). The objectives of the present study were to estimate the prevalence of PCOS using different criteria among adolescents and young women and to evaluate risk factors associated with PCOS. **Materials and Methods:** A total of 518 participants, adolescents (12–17 years, $n = 246$) and young women (18–30 years, $n = 272$), were recruited. Participants who were overweight and having menstrual disorders or biochemical abnormalities were invited for ultrasonographic examination. A standardized questionnaire assessed the regularity of menstrual cycles, body hair growth, skin, body weight, sleep, and androgen excess. The ovarian volume and follicular size were assessed transabdominally. Prevalence of PCOS was assessed by the Rotterdam, AE-PCOS, and NIH criteria. **Results:** The mean age of participants with PCOS was 19.7 ± 4.2 years and those without PCOS was 18.4 ± 4.2 years. Mean body weight, body fat %, body mass index, waist circumference, systolic and diastolic blood pressures, and fasting insulin were significantly higher in the PCOS group. Prevalence of polycystic ovaries on ultrasonography was observed in 78.6% of the women with PCOS as against 5% in women without PCOS. Obesity (odds ratio (OR): 3.09, 95% confidence interval (CI): 1.32–7.21), insulin resistance (OR: 2.12, 95% CI: 1.12–4.0), and hypertension (OR: 4.46, 95% CI: 1.52–13.06) were significantly associated with PCOS ($P < 0.05$). The overall prevalence of PCOS was highest with 8.1% according to the Rotterdam criteria followed by AE-PCOS (2.9%) and NIH (2.1%). Irrespective of the criterion used, the prevalence increased with age. **Conclusion:** There is a high prevalence of PCOS in urban India, which emphasizes the need for urgent preventive and control measures. Early diagnosis is therefore crucial in incorporating lifestyle and dietary modifications for weight reduction and better control of blood pressure at a younger age to further prevent long-term reproductive and metabolic disorders.

Keywords: Adolescence, India, PCOS, prevalence

INTRODUCTION

Polycystic ovarian syndrome (PCOS) also referred to as Stein–Leventhal syndrome^[1] is a heterogeneous endocrine disorder in women of reproductive age and is associated with a broad range of health conditions including hypertension, dyslipidemia, insulin resistance, hyperandrogenemia, and type 2 diabetes mellitus (T2DM).^[2] Globally, the prevalence of PCOS is estimated to be between 5.5% and 12.6% in women in the age group of 17–45 years.^[3] In India, the prevalence estimates are

between 8.2% and 22.5% depending on the diagnostic criteria used.^[4,5]

PCOS is one of the primary causes of infertility in women. Overweight and obesity, sedentary lifestyle, and a family history of PCOS may predispose a young girl to

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PCOS. Although the etiology of this condition remains uncertain, its diagnosis is based on abnormalities of the reproductive system, hyperandrogenism, and persistent anovulation after exclusion of primary diseases of the ovaries and adrenal and pituitary glands.^[6] Women with PCOS have a 11-fold increased risk of developing metabolic syndrome and glucose intolerance when compared with age-matched controls.^[7] However, early diagnosis and management in PCOS can help prevent long-term metabolic abnormalities. Achieving modest weight loss can help improve reproductive, metabolic, and mental health, which are the key aspects in overcoming the burden of PCOS.^[8]

The objectives of the present study were to estimate the prevalence of PCOS using different criteria used to diagnose PCOS among adolescents (12–17 years) and young women (< 30 years) in Chennai, India and to evaluate risk factors associated with PCOS.

PARTICIPANTS AND METHODS

Participant selection

The participants for the present study were derived from two sources. The first cohort belonged to the Obesity Reduction and Awareness of Non-communicable diseases through Group Education (ORANGE) project. This was a longitudinal follow-up ORANGE community component study between 2008 and 2011 ($n = 1519$) carried out in children and adolescents in Chennai, India aged less than 20 years. Since the follow-up was done after an average of 7 years, the age group was between 10 and 30 years during phase II of the ORANGE study.^[9] The database of another ongoing study at that point of time which aimed to assess physical activity patterns and environmental correlates and their relative contributions to metabolic health in Indian adolescents in the age group of 12–17 years was also used as a secondary source for PCOS screening. The girls from this cohort were screened for PCOS between 2015 and 2017. Participants from both these cohorts who were overweight or having menstrual disorders and any biochemical abnormalities were invited for ultrasonographic (USG) examination to a tertiary diabetes center in Chennai, south India. Finally, the total number of study participants was 518 comprising 246 adolescents (ages 10–17 years) and 272 young women (ages 18–30 years).

Anthropometry and biochemical parameters

Anthropometric measurements including height, weight, and waist measurements were determined by standardized methods. The body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Fasting plasma glucose (glucose oxidase–peroxidase method), serum cholesterol (cholesterol oxidase–peroxidase–amidopyrine method), serum triglycerides (glycerol phosphate oxidase–peroxidase–amidopyrine

method), high-density lipoprotein cholesterol (HDL-C) (direct method–polyethylene glycol–pretreated enzymes), and creatinine (Jaffe's method) were measured using a Hitachi-912 Autoanalyser (Hitachi, Mannheim, Germany).

USG examination of the abdomen

Participants who were overweight or having menstrual disorders and any biochemical abnormalities were invited for USG examination. The ovarian volume and follicular size was assessed transabdominally using a 3.5–5 MHz curvilinear probe (Siemens Healthineers Acuson Juniper). Based on the Rotterdam criteria,^[10] the findings from USG were categorized as participants having PCOS or not.

Questionnaire for PCOS assessment

The participants were administered a standardized questionnaire which assessed the regularity of menstrual cycles, body hair growth, skin, body weight, and sleep. The Ferriman–Gallwey score was used for evaluating hirsutism, and a score of 1–4 was used for nine areas of the body. A total score less than 8 is considered normal, a score of 8–15 indicates mild hirsutism, whereas a score greater than 15 indicates moderate or severe hirsutism.^[11]

Diagnosis of PCOS

There are three different diagnostic criteria available in the assessment of PCOS, namely, (1) *National Institutes of Health (NIH)'s International Conference on PCOS in 1990*^[12]; (2) *The European Society of Human Reproduction and Embryology and the American Society for Reproductive Medicine (ESHRE/ASRM) criteria* (2003) which is commonly referred to as the *Rotterdam criteria*^[10]; and (3) *The Androgen Excess Society and PCOS Society (AE-PCOS) criteria* published in 2006.^[2] The 1990 NIH criteria suggest that the presence of symptoms of oligo-ovulation and androgen excess (clinical or biochemical) is indicative of PCOS. According to the Rotterdam 2003 criteria, the individual must exhibit symptoms in two out of three categories, which include oligo/anovulation, androgen excess, and the presence of polycystic ovaries. The 2006 AE-PCOS criteria require androgen excess, along with either one of the two symptoms for confirmation of PCOS. In 2018, the International evidence-based guideline for PCOS^[13] recommended the use of Rotterdam criteria with some caveats. In adolescents, an ultrasound is not required for diagnosis in those who have irregular menstrual cycles and hyperandrogenism. It is recommended that adolescents are assessed for irregular cycles for a minimum of 2 years after menarche and undergo clinical and biochemical evaluation for androgen excess as well as ovulatory dysfunction after excluding for secondary causes. In adults, the criteria require two of the following three features: androgen excess, ovulatory dysfunction, or polycystic ovarian morphology to be present after excluding secondary causes [Table 1]. In our

study, the Rotterdam criteria (2003) were used to classify the participants with and without PCOS, whereas the other two diagnostic criteria, namely, NIH 1990 and AE-PCOS 2006, were used for the comparison of prevalence of PCOS with the Rotterdam criteria.

Statistical analysis

IBM SPSS Statistics 23.0 was used for compilation and analysis of data. The dataset was cleaned or corrected for outliers by replacing missing values with mean values for interval data. Demographic, anthropometric, and clinical and biochemical parameter variables and symptoms were used for comparing participants based on PCOS. Comparison between PCOS and non-PCOS participants was done using independent *t*-tests for continuous variables and χ^2 tests for categorical variables. Continuous variables were represented as mean \pm standard deviation and categorical variables using frequency (%). *P*-value less than 0.05 was considered statistically significant. Relationship between categorical variables was represented through odds ratios (ORs). Sensitivity analyses were carried out to determine which of the three criteria best identified PCOS prevalence in our population.

Ethical approval

All procedures in this study were performed in accordance with the ethical standards of the Institutional Research Committee and is compliant with the 1975 Helsinki Declaration and its later amendments.

RESULTS

Table 2 shows the clinical and biochemical characteristics of the PCOS and non-PCOS groups. Mean body weight, body fat %, BMI, waist circumference, systolic and diastolic blood pressures, and fasting insulin were significantly higher in the PCOS group when compared with the non-PCOS group. The prevalence of acne (45.2% and 34.7%) and acanthosis was higher in the PCOS group (20% and 10%), respectively, compared with the non-PCOS group. The prevalence of polycystic ovaries (PCO) on USG was observed in 78.6% of the women with PCOS when compared with 5% in women without PCOS.

Table 3 shows that obesity (OR: 3.09, 95% CI: 1.32–7.21), insulin resistance (OR: 2.12, 95% CI: 1.12–4.0), and hypertension (OR: 4.46, 95% CI: 1.52–13.06) were significantly associated with PCOS (*P* < 0.05).

Figure 1 shows that the overall prevalence of PCOS was highest with 8.1% according to the Rotterdam criteria, followed by AE-PCOS (2.9%) and NIH (2.1%). It was also noted that irrespective of the criterion used, the prevalence increased with age. Additionally, a sensitivity analysis was carried out on each of the indicators under the NIH, AE-PCOS, and Rotterdam criteria for all age groups, to understand their role in predicting PCOS (*table not shown*).

Table 1: Various criteria used for the diagnosis of PCOS in the literature

National Institutes of Health (1990) ^[12]	Rotterdam (2003) ^[10]	AE-PCOS Society (2006) ^[2]	NIH (2012)/International PCOS Guidelines (2018) ^[13]
Oligomenorrhea (<10 menses a year) or oligo-ovulation	Ovarian dysfunction: oligomenorrhea (<10 menses a year) or oligo-ovulation and/or	Clinical hyperandrogenism and/or biochemical hyperandrogenism (elevated total/free testosterone and/or DHEAS), as well as one of the following: Oligomenorrhea (<10 menses a year) or oligo-ovulation	Oligomenorrhea or amenorrhea for 2 years after menarche
Clinical hyperandrogenism	Clinical hyperandrogenism	Oligomenorrhea (<10 menses a year) or oligo-ovulation	Clinical hyperandrogenism
or	or	and/or	and
Biochemical hyperandrogenism (elevated total/free testosterone and/or DHEAS)	Biochemical hyperandrogenism (elevated total/free testosterone and/or DHEAS)	Polycystic ovaries on ultrasound (≥ 12 antral follicles in one ovary or ovarian volume ≥ 10 cm ³ in one ovary)	Biochemical hyperandrogenism (elevated total/free testosterone and/or DHEAS)
Requires 2 of 2	Biochemical hyperandrogenism (elevated total/free testosterone and/or DHEAS) Requires 2 of 3	Requires hyperandrogenism	Ovarian volume ≥ 10 cm ³ in one ovary Requires 2 of 3 after exclusion for other etiologies

Table 2: Clinical and biochemical characteristics of the PCOS and non-PCOS groups

Variable	PCOS (n=42)	Non-PCOS (n=476)	P-value
Age (years)	19.7±4.2	18.4±4.2	0.041
Height (cm)	160±6	157±6	0.030
Weight (kg)	65.4±14.9	56.0±13.4	<0.001
Body fat (%)	37.9±7.8	31.9±8.8	<0.001
BMI (kg/m ²)	25.6±5.1	22.6±4.9	<0.001
Waist circumference (cm)	80±11	73±12	<0.001
Systolic blood pressure (mmHg)	111±11	107±10	0.021
Diastolic blood pressure (mmHg)	73±9	70±8	0.025
Fasting plasma glucose (mg/dL)	88±10	88±9	1.000
Fasting insulin (µIU/mL)	17±9	13±6	0.025
Total cholesterol (mg/dL)	163±36	155±30	0.125
LDL cholesterol (mg/dL)	98±64	86±69	0.308
HDL cholesterol (mg/dL)	42±9	44±25	0.727
Triglycerides (mg/dL)	98±64	86±69	0.308
Thyroid-stimulating hormone (µg/dL)	3.4±2.1	3.6±8.1	0.882
Symptoms			
Acne	19 (45.2)	165 (34.7)	0.170
Snoring	2 (4.8)	33 (6.9)	0.591
Acanthosis nigricans	7 (20.0)	35 (9.6)	0.055
Do you think you are overweight?	29 (69.0)	188 (39.5)	<0.001
Polycystic ovaries on USG	33 (78.6)	24 (5.0)	<0.001

Table 3: Association of PCOS with obesity, insulin resistance, and hypertension

Variables	PCOS OR (95% CI)
Obesity	3.09 (1.32–7.21) P=0.009
Insulin resistance	2.12 (1.12–4.0) P=0.021
Hypertension	4.46 (1.52–13.06) P=0.006

It was observed that participants with irregular menstrual history had 74.2 (95% CI: 25.5–216.1) times higher chance of getting detected as having PCOS than those with regular periods. Similarly, the OR of detecting PCOS in participants with hirsutism and confirmation of polycystic ovaries by ultrasound was 12 (95% CI: 6–26) and 51 (95% CI: 14–180) times higher, respectively, when compared with those without these symptoms. When restricting the analysis to adolescents, it was observed that girls with irregular menstrual history for at least 2 years as per the latest NIH 2012/International PCOS Guidelines 2018 had 143 (95% CI: 16–1275) times of getting diagnosed with PCOS when compared with those with a lesser duration of irregular menstrual history.

DISCUSSION

The salient findings of this study are as follows: (1) The Rotterdam criteria reported the highest prevalence when compared with the other two criteria to detect prevalence and evaluate risk for diagnosing PCOS among Indian

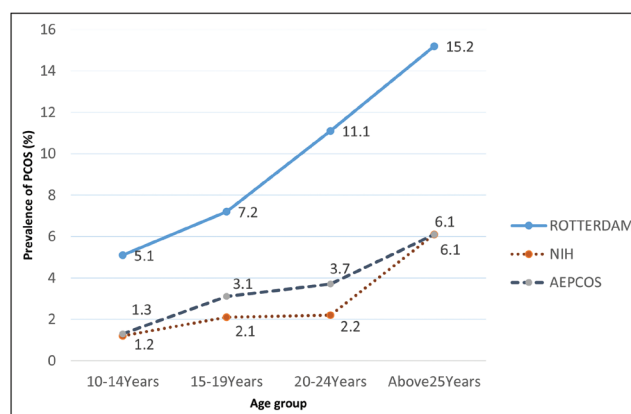


Figure 1: PCOS prevalence based on various diagnostic criteria

adolescent girls and women; (2) the prevalence of PCOS is high among young girls in India which steadily increases with age; (3) menstrual irregularity for 2 years can be used as an early indicator for PCOS; and (4) obesity, insulin resistance, and hypertension are the metabolic parameters associated with PCOS.

The pooled prevalence of PCOS based on the Rotterdam criteria was found to be 8.1% in our study which increased with age, as shown in Figure 1. This was similar to PCOS estimates reported from Bhopal, Central India (8.2%) and Andhra Pradesh, South India (9.1%).^[4,14] A systematic review done on prevalence based on ethnicity suggested that China had the lowest prevalence of 5.6%, whereas the highest prevalence was noted for women residing in the Middle East (16%).^[3]

We report that the overall prevalence of PCOS was the highest by Rotterdam when compared with NIH and AE-PCOS criteria. Similar findings have been reported by others. In a cross-sectional study done in Mumbai among 778 participants belonging to the age group of 15–24 years, the prevalence reported by the Rotterdam criterion was 22.5% whereas using AE-PCOS criterion it was 10.7%.^[5] Among a relatively large Caucasian population of 18–45 aged women studied at Turkey, the prevalence was 6.1%, 19.9%, and 15.3% according to the NIH, Rotterdam, and AE-PCOS criteria.^[15] Among Australian women also the prevalence of PCOS was 15.3% and 20.9% by the NIH and Rotterdam criteria, respectively.^[16] Ding *et al.*^[3] confirmed with their meta-analysis that the prevalence estimates were the highest with the Rotterdam criteria and the lowest with NIH on comparing studies done across different continents.

As seen in other studies,^[17] symptoms of hyperandrogenism, hyperinsulinemia, and adiposity were commonly noted in our study participants with PCOS. Weight gain and body fat are strongly associated with PCOS, and obesity is well known to worsen the severity of this disorder.^[15] In a study done among south Indian adolescents with PCOS, weight gain was the most common symptom reported in menstrual disorders.^[18] There is a male pattern of body fat distribution in females with PCOS due to hyperandrogenism, which in turn sets up a vicious circle of hyperinsulinemia, hyperandrogenemia, central obesity, and metabolic dysfunction.^[19] Also, with every unit increase in BMI, the risk of getting PCOS increases by 9%.^[20] Hence, paying attention to early symptoms like irregular menstrual cycles for over a year along with assessment of adiposity warrants a visit to the gynecologist in order to facilitate early diagnosis and treatment and to prevent co-morbidities associated with PCOS.^[5]

In a study done among reproductive aged women at Uttarakhand, the most common symptom was menstrual irregularity, otherwise known as oligomenorrhea, which was reported in 68% of the individuals,^[18] while we found it in 90.5%. Other studies record even higher estimates of oligomenorrhea with a prevalence of 97.6% in south Indian adolescents aged 15–18 years and 95.1% in a Sri Lankan population aged 15–39 years.^[14,21] A systematic review and meta-analysis done in 2016 reported lowest rates of hirsutism and hyperandrogenemia in Asian women.^[22] Our study showed that 35.7% of the PCOS participants had hirsutism.

Ovulatory dysfunction is associated with an increased prevalence of endometrial hyperplasia and endometrial cancer, in addition to infertility.^[23] A recent finding by Chhabra and Gangane^[24] in rural India reported that PCOS was present among 8% of the women suffering from endometrial cancer. In PCOS, hirsutism develops gradually and intensifies with weight gain. Oligomenorrhea is more

frequently associated with rapid onset of hirsutism. This diagnostic feature is more likely to be under-reported in adolescent girls presenting earlier in the continuum.^[25] Persistent oligomenorrhea beyond 2 years of menarche predicts ongoing menstrual irregularities and has a greater likelihood of ascertaining the true underlying ovarian dysfunction in girls.^[26] Hence, the use of the latest NIH 2012/International PCOS Guidelines 2018 for PCOS diagnosis is recommended nowadays. Furthermore, in this study, the prevalence of PCOS varied according to the diagnostic consensus used, with estimates ranging from 2.1% according to the NIH consensus up to 8.1% with the Rotterdam consensus. Since there are no universally accepted criteria for PCOS diagnosis, the three diagnostic criteria used in this study posed a challenge due to the variations in the parameters used in the three criteria. We recommend to always use the updated/revised guidelines of any of these guidelines for diagnosing this disorder.

We found fasting insulin to be an independent predictor of PCOS. There are other studies which also report that Indian women with PCOS have higher fasting insulin levels and thus greater insulin resistance (IR) when compared with White women with PCOS.^[27,28] This in turn contributes to early onset of impaired glucose tolerance and type 2 diabetes in women affected with PCOS.^[14]

In a study conducted to examine the cardiovascular risk profile in PCOS, it was found that women with PCOS had 40% greater risk of developing hypertension than those of non-PCOS population.^[29] In Czech, women aged between 25 and 42 years, blood pressure was found to be high in PCOS women even after adjusting for BMI.^[30] Elting *et al.*^[31] reported that the prevalence of hypertension in Dutch women having PCOS was 2.5 times greater than those without PCOS. Our study showed that participants having hypertension showed a 4.5 times higher rise of PCOS.

The strengths of this study are the use of two community-based cohorts of ongoing studies in estimating the prevalence which thus reduces the bias of over-estimation through clinic-based studies. Also, this is one of the very few studies which includes the adolescent girls along with young women (< 30 years) for reporting PCOS prevalence as most studies include adult women from the age group of 18 years. Finally, this is one of the few studies to compare the different criteria for diagnosing PCOS.

Due to a constant evolution in the diagnostic criteria of PCOS, one of the challenges was to pick just one criterion to evaluate the prevalence in a consistent manner. Based on the previous literature, it is known that PCOS being a clinical syndrome, there are no definite criteria available that can be adequate to diagnose this condition. Biochemical assays were not analyzed for testosterone for the detection of PCOS due to the cost involved, and this is an obvious limitation of this study. As explained in the

methods section, the study participants were drawn from two ongoing study samples: (i) a longitudinal follow-up study and (ii) a cross-sectional survey that examined physical activity and environmental correlates. However, one of the limitations of our study is that the sample size was small.

In summary, the prevalence of PCOS in Chennai was found to be 8.1% according to the Rotterdam, 2.9% by AE-PCOS, and 2.1% by NIH criteria. The prevalence of PCOS and its symptoms increase with age, thus emphasizing the need for a multi-disciplinary approach to catch this disorder at an early stage. A long-term personalized management program involving evidence-based practice from a team of dermatologists, diabetologists, and diabetes educators along with appropriate obstetricians/gynecologists counseling, and appropriate referral to physicians and endocrinologists is required for effectively treating individuals with PCOS. This strategy can aid in regulating menstrual cycles, treating PCOS-related dermatological issues such as hirsutism and acne, attaining fertility, lowering the burden of obesity, diabetes, and risk of other metabolic complications, and addressing health-related quality of life issues related to this syndrome. One of the early steps in prevention and management of PCOS could be to create awareness and understanding of this disorder in the community through schools and colleges.

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Conflicts of interest

There are no conflicts of interest.

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