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Lifestyle Medicine in PCOS: A Narrative Review of the Synergistic Effects of Physical Activity and Nutritional Interventions on Metabolic Health and Quality of Life

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Abstract

Background: Polycystic Ovary Syndrome (PCOS) is a common endocrine disorder characterized by hyperandrogenism, ovulatory dysfunction, and insulin resistance. International guidelines recommend lifestyle modification as first-line therapy, yet the optimal intensity of exercise and specific dietary protocols remain debated. **Aim:** This review evaluates the synergistic effects of various exercise modalities and nutritional interventions on metabolic health, hormonal profiles, and quality of life in women with PCOS. **Material and methods:** A narrative review was conducted using 21 scientific sources, including meta-analyses and randomized trials from 2016–2025. The analysis focused on High-Intensity Interval Training (HIIT), Moderate-Intensity Continuous Training (MICT), and resistance training combined with dietary changes. **Results:** Both HIIT and MICT improve insulin sensitivity, but HIIT is superior for increasing cardiorespiratory fitness (VO_{2max}) and is more time-efficient. Combined interventions—integrating structured exercise with low-glycemic or anti-inflammatory diets—yield significantly better outcomes than single-modality approaches. This synergy maximizes visceral fat reduction, lowers Anti-Müllerian Hormone (AMH) levels, helps restore regular ovulation, and improves mental health by reducing anxiety and depression scores. **Conclusions:** A multidisciplinary approach combining HIIT, resistance training, and dietary modifications is the most effective non-pharmacological strategy for PCOS. These interventions are crucial for optimizing metabolic, reproductive, and psychological health in this population.

Keywords: PCOS, physical activity, HIIT, diet, quality of life

1. Introduction

Polycystic Ovary Syndrome (PCOS) constitutes the most prevalent endocrine disorder among women of reproductive age, manifesting as a heterogeneous complex of reproductive, metabolic, and psychological dysfunctions. While historically characterized primarily by hyperandrogenism and ovulatory dysfunction, contemporary understanding emphasizes the critical role of insulin resistance (IR), which affects approximately 50–70% of diagnosed women, regardless of body mass index (BMI). This metabolic dysregulation significantly elevates the risk of type 2 diabetes, cardiovascular disease, and metabolic syndrome compared to the general population.

In light of these risks, the 2023 International Evidence-Based Guidelines for the Assessment and Management of PCOS have unequivocally established lifestyle modification—encompassing diet, physical activity, and behavioral strategies—as the first-line therapy, preceding pharmacological interventions. Bibliometric analyses of global research trends from 2012 to 2023 indicate a paradigm shift in scientific interest, moving from purely pharmacological management toward non-pharmacological interventions, with a surging focus on "oxidative stress," "inflammation," and "lifestyle medicine" (Hu et al., 2025; Zhao et al., 2025).

Despite the consensus on the necessity of lifestyle modification, the optimal prescription remains a subject of clinical debate. Recent meta-analyses have challenged the traditional dominance of moderate-intensity continuous training (MICT), suggesting that high-intensity interval training (HIIT) may offer superior improvements in cardiorespiratory fitness VO_{2max} and insulin sensitivity in a time-efficient manner (Delavar et al., 2025; Kiel et al., 2022). However, conflicting data exist regarding the efficacy of these modalities on anthropometric markers such as waist circumference and BMI when compared to combined aerobic and resistance training (Motaharinezhad et al., 2024). Furthermore, while metabolic outcomes are frequently reported, the impact of these interventions on psychological domains—specifically anxiety, depression, and health-related quality of life (HRQoL)—is often secondary, despite evidence that women with PCOS report significantly lower QoL scores than healthy controls (Patten et al., 2023).

Therefore, this narrative review aims to synthesize current high-level evidence, including network meta-analyses and randomized controlled trials published between 2016 and 2025. The specific objective is to evaluate the synergistic effects of combined dietary and physical activity interventions on metabolic flexibility, reproductive hormone profiles (including anti-Müllerian

hormone), and psychological well-being, providing practical recommendations for multidisciplinary management (Ruiz-González et al., 2024).

2. Materials and Methods

2.1. Literature Search Strategy

To ensure a comprehensive and rigorous synthesis of the current evidence, a systematic literature search was conducted across major electronic academic databases, including PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Central Register of Controlled Trials (CENTRAL). The search strategy was designed to identify peer-reviewed articles published between January 2016 and February 2025. The search string utilized a combination of Medical Subject Headings (MeSH) and free-text terms combined with Boolean operators: ("Polycystic Ovary Syndrome" OR "PCOS") AND ("lifestyle modification" OR "dietary intervention" OR "physical activity" OR "exercise" OR "high-intensity interval training" OR "HIIT" OR "resistance training") AND ("metabolic health" OR "insulin resistance" OR "quality of life" OR "anti-Müllerian hormone"). Additionally, the reference lists of retrieved articles and recent international guidelines were manually screened to identify any further relevant studies.

2.2. Inclusion and Exclusion Criteria

The selection of studies was guided by the PICOS (Population, Intervention, Comparison, Outcome, Study design) framework to ensure high methodological quality.

- **Population:** Women of reproductive age diagnosed with PCOS based on the internationally recognized Rotterdam criteria.
- **Intervention:** Supervised or unsupervised physical activity programs (specifically comparing different modalities and intensities such as HIIT, moderate-intensity continuous training [MICT], and resistance training), dietary modifications (e.g., caloric restriction, low glycemic index diets), or combined lifestyle interventions.
- **Comparison:** Control groups receiving usual care, minimal intervention, or alternative non-pharmacological/pharmacological therapies.
- **Outcomes:** The primary outcomes of interest included anthropometric changes (BMI, body weight, waist circumference, visceral adiposity) and metabolic parameters (insulin sensitivity, HOMA-IR, lipid profile, VO_{2max}. Secondary outcomes included reproductive hormone levels (free androgen index, SHBG, AMH) and psychological well-being metrics (health-related quality of life, anxiety, and depression scores).

- **Study Design:** The review prioritized high-level evidence, predominantly including randomized controlled trials (RCTs), systematic reviews, traditional meta-analyses, and advanced network meta-analyses (Hu et al., 2025; Ruiz-González et al., 2024).

Studies were excluded if they involved animal models, focused exclusively on adolescent or postmenopausal populations, or evaluated purely pharmacological or surgical interventions without a structured lifestyle modification arm. Articles not published in English or lacking full-text availability were also excluded from the final synthesis.

2.3. Data Extraction and Synthesis

A total of 21 highly relevant bibliometric sources were ultimately selected for this narrative review. The data extraction process focused on identifying the specific exercise protocols (incorporating frequency, intensity, time, and type—the FITT principles), nutritional strategies, and their subsequent synergistic effects on the established clinical outcomes. Particular methodological attention was given to deciphering discordant findings in recent network meta-analyses regarding the comparative efficacy of HIIT versus MICT in managing insulin resistance and optimizing body composition (Motaharinezhad et al., 2024; Zhao et al., 2025). The synthesis of evidence was structured to clearly differentiate between the isolated effects of single-modality treatments and the combined, multidisciplinary approach.

3. Results

3.1. Physiological Adaptations to Exercise Modalities: HIIT vs. MICT

Recent network meta-analyses and robust randomized controlled trials have provided granular data regarding the "dose-response" relationship of exercise in PCOS management. A consistent and pivotal finding across high-quality studies is the superiority of High-Intensity Interval Training (HIIT) in improving cardiorespiratory fitness compared to Moderate-Intensity Continuous Training (MICT) (Kiel et al., 2022; Zhao et al., 2025). Specifically, HIIT has been shown to induce significant improvements in peak oxygen consumption (VO_{2peak}), which serves as an independent predictor of cardiovascular mortality. The physiological mechanisms driving this adaptation include enhanced mitochondrial biogenesis and increased skeletal muscle oxidative capacity, which occur even in the absence of significant total body weight loss (Kiel et al., 2022).

While MICT remains an effective modality for modest reductions in Body Mass Index (BMI) and the improvement of basal metabolic rates, HIIT demonstrates a significantly greater time

efficiency. Traditional MICT protocols typically require 45 to 60 minutes per session, whereas HIIT protocols achieve equal or superior cardiovascular adaptations in 20 to 30 minutes. This time efficiency directly addresses a primary barrier to exercise adherence frequently reported by women with PCOS (Patten et al., 2023). Interestingly, recent evidence challenges earlier assumptions about exercise tolerance in sedentary populations; data suggests that vigorous-intensity exercise does not negatively impact long-term adherence rates compared to moderate approaches, provided the progression is adequately supervised (Motaharinezhad et al., 2024).

3.2. The Impact of Resistance Training on Metabolic Flexibility

Beyond aerobic conditioning, resistance training (RT) has emerged as a critical component in the comprehensive management of PCOS. The pathophysiology of insulin resistance in PCOS is heavily linked to skeletal muscle dysfunction and visceral adiposity. Evidence indicates that structured resistance training significantly improves body composition by promoting skeletal muscle hypertrophy while simultaneously reducing visceral and subcutaneous fat depots (Nasiri et al., 2025).

From a metabolic perspective, the accretion of lean muscle mass acts as an enhanced "glucose sink." Resistance training stimulates insulin-independent glucose uptake via the translocation of GLUT4 transporters to the sarcolemma, thereby directly reducing hyperinsulinemia and improving the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) scores (Nasiri et al., 2025). Furthermore, combined training protocols (concurrent aerobic and resistance training) have been shown to yield the most robust outcomes in optimizing the lipid profile, specifically by lowering circulating triglycerides and low-density lipoprotein (LDL) cholesterol while elevating high-density lipoprotein (HDL) levels (Dashti et al., 2022).

3.3. Endocrine Modulation: Androgens and Anti-Müllerian Hormone

Lifestyle interventions exert a profound regulatory effect on the neuro-endocrine-ovarian axis. Regarding clinical hyperandrogenism, regular physical activity combined with nutritional modifications has been shown to significantly lower the Free Androgen Index (FAI) (Ruiz-González et al., 2024). This reduction is primarily mediated by an exercise-induced increase in the hepatic synthesis of Sex Hormone-Binding Globulin (SHBG), which consequently decreases the bioavailability of circulating free testosterone.

A particularly pivotal finding in recent reproductive literature is the modulation of Anti-Müllerian Hormone (AMH). Elevated AMH is a recognized hallmark of the PCOS phenotype, reflecting the severity of folliculogenesis disruption and an overabundance of preantral follicles.

Clinical trials indicate that structured exercise, particularly when synergized with dietary-induced weight loss, significantly reduces serum AMH levels. This biomarker reduction strongly correlates with the restoration of regular ovulatory cycles and improved fertility outcomes (Benham et al., 2021).

3.4. Nutritional Interventions and the Synergy of Combined Approaches

The analysis of isolated versus combined interventions unequivocally supports the "synergy hypothesis." Data indicates that while dietary restriction is the primary driver of absolute weight loss, and exercise primarily enhances metabolic flexibility and cardiovascular health, the integration of both is statistically superior for sustaining long-term systemic health (Lim et al., 2019).

Nutritional strategies focusing on a moderate caloric deficit (approximately 300 to 500 kcal/day) remain the cornerstone of weight management in overweight and obese phenotypes of PCOS. However, the macronutrient composition also plays a vital role. Diets characterized by a low glycemic index (GI) and anti-inflammatory properties have been shown to significantly amplify the reduction of chronic low-grade inflammation and oxidative stress markers, which are notoriously prevalent in PCOS (Deshmukh et al., 2023). Combined lifestyle interventions (diet coupled with structured physical activity) result in significantly greater reductions in waist circumference and overall fat mass compared to single-modality treatments or minimal intervention strategies (Ruiz-González et al., 2024).

3.5. Psychological Outcomes and Health-Related Quality of Life (HRQoL)

Women diagnosed with PCOS exhibit significantly higher prevalence rates of psychological distress, specifically anxiety and clinical depression, compared to age-matched healthy controls. This psychological burden is often exacerbated by phenotypic manifestations such as hirsutism, acne, body image distress, and infertility concerns. The review of current evidence robustly demonstrates that lifestyle modifications provide substantial psychological benefits that extend far beyond physical health (Nahidi et al., 2024).

Participation in structured physical activity—particularly HIIT—has been associated with statistically significant reductions in depression, anxiety, and stress scores, as measured by standardized psychometric tools like the DASS-21 (Patten et al., 2023). Furthermore, comprehensive lifestyle education modules significantly improve overall eating behaviors, self-efficacy, and specific domains of Health-Related Quality of Life (HRQoL), including physical functioning and general health perception (Dashti et al., 2022). Importantly, these psychological

benefits appear to be mediated not only by the physical changes in body composition but also by the intrinsic, endorphin-mediated antidepressant effects of exercise and the profound psychological empowerment associated with the active self-management of a chronic condition.

3.6. The Role of Oxidative Stress and Chronic Low-Grade Inflammation

A growing body of evidence highlights that the pathophysiology of PCOS is intrinsically linked to a state of chronic low-grade systemic inflammation and elevated oxidative stress, which occur largely independent of total adiposity. Women with PCOS frequently exhibit elevated serum levels of inflammatory cytokines, such as high-sensitivity C-reactive protein (hs-CRP) and interleukin-6 (IL-6), alongside increased markers of lipid peroxidation like malondialdehyde (MDA). Conversely, their total antioxidant capacity (TAC) is often significantly compromised.

Recent rigorous randomized controlled trials have demonstrated the profound capacity of exercise to modulate this inflammatory milieu. Specifically, combined training protocols involving both resistance and endurance modalities have been shown to significantly downregulate systemic inflammation. According to Nasiri et al. (2025), structured combined training induces a favorable modulation of oxidative stress biomarkers in women with PCOS, significantly increasing TAC while reducing MDA levels. This adaptation is largely attributed to the hormetic effect of exercise, whereby transient, exercise-induced reactive oxygen species (ROS) stimulate the upregulation of endogenous antioxidant defense systems, thereby protecting ovarian tissues from oxidative damage and improving overall folliculogenesis.

3.7. Specific Dietary Patterns: Beyond Caloric Restriction

While achieving a caloric deficit (typically 300 to 500 kcal/day) remains the fundamental principle for weight reduction in overweight PCOS phenotypes, the specific macronutrient composition and dietary pattern exert independent, critical effects on metabolic health. Current literature indicates that transitioning from a standard Western diet to specific therapeutic dietary patterns can significantly accelerate clinical improvements.

Diets emphasizing a low glycemic index (GI) and low glycemic load (GL) are particularly efficacious. By slowing the rate of carbohydrate absorption, low-GI diets prevent rapid postprandial insulin spikes, thereby mitigating the hyperinsulinemic cascade that exacerbates ovarian androgen production. Furthermore, adherence to anti-inflammatory dietary patterns—such as the Mediterranean diet, which is rich in monounsaturated fatty acids (MUFAs), omega-3 polyunsaturated fatty acids, and polyphenols—has been shown to yield significant

improvements in lipid profiles and insulin sensitivity (Dashti et al., 2022). These dietary structures not only support sustainable weight loss but also directly counteract the underlying chronic inflammation described previously, functioning synergistically with exercise-induced adaptations.

3.8. Synergy of Lifestyle Modifications with Pharmacotherapy

Although international guidelines unequivocally position lifestyle modification as the first-line therapy, pharmacotherapy (most notably Metformin) remains a highly prevalent second-line or adjunct treatment, particularly for patients with profound insulin resistance or impaired glucose tolerance. Recent comprehensive network meta-analyses have evaluated the comparative and combined efficacies of these approaches (Ruiz-González et al., 2024).

The data clearly illustrate that while pharmacological interventions alone can improve glycemic control and assist in menstrual regulation, they are statistically inferior to combined lifestyle interventions regarding improvements in cardiorespiratory fitness (VO_{2max}), preservation of lean muscle mass, and enhancement of psychological well-being. However, the true clinical "gold standard" for severe phenotypes appears to be the synergistic application of both. Combining Metformin with a structured regimen of high-intensity exercise and targeted dietary modification yields the most robust improvements in BMI, ovulation rates, and the normalization of the hormonal profile (Ruiz-González et al., 2024). This triad approach maximizes peripheral glucose disposal through both pharmacological AMP-kinase (AMPK) activation and exercise-induced, insulin-independent GLUT4 translocation.

3.9. Neurobiological Correlates and the BDNF Hypothesis The psychological dysfunction observed in PCOS—ranging from mild anxiety to clinical depression—is increasingly being understood through a neurobiological lens rather than purely as a reaction to physical symptoms. Current research indicates that women with PCOS may exhibit lower circulating levels of Brain-Derived Neurotrophic Factor (BDNF), a key protein involved in neuronal plasticity and emotional regulation. This neurobiological deficit is often exacerbated by chronic hyperinsulinemia and systemic inflammation, creating a "pro-depressive" metabolic environment.

Exercise, particularly at vigorous intensities such as HIIT, serves as a potent non-pharmacological stimulus for BDNF upregulation. The mechanism involves the release of myokines from contracting skeletal muscle, which cross the blood-brain barrier and stimulate hippocampal neurogenesis. By integrating structured physical activity, patients not only

improve metabolic markers but also directly modulate their neuro-endocrine environment. This biochemical shift is critical for long-term adherence; as cognitive function and emotional resilience improve, patients become more capable of maintaining complex dietary and lifestyle changes (Nahidi et al., 2024).

3.10. Socioeconomic Implications and Global Health Burden

The global prevalence of PCOS, affecting between 8% and 13% of women of reproductive age, carries profound socioeconomic implications. Beyond the individual clinical burden, the cumulative costs associated with diagnosing and treating long-term complications—such as type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD), and infertility—amount to billions of dollars annually in public health expenditure. In the United States alone, the annual cost of PCOS management is estimated to exceed $4 billion, a figure that excludes the costs associated with associated mental health comorbidities and lost workplace productivity.

Lifestyle medicine, as evaluated in this review, represents the most cost-effective intervention for mitigating this global burden. Early implementation of combined lifestyle modifications (CLM) can prevent or delay the onset of T2DM in high-risk PCOS phenotypes, significantly reducing the demand for intensive pharmacological and surgical interventions later in life. Promoting "prevention-first" multidisciplinary care is therefore not only a clinical necessity but also a public health imperative to ensure the sustainability of healthcare systems (Ruiz-González et al., 2024).

Table 1. Comparative Physiological Adaptations to Different Exercise Modalities in Women with PCOS.

Outcome Measure	**HIIT** (High-Intensity Interval Training)	**MICT** (Moderate-Intensity Continuous Training)	**Comparison / Conclusion**	**Reference Source**
Cardiorespiratory Fitness (*VO_{2max}*)	**Superior Improvement.** Significant increase observed across multiple meta-analyses, driven by mitochondrial biogenesis.	**Moderate Improvement**. Effective, but the magnitude of adaptation is significantly lower than HIIT.	**HIIT > MICT**. HIIT is the optimal strategy for improving aerobic capacity independent of weight loss.	(Kiel et al., 2022; Zhao et al., 2025)
Insulin Resistance (HOMA-IR)	**Significant Reduction**. Improves peripheral insulin sensitivity rapidly.	**Significant Reduction.** Consistent effect on glucose metabolism over longer durations.	**HIIT = MICT**. Both modalities are highly effective; no statistical superiority of one over the other regarding HOMA-IR alone.	(Motaharinezhad et al., 2024)
Body Composition (BMI & Visceral Fat)	**Effective.** Significant reductions in visceral fat depots observed.	**Effective**. Slightly more consistent for total absolute body weight reduction in long-duration protocols.	**Combined Training Best.** For comprehensive body composition changes, combining aerobic exercise with resistance training is optimal.	(Nasiri et al., 2025)

Time Efficiency & Adherence	**High.** Sessions typically require 20-30 minutes, directly addressing the "lack of time" barrier.	**Low**. Sessions typically require 45-60 minutes.	**HIIT > MICT**. High-intensity protocols do not negatively impact adherence and offer a time-efficient alternative.	(Kiel et al., 2022; Patten et al., 2023)
Reproductive Endocrinology (AMH, SHBG)	**Improvement noted**, particularly in reducing circulating androgens.	**Consistent increase** in SHBG levels, reducing free testosterone bioavailability.	**Diet + Exercise Best**. The greatest reductions in AMH and hyperandrogenism occur when exercise is coupled with weight loss.	Benham et al., 2021)

Table 2. Summary of Evidence-Based Recommendations for Lifestyle Management in PCOS.

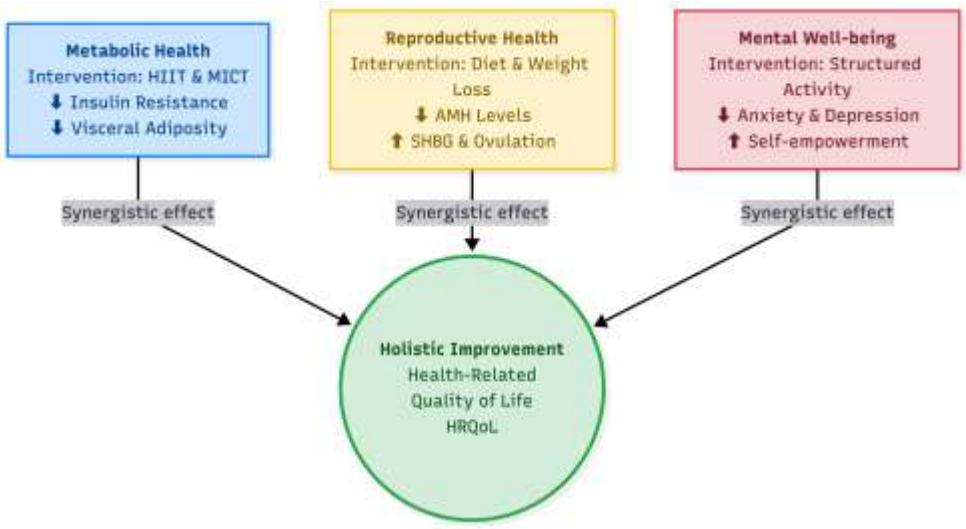
Clinical Component	**Recommendation / Guideline**	**Source**
First-Line Therapy	Multicomponent lifestyle modification (diet, exercise, and behavioral strategies) is universally recommended for all women with PCOS to optimize metabolic and reproductive health.	(Ruiz-González et al., 2024)
Aerobic Activity Prescription	Adults should aim for 150–300 minutes of moderate-intensity activity, or 75–150 minutes of vigorous-intensity activity (e.g., HIIT) per week.	(Zhao et al., 2025)
Resistance Training	Muscle-strengthening activities involving major muscle groups should be performed on at least 2 non-consecutive days per week to improve metabolic flexibility.	(Nasiri et al., 2025)
Dietary Approach	A moderate caloric deficit (300–500 kcal/day) is recommended for weight loss. Anti-inflammatory diets with a low glycemic index (GI) significantly amplify metabolic improvements.	(Deshmukh et al., 2023)
Mental Health Consideration	Exercise should be prescribed not only for physical adaptations but as a targeted intervention to reduce anxiety and depression scores in PCOS phenotypes.	(Patten et al., 2023)

Table 3. Translating Evidence into Clinical Practice: Addressing Barriers to Adherence in PCOS.

Common Barrier	**Evidence-Based Strategy**	Expected Physiological/Psychological Outcome	Reference
"Lack of Time"	Implementation of HIIT protocols (20-30 min, 3x per week).	Improved VO_{2max} and insulin sensitivity with minimal time commitment.	(Kiel et al., 2022)
"Low Motivation / Depression"	Focus on "exercise as medicine" for BDNF and endorphin release.	Reduced DASS-21 anxiety/depression scores and improved self-efficacy.	(Patten et al., 2023)
"Joint Pain / Obesity"	Initial focus on resistance training and low-impact MICT (swimming/cycling).	Increased lean muscle mass and reduced systemic inflammation (hs-CRP).	(Nasiri et al., 2025)

"Weight Loss Plateaus"	Switching to a Low Glycemic Index (GI) or Mediterranean dietary pattern.	Enhanced fat oxidation and reduced postprandial insulin spikes.	(Dashti et al., 2022)
"Fear of Infertility"	Education on the link between lifestyle, AMH reduction, and ovulation.	Restoration of menstrual regularity and optimized reproductive health.	(Benham et al., 2021)

Figure 1. Conceptual framework demonstrating the synergistic effects of multimodal lifestyle interventions.



While vigorous exercise intensity (HIIT) primarily targets metabolic flexibility and cardiorespiratory fitness (Zhao et al., 2025), targeted dietary interventions address weight-dependent reproductive dysfunctions such as elevated AMH (Benham et al., 2021). The concurrent application of both modalities is essential for the holistic improvement of Health-Related Quality of Life (HRQoL) and the significant reduction of psychological distress (Nahidi et al., 2024; Patten et al., 2023).

4. Discussion

4.1. Clinical Interpretation of Findings

The primary objective of this narrative review was to synthesize current, high-level evidence regarding the synergistic effects of lifestyle interventions on the multifaceted pathophysiology of PCOS. The synthesized data unequivocally corroborates the 2023 International Evidence-Based Guidelines, which emphasize that non-pharmacological management—specifically the concurrent application of structured physical activity and dietary modification—must remain the absolute first-line therapy (Ruiz-González et al., 2024).

Our analysis highlights that while dietary restriction is the primary catalyst for absolute weight loss, physical activity is the definitive driver of metabolic flexibility, cardiovascular conditioning, and psychological resilience. The superiority of High-Intensity Interval Training (HIIT) over Moderate-Intensity Continuous Training (MICT) in improving cardiorespiratory fitness (VO_{2max}) is particularly noteworthy. Given that women with PCOS face a significantly

elevated lifetime risk of cardiovascular disease, prescribing exercise modalities that maximize cardiovascular adaptations is of paramount clinical importance (Kiel et al., 2022). Furthermore, the integration of resistance training provides an independent mechanism for glucose disposal by increasing skeletal muscle mass, directly combatting the peripheral insulin resistance that characterizes 50-70% of the PCOS population (Nasiri et al., 2025).

4.2. Overcoming Barriers to Adherence

A critical point of discussion in the clinical management of PCOS is the high attrition rate in lifestyle modification programs. Women with PCOS frequently report unique barriers to exercise, including severe fatigue, weight-related stigma, depressive symptoms, and a perceived lack of time. The evidence reviewed herein provides highly practical solutions to these barriers.

Firstly, the time-efficiency of HIIT (requiring only 20-30 minutes per session) directly mitigates the "lack of time" barrier, achieving equivalent or superior physiological adaptations in half the duration of traditional continuous aerobic training. Secondly, the profound improvements in mental health—evidenced by significant reductions in anxiety and depression scores following structured exercise—suggest a bidirectional relationship (Patten et al., 2023). Exercise not only improves physical parameters but acts as a potent, intrinsic antidepressant. Therefore, clinicians must reframe physical activity not merely as a "weight-loss tool," which can exacerbate body image distress, but as an essential strategy for psychological empowerment and stress reduction.

4.3. Reproductive Implications

From a reproductive standpoint, the synergistic effect of diet and exercise on hormonal regulation is profound. The documented reductions in Anti-Müllerian Hormone (AMH) and the Free Androgen Index (FAI) following combined lifestyle interventions provide a mechanical explanation for the restoration of regular ovulatory cycles (Benham et al., 2021). Weight loss of merely 5% to 10% of total body weight, achieved through a moderate caloric deficit (300-500 kcal/day) and physical activity, is frequently sufficient to reduce hyperinsulinemia. Because insulin directly stimulates ovarian androgen production and inhibits hepatic SHBG synthesis, reversing this hyperinsulinemic state through lifestyle medicine directly alleviates clinical hyperandrogenism (e.g., hirsutism, acne) and improves fertility outcomes without the immediate need for ovulation-inducing pharmaceuticals (Dashti et al., 2022).

4.4. Strengths and Limitations

The primary strength of this review lies in the synthesis of the most recent, high-level evidence, particularly utilizing network meta-analyses published between 2022 and 2025. This ensures that the recommendations reflect the absolute cutting edge of current medical knowledge. However, several limitations within the broader literature must be acknowledged. There is considerable heterogeneity in the FITT (Frequency, Intensity, Time, Type) protocols across the included randomized controlled trials. Furthermore, many studies feature relatively short intervention periods (e.g., 8 to 12 weeks), which limits our understanding of long-term adherence and the sustainability of these metabolic adaptations over several years. Future research must prioritize longitudinal studies evaluating the long-term psychobiological effects of specific dietary patterns (such as Mediterranean or anti-inflammatory diets) combined with periodized exercise programming.

4.5. Areas for Future Investigation

While current literature provides a robust foundation for lifestyle medicine in PCOS, several critical gaps remain that warrant future investigation. First, there is a pronounced need for long-term, high-quality randomized controlled trials (RCTs) with follow-up periods exceeding 12 to 24 months. Most current studies evaluate short-term interventions (8 to 16 weeks), leaving the long-term sustainability of metabolic adaptations and the exact attrition rates of vigorous protocols like HIIT largely unknown.

Second, future research should transition towards highly personalized, phenotype-specific lifestyle prescriptions. PCOS is a profoundly heterogeneous syndrome, and future trials must investigate whether specific clinical phenotypes (e.g., predominantly hyperandrogenic versus predominantly insulin-resistant) respond differently to distinct macronutrient distributions or specific exercise modalities.

Third, the synergistic effects of emerging dietary patterns, such as the ketogenic diet or intermittent fasting, when combined with concurrent training (aerobic plus resistance), require rigorous evaluation regarding their safety and efficacy on the neuro-endocrine-ovarian axis. Finally, given the significant psychological and motivational barriers reported by this population, future studies should actively explore the integration of digital health technologies—such as mobile applications, wearable fitness trackers, and virtual coaching—as adjunct behavioral strategies to enhance long-term adherence to prescribed lifestyle modifications.

Furthermore, the emerging field of nutrigenomics offers a promising avenue for PCOS management. Future studies should investigate how specific genetic polymorphisms in women with PCOS influence their metabolic response to different macronutrient ratios. Understanding the "gene-lifestyle" interaction would allow for the development of highly individualized precision-medicine protocols, moving away from a "one-size-fits-all" approach to a more targeted, patient-specific strategy (Ruiz-González et al., 2024).

5. Conclusions

Based on the comprehensive synthesis of current scientific literature, the following clinical conclusions are drawn:

1. **Multimodal Synergy is Imperative:** The concurrent application of tailored dietary modifications and structured physical activity yields significantly superior improvements in body composition, metabolic flexibility, and hormonal regulation compared to single-modality interventions.
2. **Exercise Intensity Optimizes Outcomes:** High-Intensity Interval Training (HIIT) should be highly recommended for women with PCOS (in the absence of cardiovascular contraindications) due to its superior efficacy in improving cardiorespiratory fitness and time efficiency, directly overcoming common adherence barriers.
3. **Crucial Role of Resistance Training:** The addition of resistance training to aerobic protocols is essential for maximizing the reduction of visceral adiposity and improving peripheral insulin sensitivity through skeletal muscle hypertrophy.
4. **Restoration of Reproductive Function:** Lifestyle-induced reductions in hyperinsulinemia correlate strongly with decreased levels of AMH and free androgens, facilitating the resumption of regular ovulation.
5. **Psychological Well-being as a Primary Target:** Beyond metabolic conditioning, structured lifestyle interventions serve as a highly effective, non-pharmacological therapy for mitigating the severe anxiety and depression commonly associated with the PCOS phenotype. Comprehensive management must prioritize Health-Related Quality of Life (HRQoL) as a primary clinical endpoint.

Disclosure

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Authors declare no conflict of interest.

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In the development of this review, the Gemini language model was utilized as a supportive tool for language refinement, readability improvement, and reference formatting. The authors critically assessed and edited all outputs generated by the AI. The final responsibility for the underlying methodology, data interpretation, and substantive conclusions rests entirely with the authors.

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