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Research Paper

Nutrition and polycystic ovary syndrome: emerging evidence for dietary management

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ABSTRACT

Background: Polycystic ovarian syndrome is a prevalent endocrine and metabolic disorder that affects women of reproductive age. Its characteristics include ovulatory failure, hyperandrogenism, insulin resistance, and an increased risk of obesity, type 2 diabetes, heart disease, and infertility.
Objective: This review aims to examine the current evidence on the role of nutrition in PCOS management, focusing on dietary patterns, micronutrients, dietary supplements, gut microbiota, lifestyle interventions, and emerging nutritional approaches.
Methods: A narrative review of recent literature was conducted using peer-reviewed studies, clinical guidelines, systematic reviews, and randomized controlled trials published on nutrition and PCOS management.
Results: Research suggests that dietary interventions can enhance insulin sensitivity, weight control, and metabolic health in women with PCOS, including the Mediterranean diet, DASH diet, low-glycemic index diets, and calorie-restricted methods. Vitamin D, inositol, omega-3 fatty acids, and probiotics are examples of nutritional supplements that have shown promise in enhancing hormonal and metabolic outcomes.
Conclusion: Nutritional management is a cornerstone of PCOS treatment and can significantly improve metabolic and reproductive outcomes. Even while the results are encouraging, further high-caliber research is required to develop individualized, scientifically supported dietary guidelines for women with PCOS.

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1. INTRODUCTION

Almost 21% of women in their reproductive ages have PCOS, an intricate and common endocrine disease. It causes several gynecological, metabolic, and psychological problems due to its characteristic features like hyperandrogenism, absence of ovulation, and polycystic ovarian morphology [1]. Endometrial cancer, psychological disorders, pre-eclampsia, recurrent abortion, and perinatal mortality are some of the complications that can arise from PCOS, both immediately and over time. Obesity, diabetes type 2, metabolic syndrome, hypertension, fetal macrosomia (weight of the baby at birth is over 4 kg); dyslipidemia, heart diseases, thyroid disorder, and hyperplasia could cause breast cancer [2].

Because PCOS is complicated and multigenetic, its pathophysiology is unknown. Ovarian and adrenal steroid production, obesity, and PCOS energy regulation are all influenced by genes. Increased androgen levels and insulin resistance are its main characteristics [3]. Insulin appears to be a major factor in PCOS, despite the fact that the precise origin and pathophysiology of the condition are yet unknown. PCOS is associated with inflammation, just like other chronic conditions. However, new studies show that a nutritious diet might improve metabolic and reproductive processes as well as insulin resistance (IR), making it a viable therapy option for reducing PCOS symptoms [4].

Dietary and lifestyle decisions have a major impact on androgen activity, especially when it comes to body weight. Even if they are not obese, 30–75% of women with PCOS frequently have extra body fat, particularly central adiposity [5]. Common therapeutic approaches include changing one's diet, adding exercise, and utilizing nutritional supplementation therapy. While obesity is often associated with PCOS in women, a significant number of slim individuals also have the condition [6].

Numerous pharmaceutical approaches targeting androgen excess, central neuroendocrine dysfunction, and/or metabolic pathology are among the promising novel therapies for PCOS. The possibility of therapeutic regulation of SHBG to address hyperandrogenism is gaining attention, even though there are currently no licensed AR antagonists for treating PCOS[7]. Depending on the patient's goals and specific symptoms, PCOS treatment can vary. Laser therapy for ovarian cysts, gene therapy, stem cell treatment, nutrigenomics, customized diets, and AI Initiatives is some of the cutting-edge technologies and creative approaches being investigated for PCOS treatment [8].

Despite extensive investigation of the association between diet and PCOS, the literature on the topic is highly heterogeneous because of various factors including differences in diets, patients, diagnostics, and outcomes. This narrative review's objective is to assess the available data on how nutrition affects the management of polycystic ovarian syndrome. Specifically, this study evaluates the importance of the gut microbiome, reviews the underlying physiological mechanisms that link nutrition and PCOS, explores the effectiveness of diverse dietary regimes and nutritional supplements, and provides information about innovative approaches in the field.

2. RELATED WORK

PCOS that occurs in women of reproductive age is the commonest metabolic endocrine disorder that is characterized by disturbances in both metabolism and reproduction [9]. The other feature is androgen excess, and this condition occurs between 60% to 80% of PCOS patients. Hirsutism and hyperandrogenism are adverse effects of high androgen production. In actuality, hirsutism and hyperandrogenism are adverse effects of the most common androgen production. In actuality, PCOS pathogenesis is caused by the most common hormones. One typical sign of hyperandrogenism is elevated blood levels of free testosterone [10]. The exact cause of PCOS is unclear due to its complex, multi-genetic nature. Genes are involved in the genesis of ovarian and adrenal steroids, obesity, and energy regulation in

PCOS [3]. The underlying mechanisms of PCOS are still not well understood. High-throughput sequencing and molecular biology techniques have advanced, demonstrating the combined impact of genetic and epigenetic factors on its pathogenesis [11]. It is important to mention that the lack of robust genetic determinants, along with increasing evidence pointing to the involvement of intrauterine and lifestyle-related factors, provides significant backing for the epigenetic model concerning the inheritance and development of PCOS [12]. New treatments and better patient outcomes could result from an enhanced understanding of the disease's pathogenesis. Our understanding of these pathophysiological processes has been enhanced by recent studies [13]. Hyperandrogenism, a condition linked to PCOS, is shaped by a mix of genetic and environmental factors. An imbalance in signaling within the hypothalamus–pituitary–ovarian axis can lead to hyperandrogenism, resulting in the overproduction of luteinizing hormone and insulin [14]. PCOS is recognized as a complex multigenic disorder influenced by environmental, genetic, and epigenetic variables, even if its precise origin is still unknown. The pathophysiology of PCOS and the impact of genetic differences in the likelihood of developing the illness remain unknown due to the absence of a suitable study model. Reprogrammed somatic cells, with their capacity for self-renewal and multidirectional differentiation, have become outstanding instruments for investigating various disease mechanisms since the advent of iPSC technology. Recently, researchers have managed to create human in vitro models of PCOS using iPSC lines derived from diverse groups of PCOS patients (iPSCPCOS) [15].

3. METHODOLOGY

The narrative review was carried out with an objective of evaluating current research on the significance of nutrition in the treatment of polycystic ovary syndrome (PCOS). A thorough literature search was carried out with the use of various databases including PubMed, Scopus, Web of Science, Google Scholar, and Science Direct. Literature in the form of peer-reviewed articles between the years 2022 and 2025 published in English was taken into consideration. Search terms included the following: "Polycystic Ovary Syndrome," "PCOS," "nutrition," "dietary management," "Mediterranean diet," "DASH diet," "low glycemic index diet," "gut microbiota," "micronutrients," "dietary supplements," and "lifestyle intervention."

Research studies, systematic reviews, meta-analyses, randomized control trials, clinical guidelines, and review articles addressing the topic of dietary treatment for PCOS were selected. Studies that do not relate to nutrition, non-English articles, abstracts from conferences lacking full text, editorials, and repeated publications were excluded. Selected literature was critically evaluated and organized into thematic blocks of dietary patterns, micronutrients and supplements, gut microbiota, lifestyle changes, current guidelines, and future research prospects.

4. RESULTS AND DISCUSSION

4.1 Role of Nutrition in PCOS

The medical literature generally acknowledges that PCOS is a highly heterogeneous condition and that a multidisciplinary approach involving gynecologists, endocrinologists and nutritional experts, particularly dietitians, is essential to provide immediate care and address long-term risk factors associated with PCOS comorbidity [16]. Achieving weight loss by dietary and lifestyle modifications, followed by pharmaceutical or surgical treatments, are crucial components in treating PCOS in adolescents. In adolescents with PCOS, the first-line treatment involves nutritional interventions. However, it is crucial to determine the benefits and efficacy of the most well-known nutritional techniques given the range of dietary regimens that are available. Benefits for PCOS sufferers can be increased by combining high-fat diets with more nutrient-dense eating regimens [17]. PCOS and obesity are closely related. A significant number of well-rounded treatments targeted at improving patients' lifestyles are advised, such as adopting appropriate foods to lower exposure to inflammatory substances and stop aberrant immune system stimulation. Supplementing with probiotics and synbiotics may help reduce weight during the dieting period and improve the gut flora, which may also benefit metabolic and inflammatory variables [18]. Improving health outcomes for women with PCOS requires a combination of technology, medical care, and

diet [19]. A balanced diet with 40% of energy coming from carbohydrates, 30% from fats, and 30% from protein has been suggested, coupled with appropriate physical activity, to enhance metabolic balance and lessen severe PCOS symptoms. Patients with PCOS may also benefit from dietary and activity modifications [20].

4.2 Dietary Patterns

The best way to prevent and treat PCOS may be through dietary changes. A DASH diet with calorie restriction appeared to help women with PCOS lose weight and control their blood sugar. The conflicting results made it difficult to determine the advantages of a high-protein, low-GI, and low-carb diet. Despite the paucity of data, KD and a low-calorie diet seem to be significant factors in PCOS. These results suggest that a woman's diet composition may play a major role in PCOS management. Specifically, adhering to the DASH eating pattern has been suggested as a potential strategy for regulating blood sugar levels and losing weight [21]. A pro-inflammatory diet increased the risk of getting PCOS. The meat-egg and shellfish-shrimp-dairy diets increased the risk of PCOS, but the Mediterranean diet reduced it. The Mediterranean diet has been found to have a negative correlation with the Dietary Inflammatory Index. Women with PCOS were found to have higher levels of oxidative stress, neutrophil-lymphocyte ratio, and systemic immune-inflammation index [22]. Women with PCOS have common dietary patterns characterized by excessive ingestion of various unhealthy food products. Even though some studies produce contradictory results, these differences highlight the need for additional research with a bigger sample size [23]. Count calories to change patients' eating habits or achieve weight loss. It is impossible to make calorie counting work without proper dietary recommendations, for example, restrictions on sugar and alcohol intake. The importance of formulating concrete dietary goals rather than general nutrition objectives is demonstrated in this study. It is feasible to attain better results in both managing PCOS symptoms and avoiding related metabolic issues by empowering individuals through education, early diagnosis, and continuous encouragement [24]. Additionally, appropriate levels of metabolic indicators were associated with low WDLP adherence. High PDLP adherence was linked to type two PCOS. Vigorous physical activity and a greater frequency of plant-based food consumption were characteristics of the PDLP. High intake of animal items and a low level of physical activity were characteristics of the least desired WDLP. Plant-based foods may play a larger role in diet therapy than currently recognized, warranting further exploration [25]. A lower risk of PCOS is linked to greater adherence to the Med-Diet and PDQS [26]. Compared to women without NAFLD, those with PCOS with coexisting NAFLD had greater BMI. PCOS women with NAFLD did not significantly differ from those without NAFLD in terms of food group consumption, macro and micronutrient intake, or diet quality, according to dietary evaluation [27]. Dietary patterns for PCOS management are shown in Table 1.

Table 1. Dietary Patterns for PCOS Management

Dietary Pattern	Main Features	Benefits in PCOS	Key References
Mediterranean Diet	Fruits, vegetables, olive oil	Improves insulin sensitivity, reduces inflammation	[21], [25]
DASH Diet	Low sodium, high fruits and vegetables	Weight reduction, improved glycemic control	[20], [21]
Low-Glycemic Index Diet	Low GI carbohydrates	Better glucose control, reduced insulin resistance	[20], [22]
Ketogenic Diet	Very low carbohydrate	Short-term weight loss and metabolic improvement	[20]

4.3 Micronutrients and Dietary Supplements

Follicular homocysteine could serve as a suitable reporter for investigating oocyte-embryo selection. In cases of PCOS, a diet high in methyl donors may be beneficial, and supplements could also provide assistance. These results may also apply to women without PCOS, which calls for more research [28]. Vitamin D, omega-3 fatty acids, and inositol were identified as the most essential supplements among

various micronutrients for addressing oxidative damage. Additionally, cinnamon, curcumin, sage that have shown promise as effective complementary therapy options for improving glycemic control, reducing inflammation, and regulating the menstrual cycle [29]. The nutritional supplements have been found to give encouraging results for reversing reproductive, metabolic, and mental health disorders in PCOS patients by altering the above-mentioned crucial pathways which are involved in the development of PCOS [30]. Individuals suffering from PCOS should consume diets that are full of minerals. Compared to the consumption of supplements, foods are less likely to cause toxicity [31]. It is advisable to carry out long-term observational studies on vitamin D among the most promising supplements to evaluate its potential toxic effects at various doses and administration durations [32]. The clinical and biochemical aspects of PCOS can be effectively managed with the help of micronutrient and macronutrient interventions, according to an increasing number of clinical trials. However, the potential benefits of these micronutrient and macronutrient approaches may vary when considered individually, especially across different phenotypes of PCOS. For the best outcomes to be achieved, it is necessary to provide information about safety and the optimal dose selection of macronutrients and micronutrients [33]. All micronutrients and dietary supplements with their mechanism and benefits shown in Table 2.

Table 2. Micronutrients and Dietary Supplements in PCOS

Supplement	Mechanism	Reported Benefits	References
Vitamin D	Improves insulin sensitivity	Better metabolic profile	[31], [32]
Inositol	Insulin signaling	Improved ovulation	[29]
Omega-3 Fatty Acids	Anti-inflammatory	Reduced triglycerides	[28]
Probiotics	Modulates gut microbiota	Improved gut health and metabolism	[33]

4.4 Gut Microbiota and PCOS

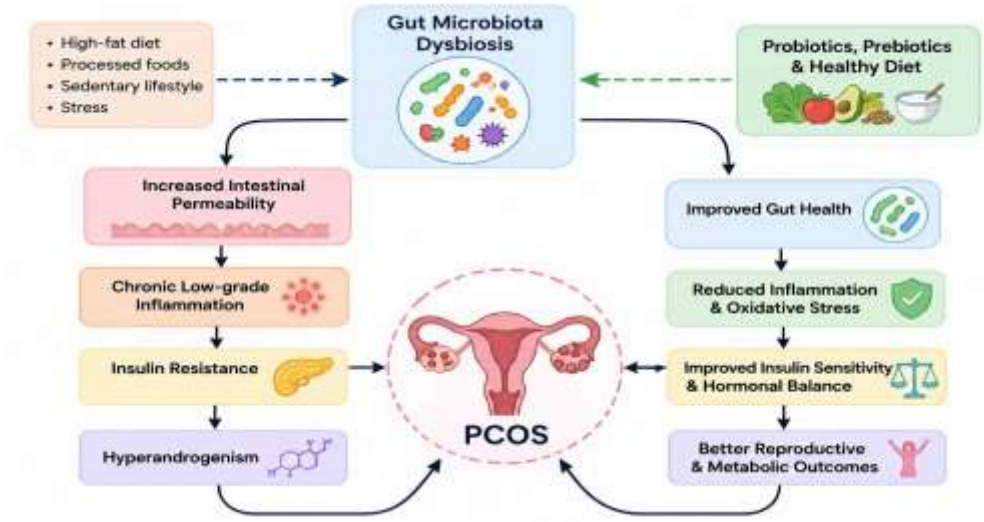

Figure 1. Gut Microbiota and PCOS

PCOS can arise due to a variety of factors. These women frequently show signs of high insulin resistance, hyperandrogenism, menstrual irregularities, and infertility. Many researchers have taken an interest in the gut microbiota (GMB) dysbiosis in women with PCOS. The gut microbiota produces short-chain fatty acids through fermentation, which are essential for controlling metabolic processes, reducing insulin resistance, and easing the symptoms of PCOS [34]. Reduced diversity and changes in bacteria engaged in microbiota-host interaction are linked to gut dysbiosis in PCOS [35]. Observational studies reveal differences in the gut microbiota of PCOS patients and controls. However, specific gut microbiota taxa that are causally associated with PCOS have been discovered by MR studies. Future research should

examine the gut microbiota that demonstrated significant results in the MR analysis, the mechanisms behind this causal relationship, and any possible therapeutic implications [36]. PCOS patients' gut microbiome characteristics may also be connected to clinical parameters and differ from those in both PCOS patients and controls. It may be employed as a substitute treatment in the future to regulate PCOS patients' clinical cholesterol levels [37]. The gut microbiome is significantly altered in women with PCOS. In particular, compared to the control group, the PCOS group showed a large rise in the relative abundance of Bacteroidaceae and a significant decrease in alpha diversity. Moreover, dysbiosis could be considered a major factor in the development and progression of PCOS [38]. The complex connections between gut microbiota and metabolic pathways in PCOS highlight the need for more studies using standardized methods and larger sample sizes to clarify the microbiome's function in PCOS [39]. Women with PCOS have considerably different gut microbiomes. Specifically, the PCOS group exhibited a considerable drop in alpha diversity and a large increase in the relative abundance of Bacteroidaceae as compared to the control group. Furthermore, dysbiosis may have a significant role in the onset and advancement of PCOS [38]. The intricate relationships between gut microbiota and metabolic pathways in PCOS underscore the need for additional research employing standardized techniques and bigger sample sizes to elucidate the role of the microbiome in PCOS [40]. Gut microbiota and PCOS process shown in Figure 1.

4.5 Lifestyle Interventions

Patients with PCOS can improve their biochemical, hormonal, and anthropometric parameters through lifestyle changes, which can also reduce their long-term risk of metabolic and CVD [41]. To create lifestyle recommendations for PCOS management, it is important to understand and communicate the evidence for dietary, physical activity, and behavioral interventions. By giving women more alternatives and more control over their treatment decisions, this will assist physicians in delivering patient-centered care [42]. Effective lifestyle modifications, such as dietary modifications, increased physical activity, and behavioral strategies, can enhance the general quality of life, mental health, and reproductive health of women with PCOS [43]. Lifestyle intervention is seen as the primary management strategy for women with PCOS who present with infertility [44]. Three-component LSI proved to be more effective than CAU in enhancing metabolic health. For this reason, we advise this intervention for women with PCOS and excess weight, as long as they are aiming for a clinically significant weight loss [45]. The relationship between PCOS and lifestyle modifications also looked at future research topics. For lifestyle changes intended to treat PCOS and other related endocrine problems, the findings may be a very useful guide [46].

4.6 Current Clinical Guidelines

The endocrine condition known as PCOS is influenced by both hereditary and epigenetic factors. The disease's clinical presentation, diagnosis, and treatment approaches differ according to a woman's stage of life [47]. About 12% of women in their reproductive years have PCOS. After being published in 2018, an updated version of the first evidence-based recommendations for PCOS diagnosis and treatment was made available in August 2023. Because these standards adhered to best practices and were approved by 39 organizations worldwide, they are the most reliable sources of evidence-based practice. The diagnostic criteria have been further improved by the 2023 guideline, which permits the use of gynecological ultrasonography or high anti-Müllerian hormone levels to assess polycystic ovary morphology [48]. The guideline recommendations are copyrighted, but a clear process for adapting them to regional contexts can be accessed by contacting the author for correspondence at www.monash.edu/medicine/mchri/pcos. The translation program will be free and accessible globally using the current variety of codesigned tools, such as the patient-focused, evidence-based PCOS APP (AskPCOS), which is used in 186 countries and is based on a carefully crafted question prompt list [49]. The International Evidence-Based Guidelines have recognized numerous aspects of PCOS that need more research [50]. Using a creative and systematic multi-stage co-production approach, international partners have contributed to the creation of the International PCOS Guideline for clinical research priority roadmap. In addressing the significant issues and clinical requirements related to this prevalent but frequently disregarded illness, the roadmap is a significant advancement. In this sense, broad principles that enhance

the caliber of research are not the main priority for clinical research but also specific clinical areas that need further study. Nutrition management strategies for PCOS shown in Figure 2.

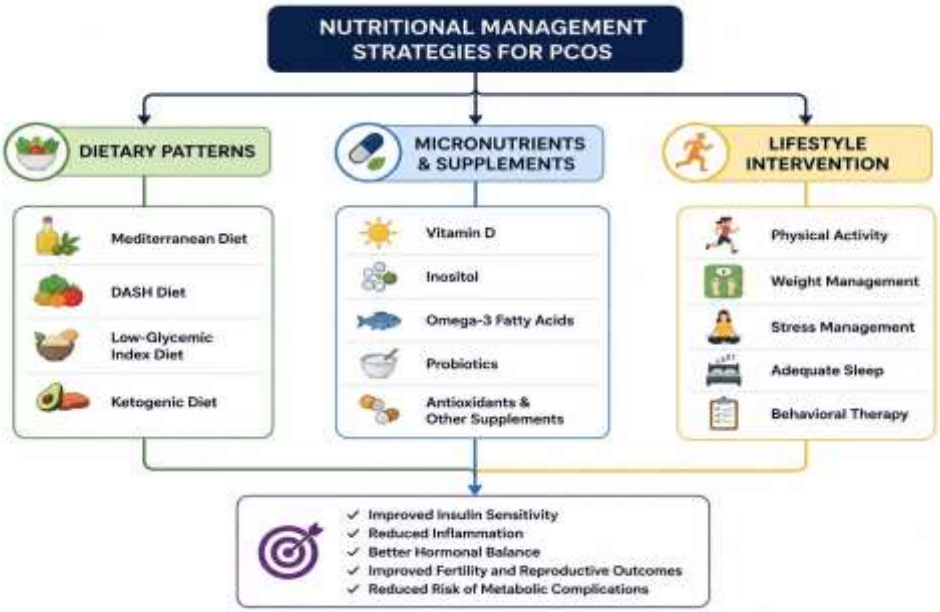

Figure 2. Nutritional Management Strategies for PCOS

4.7 Research Gaps and Future Directions

However, the small sample size, short research length, and variable diets employed in different investigations limit the present studies on nutritional therapy of PCOS. Standardized methods are required for the comparison of effectiveness of the diets. Moreover, the evidence about individualized nutrition, long-term results, and gut microbiota needs further development. Future research should be oriented towards large-scale randomized controlled studies, nutrigenomics-based diet, manipulation of gut microbiota, and individualized nutrition plans for different PCOS phenotypes.

5. CONCLUSION

Nutrition is very important in the management of PCOS due to its insulin resistance, lowering properties, anti-inflammatory effects, contribution to weight control, and reproductive health support. Mediterranean, DASH and other dietary patterns, along with proper micronutrients intake and other lifestyle changes, provide great benefits. Still, more quality research is required for developing evidence-based recommendations for PCOS patients.

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C: **C**onceptualisation
M: **M**ethodology
So: **So**ftware
Va : **Va**lidation
Fo: **Fo**rmal analysis
I: **I**nvestigation
R: **R**esources
D: **D**ata Curation
O: Writing-**O**riginal Draft
E: Writing-Review & **E**diting
Vi: **Vi**sualisation
Su: **Su**pervision
P: **P**roject administration
Fu: **F**unding acquisition

Conflict of Interest Statement

The authors state no conflict of interest.

Informed Consent

This study is a narrative review based exclusively on previously published literature and did not involve human participants or identifiable personal data.

Ethical Approval

This narrative review did not involve experiments on human participants or animals and therefore did not require ethical approval from an institutional review board.

Data Availability

Data availability is not applicable to this paper as no new data was created or analyzed in this study. All information supporting the findings is available within the published literature cited in this review.

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