DOI: 10.7860/JCDR/2026/85119.23262

Review Article

Nutrition Section

Complementary and Alternative Medicine Practices in the Management of PCOS Through Gut Microbiome Modulation: A Narrative Review

MANIKA SETIA[1], MADHVI AWASTHI[2]

ABSTRACT

Polycystic Ovary Syndrome (PCOS) is a condition characterised by hormonal imbalance, chronic inflammation, and changes in the gut microbiome. Recent research highlights the importance of the gut-hormone axis in the progression of certain gynaecological conditions, suggesting that modulation of the gut is a new approach in the management of PCOS. Complementary therapies such as probiotics, prebiotics and polyphenols have shown promising results by altering the gut microbiome, supporting oestrogen metabolism, and modulating immune function. Complementary therapies like yoga and meditation can be used as an adjunct therapy to improve the symptoms of PCOS. Sleep, yoga, and meditation have been shown to improve gut dysbiosis, regulate circadian rhythm and normalise cortisol levels in the body. These effects may contribute to better hormonal balance and improvements in anthropometric parameters in individuals with PCOS. However, PCOS and the gut microbiome are highly multifactorial and are influenced by several variables. Therefore, longitudinal, well-structured studies are required to establish the relationship between them. The modulation of the gut microbiome through complementary therapies is an emerging area of research, and gut-targeted complementary approaches may have promising potential as adjuncts to conventional therapies to improve gut microbiota.

Keywords: Hyperandrogenism, Intermittent fasting, Probiotics, Sleep

INTRODUCTION

The gut hosts a diverse community of microorganisms, including bacteria, fungi, viruses, and protozoa. Microorganisms, along with their metabolites and genetic material, are collectively referred to as the gut microbiome. This complex ecosystem plays a pivotal role in hormonal regulation, nutrient synthesis, immune function, and inflammation, all of which are integral to women's health [1]. Disruption in gut microbial diversity and function, collectively termed gut dysbiosis, has been associated with a wide range of chronic diseases, including those affecting the reproductive system. Women with PCOS exhibit distinct patterns of gut microbial imbalance, characterised by reduced microbial diversity, overgrowth of pathogenic species, and diminished population of beneficial bacteria [2].

The PCOS is a common gynaecological and endocrine disorder affecting women of the reproductive age group. The prevalence of PCOS ranges 7.1-11.5% worldwide, depending on the population studied and the diagnostic criteria used [3]. Women suffering from PCOS mainly present with excess androgens which is a distinguishing characteristic of PCOS, along with polycystic ovary morphology and irregular periods/anovulation. Women with PCOS also present with insulin resistance, hyperinsulinaemia, and inflammation, which leads to metabolic disorders [4]. With advancements in research, the gut-hormone axis has emerged as a key player in the development and progression of PCOS, offering new insight into potential treatment pathways. Recent research has focused attention on the gut microbiome as a central modulator in the development and progression of PCOS [5].

Recent findings suggest an important role of gut microbiota in oestrogen regulation, immune function, and inflammatory processes, all of which are directly associated with the development and progression of PCOS. Complementary and Alternative Medicine (CAM) is defined as a group of diverse medical and healthcare systems, practices, and products that are not currently considered a part of conventional medicine (NIH). When CAM therapies are used in conjunction with conventional treatment to supplement, they are termed complementary therapies [6]. CAM is divided into three categories: natural products including herbs, vitamins, minerals, probiotics, prebiotics, and phytochemicals, the second category- mind-body practices including yoga, tai-chi, acupuncture, meditation and the third category -other complementary approaches which includes ayurvedic medicine, traditional Chinese medicine, naturopathy, and others, according to National Centre for Complementary and Integrative Health [6]. This narrative review highlights specific CAM interventions that may affect PCOS by modulating the gut microbiome. It discusses nutritional approaches such as probiotics and prebiotics, as well as phytochemicals, including curcumin and cinnamon. Lifestyle-based mind-body approaches that act via the modulation of the gut-brain-hormone axis, including yoga, Intermittent Fasting (IF), and sleep. Disruption of sleep and circadian rhythm is associated with microbial dysbiosis, metabolic dysfunction and inflammation [7]. These approaches have demonstrated potential to improve gut health and hormonal balance, as well as address underlying factors such as inflammation and insulin resistance. However, a comprehensive understanding of their role in the management of these conditions is still limited.

This narrative review aims to explore how CAM may be used alongside standard treatments to address the underlying hormonal, metabolic, and microbiome-related imbalances seen in PCOS.

METHODOLOGY

This narrative review was conducted through a systematic search of relevant literature across multiple scientific databases, including PubMed, Web of Science, and Google Scholar. All types of study designs were considered, and articles in the English language and published from 2006 onwards were considered. Studies were selected based on their relevance to the central themes of hormonal disorders, gut microbiota, lifestyle interventions, and non conventional therapeutic strategies.

Role of Gut Microbiota in the Pathogenesis of PCOS

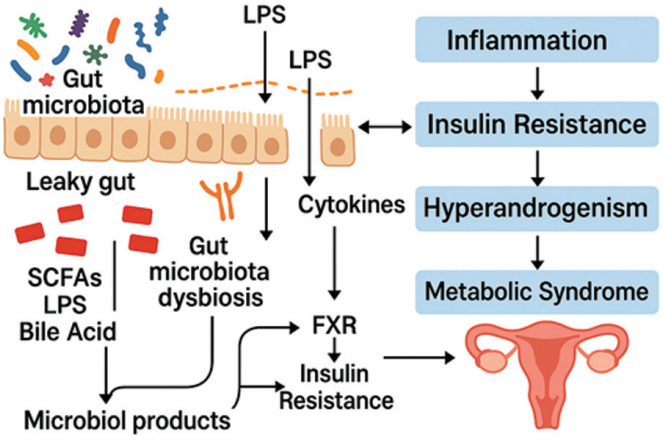
Alterations in the gut microbiome are linked to the progression of PCOS symptoms involving inflammation, insulin sensitivity, and hyperandrogenism [8]. There are multiple pathways through which the gut can influence the development of PCOS. One of them is that dysbiosis often leads to an overgrowth of gram-negative bacteria, which release Lipopolysaccharides (LPS) into the gut lumen [8]. Once LPS crosses the gut barrier and enters systemic circulation, it activates the body's immune system, triggering the release of proinflammatory cytokines like TNF-alpha and Interleukin-6, leading to systemic inflammation [9]. Proinflammatory cytokines like TNF-alpha and IL-6 interfere with the insulin signalling pathways involving c-Jun N-terminal Kinase (JNK), IKK (enzyme involved in intracellular signalling), and Nuclear Factor Kappa B (NF-kB) pathways which promote phosphorylation of serine kinase on Insulin Receptor Substrate-1(IRS-1) which interferes with the transport of glucose inside the cell and thus leading to insulin resistance [10].

Another mechanism by which gut dysbiosis contributes to PCOS is through changes in the bile acid metabolism. Bile acids are synthesised in the liver and further modified by gut bacteria through enzymes such as Bile Salt Hydrolase (BSH) which deconjugates bile acids, which can then undergo further microbial and host-mediated transformations to form secondary and tertiary bile acids such as Tauroursdeoxycholic Acid (TUDCA) and Glycodeooxycholic Acid (GDCA). These bile acids act as signalling molecules by binding to receptors such as the Farnesoid X Receptor (FXR) and the G-protein coupled bile acid receptor (TGR5). Activation of these receptors influences glucose metabolism, insulin sensitivity, inflammation, and hormonal signalling, including the Hypothalamic-Pituitary-Ovarian (HPO) axis. Disruption in this signalling pathway may affect ovarian function by altering steroid hormone synthesis and contributing to increased androgen (testosterone) production [11].

Gut dysbiosis has been associated with the development of hyperinsulinaemia and insulin resistance, common features in PCOS, which can further exacerbate hyperandrogenism through multiple mechanisms [Table/Fig-1]. High insulin levels suppress hepatic production of Sex Hormone-Binding Globulin (SHBG), the primary protein responsible for binding and inactivating circulating testosterone [12]. A reduction in SHBG leads to an increase in free, bioavailable testosterone, which contributes to clinical symptoms like acne, hirsutism, and menstrual irregularities. Additionally, insulin can directly stimulate androgen production in the ovaries by increasing the expression of steroidogenic enzymes, such as cytochrome P450c17 (CYP17A1), in theca cells [13].

Gut-microbiome Composition in PCOS

The gut microbiome is primarily composed of five major phyla. Firmicutes, Proteobacteria, Actinobacteria, Bacteroidetes, and Fusobacteria.



[Table/Fig-1]: Possible pathways leading to the development of PCOS via dysbiosis of the gut.
SCFA: Short chain fatty acid; LPS: Lipopolysaccharide; FXR: Farnesoid X receptor; TGR-5: G-Protein coupled bile receptor

The Firmicutes phylum mainly comprises gram-positive bacteria, with a few exceptions. It is classified into three classes, of which one class is not very abundant; the two main classes include Clostridia and Bacilli. Clostridia, which includes the genera comprising Christensenellaceae, Clostridiaceae, Eubacteriaceae, Lachnospiraceae, Peptococcaceae, Peptostreptococcaceae, Ruminococcaceae, and Veillonellaceae family, the class Bacilli, which further have two main orders: Bacillales, which includes Bacillaceae, Staphylococcaceae and order Lactobacillales, which includes genera belonging to Aerococcaceae, Carnobacteriaceae, Lactobacillaceae, Leuconostocaceae, Lactococcaceae, Streptococcaceae family. Many Firmicutes are responsible for the production of SCFA, which is important in maintaining the gut lining and immune regulation [14].

Phylum Bacteroidetes includes gram-negative rod-shaped bacteria; these species play a vital role in metabolising complex molecules into simpler molecules to be used for energy purposes. Bacteroidia include species belonging to the families Prevotellaceae and Bacteroidaceae. The phylum Proteobacteria consists of a highly diverse group of Gram-negative microorganisms and is classified into five major classes: α, β, γ, δ, and ε. Among these, γ-Proteobacteria include several genera belonging to the families Enterobacteriaceae, Pasteurellaceae, Succinivibrionaceae, Pseudomonadaceae, and Moraxellaceae. *Escherichia coli* is one of the most abundant species in the human gut that belongs to this phylum. The Phylum Actinobacteria consist of Gram-positive families that consist of three orders and 19 families, consisting of beneficial species *Bifidobacterium* and *Propionibacterium*. Species in *Propionibacterium* are highly beneficial and help in the production of propionic acid from lactic acid and in the production of vitamin B12 [14].

Phylum Verrucomicrobia, consisting of *Akkermansia muciniphila.* A large proportion of the gut microbiome is composed of the phyla Firmicutes and Bacteroidetes, followed by Actinobacteria and Proteobacteria, while Verrucomicrobia is present in the lowest abundance.

The phylum Fusobacteria includes gram-negative bacteria. This phylum consists of species belonging to Fusobacteriaceae and Leptotrichiaceae families. Species belonging to Leptotrichiaceae *are* found in the female reproductive system, and Fusobacteriaceae species have been linked to inflammatory diseases [14].

Insulin resistance is present in more than 50% of women with PCOS. An increase in branched-chain amino acid synthesis is linked to increased insulin resistance. A study reported an increase in *Bacteroides vulgatus* in PCOS and found an association with reduced interleukin-22, reduced bile acids, and increased insulin resistance. The beneficial species of *Akkermansia*- involved in energy and insulin metabolism- were found to be reduced in PCOS patients [15]. Women with PCOS are characterised by heightened inflammation and androgen excess. Torres PJ et al., studied the gut microbiota of females with PCOS and reported a less diverse microbiome. This reduced microbial diversity was negatively correlated with elevated testosterone levels and hirsutism [Table/Fig-1] [16].

Liu R et al., reported an increase in the abundance of *Escherichia* and *Shigella* in women with PCOS, which was also found to be positively correlated to excess testosterone [17]. A study indicated that *Prevotella* and *Bacteroides* species levels -associated with inflammation and insulin resistance, respectively- were grossly elevated in obese PCOS. Beneficial microbes, including *Akkermansia* and *Ruminococcaceae*, which mediate gut barrier integrity and anti-inflammatory function, were strongly reduced. The study further highlighted that obese PCOS had a higher percentage of phyla *Actinobacteria* (p-value=0.027), lower *Bacteroidetes* (p-value=0.004), and similar *Firmicutes* and *Proteobacteria* [Table/Fig-2] [18]. Several studies in rodent models have reported a

decrease in beneficial *Lactobacilli* and *Bifidobacteria* in PCOS-induced mice; these bacterial communities play an important role in immunity and nutrient absorption [19]. Therefore, maintaining a balanced gut microbiota is essential for the effectiveness of lifestyle and therapeutic interventions targeting women's health.

Health condition	Bacterial strains	Change	Effect	Reference
PCOS	*Bacteroides vulgatus*	Increase	Deconjugation of bile acid LPS secretion	Qi X et al., [15]
PCOS	*Prevotella*	Increase	Increased synthesis of BCAA Increasing BCAA is associated with Insulin Resistance	Jobira B et al., [18] Guo Y et al., [19]
PCOS	*Lactobacillus*	Decrease	Absorption of nutrients	Guo Y et al., [19]
PCOS	*Ruminococcus*	Decrease	Production of Short-Chain Fatty Acids (SCFA), Maintain gut integrity	Guo Y et al., [19]
PCOS	*Akkermansia*	Decrease	Energy and insulin metabolism	Liu R et al., [17] Elkafas H et al., [5]
PCOS	*Escherichia coli/ Shigella ratio*	Increase	Correlated with increased androgen levels	Liu R et al., [17]
PCOS	*Firmicutes: Bacteroidetes* ratio	Increase	Waist-to-Hip ratio	Jobira B et al., [18]

[Table/Fig-2]: Changes in the gut microbiome composition in PCOS women.
LPS: Lipopolysaccharide; BCAA: Branched chain amino acids

Role of Probiotics

Probiotics, live microorganisms that have potential benefits when administered in adequate amounts, are proposed to improve the health of gut microbiota by antagonising the growth of pathogenic microorganisms and reducing gut leakiness and inflammation [20]. Recent studies have highlighted the role of probiotics in modulating gut barrier integrity and attenuating LPS translocation. In PCOS patients, increased serum zonulin levels, a biomarker of tight junction permeability, have been consistently reported, suggesting a leaky gut phenotype. Probiotic supplementation has been reported to have favourable effects on serum zonulin levels. A recent meta-analysis reported that probiotic supplementation significantly improved serum zonulin levels (p-value=0.0007) and reduced serum LPS levels (p-value=0.02) [21]. Karamali M et al., (2018) investigated the effect of probiotic supplementation {mixture of *Lactobacillus acidophilus*, *Lactobacillus casei*, and *Bifidobacterium bifidum* (2×10^9 CFU/g each)} for 12 weeks in 60 individuals with PCOS (18-40 years). They reported significant improvements in total testosterone (p-value=0.03), SHBG (p-value <0.001), and hirsutism scores, such as the modified Ferriman-Gallwey score (p-value <0.001) [22]. Insulin resistance and inflammation are key drivers of PCOS, and gut dysbiosis exacerbates the conditions; therefore, probiotics can be used as an effective intervention to maintain gut homeostasis. Women with PCOS, when supplemented with L. *rhamnosus*, L. *casei*, L. *acidophilus*, L. *bulgaricus*, B. *longum*, B. *breve*, and *Streptococcus thermophilus* supplements for eight weeks, showed a significant reduction in serum insulin and plasma glucose levels [23].

Prebiotics

Dietary fibres are carbohydrate polymers that bypass digestion and absorption in the gastrointestinal tract. They are instead fermented by gut bacteria, affecting the diversity of the gut microbiome and production of beneficial byproducts. Some dietary fibres also function as prebiotics, which are defined as "Substrates that are selectively utilised by host microorganisms, leading to beneficial effects on host health". Dietary fibre promotes the production of Short-Chain Fatty Acids (SCFAs) such as acetate, propionate, and butyrate, which help maintain the intestinal barrier, thereby reducing the risk of LPS translocation into the systemic circulation and preventing inflammation [24].

Soluble fibres, such as β-glucan present in barley, oats, wheat, and rye, contain metabolic benefits, including improved glycaemic control, reduced serum cholesterol, and reduction of oxidative stress [24]. Such effects are important in conditions like PCOS, which are associated with metabolic disorders.

In an observational study, a dietary survey was conducted among 20 women with PCOS and 20 healthy controls. Blood samples were collected to assess metabolic, endocrine, and inflammatory parameters, and faecal samples were analysed using 16S rDNA gene sequencing. The results showed decreased intake of fibre and vitamin D in women with PCOS, which was associated with an increased abundance of bacterial species such as *Parabacteroides distasonis*, *Bacteroides fragilis*, and *Escherichia coli*, indicating a strong correlation between low fibre intake and gut dysbiosis in individuals with PCOS [25].

In a randomised clinical trial, involving 62 women with PCOS, participants were assigned to receive either 20 grams of dextrin- a prebiotic fibre- or a placebo (maltodextrin) over 12 weeks. The dextrin group showed statistically significant reductions in total cholesterol (p-value <0.0001), high-sensitivity C-Reactive Protein (hs-CRP) (p-value=0.004), free testosterone (p-value=0.010), and Dehydroepiandrosterone Sulfate (DHEA-S) (p-value=0.017). Clinically, meaningful improvements were also observed in menstrual regularity and hirsutism (p-value <0.0001), suggesting the therapeutic potential of fibre-based gut modulation in PCOS management [26].

Phytochemicals

Phytochemicals are a diverse group of biologically active compounds naturally occurring in plants. These compounds are present in various plant parts, roots, seeds, leaves, bark, flowers, and fruits, and have recently gained attention because of their biological properties, including antimicrobial, anti-inflammatory, and antioxidant effects [27]. Emerging research suggests that phytochemicals can modulate the gut microbiome through prebiotic activity, antimicrobial effects, the production of bioactive metabolites, the regulation of gut barrier function, the promotion of a healthy microbial balance, and the enhancement of metabolic functions [27]. Curcumin has been shown to have a potential role in improving insulin resistance and reducing inflammation [28].

Curcumin is known to improve the abundance of beneficial bacteria such as *Bifidobacteria, Lactobacilli*, and butyrate-producing bacteria, and reduces the abundance of the pathogenic ones, such as *Prevotellaceae* and *Enterobacteria* which are associated with chronic systemic diseases [29], curcumin administration have also been shown to improve the intestinal barrier which helps to prevent leaky gut and thus chronic inflammation [30]. In a study conducted on mice, curcumin administration was shown to reduce intestinal mucosal permeability (increase in tight junction protein, Zonulin, and decrease in LPS), suppress the inflammatory markers and increase the insulin signalling pathways NF-kB (improved insulin resistance), therefore suggesting the use of curcumin as an alternative strategy in managing PCOS through gut modulation [31].

Curcuma longa has been shown to improve insulin sensitivity in patients with PCOS. A recent meta-analysis involving 447 participants from seven randomised controlled trials reported a significant reduction in fasting blood glucose and the HOMA-IR index, along with a marked improvement in the QUICKI index in women with PCOS following curcumin supplementation [32]. Another randomised controlled trial involving 72 individuals with PCOS who consumed 500 mg of curcumin three times a day for 12 weeks showed a significant decrease in fasting glucose levels and

the androgen marker dehydroepiandrosterone. The study concluded that curcumin may be useful in managing hyperglycaemia and hyperandrogenism in individuals with PCOS [33]. In another clinical trial, 27 women with PCOS aged 18-40 years were administered 500 mg of curcumin twice daily for six weeks. The results showed a significant improvement in the QUICKI index and a marginal improvement in HOMA-IR [34].

Cinnamon contains cinnamaldehyde, found in its essential oil, which exhibits antibacterial and anti-inflammatory effects. It has been found to have gut-altering properties, increasing the production of SCFAs due to an increase in species such as *Alloprevotella* and *Lachnospiraceae* in the gut microbiome. Cinnamon has been shown to increase the abundance of microbes like *Akkermansia* and *Bacteroides* while suppressing harmful bacteria such as *Ruminococcus* and *Escherichia-Shigella*. Furthermore, cinnamon has been associated with reduced blood glucose levels and the prevention of insulin resistance [35,36].

Clinical studies on women with PCOS have shown cinnamon to reduce insulin resistance markers. For instance, one study involving 66 women reported significant reductions in fasting insulin and HOMA-IR after 12 weeks of 1.5g/day cinnamon supplementation compared to placebo [36]. Another study supported the use of cinnamon in the improvement of the menstrual cyclicity in PCOS women [37].

Yoga

Yoga encompasses a wide range of physical and mental practices aimed at promoting overall wellbeing. Among its various forms, Yoga Nidra, Hatha Yoga, and Restorative Yoga are particularly recognised for enhancing mindfulness and providing distinct therapeutic benefits. These practices have been shown to alleviate pain by improving flexibility, reducing muscle tension, decreasing inflammation, and promoting deep relaxation [38].

In a recent study, 40 premenopausal women were recruited and classified into active and sedentary groups based on their level of physical activity. Gene sequencing analysis revealed a higher abundance of health-promoting bacterial species in physically active women, including *Faecalibacterium prausnitzii*, *Roseburia hominis*, and *Akkermansia muciniphila*. These butyrate-producing bacteria help maintain gut integrity and reduce inflammation, while increased lean body mass has been associated with *Akkermansia muciniphila* [39].

Yoga and other stress-reducing exercises have a unique impact on the gut through the gut-brain axis. Research by Thirthalli J et al., highlights that yoga intervention reduces stress and cortisol levels, thereby improving gut microbiota composition and gut-brain communication [40]. The studies demonstrate the role of yoga in mitigating stress-induced dysbiosis and enhancing gastrointestinal health [40]. A recent prospective randomised controlled study involving 90 adolescent girls with PCOS who met the Rotterdam criteria divided participants into a control group that received one hour of physical activity and an intervention group that received one hour of a holistic yoga module for 12 weeks. The results showed significant differences in the Anti-Mullerian Hormone (AMH) level (p-value=0.006), luteinising hormone (p-value=0.005), testosterone (p-value=0.014), and Modified Ferriman Gallway Score (p-value=0.002), indicating the use of yoga as an important technique to reduce the symptoms of PCOS at the hormonal level [41].

Intermittent Fasting (IF)

The IF is a general term describing alternate eating and fasting practices, Alternate Day Fasting (ADF), the 5:2 diet, and Time-Restricted Eating (TRE). In Alternate-Day Fasting (ADF), individuals alternate between "feast days," when they eat freely, and "fast days," during which they either consume only water or restrict their intake to about 25% of their daily caloric needs. TRE limits food intake to a specific period known as the "eating window," typically 8-12 hours per day, without necessarily changing the total energy intake [42]. IF in human trials has been shown to decrease body weight, inflammation, and appetite, and improve insulin levels [42]. Fasting has also been reported to enhance gut microbial diversity and reduce intestinal permeability through the production of SCFAs, leading to improved inflammation and insulin resistance [43].

The IF also has an impact on women's hormones. Women with obesity have higher oestrogen when compared to normal females. Weight loss has been shown to improve SHBG levels in women and reduce oestrogen levels, making IF an effective weight-loss strategy. Li C et al., reported that women with PCOS aged 18-31 years with anovulation showed significant improvements in body weight, body fat percentage, SHBG, Free Androgen Index, HOMA-IR, hs-CRP, and Insulin-Like Growth Factor-1 (IGF-1) during the Time-Restricted Feeding (TRF) period. An improvement in menstrual cycle irregularity was found in 73.3 % of patients [44]. Harvie MN et al., studied the effect of Intermittent Energy Restriction (IER) (providing 2710 kJ/day for 2 days/week) and Continuous Energy Restriction (CER) (providing 6267 kJ/day for 7days/week) in 107 young overweight women. Both types of energy restrictions showed effectiveness in weight loss, free androgen index, inflammation (CRP), and sex hormone binding globulin. However, reduction in fasting insulin and insulin resistance was significantly greater in the IER group as compared to the CER group (p-value=0.04) [45]. A recent study investigated the effects of a 6-week program of 8-hour TRF in patients with PCOS and assessed anthropometric, hormonal, and metabolic profiles, along with faecal calprotectin levels (a marker of gut inflammation). The results showed a significant reduction in Body Mass Index (BMI) and Waist-Hip Ratio (WHR). Reproductive hormone (Free Androgen Index), Homeostatic Model of Assessment of Insulin Resistance (HOMA-IR) and faecal calprotectin significantly reduced from pre-diet to post-diet (p-value <0.001), indicating a positive effect of TRF [46].

The TRF can improve the diversity and richness of the gut flora. In a study involving 80 healthy male participants, divided into two groups: TRF (TRF, n=56), and non TRF (n=24), the effect of 16 hours of fasting for 25 days showed significant improvement in the composition of the gut and increased abundance of helpful bacteria *Prevotellaceae* and *Bacteroideaceae* [47]. In a recent study conducted on 49 individuals, participants followed a 16-hour fasting period with an 8-hour eating window from 9 am to 5 pm for 30 days. They were provided with balanced, nutritious meals and were assessed for changes in body weight, immune markers, serum metabolites, and gut microbiota. It was reported that 95.9% of participants experienced weight loss, and an increase in the abundance of *Akkermansia* and *Rikenellaceae* was observed. *Akkermansia* is associated with improved insulin sensitivity and preventing obesity, and *Rikenellaceae* have been associated with healthy ageing and longevity [48].

There are also concerns regarding the use of IF and the imbalance of hormones by a study conducted on mice in which young rats underwent 24 hours of IF every other day for 12 weeks. In a rodent model, luteinising hormone and serum estradiol were significantly decreased; however, the applicability of these findings to humans, remain uncertain and requires further investigation [49]. The above studies suggest the use of IF with caution and for shorter intervals. A reduction in nutrient intake can alter the gut microbiota by increasing the beneficial bacteria, increasing the production of SCFAs. But detail studies involving metabolomics and metagenomics are required to understand the correlation between gut health and IF especially in subjects with metabolic disorders.

Sleep

Sleep disturbances have been associated with changes in the composition of the gut microbiota. A recent meta-analysis involving

16,152 PCOS women found that they had a higher prevalence of sleep disorders among women with PCOS (p-value <0.001) and shorter duration of sleep (p-value=0.008) [50]. The study also indicated significantly higher waist circumference and fasting glucose in PCOS women with sleep disturbances as compared to PCOS women without sleep disturbances [50]. Studies in mice have shown that disrupted sleep patterns, particularly Sleep Fragmentation (SF), can lead to inflammation in white adipose tissue and worsen insulin resistance. This occurs partly due to damage to the gut lining, which increases intestinal permeability, a condition often referred to as "leaky gut." The study reported an increase in highly fermentative members of the Lachnospiraceae and Ruminococcaceae families and a decrease in the Lactobacillaceae family, allowing bacterial components such as LPS to enter the bloodstream and trigger inflammation. These findings suggest that poor sleep may negatively affect metabolism in patients with PCOS [51]. Studies in PCOS individuals indicate that disrupted sleep can change the way the body utilises energy, it can lead to increased fat storage and increased insulin resistance, both of which are associated with PCOS. Sleep disturbances have also been associated with increased secretion of ghrelin, a hunger hormone, and a greater appetite for carbohydrate-rich foods, which may contribute to the metabolic disturbances observed in PCOS [52].

Gut bacteria produce important substances like vitamins, SCFAs, and serotonin precursors, which help maintain gut lining integrity and influence brain and body functions. About 90% of serotonin, essential for mood, appetite, digestion, and sleep, is made by gut bacteria. Specific bacteria, like those in the *Firmicutes* and *Corynebacterium* groups, contribute to serotonin production. Serotonin also serves as a building block for melatonin, a hormone that regulates sleep cycles. Certain gut bacteria can influence melatonin levels and sleep quality by producing compounds like GABA, which aids melatonin production, and glutamate, which promotes sleep [53]. Research suggests that gut microbes, including those from the Bacteroidetes, Firmicutes, and Actinobacteria groups, play a role in controlling sleep, food intake, and daily rhythms [54]. Recent studies highlight the impact of fermented foods on mental health. For instance, research on GABA-enriched fermented milk demonstrated its ability to reduce anxiety by altering the gut microbiota composition and boosting the production of SCFAs, which are linked to neural and mood regulation [55].

Disturbed sleep not only alters the composition and function of gut microbiota but also affects key processes such as serotonin and melatonin production, appetite regulation, and inflammation, and factors closely linked to this reproductive disorder. Evidence suggests that poor sleep quality can worsen metabolic symptoms in PCOS. Integrating sleep management along with the conventional treatment can offer an effective approach to enhance both the gut flora and, hence, improve hormonal and metabolic health in women with PCOS.

CONCLUSION(S)

This narrative review highlights the potential of complementary and alternative therapies, including probiotics, prebiotics, polyphenols, sleep regulation, yoga, and TRF, modulation of gut health and the management of clinical symptoms of PCOS. The gut–hormone–immune axis represents a promising target for therapeutic intervention. However, the gut microbiome is highly dynamic and sensitive to various lifestyle and environmental variables. Future clinical trials on CAM and Practices therapies should incorporate longer trials and gut microbiome assessments, such as 16S rRNA sequencing and metabolomics profiling, to better understand the exact pathways. Integrative approaches aimed at modulating the gut microbiome through targeted therapies may open new avenues for managing the clinical manifestations of PCOS.

REFERENCES

[1] Singh RK, Chang HW, Yan DI, Lee KM, Wong K. Influence of diet on the gut microbiome and implications for human health. J Transl Med. 2017;15(1):1-17.
[2] Moustakli E, Stavros S, Katopodis P, Potiris A, Drakakis P, Dafopoulos S, et al. Gut microbiome dysbiosis and its impact on reproductive health: Mechanisms and clinical applications. Metabolites. 2025;15(6):390. Doi: 10.3390/metabo15060390.
[3] Salari N, Nankali A, Ghanbari A, Jafarpour S, Ghasemi H, Dokaneheifard S, et al. Global prevalence of polycystic ovary syndrome in women worldwide: A comprehensive systematic review and meta-analysis. Arch Gynecol Obstet. 2024;310(3):1303-14. Doi: 10.1007/s00404-024-07607-x.
[4] Luque-Ramírez M, Escobar-Morreale HFJ. Polycystic ovary syndrome as a paradigm for prehypertension, prediabetes, and preobesity. Curr Hypertens Rep. 2014;16:1-10. Doi: 10.1007/s11906-014-0500-6.
[5] Elkafas H, Walls M, Al-Hendy A, Ismail N. Gut and genital tract microbiomes: Dysbiosis and link to gynecological disorders. Front Cell Infect Microbiol. 2022;12:1059825. Doi: 10.3389/fcimb.2022.1059825. Erratum in: Front Cell Infect Microbiol. 2023;13:1211349. Doi: 10.3389/fcimb.2023.1211349.
[6] US department of health and human services. complementary, alternative, or integrative health: What's in a name. Natl Cent Complement Integr Health. 2021. Available from: https://www.nccih.nih.gov/health/complementary-alternative-or-integrative-health-whats-in-a-name.
[7] Das M, Muralitharan G, Saini S, Patra S. Sleep, gut microbiota, and mind-body medicine. Brain Behavior and Immunity Integrative. 2025;11:100128.
[8] Tremellen, K, Pearce K. Dysbiosis of the Gut microbiota (DOGMA)- A novel theory for the development of polycystic ovarian syndrome. Medical Hypotheses. 2012;79(1):104-12.
[9] He FF, L YM. Role of Gut microbiota in the development of insulin resistance and the mechanism underlying polycystic ovary syndrome: A review. J Ovarian Res. 2020;13(1):73. Doi: 10.1186/s13048-020-00670-3.
[10] Zhao H, Zhang J, Cheng X, Nie X, He B. Insulin resistance in polycystic ovary syndrome across various tissues: An updated review of pathogenesis, evaluation, and treatment. J Ovarian Res. 2023;16(1):9. Doi: 10.1186/s13048-022-01091-0.
[11] Zhao X, Jiang Y, Xi H, Chen L, Feng X. Exploration of the relationship between gut microbiota and Polycystic Ovary Syndrome (PCOS): A review. Geburtshilfe Frauenheilkd. 2020;80(2):161-71. Doi: 10.1055/a-1081-2036.
[12] Daka B, Rosen T, Jansson PA, Råstam L, Larsson CA, Lindblad U. Inverse association between serum insulin and sex hormone-binding globulin in a population survey in Sweden. Endocrine Connections. 2012;2(1):18-22. Available from: https://doi.org/10.1530/EC-12-0057.
[13] Ye W, Xie T, Song Y, Zhou L. The role of androgen and its related signals in PCOS. Journal of Cellular and Molecular Medicine. 2021;25(4)1825-37. https://doi.org/10.1111/jcmm.16205.
[14] Eid HM, Wright ML, Anil Kumar NV, Qawasmeh A, Hassan STS, Mocan A, et al. Significance of microbiota in obesity and metabolic diseases and the modulatory potential by medicinal plant and food ingredients. Front Pharmacol. 2017;8:387. Doi: 10.3389/fphar.2017.00387.
[15] Qi X, Yun C, Sun L, Xia J, Wu Q, Wang Y, et al. Gut microbiota-bile acid-interleukin-22 axis orchestrates polycystic ovary syndrome. Nat Med. 2019;25(8):1225-33. Doi: 10.1038/s41591-019-0509-0. Epub 2019 Jul 22. Erratum in: Nat Med. 2019;25(9):1459. Doi: 10.1038/s41591-019-0562-8.
[16] Torres PJ, Siakowska M, Banaszewska B, Pawelczyk L, Duleba AJ, Kelly ST, et al. Gut microbial diversity in women with polycystic ovary syndrome correlates with hyperandrogenism. Journal of Clinical Endocrinology and Metabolism. 2018;103(4):1502-11.
[17] Liu R, Zhang C, Shi Y, Zhang F, Li L, Wang X, et al. Dysbiosis of gut microbiota associated with clinical parameters in polycystic ovary syndrome. Front Microbiol. 2017;8:324. Doi: 10.3389/fmicb.2017.00324.
[18] Jobira B, Frank DN, Pyle L, Silveira LJ, Kelsey MM, Garcia-Reyes Y, et al. Obese adolescents with PCOS have altered biodiversity and relative abundance in gastrointestinal microbiota. J Clin Endocrinol Metab. 2020;105(6):e2134-e2144. Doi: 10.1210/clinem/dgz263.
[19] Guo Y, Qi Y, Yang X, Zhao L, Wen S, Liu Y, et al. Association between polycystic ovary syndrome and gut microbiota. PLoS One. 2016;11(4):e0153196. Doi: 10.1371/journal.pone.0153196.
[20] Chen LA, Sears CL. Prebiotics, probiotics, and Synbiotics. In: Bennett JE, Dolin R, Blaser MJ. editors. Mandell, Douglas, and Bennett's principles and practice of infectious diseases. 8th ed. Philadelphia: Elsevier; 2015. p. 19-25.
[21] Ramezani Ahmadi A, Sadeghian M, Alipour M, Ahmadi Taheri S, Rahmani S, Abbasnezhad A. The effects of probiotic/synbiotic on serum level of zonulin as a biomarker of intestinal permeability: A systematic review and meta-analysis. Iranian Journal of Public Health. 2020;*49*(7):1222-31. https://doi.org/10.18502/ijph.v49i7.3575.
[22] Karamali M, Eghbalpour S, Rajabi S, Jamilian M, Bahmani F, Tajabadi-Ebrahimi M, et al. Effects of probiotic supplementation on hormonal profiles, biomarkers of inflammation and oxidative stress in women with polycystic ovary syndrome: A randomized, double-blind, placebo-controlled trial. Arch Iran Med. 2018;21(1):01-07.
[23] Shoaei T, Heidari-Beni M, Tehrani HG, Feizi A, Esmaillzadeh A, Askari G. Effects of probiotic supplementation on pancreatic β-cell function and c-reactive protein in women with polycystic ovary syndrome: A randomized double-blind placebo-controlled clinical trial. Int J Prev Med. 2015;6:27. Doi: 10.4103/2008-7802.

[24] Miyamoto J, Watanabe K, Taira S, Kasubuchi M, Li X, Irie J, et al. Barley β-glucan improves metabolic condition via short-chain fatty acids produced by gut microbial fermentation in high fat diet fed mice. PLoS One. 2018;13(4):e0196579. Doi: 10.1371/journal.pone.0196579.
[25] Liang Z, Di N, Li L, Yang D. Gut microbiota alterations reveal potential gut-brain axis changes in polycystic ovary syndrome. J Endocrinol Invest. 2021;44(8):1727-37. Doi: 10.1007/s40618-020-01481-5.
[26] Shamasbi GS, Dehgan P, Mohammad-Alizadeh CS, Aliasgarzadeh A, Mirghafourvand M. The effect of resistant dextrin as a prebiotic on metabolic parameters and androgen level in women with polycystic ovarian syndrome: A randomized, triple-blind, controlled, clinical trial. Eur J Nutr. 2019;58:629-40. https://doi.org/10.1007/s00394-018-1648-7.
[27] Santhiravel S, Bekhit AE, Mendis E, Jacobs JL, Dunshea FR, Rajapakse N, et al. The impact of plant phytochemicals on the gut microbiota of humans for a balanced life. Int J Mol Sci. 2022;23:8124.
[28] Hewlings SJ, Kalman DS. Curcumin: A review of its effects on human health. Foods (Basel). 2017;6(10):92. https://doi.org/10.3390/foods6100092.
[29] Shen L, Liu L, Ji HF. Regulative effects of curcumin spice administration on gut microbiota and its pharmacological implications. Food & Nutrition Research. 2017;61(1):1361780. https://doi.org/10.1080/16546628.2017.1361780.
[30] Cerullo M, Armeli F, Mengoni B, Menin M, Crudeli ML, Businaro R. Curcumin modulation of the gut-brain axis for neuroinflammation and metabolic disorders prevention and treatment. Nutrients. 2025;17(9):1430. https://doi.org/10.3390/nu17091430.
[31] Yang Q, Wan Q, Wang Z. Curcumin mitigates polycystic ovary syndrome in mice by suppressing TLR4/MyD88/NF-κB signaling pathway activation and reducing intestinal mucosal permeability. Sci Rep. 2024;14(1):29848. Doi: 10.1038/s41598-024-81034-5. PMID: 39617843; PMCID: PMC11609283.
[32] Shen W, Qu Y, Jiang H, Wang H, Pan Y, Zhang Y, et al. Therapeutic effect and safety of curcumin in women with PCOS: A systematic review and meta-analysis. Front. Endocrinol. 2022;13:1051111. Doi: 10.3389/fendo.2022.1051111.
[33] Heshmati J, Moini A, Sepidarkish M, Morvaridzadeh M, Salehi M, Palmowski A, et al. Effects of curcumin supplementation on blood glucose, insulin resistance and androgens in patients with polycystic ovary syndrome: A randomized double-blind placebo-controlled clinical trial. Phytomedicine: International Journal of Phytotherapy and Phytopharmacology. 2022;80:153395. https://doi.org/10.1016/j.phymed.2020.153395.
[34] Sohaei S, Amani R, Tarrahi MJ, Ghasemi-Tehrani H. The effects of curcumin supplementation on glycemic status, lipid profile and Hs-CRP levels in overweight/obese women with polycystic ovary syndrome: A randomized, double-blind, placebo-controlled clinical trial. Complement Ther Med. 2019;47:102201. Doi: 10.1016/j.ctim.2019.102201.
[35] Qi L, Mao H, Lu X, Shi T, Wang J. Corrigendum: Cinnamaldehyde promotes the intestinal barrier functions and reshapes gut microbiome in early weaned rats. Front Nutr. 2022;9:1038451. Doi: 10.3389/fnut.2022.1038451. Erratum for: Front Nutr. 2021;8:748503. Doi: 10.3389/fnut.2021.748503.
[36] Hajimonfarednejad M, Nimrouzi M, Heydari M, Zarshenas MM, Raee MJ, Jahromi BN. Insulin resistance improvement by cinnamon powder in polycystic ovary syndrome: A randomized double-blind placebo controlled clinical trial. Phytotherapy Research: PTR. 2018;32(2):276-83. https://doi.org/10.1002/ptr.5970.
[37] Kort DH, Lobo RA. Preliminary evidence that cinnamon improves menstrual cyclicity in women with polycystic ovary syndrome: A randomized controlled trial. Am J Obstet Gynecol. 2014;211(5):487.e1-6. Doi: 10.1016/j.ajog.2014.05.009. Epub 2014 May 9. PMID: 24813595.
[38] Rostkowska W, Gajdzińska N, Salwa A, Rutkowski W, Rzepka M, Sztuba K, et al. Can yoga be the answer? The positive aspects of practicing yoga across various medical conditions - A mini review. Quality in Sport. 2024;19:53684. https://doi.org/10.12775/QS.2024.19.53684.
[39] Bressa C, Bailén-Andrino M, Pérez-Santiago J, González-Soltero R, Pérez M, Montalvo-Lominchar MG, et al. Differences in gut microbiota profile between women with active lifestyle and sedentary women. PloS one. 2017;12(2):e0171352. https://doi.org/10.1371/journal.pone.0171352.
[40] Thirthalli J, Naveen GH, Rao MG, Varambally S, Christopher R, Gangadhar BN. Cortisol and antidepressant effects of yoga. Indian J Psychiatry. 2013;55(Suppl 3):S405-S408. Doi:10.4103/0019-5545.116315.
[41] Nidhi R, Padmalatha V, Nagarathna R, Amritanshu R. Effects of a holistic yoga program on endocrine parameters in adolescents with polycystic ovarian syndrome: A randomized controlled trial. J Altern Complement Med. 2013;19(2):153-60. Doi: 10.1089/acm.2011.0868.
[42] Carvajal V, Marín A, Gihardo D, Maluenda F, Carrasco F, Chamorro R. Intermittent fasting and human metabolic health. Rev Méd Chile. 2023;151(1):81-100. doi.org/10.4067/s0034-98872023000100081.
[43] Mohr AE, Gumpricht E, Sears DD, Sweazea KL. Recent advances and health implications of dietary fasting regimens on the gut microbiome. Am J Physiol Gastrointest Liver Physiol. 2021;320(5):G847-63. Doi: 10.1152/ajpgi.00475.2020.
[44] Li C, Xing C, Zhang J, Zhao H, Shi W, He B. Eight-hour time-restricted feeding improves endocrine and metabolic profiles in women with anovulatory polycystic ovary syndrome. J Transl Med. 2021;19(1):148. Doi: 10.1186/s12967-021-02817-2.
[45] Harvie MN, Pegington M, Mattson MP, Frystyk J, Dillon B, Evans G, et al. The effects of intermittent or continuous energy restriction on weight loss and metabolic disease risk markers: A randomized trial in young overweight women. Int J Obes (Lond). 2011;35(5):714-27. Doi: 10.1038/ijo.2010.171.
[46] Feyzioglu BS, Güven CM, Avul Z. Eight-hour time-restricted feeding: A strong candidate diet protocol for first-line therapy in polycystic ovary syndrome. Nutrients. 2023;15(10):2260. Doi: 10.3390/nu15102260.
[47] Zeb F, Wu X, Chen L, Fatima S, Haq IU, Chen A, et al. Effect of time-restricted feeding on metabolic risk and circadian rhythm associated with gut microbiome in healthy males. Br J Nutr. 2020;123:1216-26. Doi: 10.1017/S0007114519003428.
[48] Chen Y, Li X, Yang M, Jia C, He Z, Zhou S, et al. Time-restricted eating reveals a "younger" immune system and reshapes the intestinal microbiome in human. Redox Biology. 2024;*78*:103422. https://doi.org/10.1016/j.redox.2024.103422.
[49] Kumar S, Kaur G. Intermittent fasting dietary restriction regimen negatively influences reproduction in young rats: A study of hypothalamo-hypophysial-gonadal axis. PLoS One. 2013;8(1):e52416. Doi: 10.1371/journal.pone.0052416.
[50] Zhang J, Ye J, Tao X, Lu W, Chen X, Liu C. Sleep disturbances, sleep quality, and cardiovascular risk factors in women with polycystic ovary syndrome: Systematic review and meta-analysis. Frontiers in Endocrinology. 2022;*13*:971604. https://doi.org/10.3389/fendo.2022.971604.
[51] Poroyko VA, Carreras A, Khalyfa A, Khalyfa AA, Leone V, Peris E, et al. Chronic sleep disruption alters gut microbiota, induces systemic and adipose tissue inflammation and insulin resistance in mice. Sci Rep. 2016;6:35405. Doi: 10.1038/srep35405.
[52] Teo P, Henry BA, Moran LJ, Cowan S, Bennett C. The role of sleep in PCOS: What we know and what to consider in the future. Expert Rev Endocrinol Metab. 2022;17(4):305-18. Doi: 10.1080/17446651.2022.2082941.
[53] Yano JM, Yu K, Donaldson GP, Shastri GG, Ann P, Ma L, et al. Indigenous bacteria from the gut microbiota regulate host serotonin biosynthesis. Cell. 2015;161(2):264-76. Doi: 10.1016/j.cell.2015.02.047. Erratum in: Cell. 2015;163:258.
[54] Strandwitz P. Neurotransmitter modulation by the gut microbiota. Brain Res. 2018;1693(Pt B):128-33. Doi: 10.1016/j.brainres.2018.03.015.
[55] Yu L, Han X, Cen S, Duan H, Feng S, Xue Y, et al. Beneficial effect of GABA-rich fermented milk on insomnia involving regulation of gut microbiota. Microbiol Res. 2020;233:126409. Doi: 10.1016/j.micres.2020.126409.

PARTICULARS OF CONTRIBUTORS:
1. PhD Scholar, School of Allied Health Sciences, Nutrition and Dietetics, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India.
2. Associate Professor, School of Allied Health Sciences, Nutrition and Dietetics, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Manika Setia,
PhD Scholar, School of Allied Health Science, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India.
E-mail: manikasetia@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Dec 05, 2025
- Manual Googling: Mar 09, 2026
- iThenticate Software: Mar 11, 2026 (6%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Oct 29, 2025**
Date of Peer Review: **Jan 21, 2026**
Date of Acceptance: **Mar 13, 2026**
Date of Publishing: **May 01, 2026**