

NUTRITION AND METABOLIC HEALTH CHANGES IN POLYCYSTIC OVARY SYNDROME: A NARRATIVE REVIEW OF DIETARY PATTERNS, TARGETED SUPPLEMENTATION, AND THE DIET–MICROBIOTA–METABOLISM AXIS

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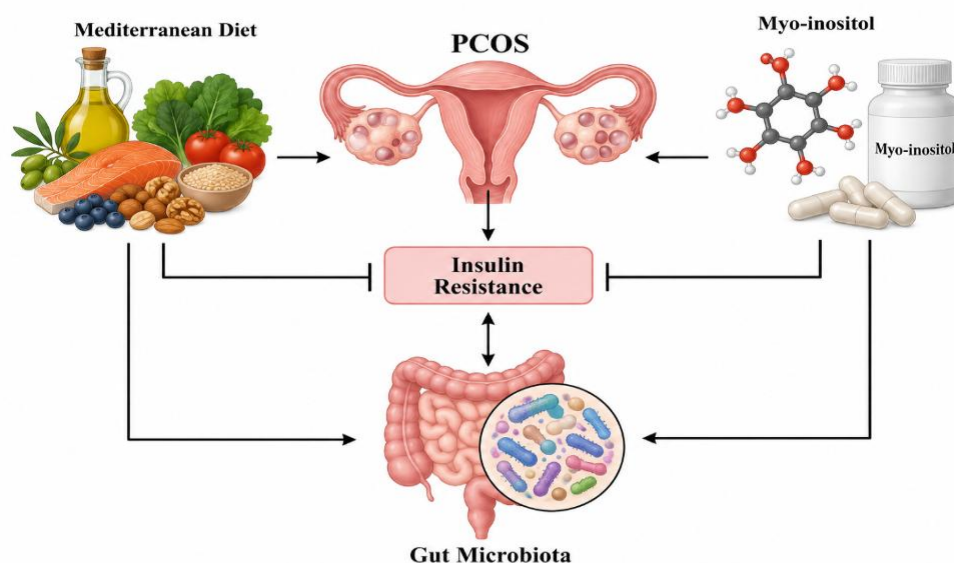
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ABSTRACT

Polycystic ovary syndrome (PCOS) is a heterogeneous endocrine–metabolic disorder characterized by insulin resistance, dyslipidaemia, and an increased long-term cardiometabolic risk. This is a narrative review of evidence regarding diet, dietary supplements and diet-gut microbiota-metabolism in PCOS. Qualitative synthesis of evidence was carried out from clinical trials, systematic reviews, meta-analyses and international guidelines. There is no single dietary composition that is clearly superior, but more sustainable individual dietary approaches may offer benefits for insulin sensitivity and metabolic health. There are reports of benefits for certain outcomes with low-glycaemic-index, Mediterranean, DASH, and low-carbohydrate diets. For those with overweight or obesity, energy restriction and hasty weight loss may be beneficial, but lifestyle interventions can have health benefits without weight loss. Myo-inositol and omega-3 fatty acids may provide metabolic benefits, and the use of vitamin D supplementation may apply to those who are deficient. The effect of probiotics, prebiotics and synbiotics on metabolic markers has been found to be inconsistent. Association of diet with PCOS related metabolic dysfunctions could be linked to gut microbial composition, short chain fatty acids, intestinal barrier function, inflammation and bile acid signalling, but there is limited evidence for causality. Nutrient management should focus on diet quality, diet adequacy, diet sustainability and personal dietary requirements. Additional long-term, well-designed studies are needed to better understand efficacy and mechanisms of interventions.

KEYWORDS: polycystic ovary syndrome; insulin resistance; dietary pattern; myo-inositol; omega-3 fatty acids; gut microbiota; metabolic syndrome



Graphical Abstract

1. INTRODUCTION

The prevalence of PCOS is the highest among women of reproductive age, ranging from 11-13% based on the applied diagnostic criteria globally (Stener-Victorin et al., 2024). Diagnosis in adults is done based on the International Evidence-based Guideline for the diagnosis of PCOS and is supported by three or more of the following findings: clinical

hyperandrogenism, ovulatory dysfunction, and/or polycystic ovarian morphology and/or elevated anti-Müllerian hormone (AMH) (Teede et al., 2023). The syndrome is classically described with regard to its reproductive implications, but modern evidence places the syndrome as an endocrine–metabolic disorder that lasts throughout a person's life, with insulin resistance and its subsequent hyperinsulinaemia being key pathophysiological mechanisms that underlie both male androgen excess and adverse metabolic effects (Stener-Victorin et al., 2024).

Insulin resistance is found in the majority of women with PCOS and is seen outside of the BMI range, so lean women with PCOS may also have impaired insulin signalling (Barber et al., 2019). The metabolic susceptibility of these intrinsic factors results in an increased risk for impaired glucose tolerance, type 2 diabetes, atherogenic dyslipidaemia, metabolic associated steatotic liver disease and the metabolic syndrome (Herbert & Woolf, 2023). Thus, the metabolic dimension of PCOS is not a consequence of the disease but a central feature of PCOS, and one that is susceptible to nutritional triggers. All PCOS phenotypes are recommended to undergo lifestyle modification (including nutrition) as first-line management, and across the entire BMI spectrum (Teede et al., 2023). However, specific dietary patterns, macronutrient distributions and nutraceuticals are beginning to be a growing multitude of conflicting information, and the link between food and metabolic effects has become even more complicated with the recognition of the gut microbiota as a critical member of the gut–body axis in that relationship (Li et al., 2025). This narrative review aims at elucidating the links between diets, dietary targets, targeted dietary supplementation and diet–microbiota–senescence/metabolism axis related to metabolic health, in order to provide the evidence to guide individualized and evidence-based dietary care for PCOS.

2. METHODS

This article is a narrative (non-systematic) review. Structured searches were performed on PubMed, Scopus and Web of Science databases using various combinations of the following terms: “polycystic ovary syndrome,” “insulin resistance,” “dietary pattern,” “Mediterranean diet,” “glycaemic index,” “ketogenic,” “inositol,” “omega-3,” “gut microbiota,” and “metabolic syndrome.” Primary consideration given to randomised controlled trials, systematic reviews, meta-analyses, and authoritative clinical guidelines published predominantly between 2019 and 2025, supplemented by seminal earlier work where appropriate. Studies were chosen and included based on their relevance to the metabolic and nutrition outcome in human populations with PCOS; formal risk-of-bias scoring was not performed consistent with the narrative approach. The synthesis is structured around the metabolic aspects of PCOS, dietary aspects, targeted supplementation, and the gut microbiota.

3. The Metabolic and Nutritional Phenotype of PCOS

Insulin resistance is the hallmark of the metabolic phenotype of PCOS. A significant number of affected women also develop reduced insulin sensitivity which can be present even in non-obese women, but may be exacerbated by excess adiposity (Barber et al., 2019; Moghetti & Tosi, 2021). Hyperinsulinaemia is a compensating mechanism to insulin resistance that can lead to hyperandrogenism and hyposex hormone-binding globulin (SHBG) production in the liver, which increases the availability of free androgens, while at the same time, sub-optimal insulin action is responsible for glucose and lipid metabolic abnormalities (Barber et al., 2019; Stener-Victorin et al., 2024). Most importantly, insulin resistance in PCOS is not a one-size-fits-all issue: insulin resistance in different tissues and different PCOS phenotypes may vary, and genetic and epigenetic factors, hyperandrogenism and obesity all contribute to the severity of IR (Zhao et al., 2023). The mechanisms by which insulin resistance acts as a common centre connecting drivers upstream with reproductive and metabolic outcomes are summarized in figure 1.

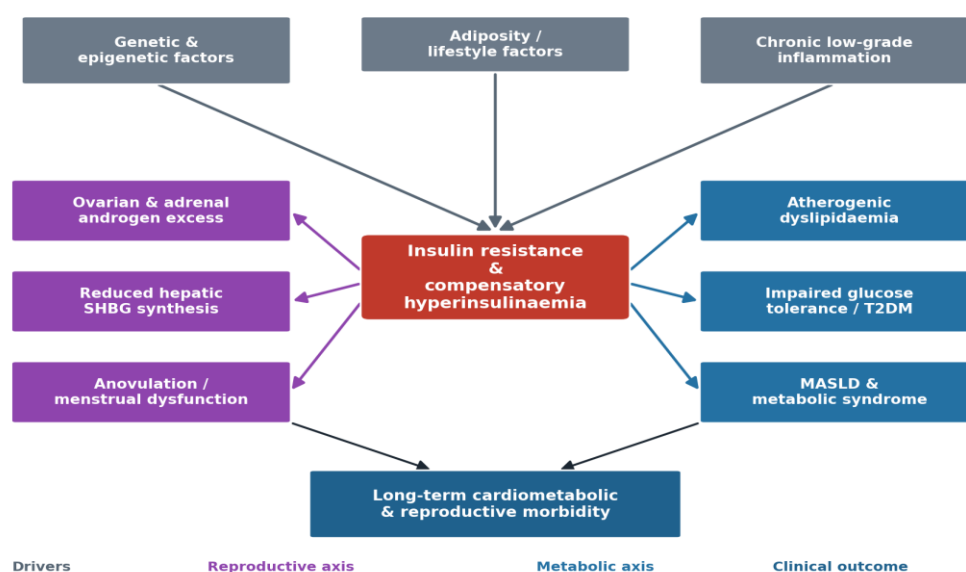


Figure 1. Insulin resistance at the core of PCOS pathophysiology, bridging the genetic, adiposity-related and inflammatory factors with reproductive and metabolic impact. Type 2 diabetes mellitus (T2DM), metabolic-associated steatotic liver disease (MASLD), sex hormone-binding globulin (SHBG).

This metabolic susceptibility is further influenced by adiposity, although not only by the overall amount of fat in the body. Obesity and centrally distributed adipose tissue have been shown to be a risk factor for insulin resistance and metabolic abnormalities, and abnormalities of adipose tissue have been found in women with PCOS who do not have excess adiposity (Bril et al., 2023; Barber et al., 2019). In addition to increased fat mass, qualitative alterations of the function of adipose tissue have been reported, which could contribute to the metabolic phenotype, such as impaired insulin signalling and glucose transport, altered lipolysis, dysregulated secretion of adipokines and cytokines, and low-grade inflammation (Bril et al., 2023). However, insulin resistance can also affect androgen levels and insulin resistance is closely linked to hyperinsulinaemia, which can in turn cause insulin resistance, with adiposity playing a role in this interplay (Moggetti & Tosi, 2021). However, visceral and ectopic fat may be of particular importance; women with PCOS had significant amounts of visceral and epicardial fat, as well as insulin-resistance parameters, LDL cholesterol and triglycerides, and there was a correlation between visceral fat and insulin-resistance and triglyceride levels (Cavalcante et al., 2025). While there is a strong link between adiposity and metabolic dysfunction, it is not limited to women with obesity and metabolic risk in PCOS. In contrast, the International Evidence-based Guideline 2023 suggests that glycaemic check should be carried out on all PCOS-affected women, irrespective of age and BMI, as they are more likely to develop of impaired fasting glucose, impaired glucose tolerance and type 2 diabetes (Teede et al., 2023). Metabolic dysfunction, such as MASLD, can be present in this wider cardiometabolic phenotype, and is associated with insulin resistance and ectopic adiposity (Stener-Victorin et al., 2024; Cavalcante et al., 2025). Even the nutritional properties may vary depending on metabolism. The micronutrient status of women with and without PCOS and metabolic syndrome differed with dietary composition, suggesting that nutritional assessment should go beyond the energy intake to consider food composition in women with PCOS (Zaemzadeh et al., 2021). The main metabolic and nutrition-related characteristics of PCOS are summarised in Table 1.

Table 1. Common metabolic and nutrition-related features of PCOS.

Domain	Typical finding	Clinical note	Representative source
Insulin resistance	Impaired post-receptor insulin signalling; compensatory hyperinsulinaemia	Present in the majority; independent of BMI	Barber et al., 2019; Stener-Victorin et al., 2024
Overweight / central obesity	Higher prevalence and central fat distribution	Aggravates insulin resistance	Barber et al., 2019
Dyslipidaemia	Elevated triglycerides, reduced HDL-C, atherogenic profile	Common cardiometabolic feature	Herbert & Woolf, 2023
Glucose dysregulation	Impaired fasting glucose, impaired glucose tolerance, increased risk of type 2 diabetes	Increased odds versus controls	Stener-Victorin et al., 2024; Teede et al., 2023
Hepatic / MetS	MASLD and metabolic syndrome	Linked to hyperinsulinaemia	Stener-Victorin et al., 2024
Gut microbiota	Reduced diversity; altered Firmicutes:Bacteroidetes	Emerging metabolic mediator	Li et al., 2025
Micronutrient intake	Distinct intake patterns with metabolic syndrome	Diet quality relevant	Zaemzadeh et al., 2021

4. Dietary Patterns and Metabolic Health

Dietary patterns are the most studied non-pharmacological approach in PCOS as there is no more accessible pathophysiological lever than diet. One key part of the 2023 international guideline is that a healthy lifestyle is important at any age and that weight management for many women is beneficial but there is no clear evidence of any particular dietary approach being superior to any other and that adherence and sustainability is as important as composition (Teede et al., 2023; Forslund et al., 2024). The results of a network meta-analysis ranking dietary interventions further confirmed that there are a number of dietary programmes that have measurable effects, and the differences between these interventions are in many cases relatively small (Juhász et al., 2024). Figure 2 illustrates the ways in which the key nutritional strategies exert similar mechanisms and cause similar metabolic effects.

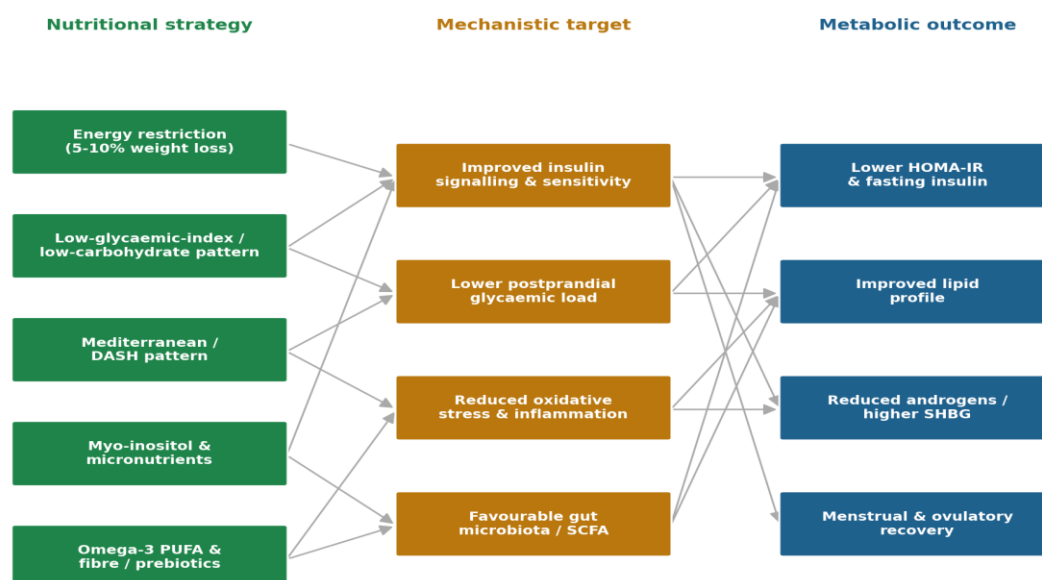


Figure 2. Convergent pathways linking nutritional strategies to mechanistic targets and metabolic outcomes in PCOS. SCFA, short-chain fatty acids; HOMA-IR, homeostatic model assessment of insulin resistance; SHBG, sex hormone-binding globulin; PUFA, polyunsaturated fatty acids.

4.1 Energy restriction and weight management

Moderate weight loss (about 5-10% of body weight) is the most consistent nutritional intervention for women with overweight/obesity and has been shown to improve insulin sensitivity, ovulation, and androgens, regardless of the macronutrient approach to creating the energy deficit (Lim et al., 2019; Teede et al., 2023). Combining lifestyle modifications with dietary changes, physical activity and behavioural support improves anthropometric and metabolic parameters, with weight regain and attrition known as limitations of weight-centred interventions (Lim et al., 2019). Hence, the focus on the new commentaries is increasingly on “moving beyond weight” towards a diet that is more of a cardiometabolic risk reduction for women regardless of their weight status (Herbert & Woolf, 2023). Metabolic and bariatric surgery is an indication for metabolic surgery in the context of severe obesity in the presence of PCOS (Eisenberg et al., 2022).

4.2 Low-glycaemic-index and low-carbohydrate patterns

As insulin resistance is a central process, it is logical to focus on reducing glycaemic load. Low-glycaemic-index patterns focus on the foods which are slowly digested or broken down, such as legumes, intact whole grains, nuts, fruit and non-starchy vegetables, and reduce the consumption of refined starches and sugars, which raise blood glucose and insulin levels. An energy-restricted Mediterranean/low-carbohydrate diet resulted in greater reductions in body weight, body mass index, fasting insulin, and insulin resistance indices than an energy-restricted low-fat diet in overweight women with PCOS, and resulted in favourable changes in reproductive endocrine measures in a 12-week randomised controlled trial (Mei et al., 2022). Carbohydrate modified and combined approaches are also among the more effective dietary strategies for metabolic endpoints, as determined by network meta-analytic ranking (Juhász et al., 2024).

4.3 Mediterranean and DASH patterns

Besides glycaemic control, the Mediterranean dietary pattern which is rich in vegetables, fruit, whole grains, legumes, fish, monounsaturated and polyunsaturated fats and low in processed foods, focuses on the inflammatory and oxidative part of PCOS. A recent review concludes that plant-focused anti-inflammatory diets (e.g. Mediterranean-style eating) are linked to better insulin sensitivity and healthier blood lipid levels in women with PCOS (Xenou & Gourounti, 2021). The positive effect that has been noted with the use of the Mediterranean pattern and carbohydrate restriction indicates that the pattern's influence is not limited to any single macronutrient but that the pattern is representative of the overall quality of diet (Mei et al., 2022). The Dietary Approaches to Stop Hypertension (DASH) pattern, which has a similar focus on whole foods and reduced sodium and refined sugar intake, is often considered a guideline-consistent pattern (Teede et al., 2023).

4.4 Ketogenic, high-protein, and time-restricted approaches

Some short-term metabolic and weight loss benefits of very-low carbohydrate ketogenic and higher-protein diets are of interests and several of these are included on the ranking analyses of effective diets for specific endpoints (Juhász et al., 2024). The guideline's message, however, is tempered by the fact that none of the restrictive patterns is clearly superior and sustainability is key, and that the long-term safety and adherence of the patterns to use in women of reproductive age is not yet fully known (Teede et al., 2023). Another frontier is chrononutrition and time-restricted eating, which involves eating at the right time of day, as this could also affect insulin sensitivity and the gut microbiota, but there is evolving trial evidence that supports this for PCOS specifically (Li et al., 2025). Table 2 shows the main dietary patterns and their perceived metabolic effects.

Table 2. Dietary patterns evaluated in PCOS and their reported metabolic effects.

Dietary pattern	Core principles	Reported metabolic effects	Evidence note
Energy-restricted (any composition)	5–10% weight loss via caloric deficit	Lower weight, improved insulin sensitivity, ovulatory recovery	Guideline foundation (Teede et al., 2023; Lim et al., 2019)
Low-GI / low-carbohydrate	Slow-release carbohydrates; reduced glycaemic load	Lower fasting insulin and HOMA-IR; improved lipids	Mei et al., 2022; Juhász et al., 2024
Mediterranean / DASH	Whole foods, healthy fats, fibre, minimal processing	Reduced inflammation; improved lipids and insulin sensitivity	Xenou & Gourounti, 2021; Mei et al., 2022
Ketogenic / high-protein	Marked carbohydrate restriction; higher protein	Short-term weight and glycaemic benefit; mixed data	Juhász et al., 2024
Time-restricted eating	Intake aligned to circadian window	Emerging insulin and microbiota effects	Li et al., 2025
Overall guideline stance	Adherence-focused, individualised pattern	No single superior diet established	Teede et al., 2023; Forslund et al., 2024

5. Targeted Nutritional Supplementation

Nutraceuticals are also commonly used to supplement diet modification in PCOS and a large meta-analysis, umbrella analysis, of 46 RCTs including over 30,000 participants has helped delineate those agents with the most consistent metabolic signal (Wang et al., 2025). Myo-inositol and omega-3 polyunsaturated fatty acids are most promising, and several others among the heterogeneous data show promise.

5.1 Inositols

Myo-inositol (alone or with D-chiro-inositol) is a well-established insulin-sensitizing supplement in PCOS. Multiple trials and meta-analyses report that inositol significantly improves insulin resistance (i.e. a standardised mean difference (SMD) of around -0.81) and a significant increase in SHBG, which supports a role for improved insulin signalling and less exposure to free androgen (Wang et al., 2025). To solve the problem of variable bioavailability (Kamenov et al., 2023), combination formulations with myo-inositol (M), α -lactalbumin (AL) to enhance absorption have been investigated. Importantly, the 2023 guideline takes a measured approach, concluding inositol has a limited clinical benefit, and that metformin has greater activity for metabolic features, so inositol should be considered an option that is part of shared decision making, not a formal therapy (Teede et al., 2023).

5.2 Omega-3 polyunsaturated fatty acids

The anti-inflammatory effect and lipid-modulating activities of omega-3 (n-3) polyunsaturated fatty acids (PUFAs) are relevant to the PCOS metabolic phenotype (Salek et al., 2019). Mechanistic and clinical studies suggest benefits of n-3 supplementation on improving metabolic dysfunction (Albardan et al., 2024). The n-3 supplement group demonstrated a significantly higher levels of adiponectin and HDL-cholesterol, and a significant reduction in fasting blood glucose and BMI compared with placebo in the umbrella synthesis (Wang et al. 2025) (Figure 3).

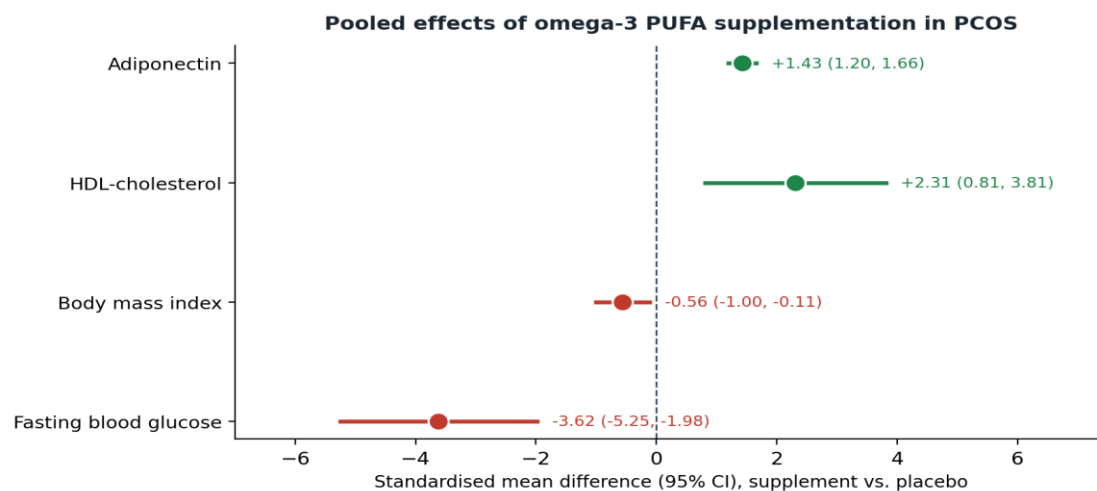


Figure 3. Pooled standardised mean difference for omega-3 PUFAs supplementation compared to placebo for selected metabolic markers in PCOS. The adiponectin and HDL-cholesterol levels are positive and the body mass index and fasting blood glucose levels are negative, reflecting a metabolic benefit. Data from Wang et al. (2025).

5.3 The combined micronutrients, probiotics, and vitamin D

Other agents have adjunctive potential, in addition to inositol and n-3 fatty acids. Vitamin D correction may positively change insulin and lipid markers; there is however limited evidence – most likely in women with vitamin D deficiency (Wang et al., 2025). Probiotic and synbiotic interventions have produced favourable changes in certain metabolic and inflammatory indicators, highlighting the contribution of gut microbial communities. (Wang et al., 2025; Senthilkumar & Arumugam, 2025). However, standardised multi-micronutrient supplementation has shown to improve PCOS typical parameters in a randomized trial, highlighting the importance of considering micronutrient adequacy as a whole instead of solely focusing on one nutrient (Hager et al., 2019). Heterogeneity in dose, formulation, bioavailability and metabolic phenotype across agents makes it difficult to draw definite conclusions, and supplements should not take the place of dietary quality (Wang et al., 2025). The main supplements and their reported effects are summarized in Table 3.

Table 3. Selected nutritional supplements and their reported metabolic effects in PCOS.

Supplement	Reported metabolic effect	Strength of evidence	Representative source
Myo-inositol ($\pm$ D-chiro-inositol)	Improved insulin sensitivity (HOMA-IR SMD ≈ -0.81); higher SHBG	Multiple RCTs; guideline rates clinical benefit as limited	Wang et al., 2025; Kamenov et al., 2023; Teede et al., 2023
Omega-3 PUFA	Lower fasting glucose and BMI; higher adiponectin and HDL-C	Meta-analytic support	Albardan et al., 2024; Salek et al., 2019; Wang et al., 2025
Vitamin D (if deficient)	Possible improvement in insulin and lipid markers	Mixed; correct deficiency	Wang et al., 2025
Probiotics / synbiotics	Modest metabolic and inflammatory improvement	Emerging	Wang et al., 2025; Senthilkumar & Arumugam, 2025
Combined micronutrients	Improvement in PCOS-typical parameters	Randomised trial evidence	Hager et al., 2019

6. The Diet–Microbiota–Metabolism Axis

In a systematic review with GRADE assessment in 2025, both alpha- and beta-diversity were found to be highly heterogeneous across studies; the changes in microbial diversity were reported as increased, decreased or unchanged depending on the population and analytical approach (Kaur et al., 2025). Another systematic review also found a significant diversity in the microbial communities found in the studies, and this was attributed to variations in BMI, ethnicity, study methodology, and other factors that could affect the observed associations (Sola-Leyva et al., 2023; Hanna et al., 2025). Huang et al. (2024) noted increased alpha diversity in women with PCOS in both faecal and salivary samples and differences in microbial taxa and in some functional pathways, suggesting that decreased diversity is not a universal phenomenon in PCOS. However, a loss of diversity or certain taxonomic ratio should not be considered a microbiological signature of the PCOS syndrome as this has been reported numerous times (Kaur et al., 2025; Sola-Leyva et al., 2023). Importantly, recent evidence has shown that overall microbial function could be more informative than overall diversity. Li et al. (2026) used a combination of re-analysis of microbial communities through 16S rRNA gene sequencing and shotgun metagenomic approaches, alongside untargeted metabolite profiling of feces. With the inclusion of publicly available datasets and 24 normal weight women diagnosed with PCOS and 12 control participants without PCOS, no statistically significant differences between alpha- or beta-diversity were found in the 16S analysis, while some taxa showed higher or lower abundance in women with PCOS compared to the controls. Functional changes were revealed especially in the pathways associated with lipid metabolism and secondary bile-acid metabolism in a selected subset of six women with PCOS and four controls who were normal weight. Similarly, the ruminococcins and Roseburia were associated with HOMA-IR and HDL levels in the PCOS group (Li et al., 2026). The use of taxonomic diversity alone may not be adequate to describe microbiome-related metabolic changes in PCOS; these results provide further evidence of the need to use multiple omics.

The intestinal microbial community is a functional link to host physiology via microbial metabolites. Acetate, propionate, and butyrate, collectively known as short-chain fatty acids (SCFAs), are generated through gut microbial fermentation of dietary substrates and have been investigated for their associations with intestinal barrier function, immune regulation, and metabolic signalling in PCOS (Senthilkumar & Arumugam, 2025; Qin et al., 2025). Human evidence shows that these metabolites have direct connection to dietary exposure, as da Silva et al. (2024) compared women with PCOS and controls, and examined gut microbiota, microbial metabolites and dietary intake. Within PCOS, the study found that dietary glycaemic load was related to gut microbial composition whereas dietary variables were related to microbial metabolites (da Silva et al., 2024) within the PCOS group. These results indicates that there is a relationship between dietary exposure and microbial-metabolite environment in PCOS; however, the cross-sectional study does not prove that diet-induced changes in the microbes cause metabolic dysfunction.

In addition to alterations in the composition of the microbial community, dietary changes can alter the intestinal environment, affecting both intestinal barrier function and inflammatory/metabolic signalling by microbial products. While SCFAs promote barrier integrity and immune and metabolic signalling, rises in bacterial exposure to the intestine through lipopolysaccharide (LPS) can trigger the activation of Toll-like receptor 4 (TLR4)-dependent inflammatory pathways such as nuclear factor- κ B signalling (Senthilkumar & Arumugam, 2025; Qin et al., 2025). Therefore, it has been suggested that enhanced intestinal permeability and the transcellular movement of microbial products could be one of the mechanisms involved in the relationship between altered microbial activity and chronic low-grade inflammation and insulin resistance in PCOS (Senthilkumar & Arumugam, 2025; Qin et al., 2025). While these pathways offer plausible connections between dietary exposures, the activity of intestinal microbes, barrier function, inflammation, and insulin resistance, it is unclear to what degree each pathway is associated to the clinical phenotype of PCOS (Kieffer et al., 2019; Senthilkumar & Arumugam, 2025; Qin et al., 2025). The proposed diet–microbiota–metabolism axis in PCOS is shown in figure 4.

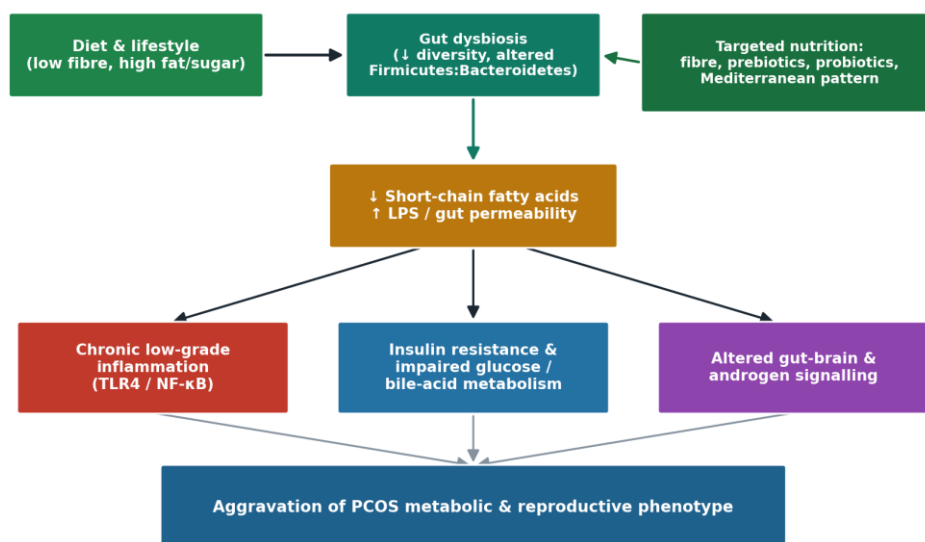


Figure 4. The diet–microbiota–metabolism axis in PCOS. Dietary patterns can influence gut microbial composition and function, with microbial metabolites and alterations in intestinal barrier function potentially contributing to inflammatory and metabolic signalling through pathways involving short-chain fatty acids (SCFAs), lipopolysaccharide (LPS), and Toll-like receptor 4 (TLR4). Fibre-rich, prebiotic, probiotic, and Mediterranean-style dietary approaches may modulate this axis and potentially support metabolic health. LPS, lipopolysaccharide; SCFA, short-chain fatty acids; TLR4, Toll-like receptor 4.

A second, mechanistically different interface between the microbiota and host metabolism is bile acid metabolism. The intestinal microorganisms convert primary bile acids (made by the liver) into secondary bile acids, and these bile acids can also act as signalling molecules by binding to receptors such as farnesoid X receptor (FXR) and Takeda G-protein-coupled bile-acid receptor 1 (TGR5), which can affect metabolic and immune responses (Qian et al., 2026; Qin et al., 2025). There is experimental evidence for this pathway in PCOS: PCOS women had higher levels of *Bacteroides vulgatus* and lower levels of glycodeoxycholic acid and tauroursodeoxycholic acid, with the experimental models showing that *B. vulgatus* and the changes in bile acids correlated with disrupted interleukin-22 signalling, insulin resistance and ovarian dysfunction (Qi et al. 2019). Similarly, recent human multi-omic studies by Li et al. (2026) also identified changes in pathways involved in secondary bile-acid metabolism among normal-weight PCOS. These findings offer a plausible mechanistic basis for microbiota–bile-acid interactions in PCOS, but, due to the experimental nature of some of the evidence and the limited number of human multi-omic samples, these pathways should not yet be regarded as viable therapeutic targets. On this axis, diet plays a special role since it provides the substrates that can be metabolised by intestinal microorganisms. Dietary fibre and other fermentable substrates can promote the production of SCFAs by microbes and other dietary patterns might shape the microbial composition and function (Senthilkumar & Arumugam, 2025; Qin et al., 2025). There are limited direct evidence for PCOS, but a study by da Silva et al. (2024) showed that the glycaemic load of diet was associated with dysbiosis in the gut of women with PCOS. An increasing number of studies also show that dietary pattern has the potential to influence the gut microbial ecosystem in the general population. In a systematic review of 37 observational and interventional studies, the microbial diversity and composition were found to change with adherence to the Mediterranean diet, with *Faecalibacterium* and *Prevotella* genera being common genera reported to increase (Khavandegar et al., 2024). However, the majority of these studies were carried out in healthy or metabolically altered individuals, thus findings may be expected to be applicable to healthy individuals but not necessarily to women with PCOS (Khavandegar et al., 2024). The distinction is significant, as microbial response to dietary patterns is heterogeneous and could vary depending on other factors such as host characteristics, baseline diet, metabolic phenotype, and the existing microbial community (Hanna et al., 2025; Qin et al., 2025). Therefore, dietary manipulation

could be a dietary intervention in the diet–microbiota–metabolism axis and the specific microbiota modifications associated with clinical benefit in PCOS has yet to be identified.

The possibility of modifying this axis therapeutically has led to increasing interest in probiotics. Therapeutic modulation of this axis has garnered growing interest in probiotics, prebiotics and synbiotics. Eleven studies were found in a systematic review of randomized clinical trials that examined these interventions in women with PCOS, suggesting improvements in insulin resistance and certain hormonal and metabolic parameters (Guevara et al., 2024). However, this was only with studies undertaken in Iran and majority of the studies included were overweight or obese study participants, making the results less generalizable (Guevara et al., 2024). In a second systematic review and meta-analysis of 20 RCTs with 1271 women with PCOS, prebiotics/synbiotics were found to have a variable effect on several cardiometabolic outcomes, with the body mass index and diastolic blood pressure showing significant improvement, while evidence for some of the other outcomes was very low or low quality (Razmpoosh et al., 2025). Based on these results, a possible metabolic effect of microbiota-based nutritional strategies is suggested, but probiotics, prebiotics and synbiotics cannot be used as standard treatment for PCOS targeting the microbiome.

In conclusion, the available data suggest that the gut microbiota may be a mediator in the link between diet and metabolic parameters in PCOS, but not a single, stand-alone abnormality. Microbiological functions and metabolites, such as SCFAs, LPS-linked inflammatory pathways, and bile-acid pathways, are increasingly the most informative evidence, alongside taxonomic composition (Li et al., 2026; da Silva et al., 2024; Qin et al., 2025). However, there is significant variation in microbial data (Kaur et al., 2025; Hanna et al., 2025) due to differences in the people studied and the methods used, lack of longitudinal data and the small sample size of some multi-omic studies, which make it difficult to draw firm conclusions about causation or the microbial features that should be targeted clinically. Future studies in PCOS and nutrition should, therefore, be more targeted and aim to uncover specific dietary exposures that can consistently alter specific microbial functions and metabolites that associate with clinically relevant metabolic outcomes.

7. Clinical Translation and Individualised Nutrition

The take-home message from the existing evidence is that nutritional care in PCOS should be personalised, metabolically guided, and focused on long-term maintenance. It is crucial to remember that the dietary goals outlined in this guideline are based on evidence derived from the general population and should be adapted to personal preferences, needs and circumstances but not a specific dietary composition across PCOS phenotypes or weight categories (Teede et al., 2023). The guideline also highlights that positive changes in a healthy lifestyle can be seen without losing weight, and that weight-centred care should not include weight stigma or overemphasis on body weight only (Teede et al., 2023; Herbert & Woolf, 2023).

In this context, clinicians are able to assist patients to choose a sustainable eating pattern based on their dietary preferences, culture, metabolic requirements, co-morbidities and adherence potential. There was no evidence that one dietary composition was better than another for anthropometric, metabolic, hormonal, reproductive or psychological outcomes in the 2023 guideline, and Juhász et al. (2024) showed that different dietary interventions have different effects on individual metabolic outcomes, but not a consistent pattern. In 2025, a review of 21 randomized controlled trials (RCTs) emphasized the need to consider the distinction of dietary composition from energy restriction, as results from dietary patterns differed depending on whether they were calorie-restricted or isocaloric (Choi et al., 2025). In 2026, a larger systematic review of 38 trials of all types of dietary interventions (low-glycaemic, ketogenic, intermittent-fasting, DASH, Mediterranean-style, etc.) showed positive results for body weight, body mass index, waist circumference and various metabolic, hormonal, and menstrual parameters across all diets, while lipid, inflammatory, and oxidative-stress parameters yielded less consistent findings (Akbaş et al., 2026).

Personalized nutrition strategies, however, may still be helpful for some patients. A study in overweight women with PCOS showed that the low-carbohydrate Mediterranean-style dietary pattern compared to the low fat comparison diet yielded significantly better results in various anthropometric, hormonal, insulin-resistance and lipid parameters (Mei et al., 2022). This finding supports the use of specific dietary patterns when clinically appropriate, but the study population and intervention design do not establish this combination as a universally superior PCOS diet. Therefore, dietary choices should be flexible and not restricted to a favoured dietary model.

Individualisation also applies to the delivery of dietary advice. A clinical decision support system (CDSS) was used to provide personalized Mediterranean diet (MD) plans to adolescent girls with PCOS, which showed greater adherence to the MD diet than general diet advice over a 3-month period (Foscolou et al., 2024). A mixed-method systematic review of 68 studies also identified inadequate healthcare-professional education, weight-focused care, and inadequate individualised advice as barriers to lifestyle management, and multidisciplinary care with the inclusion of dietitians and PCOS specific individualised lifestyle advice as facilitators (McGowan et al., 2025). These results provide support for a clinical process of dietary counselling tailored to the person's objectives, context, and ability to execute change on a long-term basis, instead of solely on theoretical dietary pattern effectiveness.

Dietary and lifestyle foundations are also the most effective method, and targeted supplementation should be available as an addition to these. A meta-analysis of 46 randomized trials with 30,133 subjects suggested that some nutraceuticals may be beneficial in PCOS, such as myo-inositol for insulin sensitivity, omega-3 fatty acids for lipid parameters and probiotics for inflammatory outcomes, but notable heterogeneity was identified in terms of the supplementation protocols and patient characteristics (Wang et al., 2025). Myo-inositol is still one of the most studied nutritional supplements, but the effect of these should not be exaggerated. The systematic review and meta-analysis informing the 2023 international guideline found possible benefits for selected metabolic outcomes, while evidence for broader clinical outcomes remained inconsistent (Fitz et al., 2024). It is therefore recommended that inositol be used at the individual's preference and value,

and that its clinical benefits (such as ovulation, hirsutism, and weight) are limited, and there are no currently recommended formulations, doses, or combinations (Teede et al., 2023; Fitz et al., 2024).

Evidence of vitamin D supplementation is another example of the need to interpret the evidence in relation to clinical context. There was an umbrella systematic review and meta-analysis of 15 meta-analyses of randomized trials that showed that supplementation with vitamin D was associated with a decrease in triglycerides, total cholesterol, LDL cholesterol, total testosterone, and DHEA; however, HDL cholesterol, insulin, and BMI did not significantly improve (Yin et al., 2024). The results suggest possible metabolic and hormonal effects and do not mean that vitamin D should be routinely used in the treatment of PCOS; vitamin D supplementation should be used based on nutritional status and clinical indication, not just the diagnosis of PCOS. An additional layer of nutritional advice is added when considering fibre and microbiota promoting dietary components. Some microbial metabolites and microbial associated inflammatory pathways have been demonstrated to be involved in metabolic and inflammatory pathways associated with PCOS such as short chain fatty acids and lipopolysaccharide related signaling (Senthilkumar & Arumugam, 2025). Probiotics, prebiotics and synbiotics have also been found to have beneficial effects on a range of metabolic and hormonal parameters, with findings variably reported. This systematic review of randomized trials showed that such interventions could have potential benefits on insulin resistance and certain metabolic outcomes, whereas the subsequent meta-analysis indicated potential improvements in multiple cardiometabolic parameters with prebiotic or synbiotic interventions, with varying levels of certainty (Guevara et al., 2024; Razmpoosh et al., 2025). Based on these findings, more research is needed before microbiota based nutritional interventions can be routinely recommended as a microbiome-targeted treatment.

In summary, clinical nutrition in PCOS can be considered as an adaptive, chronic approach that prioritizes diet quality, metabolic and clinical features, nutritional sufficiency, personal preferences, cultural factors, and practical compliance. There is no evidence at this time to suggest any one restrictive “PCOS diet” or reliance on supplements. Rather, nutritional management should be tailored to an individual's dietary pattern that is not necessarily “sustainable” but may involve targeted dietary changes, and adjunctive supplementation, where clinically appropriate, should be considered, along with the recognition of the heterogeneity of PCOS and the wide variation in certainty of evidence for specific interventions (Teede et al., 2023; Juhász et al., 2024; Akbaş et al., 2026).

8. Limitations and Future Directions

Several limitations constrain current conclusions. Many dietary and supplement trials are short, modestly sized, and heterogeneous in population, phenotype, dose, duration, and outcome definition, which complicates pooling and limits generalisability (Wang et al., 2025; Juhász et al., 2024). Much of the current mechanistic evidence regarding the gut microbiota comes from observational human studies and experimental models, limiting causal inference and leaving longitudinal human evidence comparatively scarce (Li et al., 2025). Although comparative trials have evaluated different dietary compositions, the available evidence has not established a consistently superior dietary approach, partly because studies vary in design, population, duration, and outcomes (Teede et al., 2023; Juhász et al., 2024). Future research should prioritise adequately powered, longer-term randomised trials comparing dietary patterns with standardised metabolic outcomes; integration of multi-omics and microbiome profiling to support the development of nutrigenomic and precision-nutrition approaches; and pragmatic studies that assess adherence and quality of life alongside biochemical outcomes (Wang et al., 2025; Senthilkumar & Arumugam, 2025). This narrative review is itself limited by its non-systematic methodology and selective synthesis.

9. CONCLUSION

PCOS is a heterogeneous endocrine–metabolic disorder in which insulin resistance contributes to a broad range of metabolic outcomes. A sustainable, high-quality dietary pattern, with modest weight loss where appropriate, remains the most consistently supported nutritional approach rather than any single prescriptive diet. Low-glycaemic-index, Mediterranean, DASH, and combined low-carbohydrate dietary approaches have each shown benefits for selected metabolic outcomes, but no single dietary composition has demonstrated consistent superiority. Myo-inositol and omega-3 fatty acids are among the more extensively studied nutritional adjuncts, although their effects remain modest and heterogeneous. The gut microbiota is emerging as a potentially important and diet-responsive mediator of metabolic health in PCOS, although causal relationships remain incompletely established. Overall, individualised nutrition that prioritises dietary quality, adherence, and metabolic risk reduction offers the most evidence-based approach to improving metabolic health among women with PCOS.

10. DECLARATIONS

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Data availability: No new data were created or analysed during this study, so data sharing is not applicable.

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Note on figures: The figures are original schematics prepared for this manuscript. The quantitative values presented in Figure 2 are illustrative syntheses of the cited literature and are not derived from a single primary dataset.

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