

## Lifestyle Factors and Sonographic Characteristics in PCOS: A Systematic Review

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### Abstract

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and reproductive disorders affecting women of reproductive age worldwide (8, 9, 10). It is a heterogeneous condition characterized by reproductive, metabolic, and hormonal abnormalities, including ovulatory dysfunction, hyperandrogenism, insulin resistance, and polycystic ovarian morphology (1, 2, 10). According to the Rotterdam criteria, PCOS is diagnosed when at least two of the following features are present: oligo/anovulation, hyperandrogenism, and polycystic ovaries on ultrasound after excluding other endocrine disorders. The prevalence of PCOS has been reported to reach approximately 13% among reproductive-aged women depending on the diagnostic criteria used (9, 10). PCOS is clinically important because it adversely affects fertility, metabolic health, and quality of life and is

associated with obesity, insulin resistance, dyslipidaemia, type 2 diabetes mellitus, cardiovascular disease, anxiety, and depression (3, 4, 9)

Women with PCOS commonly present with menstrual irregularities, oligomenorrhea, amenorrhea, chronic anovulation, and infertility. Hyperandrogenism is a hallmark feature and may present as hirsutism, acne, androgenic alopecia, and elevated serum androgen levels (7,9,10). Obesity and insulin resistance frequently coexist with PCOS and contribute to worsening hormonal imbalance and reproductive dysfunction. Several studies reported that obesity, hyperinsulinaemia, dyslipidaemia, and altered adipokine production contribute to disrupted folliculogenesis, follicular arrest, and reduced fertility (2, 8, 9). Psychological manifestations such as anxiety, depression, poor body image, and reduced quality of life are also frequently reported among women with PCOS (4, 9, 10).

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## **Introduction**

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and reproductive disorders affecting women of reproductive age worldwide (8, 9, 10). It is a heterogeneous condition characterized by reproductive, metabolic, and hormonal abnormalities, including ovulatory dysfunction, hyperandrogenism, insulin resistance, and polycystic ovarian morphology (1, 2, 10). According to the Rotterdam criteria, PCOS is diagnosed when at least two of the following features are present: oligo/anovulation, hyperandrogenism, and polycystic ovaries on ultrasound after excluding other endocrine disorders. The prevalence of PCOS has been reported to reach approximately 13% among reproductive-aged women depending on the diagnostic criteria used (9, 10). PCOS is clinically important because it adversely affects fertility, metabolic health, and quality of life and is associated with obesity, insulin resistance, dyslipidaemia, type 2 diabetes mellitus, cardiovascular disease, anxiety, and depression (3, 4, 9).

Women with PCOS commonly present with menstrual irregularities, oligomenorrhea, amenorrhea, chronic anovulation, and infertility. Hyperandrogenism is a hallmark feature and may present as hirsutism, acne, androgenic alopecia, and elevated serum androgen levels (7,9,10). Obesity and insulin resistance frequently coexist with PCOS and contribute to worsening hormonal imbalance and reproductive dysfunction. Several studies reported that obesity, hyperinsulinaemia, dyslipidaemia, and altered adipokine production contribute to disrupted folliculogenesis, follicular arrest, and reduced fertility (2, 8, 9). Psychological manifestations such as anxiety, depression, poor body image, and reduced quality of life are also frequently reported among women with PCOS (4, 9, 10).

Ultrasound plays a central role in the diagnosis and evaluation of PCOS because polycystic ovarian morphology is one of the major diagnostic criteria (6,9,10). Sonographic assessment commonly includes ovarian volume, follicle number per ovary (FNPO), and antral follicle count (AFC) (2,8,10). Women with PCOS typically demonstrate enlarged ovaries and increased ovarian volume compared with healthy controls (3,6, 10). Multiple small follicles measuring approximately 2–10 mm in diameter are commonly observed on ultrasound examination (6, 10). Polycystic ovarian morphology is generally characterized by increased ovarian volume and increased follicle number. Additional sonographic findings include excess antral follicles, abnormal follicular recruitment, disrupted folliculogenesis, follicular arrest, and ovarian stromal hyperplasia. These ultrasound markers are useful for diagnosis, assessment of disease severity, and monitoring treatment response (2,9,10).

Lifestyle factors play a major role in both the development and management of PCOS. Obesity, particularly central obesity and visceral adiposity, is strongly associated with insulin resistance, hyperinsulinaemia, hyperandrogenism, menstrual irregularities, and impaired fertility. Excess adiposity contributes to abnormal follicular development, chronic anovulation, and worsening reproductive outcomes. Current evidence supports lifestyle modification as the first-line treatment for PCOS. Weight reduction through healthy dietary practices and regular physical activity has been shown to improve insulin sensitivity, reduce androgen levels, restore menstrual cyclicity, and improve ovulation. Several studies reported that weight loss can reduce ovarian volume, decrease follicle number, and improve ovarian morphology. Although no single dietary pattern has been shown to be superior, long-term adherence to healthy lifestyle behaviours remains essential for improving PCOS outcomes (3,8,9,10).

## **Objectives**

The aim of this review was to evaluate the relationship between lifestyle factors (obesity, diet, and physical activity) and sonographic characteristics in women with Polycystic Ovary Syndrome (PCOS).

## **Methodology:**

This study was conducted as a systematic review to evaluate the association between lifestyle factors and sonographic characteristics of polycystic ovary syndrome (PCOS). A comprehensive literature search was performed using PubMed, Google Scholar, and ScienceDirect databases. The search strategy incorporated keywords including “PCOS,” “lifestyle factors,” “sonographic characteristics of PCOS,” “ovarian morphology,” “obesity,” “diet,” and “physical activity.” Studies were eligible for inclusion if they involved women diagnosed with PCOS, discussed lifestyle-related factors, reported ultrasound findings, were published in English, and were published from 2020 onward. Studies were excluded if they were case reports or published in languages other than English. Relevant studies meeting the eligibility criteria were reviewed and synthesized to assess the relationship between lifestyle factors and the sonographic manifestations of PCOS.

## **Number of Articles Selected**

A total of 10 research articles were selected for inclusion in this review after screening for relevance to the study objectives. The selected articles focused on obesity, body mass index (BMI), dietary factors, physical activity, lifestyle interventions, and sonographic characteristics of Polycystic Ovary Syndrome (PCOS). Only articles that provided relevant information regarding the relationship between lifestyle factors and ultrasound findings in PCOS were included in the review.

## **Data Extraction Process**

Data were extracted manually from the selected articles using a structured approach. Information related to study objectives, study population, obesity and BMI, dietary factors, physical activity, lifestyle interventions, and sonographic characteristics of PCOS was identified and recorded. Key findings regarding ovarian volume, follicle number per ovary (FNPO), antral follicle count (AFC), polycystic ovarian morphology (PCOM), and the effects of diet and physical activity on PCOS outcomes were extracted and summarized. The extracted information was then synthesized to identify common findings, differences among studies, and overall trends in the literature.

## **Literature review:**

### **Obesity and BMI**

Obesity is one of the most common comorbidities associated with PCOS and contributes significantly to reproductive, endocrine, and metabolic dysfunction. Women with PCOS consistently demonstrate higher BMI, waist circumference, abdominal adiposity, and obesity prevalence compared with healthy controls. (3, 4, 8) Increased BMI is strongly associated with insulin resistance, hyperinsulinaemia, dyslipidaemia, altered adipokine production, and impaired glucose regulation, all of which contribute to the pathophysiology of PCOS.

Central obesity and visceral adiposity are important contributors to PCOS severity and are closely linked with hyperandrogenism, chronic anovulation, and menstrual irregularities (2, 7, 8). Obese women with PCOS exhibit higher fasting insulin levels, increased HOMA-IR values, elevated triglycerides, and lower HDL cholesterol levels compared with lean women with PCOS (8, 10). Several studies reported that obesity worsens reproductive outcomes by disrupting follicular development, impairing ovulation, and reducing fertility potential.

Women with higher BMI often demonstrate more severe metabolic abnormalities and altered ovarian morphology than women with lower BMI(2, 3, 10). More than half of women with PCOS in some populations are overweight or obese, highlighting obesity as a major public health concern within this patient group. (4, 5)

Weight reduction and improvements in insulin sensitivity are associated with restoration of ovulation, improved menstrual regularity, reduced androgen levels, and better reproductive outcomes. Lifestyle interventions involving diet, exercise, and behavioural modification are consistently recommended as first-line management strategies for women with PCOS. (7, 9, 10)

No specific dietary composition has been shown to be superior; however, sustained weight loss and improved body composition consistently improve PCOS manifestations. (9, 10)

Regular physical activity, particularly vigorous aerobic exercise, improves insulin resistance, cardiovascular fitness, body composition, and metabolic health in women with PCOS. (4, 9)

### **Sonographic Characteristics of PCOS**

#### **Ovarian Volume**

Enlarged ovaries and increased ovarian volume are among the most consistent ultrasound findings reported in women with PCOS(2, 3, 10). Ovarian volume greater than 10 mL is widely recognized as a diagnostic feature of polycystic ovarian morphology (PCOM)(6, 10). Women with PCOS have significantly larger ovarian volumes than healthy controls, with reported mean ovarian volumes ranging from approximately 11–15 mL.(8, 10) Increased ovarian volume is associated with insulin resistance, hyperandrogenism, ovarian stromal hyperplasia, and adverse metabolic outcomes. (2, 10)

Anovulatory women with PCOS tend to have larger ovarian volumes than women who experience sporadic ovulation, suggesting a relationship between ovarian size and disease severity. (3)

#### **Follicle Number and Antral Follicle Count (AFC)**

Women with PCOS demonstrate increased follicle number per ovary (FNPO) and increased antral follicle count (AFC) compared with healthy controls. Excess small follicles measuring approximately 2–9 mm or 2–10 mm are characteristic sonographic findings of PCOS. (6, 8, 10) Many studies reported increased numbers of small antral follicles, particularly within the 2–5 mm and 6–9 mm follicle ranges. (3, 8) FNPO has been identified as one of the most accurate ultrasound markers for diagnosing PCOS and may perform better than ovarian volume alone. Women with higher follicle counts often exhibit greater reproductive dysfunction and poorer metabolic profiles. (2, 10)

#### **Polycystic Ovarian Morphology (PCOM)**

PCOM is characterized by increased ovarian volume and/or increased follicle number and remains a key diagnostic criterion for PCOS. (5, 6, 10) According to the Rotterdam criteria, PCOM is typically defined by the presence of  $\geq 12$  follicles measuring 2–9 mm and/or an ovarian volume greater than 10 mL. Recent recommendations have proposed a higher threshold of  $\geq 25$  follicles per ovary for defining PCOM using modern ultrasound technology. (6,10) PCOM reflects abnormal follicular development and altered ovarian architecture and is associated with reproductive and metabolic dysfunction. (2, 3, 8)

#### **Follicular Arrest and Abnormal Folliculogenesis**

Follicular arrest is a hallmark feature of PCOS and occurs when developing follicles fail to reach ovulation despite continued recruitment. Several studies reported that follicles in women with PCOS commonly arrest around the mid-antral stage, contributing to chronic anovulation and infertility. (3, 8, )

Women with PCOS exhibit abnormal follicular recruitment, disrupted folliculogenesis, and persistent accumulation of small antral follicles. (6, 8, 10)

### **Relationship Between Obesity and Sonographic Findings**

Obesity and insulin resistance are closely associated with more pronounced ovarian morphological abnormalities in women with PCOS. Women with higher BMI frequently demonstrate larger ovarian volumes, greater follicle numbers, and more severe polycystic ovarian morphology. (2, 3, 10)

Ovarian morphology may act as a biomarker linking obesity, nutritional status, metabolic dysfunction, and reproductive health in PCOS. Weight loss and improvements in metabolic status are associated with reductions in ovarian volume, follicle number, and overall severity of polycystic ovarian morphology. (2, 3, 10)

Lifestyle interventions that improve body weight and insulin sensitivity can lead to measurable improvements in ultrasound features of PCOS. (3,9 )

### **Diet in Polycystic Ovary Syndrome (PCOS)**

Dietary modification is considered a cornerstone of lifestyle management in women with PCOS and is recommended as a first-line treatment approach for improving both metabolic and reproductive outcomes. (1, 9)

Obesity and excess adiposity are strongly associated with insulin resistance, hyperinsulinaemia, dyslipidaemia, hyperandrogenism, menstrual dysfunction, and infertility in women with PCOS. Women with PCOS generally exhibit higher BMI, increased waist circumference, and greater abdominal adiposity than healthy controls. (2, 3, 10)

Weight reduction achieved through dietary intervention improves insulin sensitivity, glucose regulation, lipid metabolism, ovulatory function, and reproductive outcomes. Improvements in metabolic health appear to be more important than the specific dietary composition used. (1, 9, 10)

Current evidence does not support one particular diet as being superior for PCOS management. Instead, long-term adherence to healthy eating behaviours and sustained weight management are considered the most important determinants of clinical improvement. (9, 10)

Dietary interventions such as pulse-based diets and Therapeutic Lifestyle Changes (TLC) diets have demonstrated beneficial effects on ovarian morphology, menstrual regularity, and hyperandrogenism. These interventions have been associated with reductions in ovarian volume, follicle number per ovary (FNPO), and free androgen index (FAI). (1, 10)

Nutritional status influences ovarian morphology and reproductive function. Obesity-related metabolic disturbances contribute to ovarian enlargement, increased follicle number, disrupted folliculogenesis, and adverse reproductive outcomes. (2, 8,)

Poor diet quality may worsen insulin resistance, metabolic dysfunction, and reproductive abnormalities, whereas improvements in dietary habits can positively influence ovarian morphology and metabolic health. (1, 2, 8)

Long-term maintenance of healthy dietary behaviours is essential because recurrence of unhealthy eating patterns may lead to weight regain and worsening of PCOS-related abnormalities. (1, 10)

### **Physical Activity in Polycystic Ovary Syndrome (PCOS)**

Physical activity is an essential component of PCOS management and is recommended as a first-line lifestyle intervention because it improves reproductive, metabolic, and psychological outcomes. Regular exercise improves insulin resistance, body composition, cardiovascular fitness, and overall metabolic health, even in the absence of substantial weight loss. (4,9)

Vigorous aerobic exercise appears to provide the greatest benefits for improving insulin sensitivity, cardiorespiratory fitness, and body composition in women with PCOS. (9, 10)

Exercise interventions combined with dietary modification improve ovulatory function, menstrual regularity, hyperandrogenism, and fertility outcomes. (1, 9, 10)

Lifestyle programs incorporating regular exercise have demonstrated improvements in ovarian morphology, including reductions in ovarian volume and follicle number, suggesting a positive effect on both metabolic status and sonographic manifestations of PCOS. (1, 3, 10)

Several studies reported that women with PCOS participate in lower levels of physical activity and exhibit greater sedentary behaviour than women without PCOS. Physical activity levels tend to decline as BMI increases, while overweight and obese women are less likely to achieve recommended exercise targets. (4, 10)

Reduction of visceral adiposity through regular physical activity may improve ovulatory function, metabolic abnormalities, and overall reproductive health. (3,7, 10,)

Behavioural support strategies such as goal setting, self-monitoring, problem solving, and relapse prevention improve adherence to exercise programs and long-term lifestyle modification. (9)

Sustained participation in physical activity is important because deterioration in healthy lifestyle behaviours may result in recurrence of metabolic and reproductive abnormalities associated with PCOS. (1, 9, 10)

Overall, regular physical activity contributes significantly to weight management, improved insulin sensitivity, enhanced reproductive function, better ovarian morphology, and improved long-term health outcomes in women with PCOS. (4, 9, 10)

### **Research Gap**

Although the reviewed studies consistently demonstrated an association between obesity and PCOS, limited evidence specifically examined the relationship between BMI and individual sonographic characteristics such as ovarian volume, follicle number per ovary, and antral follicle count. Additionally, few studies were conducted in Pakistani populations. Therefore, further research is needed to investigate the association between BMI and sonographic features of PCOS in local populations to improve understanding of disease severity and clinical management

### **Discussion**

The findings of this systematic review indicate that most studies agreed that obesity and increased BMI are strongly associated with the development and severity of PCOS. Women with PCOS consistently exhibited higher BMI, waist circumference, abdominal adiposity, insulin resistance, and metabolic abnormalities compared with healthy controls. The reviewed studies also agreed that obesity contributes to hyperandrogenism, menstrual irregularities, chronic anovulation, and reduced fertility. Furthermore, most studies reported that weight reduction and improvements in insulin sensitivity were associated with better reproductive and metabolic outcomes. (2, 3, 7,9,10)

Regarding sonographic characteristics, there was strong agreement that enlarged ovaries, increased ovarian volume, and increased follicle number are among the most common ultrasound findings in women with PCOS. Most studies reported that women with PCOS have significantly larger ovarian volumes and higher follicle counts than healthy controls. Polycystic ovarian morphology was consistently described as being characterized by increased ovarian volume, multiple small follicles, and abnormal follicular development. (2, 3,5,8 10)

Most studies also agreed that obesity is associated with more pronounced ovarian morphological abnormalities. Women with higher BMI frequently demonstrated

larger ovarian volumes, increased follicle numbers, and more severe polycystic ovarian morphology. In addition, weight loss and improvements in metabolic status were associated with reductions in ovarian volume and follicle number, suggesting that ovarian morphology may improve following lifestyle modification. (2, 3,8, 9,10) Some differences were observed regarding the assessment of sonographic features. While all studies recognized ovarian volume and follicle number as important markers of PCOS, some studies suggested that follicle number per ovary (FNPO) may be a more accurate diagnostic marker than ovarian volume alone. In addition, newer ultrasound guidelines proposed higher follicle-count thresholds for defining polycystic ovarian morphology compared with earlier Rotterdam criteria. (5, 6, 10) The findings related to lifestyle factors showed considerable consistency across studies. Most studies reported that dietary modification and regular physical activity improve insulin sensitivity, body composition, menstrual regularity, ovulation, and reproductive outcomes. However, there was no clear evidence that one specific dietary pattern was superior to others. Instead, long-term adherence to healthy lifestyle behaviours and sustained weight management appeared to be the most important factors for improving PCOS outcomes. (1, 9, 10) Overall, the reviewed literature suggests that obesity plays a significant role in both the metabolic and sonographic manifestations of PCOS. Increased BMI is associated with more severe ovarian morphological abnormalities, whereas lifestyle interventions involving diet and physical activity may improve metabolic health, reproductive function, and ultrasound characteristics. These findings highlight the importance of lifestyle management as a key component of PCOS treatment and support the use of ultrasound as an important tool for assessing disease severity and monitoring response to intervention.

## **Conclusion**

This literature review examined the relationship between lifestyle factors and sonographic characteristics in women with Polycystic Ovary Syndrome (PCOS). The reviewed studies focused on the influence of obesity, body mass index (BMI), dietary habits, physical activity, and lifestyle interventions on ovarian morphology and reproductive health outcomes in women with PCOS.

The findings consistently demonstrated that obesity and increased BMI are strongly associated with the severity of PCOS. Women with higher BMI frequently exhibited greater insulin resistance, hyperandrogenism, menstrual irregularities, and adverse metabolic outcomes. Obesity was also associated with more pronounced sonographic abnormalities, including increased ovarian volume, higher follicle number per ovary, increased antral follicle count, and more severe polycystic ovarian morphology.

The reviewed evidence further showed that lifestyle factors play a significant role in the management of PCOS. Dietary modification and weight reduction were associated with improvements in insulin sensitivity, metabolic health, reproductive function, and ovarian morphology. Similarly, regular physical activity, particularly aerobic exercise, was found to improve body composition, cardiovascular fitness, insulin resistance, and ovulatory function. Several studies reported that lifestyle interventions combining diet and exercise resulted in reductions in ovarian volume, follicle number, and other sonographic manifestations of PCOS.

Ultrasonography remains an essential diagnostic and monitoring tool in PCOS because it provides valuable information regarding ovarian volume, follicle number, and overall ovarian morphology. The reviewed studies highlighted the close relationship between metabolic status and ultrasound findings, suggesting that sonographic characteristics may reflect the severity of the disorder and the response to lifestyle interventions.

In conclusion, the available evidence indicates that obesity, diet, and physical activity significantly influence the sonographic and clinical manifestations of PCOS. Effective

lifestyle management, including healthy dietary practices, regular physical activity, and weight control, may improve metabolic health, reproductive outcomes, and ovarian morphology, thereby reducing the overall severity of PCOS and enhancing the quality of life of affected women.

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