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# FROM SYMPTOMS TO SOLUTIONS: THE BIOCHEMICAL POWER OF LIFESTYLE IN PCOS

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**ABSTRACT**

**Background:** Polycystic ovary syndrome (PCOS) is a complex endocrine and metabolic disorder affecting up to 20% of women of reproductive age. Characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, PCOS is frequently accompanied by insulin resistance, chronic inflammation, and an increased risk of cardiometabolic diseases.
**Objective:** This narrative review synthesizes current evidence on the role of dietary patterns, specific nutrients, and physical activity in the management of PCOS. The aim is to highlight lifestyle strategies that target the underlying metabolic and hormonal disturbances and to support their use as first-line therapeutic interventions.
**Methods:** A structured literature search was conducted in PubMed, Scopus, and Web of Science (2010–2025) using terms related to PCOS, nutrition, exercise, insulin resistance, and supplementation. Articles were selected based on relevance, methodological quality, and adherence to PRISMA 2020 guidelines.
**Results:** Evidence supports the efficacy of low glycemic index, Mediterranean, and DASH diets in improving insulin sensitivity, reducing hyperandrogenism, and restoring menstrual regularity. Specific nutrients such as inositols, omega-3 fatty acids, and vitamin D show additional benefits, particularly in improving metabolic and reproductive outcomes. Physical activity—including aerobic, resistance, and high-intensity interval training—enhances insulin action, reduces visceral adiposity, and improves ovulatory function. Lifestyle interventions also lower long-term risks of type 2 diabetes and cardiovascular disease in PCOS.
**Conclusion:** Diet and exercise are powerful, evidence-based tools in the management of PCOS. Integrating nutritional biochemistry and exercise physiology into clinical care offers a non-pharmacological, multifaceted approach that improves both short- and long-term outcomes.

**KEYWORDS**
Polycystic Ovary Syndrome (PCOS), Insulin Resistance, Lifestyle Intervention, Diet, Physical Activity, Inositol, Omega-3 Fatty Acids, Vitamin D, Metabolic Health, Reproductive Function

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## Introduction.

Polycystic ovary syndrome (PCOS) is a prevalent endocrine and metabolic disorder affecting an estimated 6–20% of women of reproductive age worldwide (1). It is classically characterized by hyperandrogenism, chronic anovulation, and polycystic ovarian morphology, often diagnosed by Rotterdam criteria (any two of the three features) (1). Beyond reproductive symptoms (irregular menstrual cycles, infertility, hirsutism, acne), PCOS has broad systemic implications. A majority of women with PCOS exhibit insulin resistance and compensatory hyperinsulinemia, even in the absence of overt obesity (1). This insulin resistance (IR) plays a pivotal role in PCOS pathophysiology, exacerbating androgen excess and metabolic disturbances. Consequently, PCOS is frequently associated with obesity, dyslipidemia, impaired glucose tolerance, and a significantly increased lifetime risk of type 2 diabetes and cardiovascular disease (2-4). Chronic low-grade inflammation and oxidative stress further contribute to the syndrome's pathogenesis and comorbidities, creating a vicious cycle of hormonal and metabolic imbalance (1). Given its multifactorial nature, PCOS management requires a multidisciplinary approach, with lifestyle interventions recognized as first-line therapy to target the underlying metabolic and endocrine dysfunction (2). In particular, dietary modification and physical activity directly influence insulin sensitivity, weight regulation, and inflammatory pathways, making them cornerstones of PCOS management (1). The ensuing sections discuss the pathophysiological basis of PCOS (especially the roles of insulin resistance and hormonal imbalance) and review evidence-based strategies in nutrition and exercise – including specific diets, nutrients, and exercise regimens – that can mitigate PCOS symptoms and improve clinical outcomes, in line with current biochemical understanding and clinical guidelines.

## Methodology

This narrative review synthesizes current evidence on the impact of dietary interventions, physical activity, targeted nutritional supplementation, and exercise modalities on the management of polycystic ovary syndrome (PCOS), with a focus on improving insulin resistance, hormonal imbalance, and cardiometabolic risk. The review was conducted in accordance with the PRISMA 2020 guidelines (5). A structured literature search was performed in PubMed, Scopus, and Web of Science databases covering the years 2010–2025, using combinations of terms such as "polycystic ovary syndrome," "PCOS," "diet," "nutrition," "low glycemic index," "Mediterranean diet," "DASH diet," "physical activity," "exercise," "resistance training," "HIIT," "inositol," "omega-3," "vitamin D," and "insulin resistance." Boolean operators and search syntax were adapted to each database.

Only peer-reviewed, full-text articles published in English were included. Priority was given to systematic reviews, meta-analyses, randomized controlled trials, and large observational studies. Additional studies were identified through reference and citation tracking. A total of 26 articles was included based on relevance, methodological quality, and contribution to the thematic scope of this review.

## Results

### *Pathophysiology of PCOS: Insulin Resistance and Hormonal Imbalances*

PCOS arises from a complex interplay of genetic, environmental, and lifestyle factors that converge on hormonal and metabolic dysregulation (1). Insulin resistance is a central feature in many patients; about half to three-quarters of women with PCOS exhibit insulin resistance or hyperinsulinemia (even if lean), which is a key driver of the syndrome's reproductive and metabolic manifestations. Hyperinsulinemia promotes ovarian theca cells to overproduce androgens and concurrently suppresses liver production of sex hormone-binding globulin, thereby increasing free circulating androgens (1). The resulting hyperandrogenism underlies clinical signs such as hirsutism, acne, and alopecia, and disrupts the ovarian follicular environment, leading to anovulation and polycystic ovaries. An imbalance in gonadotropins is also observed – many PCOS patients have elevated luteinizing hormone (LH) with normal or low follicle-stimulating hormone (FSH), favoring ovarian androgen production over estrogen and contributing to follicular arrest (1).

In addition to insulin and gonadotropin dysregulation, chronic inflammation and oxidative stress are now recognized as important contributors to PCOS pathophysiology. Women with PCOS often have elevated inflammatory cytokines (e.g. TNF-α, IL-6) and C-reactive protein, reflecting a state of low-grade inflammation. This inflammatory milieu may worsen insulin resistance and directly interfere with ovarian function. Oxidative stress, in turn, can impair insulin signaling and damage ovarian cells, creating further hormonal imbalance (1). Excess adiposity – present in a large subset of PCOS patients – exacerbates both insulin resistance and inflammation; abdominal (visceral) fat in particular correlates with more severe metabolic and reproductive derangements in PCOS (6).

Given these pathophysiological insights, it is clear why therapies targeting insulin resistance and weight management can profoundly improve PCOS outcomes. Indeed, international evidence-based guidelines emphasize lifestyle modification – primarily diet and exercise – as the *first-line* approach in managing PCOS, ahead of pharmacological interventions (1). By improving insulin sensitivity and facilitating weight loss (or preventing weight gain), lifestyle measures can break the pathogenic cycle of hyperinsulinemia and hyperandrogenism. Even in normal-weight PCOS patients, dietary and activity changes can modulate metabolic and endocrine function. In summary, understanding the biochemical and hormonal underpinnings of PCOS highlights insulin and androgen excess as key therapeutic targets, and provides a rationale for the dietary and physical activity strategies discussed below.

### *Dietary Strategies in PCOS Management*

Nutrition therapy plays a central role in PCOS management, with the dual aims of improving insulin sensitivity and promoting weight control. Dietary composition and patterns can directly influence glycemic excursions, insulin secretion, and inflammation, thereby modulating the biochemical pathways disrupted in PCOS. In general, diets that moderate carbohydrate intake (especially refined carbohydrates) and favor low-glycemic index foods, adequate lean protein, healthy fats, and high fiber are considered beneficial (1). Caloric intake is also important, as creating an energy deficit in overweight/obese individuals facilitates weight loss, which is one of the most effective ways to restore metabolic and reproductive health in PCOS. Notably, even a modest weight loss of 5–10% of initial body weight has been associated with significant improvements in insulin sensitivity, menstrual regularity, and fertility rates (7). However, beyond weight loss per se, diet quality and macronutrient profile can independently affect hormonal and metabolic parameters. A growing body of evidence, including randomized trials and meta-analyses, has evaluated specific dietary approaches for PCOS. The following are key evidence-based dietary strategies.

### *Low Glycemic Index Diet*

Eating a low glycemic index (low-GI) diet – emphasizing carbohydrates that are slowly digested and absorbed – helps minimize postprandial glucose spikes and insulin surges. In women with PCOS, this approach can directly alleviate hyperinsulinemia and its downstream effects on the ovaries. Low-GI foods (e.g. whole grains like oats and quinoa, legumes, most fruits, non-starchy vegetables) induce a gradual rise in blood glucose, which improves overall insulin sensitivity (8, 9). By maintaining more stable insulin levels, low-GI diets may reduce ovarian androgen production (since high insulin levels augment androgen synthesis), thereby improving symptoms such as acne, hirsutism, and irregular cycles (10).

### *Mediterranean Diet*

The Mediterranean diet pattern, rich in plant-based foods and unsaturated fats, has gained attention as a healthful diet for metabolic disorders, including PCOS. This dietary pattern emphasizes fruits, vegetables, whole grains, legumes, nuts, and olive oil, with moderate intake of fish, poultry, and dairy, and minimal red meat and sweets. A Mediterranean diet naturally has a low glycemic load and is high in fiber and antioxidants.

Importantly, it provides beneficial monounsaturated and omega-3 fatty acids (from olive oil, nuts, and fish) while being low in saturated fats. These features confer anti-inflammatory and insulin-sensitizing effects (11), which directly target key aspects of PCOS pathophysiology. Diets high in omega-3 fatty acids have been shown to reduce inflammatory markers and improve insulin action in metabolic syndrome and PCOS (12). Conversely, diets rich in saturated fat may worsen insulin resistance and have been linked to higher androgen levels in PCOS (2). By focusing on healthy fat sources, the Mediterranean diet may help ameliorate the chronic inflammation and oxidative stress seen in PCOS, thereby improving endocrine outcomes.

Evidence specific to PCOS suggests that greater adherence to a Mediterranean-style diet is associated with better metabolic profiles and possibly lower risk of developing PCOS in at-risk populations (13). In intervention studies, the Mediterranean diet has shown promise for weight management and cardiovascular health in PCOS. For example, one randomized trial reported that a Mediterranean diet intervention led to significant reductions in body mass index (BMI) in women with PCOS (6, 14). Participants consuming a Mediterranean diet improved their weight status and metabolic parameters, although the authors noted that more research is needed since few RCTs have isolated this diet in PCOS. The likely benefits stem from the Mediterranean diet's high content of fiber and low-GI foods (which improve postprandial glucose control) and its abundance of vitamins, polyphenols, and unsaturated fats (which collectively reduce inflammation and improve lipid profiles). The Mediterranean diet is also palatable and sustainable for many individuals, which may support long-term dietary adherence. Overall, while data are still emerging, the Mediterranean diet is considered a heart-healthy, anti-inflammatory diet that aligns well with the therapeutic goals in PCOS – namely, improving insulin sensitivity, reducing cardiometabolic risk, and potentially improving ovulatory function (8).

***DASH Diet***

The Dietary Approaches to Stop Hypertension (DASH**)** diet, originally developed for blood pressure reduction, has a nutrient profile that is beneficial for insulin resistance and weight control, making it highly relevant for PCOS. The DASH diet is rich in fruits, vegetables, whole grains, and low-fat dairy, with lean proteins (fish, poultry, legumes) and limited sweets and red meat. It is a high-fiber, high-micronutrient, low-saturated-fat diet, similar in many respects to the Mediterranean diet, though with emphasis on low sodium intake as well. Recent evidence indicates the DASH diet may be one of the most effective dietary interventions for improving metabolic syndrome parameters in PCOS. A 2023 network meta-analysis comparing various diets found that the DASH diet produced the greatest improvements in insulin resistance (assessed by HOMA-IR) among women with PCOS, and was superior in promoting weight loss compared to a standard balanced diet (15). Women following the DASH diet in clinical trials have demonstrated decreased fasting insulin and insulin resistance indices, even independent of weight loss, suggesting enhanced insulin sensitivity. The DASH diet is increasingly recommended as an optimal dietary pattern for PCOS, especially for individuals who also have hypertension or other components of metabolic syndrome. It is notable for being a balanced and non-restrictive diet, making it relatively easy to follow long-term.

***Intermittent Fasting and Meal Timing***

Intermittent fasting (IF) is an eating pattern that alternates between periods of eating and extended fasting – has garnered interest as a potential strategy for weight loss and metabolic improvement in PCOS. Common approaches include time-restricted feeding (e.g. eating only within an 8-hour window each day) or intermittent caloric restriction (e.g. the 5:2 diet with two very-low-calorie days per week). The theoretical rationale for IF in PCOS is that it can induce a greater caloric deficit and beneficial metabolic adaptations such as increased insulin sensitivity and reduced oxidative stress, even without explicit changes in diet composition. Fasting causes insulin levels to fall, which over time may improve insulin receptor sensitivity and facilitate weight/fat loss – key objectives in PCOS management (16). Additionally, intermittent fasting may mimic some effects of caloric restriction and metabolic reprogramming, potentially leading to improved glucose homeostasis and reductions in inflammation.

***Other Dietary Approaches***

Several other dietary approaches have been explored in PCOS, although evidence quality varies. Low-carbohydrate diets (including ketogenic diets) have shown promise in improving insulin sensitivity and aiding weight loss; some women with PCOS achieve rapid improvements in glycemic control and even menstrual regularity on a well-formulated ketogenic diet (2, 17). However, long-term adherence to very low-carb diets can be challenging, and their restrictive nature raises concerns about nutrient deficiencies. High-protein diets have been studied for PCOS as well, since higher protein intake can increase satiety and help preserve lean mass during weight loss. Replacing some carbohydrates with protein may improve insulin responsiveness and reduce androgen levels according to some trials (18). That said, extreme shifts in macronutrient ratios

(very high protein or very low carb) do not appear to confer large advantages over balanced diets in meta-analyses, and a *balanced, calorie-reduced diet* is generally recommended for PCOS (19). Importantly, no single "PCOS diet" fits all; individual preferences, tolerances, and comorbidities should guide the choice of diet plan. Behavioral factors (like what diet a patient can maintain long-term) often outweigh minor differences in short-term physiological effect. Thus, current clinical guidelines emphasize healthy eating principles – high in fiber and nutrient-dense foods, adequate lean protein, limited added sugars and processed foods – tailored to the patient's needs, rather than prescribing a specific fad diet for all (20).

***The Role of Physical Activity in PCOS Management***

Regular exercise and physical activity are crucial components of PCOS management, with well-documented benefits on metabolic, reproductive, and psychological health. Exercise improves insulin sensitivity by increasing glucose uptake in skeletal muscle and reducing visceral fat, thereby addressing the core metabolic defect in PCOS (21, 22). It also helps with weight reduction or maintenance of healthy weight, which is vital since weight loss can significantly ameliorate PCOS symptoms. Furthermore, exercise has been shown to reduce free androgen levels (partly by lowering insulin and inducing SHBG), improve menstrual regularity, and enhance mood and quality of life in women with PCOS (23, 24). For these reasons, clinical guidelines strongly recommend physical activity for all women with PCOS, including those who are normal weight. The general adult guidelines are extrapolated to PCOS with an emphasis on possibly higher volumes for weight management: experts advise at least 150 minutes per week of vigorous-intensity exercise (or ~250 minutes of moderate-intensity), along with muscle-strengthening activities on 2 days per week, to achieve meaningful improvements (25, 26). Tailoring the exercise type and intensity to the individual's preferences and abilities is important to enhance adherence and sustainability.

Different modalities of exercise have been studied in PCOS, including aerobic (endurance) exercise, resistance (strength) training, and high-intensity interval training (HIIT). Each type offers unique benefits, and a combination appears to be most effective.

In summary, exercise is a powerful therapeutic modality in PCOS, on par with pharmacological treatments in many cases. Aerobic exercise improves metabolic health and aids weight loss; resistance training builds muscle and further combats insulin resistance; and HIIT may provide additional benefits in less time. The best results are achieved when exercise is combined with dietary changes, as part of an overall lifestyle modification plan. Clinicians should encourage women with PCOS to find physical activities they enjoy and can sustain – whether it's gym workouts, sports, dancing, or brisk walking – since consistency is key. Even for those without weight concerns, exercise can improve insulin and androgen levels, thereby mitigating PCOS features. Beyond direct PCOS symptom relief, fostering a habit of regular physical activity will reduce long-term risks of diabetes and cardiovascular disease, aligning with the broader health goals for these patients (1).

***Limitations and Future Directions in Research***

While significant progress has been made in understanding and managing PCOS with diet and exercise, there are important limitations in the current research and areas ripe for further study. One limitation is the heterogeneity of PCOS itself – the syndrome presents in various phenotypes (some women are lean with primarily ovulatory issues, others are obese with severe metabolic disturbance, etc.), and thus a given intervention may not have uniform effects across all patients. Many clinical trials lump all PCOS phenotypes together, potentially diluting findings. Future studies may need to stratify results by phenotype (e.g. insulin-resistant vs non-insulin-resistant PCOS) to determine if certain diets or exercise modalities work better for specific subgroups.

In terms of dietary research, despite numerous small trials, we still lack large, long-term randomized controlled trials that directly compare different healthy diets in PCOS. As noted in a recent network meta-analysis, relatively few direct head-to-head comparisons have been done, and many RCTs had short durations (often 3–6 months) and small sample sizes (6). This makes it challenging to definitively rank dietary interventions beyond general conclusions that calorie reduction and balanced, low-GI eating are beneficial. The network meta-analysis did suggest the DASH diet and general calorie-restricted diet as top performers for insulin resistance improvement (27), but again highlighted that more trials (especially on diets like Mediterranean or low-carb in PCOS) are needed to confirm superiority. Moreover, adherence is a major issue – many diet studies report significant dropout or poor long-term maintenance. Research into behavioral strategies to improve long-term adherence to dietary changes in PCOS is warranted, as sustaining healthy eating over years is crucial for lifelong condition management.

**Conclusions**

PCOS is a complex syndrome rooted in hormonal and metabolic dysregulation, notably insulin resistance-driven hyperandrogenism. This scientific review highlights that diet and physical activity interventions are fundamental in PCOS management, offering multifaceted benefits that align with the disorder's pathophysiology. Nutritional approaches such as low-glycemic index, Mediterranean, and DASH diets, alongside targeted nutrients like inositols, omega-3 fatty acids, and vitamin D, can improve insulin sensitivity, restore endocrine balance, and reduce chronic inflammation at the biochemical level. Complementary to diet, regular exercise – be it aerobic, resistance, or high-intensity interval training – enhances insulin action, promotes weight/fat loss, and favorably modulates reproductive hormones. Together, these lifestyle strategies address the core abnormalities of PCOS and are endorsed by clinical guidelines as first-line therapy. They not only alleviate immediate symptoms (irregular cycles, hyperandrogenism, subfertility) but also mitigate long-term health risks.

The evidence-based insights presented here underscore that through nutritional biochemistry and exercise physiology, patients with PCOS can achieve significant clinical improvements, sometimes rivaling pharmaceutical interventions. Nonetheless, current research also emphasizes the need for individualized plans, sustained support for behavior change, and further studies to close knowledge gaps. In sum, an integrative management plan focusing on diet and physical activity – informed by scientific understanding of PCOS's metabolic and hormonal pathways – offers the best prospects for improving outcomes in this common and impactful condition. Ongoing and future research will continue to refine these recommendations, but the overarching message remains: empowering women with PCOS to adopt a healthy lifestyle is a scientifically sound and clinically effective strategy that should be at the forefront of care.

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The authors declare no competing interests.

**Data Availability**

The authors have compiled an Excel spreadsheet containing the key data extracted from all studies included in this systematic review. This summary dataset supports the results and conclusions presented in the article. The dataset is not publicly available, but it can be obtained from the authors upon reasonable request. There are no legal or privacy restrictions on sharing these data. Requests for access should be directed to the corresponding author.

**Contributors' Statement**

Data collection: AM, KK, NK, AB, KB, MPK, AD, JB; Drafting the Manuscript: AM, KK, NK, AB, KB, MPK, AD, JB; Critical Revision of the Manuscript: KK.

All authors reviewed and accepted the final version of the manuscript.

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