

POLYCYSTIC OVARIAN SYNDROME (PCOS) AMONG YOUNG ADULT WOMEN: AN ANTHROPOLOGICAL INSIGHT

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ABSTRACT

Polycystic Ovarian Syndrome (PCOS) is one of the most common endocrine disorders which affect women in a significant manner worldwide. India has witnessed an about 30% rise in PCOS cases in the last couple of years. PCOS has a strong association with many comorbidities with its long-term metabolic as well as other consequences. Thus, it has recently been recognized as a significant public health issue. This review paper is an attempt to reveal the prevalence, pathophysiology, knowledge and awareness of PCOS among the adolescents and young adult women of India.

An extensive search was performed using electronic search engines such as PubMed, Scopus, and Google Scholar (from 2004 to 2023) to find the relevant research papers on the prevalence, pathophysiology, knowledge, and awareness of PCOS among the adolescents and young adult women of India. The current review summarises and highlights the prevalence, pathophysiology, knowledge, and awareness of PCOS for early identification and prevention and consequent minimation of the steady upward trend of PCOS. The results of this review could identify high-risk populations and foster the implementation of preventive lifestyle measures. It also investigates the need for intervention programmes for PCOS and its associated comorbidities in different settings at an earlier stage and to improve the quality of health.

Keywords: *prevalence; pathophysiology; metabolic syndrome; menstrual dysfunction; hyperandrogenism; awareness*

INTRODUCTION

Polycystic ovary syndrome (PCOS) is one of the most common endocrine disorders encountered among women of the reproductive age [23, 46]. PCOS was initially defined by Stein and Leventhal in 1935 as an increase in the ovarian diameter, presence of numerous follicular cysts and an increase in the thickness of the capsule [133]. Later, it has been characterized by chronic hyperandrogenism, oligomenorrhoea and/or anovulation [41]. PCOS shows a wide variety of manifestations like hyperandrogenism (hirsutism, acne, alopecia), menstrual disturbance, infertility, obesity, type II diabetes mellitus, dyslipidaemia, hypertension, cardiovascular disease, and endometrial carcinoma (Figure 1) [8, 98, 152, 153].

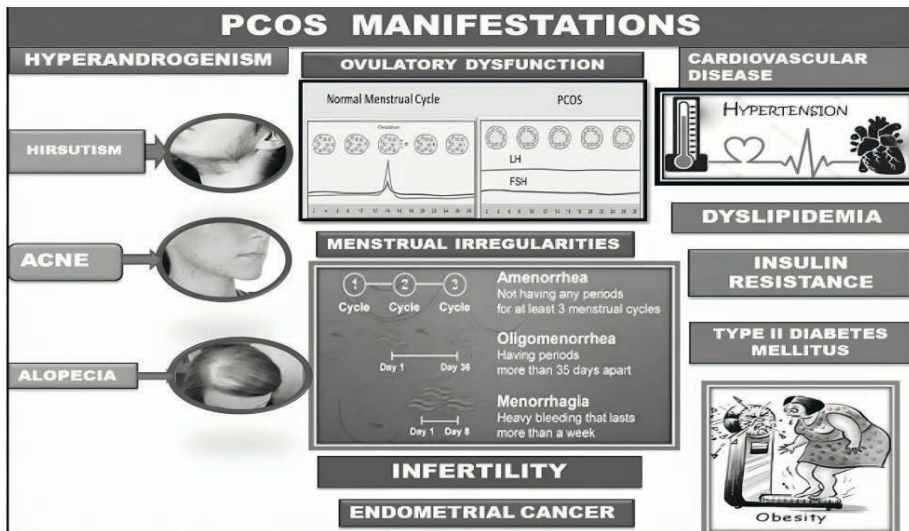


Figure 1. Manifestations of PCOS

The World Health Organization (WHO) estimates that in 2012 PCOS affected 116 million women (3.4%) worldwide [70]. Community-based studies using the Rotterdam criteria among the reproductive age group (18–45 years) women have demonstrated varied prevalence figures in few Asian countries ranging from 2% to 7.5% in China to 6.3% in Sri Lanka [8, 29, 82]. Globally, prevalence estimates of PCOS are highly variable ranging from 2.2% to as high as 26% [7, 8, 41, 76, 86]. Additionally, a study from Spain highlights an 18.8% prevalence of PCOS in women with type 1 diabetes mellitus and hirsutism [49].

The Flo app technology was utilized in a study by Jain *et al.* [63] to understand the complicated characteristics of PCOS in different countries and to

identify risk factors that lead to the onset of this illness because the Flo app is a well-known female health and wellbeing app which offers a globally representative and objective picture of PCOS symptoms along with period tracking capabilities. Five nations were selected such as the United States ($n = 243,238$), the United Kingdom ($n = 68,325$), India ($n = 40,092$), the Philippines ($n = 35,131$), and Australia ($n = 29,926$) (Figure 2). Bloating was the most common symptom reported by PCOS-positive women, and, according to the model, it was also the main predictor of PCOS. Additionally, blood glucose and elevated blood cholesterol are two major PCOS indicators. The proportion of women reporting a doctor-confirmed PCOS diagnosis increased along with BMI. However, this tendency was not noticed in Indian women.

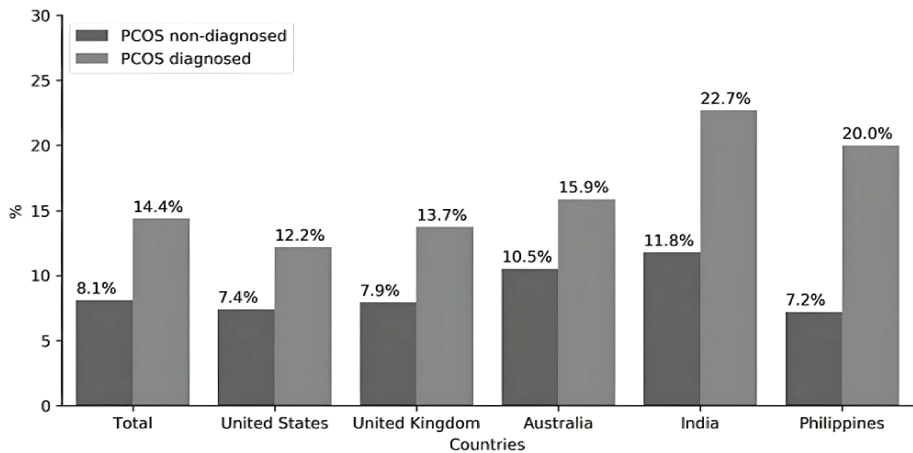


Figure 2. Scenario of PCOS in different parts of the world [63].

Adolescence as the transitional phase of physical and mental development between childhood and adulthood is characterised by immense hormonal changes. PCOS is the most common hormonal disorder among adolescent girls and adult females, affecting approximately 5%–10% of all females and 4–6% of adolescent girls and young women [48]. According to the Rotterdam criteria [115], PCOS is diagnosed if at least two of the following three features occur: (i) oligo or anovulation (OA), (ii) clinical and/or biochemical hyperandrogenism, and (iii) ultrasound appearance of polycystic ovaries with the exclusion of other causes (Figure 3).

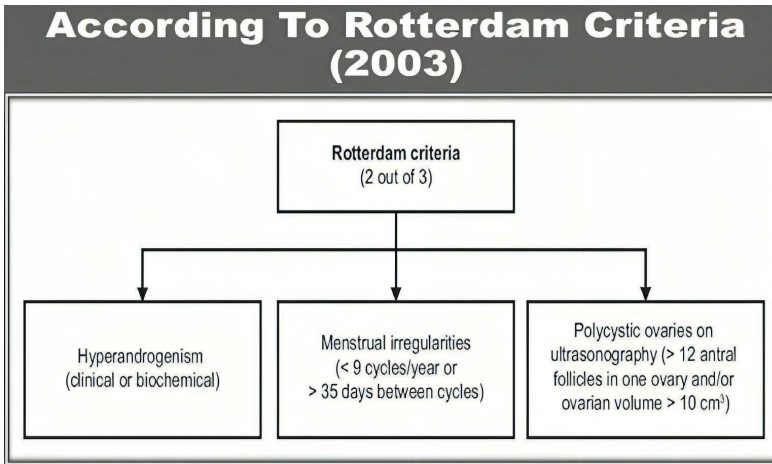


Figure 3. Rotterdam criteria of PCOS [115].

The pathophysiology of PCOS is still uncertain, and there is evidence that both genetic and environmental factors may play a role in the development of PCOS and its phenotypic expressions [13, 49, 62, 75, 81, 85, 95, 114, 147]. Familial clustering of the disorder and environmental risk factors such as obesity support the hypothesis that genetics and environment may be interconnected. There is a growing consensus in considering PCOS pathology across the lifecourse. Even though PCOS symptoms are frequently identified in adolescence, the physiological effects of the disorder have an impact on a woman throughout her life, with metabolic and hyperandrogenic signs and symptoms occurring in the early years, reproductive dysfunction becoming more obvious in adulthood, and metabolic and cardiovascular risk increasing in middle and later life [36, 97, 137, 150]. The occurrence of PCOS has been associated with an increased risk for type 2 diabetes, gestational diabetes, hypertension, gynaecological cancers, cardiovascular disease, stroke, and atherosclerosis [42, 43, 87, 151–153]. Women with PCOS are also more likely to suffer from depression, anxiety, poor self-esteem, decrease in the quality of life due to obesity, excessive body hair, infertility, and changes in their physical appearance [11, 37, 83, 116, 137, 139].

Teede *et al.* [137] emphasize that the aetiology of PCOS involves a combination of genetic and environmental causes of hormonal imbalances as well as other variables like obesity, ovarian dysfunction, and hypothalamus pituitary abnormalities (Figure 4). However, the absence of optimal tools to evaluate either hyperandrogenism or insulin resistance has slowed the progress in understanding the pathophysiological factors in PCOS. With a detection rate of 60%

to 80%, hyperandrogenism is a well-established component in the pathogenesis of PCOS. A pathophysiological factor in 50% to 80% of women with PCOS is insulin resistance.

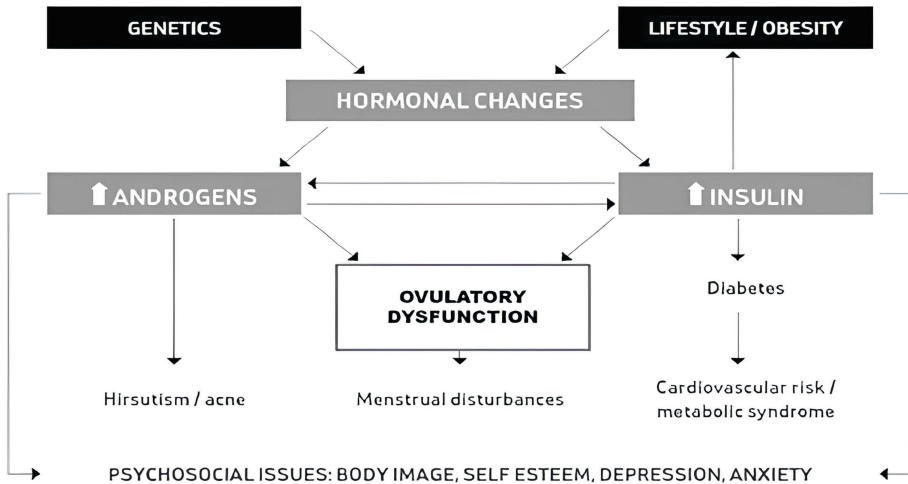


Figure 4. Pathophysiology of PCOS [137].

Awareness of PCOS symptoms and complications is essential for early treatment and to prevent further serious complications and to improve the quality of health and to lower the treatment costs [1, 55]. PCOS impacts women of all races and ethnicities who are of reproductive age, and the genetic predisposition to PCOS based on ethnicity is significantly influenced by the environment [2, 15, 22, 49, 59, 85, 149, 153]. Due to the variation in the environmental and lifestyle determinants of PCOS, a marked difference can exist in the prevalence of PCOS and also in the associated burden of PCOS among different ethnic groups and across different geographical regions of India. Literature worldwide reveals that the prevalence of PCOS is increasing gradually and also in India, and this may be a major health concern in the future.

Since adolescence is the transitional phase of physical and mental development between childhood and adulthood and is characterized by immense hormonal changes, there is a growing consensus considering PCOS pathology. Based on the existing issues, further in-depth exploration could identify high-risk populations and foster the implementation of lifestyle preventive measures for PCOS and its associated comorbidities in different settings at an earlier stage. The current literature review delineates variations in prevalence, pathophysiology, knowledge, and awareness of PCOS in India, especially in the case of adolescents and young adults.

MATERIAL AND METHODS

This study is based on the review of articles published in different online databases using search engines like Google Scholar, Pub Med, INFLIBNET, JSTOR for finding the relevant research papers on the prevalence, pathophysiology, knowledge and awareness of PCOS in adolescents and young adults. The following keywords were used for searching the literature: prevalence, pathophysiology, metabolic syndrome, menstrual dysfunction, hyperandrogenism, awareness. Some libraries were also visited, like the National Library of Kolkata and the library of the University of Calcutta. All the published articles and abstracts used in this review report were on adolescents and young adult populations. References from retrieved articles were used to identify additional relevant publications. The reference lists of included studies were manually searched for potential additional studies. A total of 122 articles were selected for this study. Out of them, 77 studies were relevant, concerning the PCOS situation in India. The publication period of the reviewed articles was from 2004 to 2022.

For this study, Litmaps visual citation navigation was used. It offers a platform for finding scientific literature, surveys the state of the field, and retrieves papers with strong regional connections. For the present study, 77 articles were considered which focused only on India for creating a map to visualize the relevance of the kinds of literature (Figure 5). The platform basically prefers the DOI to create the map, but for the articles that have no DOI, the full reference was given. Based on the logarithm of the platform, only 49 articles were used for creating the map and 6 were found missing in their database. The map made for this paper was based on the relevance of the literature. The x-axis was set to “publication date”, and the y-axis was set to “citations”, which assisted in understanding the growth of publications over time, the distribution of citation counts, and trends in citation growth over time. When the publication date option was selected, a linear arrangement of relevant articles was displayed, with older articles on the left and recent papers on the right. The size of the node was calculated by the software based on “cited by count”, and thus articles with more citations had larger circles.

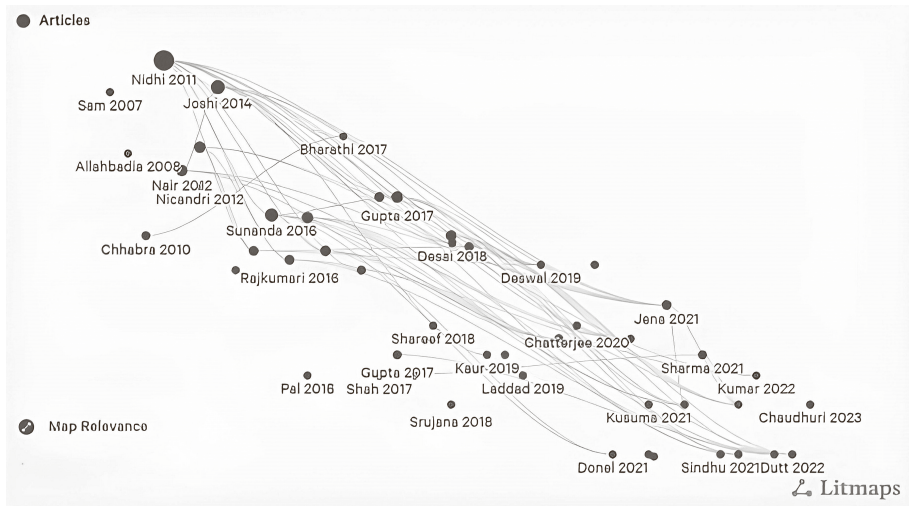


Figure 5. Map of relevant literature using Litmap.

Inclusion criteria

The pertinent research papers have been included based on the prevalence, pathophysiology, knowledge and awareness of PCOS among adolescents and young adults.

Exclusion criteria

The studies based on married women associated with infertility issues have been excluded.

RESULTS AND DISCUSSION

India has witnessed an about 30% rise in PCOS cases in the last couple of years [135]. In most industrialized countries, including India, the prevalence of PCOS is increasing owing to urbanization and change in lifestyle. Recently, various researchers have investigated the impact of the lifestyle change in PCOS girls and suggested that diet, exercise and behavioural modification appear to improve the metabolic, psychological and reproductive abnormalities of patients with PCOS [47, 49, 62, 93]. The pathophysiology of PCOS is still uncertain, and there is evidence that both genetic and environmental factors may play a role in the development of PCOS and its phenotypic expressions [13, 62, 75, 81, 85, 95, 114, 147].

Prevalence of PCOS

In India, studies show variation in the prevalence of PCOS (Table 1 and Figure 6). In Andhra Pradesh it is around 9.13% [94]. Higher prevalence of PCOS (46.8%) has been, however, reported among girls aged 13–18 years in New Delhi [146]. Other studies have found the prevalence of PCOS to be 26.4% in Kerala [55] and 23.8% in Bangalore [71]. The majority of PCOS females (3.7%) in Lucknow were lean but had abdominal obesity [53]. In most cases, diagnosing of PCOS is minimal due to lack of awareness. Joshi *et al.* [68] opined that, in Mumbai, the prevalence of PCOS for teenagers is much higher (22.5%). Similarly, Bharathi *et al.* [16] have found a strong association of family history with the incidence and manifestation of PCOS and its prevalence of 6% among the rural population of Thiruvallur and Dindugal districts of Chennai. Moreover, stress is another facet of PCOS. A study from Nagpur, Maharashtra, showed that the prevalence of PCOS among adolescents and young adults was 6% [142]. Furthermore, Rajkumari *et al.* [110] from Odisha highlighted that the prevalence of PCOS among the girls aged 14–17 years was 12%. Pal and Mallick [96] reported that the prevalence rate of PCOS among the adolescent girls of Murshidabad district of West Bengal, Eastern India, was found to be 13.1%. Evaluation of PCOS is very challenging in adolescents. A study in Hyderabad reported an increased rate (11.96%) of PCOS [130]. The prevalence of PCOS among the girls aged 17–24 years in Bhopal with the symptoms of irregular menstrual cycle and hyperandrogenism was found to be 8.2% [56]. Moreover, Desai *et al.* [38] stated that in Ahmedabad 13.54% of adolescents were diagnosed with PCOS. The study also suggested that socio-economic status, hirsutism, acne, and dysmenorrhea are the most significant indicators of PCOS. A study from Mysore stated that the prevalence rate of PCOS among the women aged 18–30 years was 4.5% [92]. The rate of PCOS among adolescent girls was also high in Jammu (12%) [57]. In Maharashtra, Laddad *et al.* [79] identified that the prevalence rate of PCOS was 17.33%. A recent study in Kolkata suggested that adolescents are at risk for developing PCOS (28%) [26]. Furthermore, a study from Tamilnadu in the Perambalur district has revealed that adolescents aged 16–17 years showed an increased risk of PCOS (14%) [143].

Table 1. Prevalence of polycystic ovary syndrome (PCOS) in different parts of India.

SI No.	Author's Name	Publication Year	State	Sample Size	Age Group (Years)	Prevalence Rate
1.	Nidhi <i>et al.</i>	2011	Andhra Pradesh	460	15–18	9.13%
2.	Gill <i>et al.</i>	2012	Lucknow	1052	18–25	3.7%
3.	Vijayan and Sonia	2013	Kottayam, Kerala.	200	18–31	15.0%
4.	Joshi <i>et al.</i>	2014	Mumbai, Maharashtra	778	15–24	22.5%
5.	Kalavathi <i>et al.</i>	2015	Bangalore	126	15–19	23.8%
6.	Pal and Mallick	2016	Murshidabad district, West Bengal	307	10–19	13.1%
7.	Rajkumari <i>et al.</i>	2016	Odisha	100	14–17	12%
8.	Bharathi <i>et al.</i>	2017	Chennai	1068	18–24	6%
9.	Gupta <i>et al.</i>	2017	Bhopal City	840	15–21	8.34%
10.	Upadhye and Shembekar	2017	Nagpur, Maharashtra	200	18–24	6%
11.	Singh <i>et al.</i>	2018	Hyderabad	117	15–19	11.96%
12.	Gupta <i>et al.</i>	2018	Bhopal	500	17–24	8.20%
13.	Desai <i>et al.</i>	2018	Ahmedabad	881	13–18	13.54%
14.	Nanjaiah and Roopadevi	2018	Mysore	396	18–30	4.5%
15.	Raja <i>et al.</i>	2018	Tamil Nadu	100	18–35	30%
16.	Laddad <i>et al.</i>	2019	Maharashtra	150	10–19	17.33%
17.	Chatterjee and Bandyopadhyay	2020	Kolkata, West Bengal	125	18–20	28%
18.	Gupta <i>et al.</i>	2021	Jammu and Kashmir	100	12–19	12%
19.	Aanandhi and Gayathri	2023	Tamilnadu	50	16–17	14%

Considering these consequences of PCOS, it is necessary to figure out the prevalence in India. In this regard, healthcare providers can chalk out the burden of the disease and allocate appropriate policies for disease management.



Figure 6. Prevalence of PCOS in different parts of India.

Pathophysiology of PCOS

The uncertainty regarding the pathophysiology of PCOS continues. It has been argued to be the result of a complex interplay of genetic, hormonal, and environmental factors [52]. There is increasing consensus that the key traits of PCOS pathophysiology are abnormal gonadotrophin dynamics, excessive testosterone, obesity, cardiovascular disease, and insulin resistance. Moreover, the primary factor influencing the pathophysiology of PCOS is increased levels of free testosterone in blood, which are demonstrated by hyperandrogenism [118]. The contributing causes of PCOS and its comorbidities include influencing risk factors such neuroendocrine, nutrition, genetic, hormone exposure, lifestyle, and environment [27]. Therefore, all medical practitioners have a responsibility to

understand the complexity of PCOS pathophysiology and alleviate the suffering of women and girls with PCOS. Infertility, hirsutism (excessive hair growth), acne, irregular periods, weight gain, and an increased risk of diabetes, cardiovascular disease, and endometrial cancer are just a few of the repercussions of PCOS on women's health. The afflicted people's quality of life and psychological health are also affected. Hyperandrogenism, anovulation, infertility, psychosocial dysfunction, and an increased risk of metabolic problems are a few of the clinical symptoms of polycystic ovarian syndrome (PCOS) [58]. Additionally, PCOS might have an impact on other lifestyle diseases such as severe metabolic and cardiovascular morbidity. Both genetic predisposition and environmental exposure may contribute to PCOS [50].

Menstrual dysfunction

Menstrual disturbances are common among adolescents with the symptoms of frequent menstrual irregularities such as oligomenorrhea, menorrhagia, polymenorrhea, primary amenorrhea, and hypomenorrhea [68, 89, 99, 108, 118, 141]. Significant differences between the women with PCOS and healthy women in menstrual and anthropometric characteristics have also been observed [123]. Menstrual cycle disorders are 9.07 times more likely to affect women with PCOS than women without the condition [134]. Menstrual dysfunction along with clinical hyperandrogenism was found among the majority of the adolescent PCOS patients [30, 56, 90]. Dysmenorrhea, oligomenorrhea, and menorrhagia are significant manifestations of PCOS revealed by the majority of the patients [10, 45]. Moreover, it was further demonstrated that dysmenorrhea in early adolescence and premenstrual symptoms in early adolescence were the most predominant menstrual-related symptoms [125]. Abnormal uterine bleeding and excessive bleeding are also widespread among PCOS patients [57, 102, 118, 126]. Some studies [9, 112] have revealed that menorrhagia or polymenorrhea were followed by oligomenorrhea or secondary amenorrhea in early teenage girls, whereas the pattern was reversed in the late adolescent group. This demonstrates that PCOS is more prevalent in the late teenage group, while puberty menorrhagia is a common symptom in the early adolescent group. Menstrual cramps and irregular periods are the other two key symptoms that are strongly linked to PCOS [66]. According to studies, there is a considerable connection between dietary choices and PCOS. Unhealthy eating habits have been identified by Dhar *et al.* [40] as a substantial risk factor for menstrual disorders. The likelihood of menstrual irregularities in PCOS patients can be considerably reduced by adopting healthy eating, sleeping, and

exercise routines, among other lifestyle adjustments. Similarly to their findings, Choudhary *et al.* [32] discovered that PCOS is frequently responsible for young individuals' irregular periods when they depend on a high-carbohydrate diet. Additionally, Lakkawar *et al.* [80] emphasized that junk food consumption has been linked to premenstrual syndrome (PMS), oligomenorrhoea, hypomenorrhoea, and dysmenorrhoea. Students who were dieting reported irregular cycles. Students who did not regularly exercise had a significant prevalence of dysmenorrhoea and PMS.

In India, PCOS is a serious issue that affects adolescents and young adults. Menstrual dysfunction is often neglected because of social stigmas and lack of knowledge. Infertility and reproductive health are both affected by the multifaceted illnesses identified as the polycystic ovarian syndrome (PCOS) in women [60]. To treat PCOS in India, there has to be more public and medical awareness of the condition. For PCOS to be effectively managed and its risks to be reduced, early diagnosis, thorough treatment tactics, lifestyle changes, such as consistent exercise and a healthy diet, and access to adequate medical care are necessary. To improve women's health in India, it is critical to encourage open dialogue, clarify misunderstandings about menstruation, educate people about period health and PCOS, increase access to healthcare facilities, and remove sociocultural barriers.

Metabolic syndrome

A cluster of metabolic diseases known as the metabolic syndrome primarily includes abdominal obesity, insulin resistance, impaired glucose metabolism, hypertension, and dyslipidemia [114]. Family history of mothers with hypertension, hyperandrogenism, hyperinsulinemia, and diabetes mellitus correlate with PCOS [31, 69]. Infertile women with PCOS also have an elevated risk of the metabolic syndrome [3, 28]. PCOS phenotypic expression and development are influenced by genetic, ethnic, and environmental variables. India has a very diverse cultural population; thus, different regions may have different metabolic syndrome prevalence rates [75]. Moreover, familial associations of women with PCOS are more prone to have metabolic disorders than the general population [124]. The metabolic and anthropometric profiles of women with PCOS across India's four main ethnic groups have highlighted that North Indian women had a higher mean body mass index and a greater waist circumference than women from South and West India. Impaired glucose tolerance was also not uncommon, with North India having the highest percentage followed by East India. Despite being slender, East Indian PCOS women had the highest

prevalence of dyslipidemia. Women with the metabolic syndrome with PCOS from North-east India had the worst metabolic profiles [75]. It was observed that adolescent girls with PCOS experience irregular menstrual periods, higher levels of fasting insulin, hirsutism, acanthosis nigricans, and have a higher body mass index [19–21, 25]. Furthermore, PCOS can alter the fat distribution and lipid distribution in the body. These are the features that lead to long-term metabolic alterations and life-threatening diseases [48]. A reliable predictor of PCOS can be the visceral adiposity index, a different biomarker of visceral adipose dysfunction. It has also been reported that Indians are genetically predisposed to having higher visceral fat than average and the cut-offs for measuring adiposity also need to be revised [67]. A study by Bhattacharya *et al.* [17] suggests a cut-off value of waist-height ratio which can be used as an inexpensive and non-invasive screening tool for early prediction of PCOS and insulin resistance among PCOS-affected women. This study also suggests that it is a better index than the body mass index. Therefore, the cheapest and most straightforward important marker of the metabolic syndrome was found to be waist circumference [20]. Co-occurrence of dyslipidemia, diabetes, and obesity are all substantial cardiovascular risk factors that can develop in women with PCOS [72].

In India, the endocrine-metabolic illness known as PCOS is on the rise. Therefore, it is recommended that all teenage PCOS patients be examined for these anomalies and given lifestyle recommendations to keep these factors under control. Considering the high prevalence of both disorders in India, it is crucial to understand how the metabolic syndrome and PCOS interact and how they affect various individuals [145]. Therefore, it is necessary to recognize, treat, and keep track of these conditions early on. Patients with the metabolic syndrome and PCOS are frequently treated in India using a multidisciplinary strategy that includes lifestyle modifications like regular exercise, a healthy diet, managing of weight, and medication if necessary.

Obesity

The likelihood of getting PCOS is extremely high in low-income and developing nations like India because of the wide variations in culture, ethnicity, nutrition, lifestyle, and genetics [136]. The young generation today depends mostly on junk food, which causes obesity. Frequent junk food consumption encourages binge eating and excessive eating without calorie restriction. Obesity and junk food are inextricably associated with hormones which can alter the hormonal regulation among PCOS patients [14]. Moreover, the large population

size, improper resource distribution, socioeconomic status, demographic and cultural differences, and inaccessibility to adequate healthcare facilities are the major contributing factors of malnutrition (e.g., undernutrition or overweight and obesity). Moreover, overweight and obesity bear significant risks of different noncommunicable diseases, such as diabetes, hypertension, and cardiovascular disease [136]. Studies have reported that Asian Indians have an increasingly high prevalence of obesity-related diseases like diabetes and cardiovascular disease as well as excess body fat, adverse body fat patterning, and the polycystic ovarian insulin resistance syndrome [4]. Central adiposity creates adverse effects on the cardiovascular profile and other associated comorbidities of PCOS patients [35]. In most cases, central adiposity leads to obesity and hyperandrogenism which further develops other metabolic diseases. Family history can also trigger the development of the condition [32, 54, 68, 88, 90]. When rural and urban areas are compared, studies have shown that women belonging to nuclear families and living in urban areas had a higher frequency of PCOS [34]. Urban regions have higher excess androgen activity than rural areas, which is reflected in increased hirsutism and is linked to higher serum insulin levels. On the contrary, Ray [113] has reported that obesity is positively associated with PCOS individuals in the rural population. Waist circumference and clinical indicators of hyperandrogenism should be taken into account while developing effective treatment plans [33, 77, 103].

In India, obesity is a developing issue that affects both urban and rural residents. Sedentary lifestyles, unhealthy eating patterns, and genetic susceptibility are a few of the causes of the upsurge in obesity prevalence. Consequently, consumption of processed and calorie-dense meals has significantly increased in recent years, while levels of physical exercise have decreased abruptly. Obesity has negative effects on health and is linked to several chronic diseases such as diabetes, cardiovascular disease, hypertension, and some types of cancer. The symptoms of PCOS can develop and worsen as a result of obesity. Visceral fat releases chemicals from adipose tissue that interfere with hormone regulation and can exacerbate insulin resistance, which advances PCOS. Women who have PCOS may find it difficult to maintain a healthy weight due to hormonal imbalances such as insulin resistance and high androgen levels [117]. Particularly insulin resistance encourages fat storage and raises the possibility of weight gain and obesity. Reduction in body weight is linked to favourable changes in hormone levels, metabolism, and clinical traits. A comprehensive strategy encompassing lifestyle changes, better access to healthcare, public awareness campaigns, and regulatory changes is needed to address obesity and PCOS in

India. Thus, encouraging frequent exercise, supporting a healthy diet, offering medical assistance for managing PCOS, and creating an environment that encourages healthy living choices are essential measures in tackling these issues.

Hyperandrogenism

Both clinical and biochemical hyperandrogenism can be used to diagnose PCOS [39]. Hirsutism, acne, and alopecia are three clinical signs of PCOS that result from increased androgen production in the female reproductive system [6]. In contrast to alopecia and acne, hirsutism is a more identifiable element of hyperandrogenism. In this regard, levels of hair growth in different androgen-sensitive locations are assessed using the Ferriman-Gallwey scale [73]. Results have also highlighted that hirsutism is present among 60–76% of PCOS women, and hyperandrogenaemia is found among 75–90% of PCOS women worldwide.

According to some studies, obesity and hyperandrogenism are interrelated. Both hirsutism and acanthosis nigricans are significant PCOS indicators [102, 103, 105, 141]. Obesity may trigger hyperandrogenism from peripheral oestrogen to androgen conversion, which leads to PCOS and anovulation, which is very common among teenagers [32]. On the other hand, several other investigations have also revealed an association between menstrual irregularity and hyperandrogenism [55]. Irregular menstrual cycle, oligomenorrhea along with signs of hyperandrogenism, can be alarming for further diagnosis [126]. Additionally, hyperinsulinemia and hypertension are also more common in obese girls with PCOS than their non-obese counterparts [18, 25, 68]. Moreover, the occurrence and causes of PCOS show variation on a regional basis as well as in different ethnic groups [141]. In this regard, there is a greater need to comprehend the syndrome's uniqueness in other groups and ethnicities. Supporting these words, a comparative study among the rural and urban participants highlighted that urban participants were more obese and hirsutism was more common than in their rural counterparts [106].

Acne is a very common phenomenon among adolescents and is also an identifying feature of PCOS. Sometimes, it is difficult to understand the clinical signs of acne among adolescents. In the PCOS group, compared to the non-PCOS group, the prevalence of irregular menstruation, hirsutism, acne, obesity, polycystic ovaries on ultrasound, and clinical hyperandrogenism is higher [25, 77, 90].

The rapidly changing lifestyle, urbanization, choices of dietary intake, and, most importantly, stressful life affect women in a very significant way. These burdens develop various diseases which become threatening to the lifestyle in

the future. PCOS is a syndrome that affects the reproductive health of women. The prevalence rate of PCOS among teenagers and adolescents is also rising. The diagnostic criteria of PCOS are very complex and hyperandrogenism is a frequent trait among Indian women who have PCOS. The clinical manifestations of hyperandrogenism can be used for early detection. In light of this, awareness about these factors is necessary to prevent further health hazards.

Knowledge and awareness of PCOS

In India, the level of awareness about PCOS varies significantly. Awareness as well as proper diagnosis is a very important factor in managing PCOS as it improves the quality of the patient's life [101]. Unfortunately, even though PCOS has serious detrimental consequences on health, most women are not aware of these risks [140]. In India, knowledge and awareness vary in a significant manner due to lack of adequate information in the school curriculum. Furthermore, cultural taboos and stigmas concerning the open discussion of menstruation or female reproductive health issues hinder sufficient knowledge about PCOS. In addition, health care access is another important factor, especially in the rural parts of India where trained health care professionals are meagre. Inappropriate medical knowledge can also cause misdiagnosis or underdiagnosis. PCOS is a very common health issue nowadays due to lack of knowledge among females. Sunanda and Nayak [135] highlighted that in Mangalore the unmarried students aged 18–25 years had usual knowledge about PCOS whereas a cross-sectional study in Bhopal, Central India, emphasized that, among unmarried girls aged 17–24 years, lack of awareness was predominant [56]. Similarly, another study from Central India observed that most of the women had heard the term from their friends and relatives and therefore assumed that menstrual pain and menstrual irregularities was an outcome of their physiological process, and there was no need to consult a doctor [98]. Conversely, in Trivandrum, adolescent girls aged 15–17 years reported adequate knowledge regarding PCOS [129].

Socio-cultural factors can influence the knowledge and attitude of the Indian women with PCOS, specifically the economically weaker section of the society. A study revealed that the lack of awareness among women was due to social sanctions as well as the expected role of the woman. In the case of married women, the obvious choice was to become pregnant to normalize their monthly periods [128]. A similar study by Srujana *et al.* [132] also revealed that in Andhra Pradesh students had inadequate knowledge regarding PCOS,

and a significant association was found between the knowledge of PCOS and their demographic variables.

Several studies [51, 64] have revealed that the majority of nursing students had ample knowledge of PCOS, but awareness of PCOS was poor. The studies also suggested an urgent need for increasing awareness about PCOS to prevent its long-term consequences.

Lack of knowledge on PCOS was found among the 3rd-year BSc students of nursing in Ujjain, Madhya Pradesh [138]. Other studies observed that the participants had moderate knowledge concerning PCOS [103, 119]. On the contrary, Upadhye and Shembekar [142] found that 72% of the medical college students were aware of PCOS. A cross-sectional study highlighted that the nursing students from Pondicherry [120] and the medical students from Chennai [5] had sufficient knowledge regarding the PCOS risk factors, although awareness about the complications of PCOS was found to be significantly lower, but, among the college students of Pune aged 15–17 years, the pervasiveness of knowledge regarding PCOS varies as follows: good knowledge – 3%, average knowledge – 73%, and poor knowledge – 24% [74].

Effective educational intervention programmes can be a catalyst for enhancing the knowledge and awareness level of PCOS. It was observed that young adult unmarried girls were less aware of PCOS [24, 61, 65, 100, 111, 121, 127], but after the intervention, the number increased [44, 122, 131, 144]. Moreover, Rajkumar *et al.* [109] highlighted that, in southern parts of India, a lack of knowledge and awareness is seen mostly among the younger individuals diagnosed with PCOS. Intervention programs acted as a trigger to uplift the knowledge and awareness of PCOS.

Delayed diagnosis can lead to the development of comorbidities. Hence, appropriate intervention programs are needed to educate the young girls and to keep them safe from lifelong complications of PCOS.

The geoepidemiology or pathophysiology of PCOS can be assessed by racial and ethnic disparities. Comparative ethnic differences may be a resultant outcome of genetic or cultural determinants of PCOS. Ethnic variation suggests that lifestyle and cultural factors are likely to play a role in the pathogenesis of PCOS. Thus, in the anthropological perspective, PCOS is explored contemplating the cultural and social dimensions. In this embodiment, different societies and cultural contexts, such as the cultural beliefs, social practices, and life experiences of individuals triggering the upsurge of PCOS are underlined. Hence, anthropologists see various ways through which individuals and communities manage PCOS and focus on a holistic cognizance of PCOS with

physiological, cultural, and social facets. Due to bio-cultural variation and lifestyle determinants of PCOS, a marked difference can exist in the prevalence of PCOS and also the associated burden of PCOS among different ethnic groups and across different geographical regions of India. Literature worldwide reveals that the prevalence of PCOS is increasing gradually and also in India, and this may be a major health concern in the future.

CONCLUSION

Polycystic Ovary Syndrome (PCOS) is an emerging disease and a serious matter of concern for the women of reproductive age group all over the world. It is evident that the prevalence of PCOS varies among different cultural settings due to dissimilar dietary practices and the level of physical activity. Because of the paucity of data focusing on the burden of PCOS in adolescents and young women of different ethnicities or cultural settings, more studies should be undertaken to examine the variation in the burden of PCOS among the women belonging to different groups. Such results could identify high risk populations and foster the implementation of lifestyle preventive measures for PCOS and its associated comorbidities in different settings.

Being a global concern, the increasing prevalence of PCOS needs enhancement of knowledge and awareness among women of all age groups, as knowledge and awareness are still limited. Thereafter, appropriate preventive health education should be investigated to convey knowledge and awareness of PCOS among young adults to improve a healthy reproductive life for their future.

ACKNOWLEDGEMENTS

I, Titas Ghosh, am a recipient of the Indian Council of Social Science Research Doctoral Fellowship. This paper is largely an outcome of my doctoral work sponsored by the Indian Council of Social Science Research. I am also thankful to my supervisors.

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