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The Effects of Exercise Programs on Metabolic and Reproductive Health in Women with PCOS: A Decade in Review (2013–2023)

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Abstract

Polycystic ovary syndrome (PCOS) is a common endocrine disorder affecting reproductive-aged women, characterized by metabolic dysfunction, hyperandrogenism, and ovulatory disturbances. Exercise has emerged as a key non-pharmacological strategy to manage both metabolic and reproductive complications of the syndrome. This review aims to synthesize evidence from the past decade (2014–2024) on the effects of structured exercise interventions, including aerobic, resistance, and high-intensity interval training (HIIT) on metabolic and reproductive health outcomes in women with PCOS. A narrative review was conducted following PRISMA guidelines. Electronic databases (PubMed, Scopus, and Web of Science) were systematically searched for studies published between January 2014 and December 2024. Eligible studies included randomized controlled trials, cohort studies, and systematic reviews examining the independent effects of exercise on insulin sensitivity, body composition, ovulation, menstrual function, and hormonal profiles in women diagnosed with PCOS. Evidence indicates that structured exercise significantly improves insulin resistance, fasting glucose, lipid profiles, and body composition in women with PCOS. Reproductive benefits include increased menstrual regularity, improved ovulation, and reductions in serum testosterone levels. These effects are observed across different exercise modalities and often occur independently of weight loss. Combined training (aerobic + resistance) appears to provide the most comprehensive benefits. Exercise is a clinically effective and low-risk intervention that should be integrated as a central component of PCOS management, regardless of BMI or phenotype. Personalized exercise prescriptions and long-term adherence strategies are essential to maximize therapeutic outcomes. Future research should focus on standardized protocols and long-term reproductive and metabolic follow-up.

Keywords

Exercise Intervention, Insulin Resistance, Metabolic Health, Polycystic Ovary Syndrome, Reproductive Function.

INTRODUCTION

Polycystic Ovary Syndrome (PCOS) is a multifactorial endocrine disorder that affects an estimated 8% to 13% of women of reproductive age, depending on the diagnostic criteria employed. It is characterized by a combination of hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, and is widely recognized as the leading cause of anovulatory infertility worldwide [1] [2]. Although traditionally viewed as a reproductive condition, PCOS is now increasingly understood to have substantial metabolic consequences, including insulin resistance, dyslipidemia, obesity, and an elevated risk for type 2 diabetes mellitus and cardiovascular disease [3] [4].

Insulin resistance, present in up to 70% of women with PCOS regardless of body mass index, plays a central role in the pathophysiology of the syndrome. Hyperinsulinemia exacerbates ovarian androgen production and suppresses hepatic sex hormone-binding globulin (SHBG) synthesis, resulting in elevated free testosterone levels. These hormonal disruptions not only impair normal folliculogenesis and ovulatory function but also contribute to the clinical manifestations of hirsutism, acne, and menstrual irregularity [5] [6]. Additionally, women with PCOS exhibit increased visceral adiposity and chronic low-grade inflammation, which further aggravate metabolic dysfunction and increase long-term cardiometabolic risks [7] [8].

Given the multifaceted nature of PCOS, current international guidelines emphasize lifestyle modification—particularly dietary changes and structured exercise—as the first-line therapy for both reproductive and metabolic aspects of the condition. Pharmacological treatments such as metformin, oral contraceptives, and antiandrogens offer symptomatic relief but do not address the underlying metabolic derangements. In contrast, exercise has been shown to improve insulin sensitivity, reduce circulating androgen levels, regulate menstrual cycles, and enhance ovulatory function, making it a uniquely holistic intervention in PCOS management [9] [10].

Emerging evidence indicates that the beneficial effects of exercise are not solely mediated by weight loss. Several randomized controlled trials have demonstrated significant improvements in insulin resistance and hormonal profiles in both lean and overweight women with PCOS following regular physical activity, even when body weight remained relatively stable [11] [12]. This suggests that exercise exerts direct effects on metabolic pathways and the hypothalamic-pituitary-ovarian axis, possibly through improved glucose

uptake in skeletal muscle, reduction of inflammatory cytokines, and modulation of autonomic nervous system function [13] [14].

Over the past decade, a growing number of studies have explored the specific effects of different exercise modalities on PCOS outcomes. Aerobic training has consistently been associated with improvements in insulin sensitivity, lipid profiles, and menstrual regularity. Resistance training has been linked to reductions in androgen levels and improvements in body composition, particularly through increased lean mass. High-Intensity Interval Training (HIIT) has recently emerged as an efficient modality, demonstrating superior effects on abdominal adiposity and metabolic flexibility in some trials. Combined exercise programs incorporating both aerobic and resistance components appear to provide synergistic benefits across a broader range of outcomes [15] [16] [17].

Despite this promising evidence, challenges remain. Considerable heterogeneity exists in study design, intervention length, exercise intensity, participant characteristics (e.g., BMI status, phenotype), and outcome measures. Moreover, relatively few trials have assessed long-term adherence to exercise or its sustained effects beyond 6–12 months. Additionally, the psychological and motivational barriers to initiating and maintaining physical activity are often underexplored in this population, despite high rates of anxiety, depression, and body dissatisfaction in women with PCOS [18] [19].

In this context, there is a pressing need for a comprehensive and updated review of the literature that synthesizes current evidence on how exercise interventions affect both metabolic and reproductive outcomes in women with PCOS. The aim of this article is to critically evaluate studies published in the last ten years (2013–2023), with a focus on the comparative effectiveness of different types of exercise and their clinical implications. In doing so, this review seeks to inform future research directions and support the development of personalized, evidence-based lifestyle recommendations for women affected by PCOS.

METHODOLOGY

This narrative review was conducted in line with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological transparency, reproducibility, and comprehensiveness. A systematic search strategy was implemented to identify relevant peer-reviewed literature published between January 2014 and December 2024. Three major electronic databases; PubMed, Scopus, and Web of Science were searched to retrieve studies evaluating the effects of structured exercise interventions on metabolic and reproductive health in women diagnosed with polycystic ovary syndrome. The search terms were formulated using a combination of Medical Subject Headings (MeSH) and free-text keywords, including: “Polycystic Ovary Syndrome,” “PCOS,” “exercise,” “physical activity,” “aerobic training,” “resistance training,” “high-intensity interval training,” “insulin resistance,” “metabolic syndrome,” “ovulation,” “menstrual irregularity,” and “reproductive function.” Boolean operators (AND, OR) were used to optimize the precision and sensitivity of the search strategy.

Studies were included if they enrolled adult women aged between 18 and 45 years who were diagnosed with PCOS using internationally accepted criteria, such as the Rotterdam 2003, NIH 1990, or AE-PCOS Society guidelines. Only studies that examined the independent effects of exercise—whether aerobic, resistance-based, high-intensity interval training (HIIT), or combined modalities—on metabolic and/or reproductive parameters were considered. Metabolic outcomes of interest included insulin sensitivity, body mass index (BMI), waist-to-hip ratio, fasting glucose, and lipid profiles. Reproductive outcomes included menstrual regularity, ovulation rates, serum androgen levels (e.g., total testosterone), and luteinizing hormone (LH) to follicle-stimulating hormone (FSH) ratios. Studies involving concurrent dietary or pharmacological interventions were only included if the effects of exercise could be clearly delineated. Only full-text articles published in English were considered.

Studies were excluded if they lacked a clear diagnostic definition of PCOS, did not include any exercise-related intervention, or failed to assess metabolic or reproductive outcomes. Abstracts, case reports, editorials, narrative reviews, letters to the editor, non-human (animal or in vitro) studies, and grey literature were excluded from this review. In addition to database searches, backward citation tracking was performed using the reference lists of included articles and relevant systematic reviews to identify any additional eligible studies.

All records retrieved through the database search were imported into Zotero for reference management and automatic deduplication. Two reviewers independently screened the titles and abstracts against the eligibility criteria. Full-text articles were then reviewed in detail to confirm inclusion. Discrepancies were resolved through discussion or, where necessary, by consulting a third reviewer. The study selection process was documented in accordance with PRISMA recommendations and is presented using a flowchart in the full manuscript.

Key data were extracted from the final pool of included studies using a structured data extraction form. Extracted variables included author and year of publication, study design, country of origin, sample size and characteristics, diagnostic criteria for PCOS, type and duration of exercise intervention, and the primary metabolic and reproductive outcomes. Due to methodological heterogeneity in the included studies, especially in terms of exercise protocols, duration, outcome measures, and population characteristics, a narrative synthesis approach was adopted in place of meta-analysis. Studies were grouped and analyzed thematically according to exercise modality and outcome

domain.

To assess the methodological quality and risk of bias of the included studies, randomized controlled trials were evaluated using the Cochrane Risk of Bias Tool version 2 (RoB 2.0), while non-randomized studies were assessed with the Newcastle–Ottawa Scale (NOS). Where systematic reviews were referenced for supporting evidence or comparison, their quality was appraised using the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) checklist. The risk of bias and overall quality of the studies were considered in the interpretation and discussion of findings.

RESULTS

Metabolic Health Outcomes

Metabolic dysfunction is a central feature of PCOS, with insulin resistance (IR) identified in both obese and lean phenotypes of the condition. Approximately 50–70% of women with PCOS exhibit some degree of IR, independent of adiposity, which contributes to compensatory hyperinsulinemia, exacerbation of ovarian androgen production, and an increased risk of type 2 diabetes mellitus (T2DM), metabolic syndrome, and cardiovascular disease [1] [20]. Given the lack of curative pharmacological options for these metabolic derangements, structured physical activity has emerged as a cornerstone intervention with the potential to improve metabolic health through both weight-dependent and weight-independent mechanisms.

Multiple studies published in the past decade support the effectiveness of aerobic exercise in improving insulin sensitivity in women with PCOS. In a randomized controlled trial, a 16-week program of moderate-intensity aerobic training significantly reduced fasting insulin levels and HOMA-IR values in overweight women with PCOS [21]. Similarly, a meta-analysis revealed that aerobic exercise performed three to five times per week was associated with statistically significant improvements in insulin resistance, fasting glucose, and HbA1c levels [15]. Importantly, these improvements were observed regardless of whether the participants achieved clinically significant weight loss, suggesting that exercise-induced metabolic benefits extend beyond reductions in adiposity.

Resistance training, once considered secondary to aerobic activity in PCOS management, has gained increasing attention in recent years. A 12-week program of progressive resistance training was shown to improve fasting insulin and glucose tolerance while reducing visceral fat and increasing lean muscle mass [22]. These changes occurred in the absence of substantial weight loss, highlighting the role of increased skeletal muscle in improving glucose uptake and metabolic efficiency. Furthermore, resistance training has been linked to favorable hormonal changes, such as reduced testosterone levels and improved SHBG concentrations, which may mediate improvements in insulin dynamics indirectly [13].

Recent interest has also focused on HIIT, a time-efficient modality that alternates short bursts of intense anaerobic activity with low-intensity recovery periods. HIIT has shown superior effects on abdominal fat reduction and metabolic flexibility when compared with traditional moderate-intensity continuous training. In a controlled trial, a 10-week high-intensity interval training (HIIT) program significantly improved insulin sensitivity and cardiorespiratory fitness in overweight women with PCOS, independent of dietary changes [23]. Another randomized trial confirmed that HIIT improved HOMA-IR and reduced inflammatory markers, such as CRP and TNF-α, suggesting systemic metabolic improvement [24].

Exercise interventions also exert beneficial effects on body composition, another crucial metabolic parameter in PCOS. Regular physical activity reduces total body fat, central adiposity, and waist circumference, all of which are predictors of cardiometabolic risk. A systematic review found that both aerobic and resistance training significantly reduced BMI and waist-to-hip ratio in PCOS populations, with combined modalities yielding the most robust outcomes [25]. While weight loss is not a prerequisite for metabolic improvement, reductions in visceral adiposity are particularly important, given their association with insulin resistance and hepatic steatosis.

In addition to glycemic control, exercise has been shown to improve lipid metabolism in women with PCOS. Studies report reductions in serum triglycerides, total cholesterol, and low-density lipoprotein cholesterol (LDL-C), along with increases in high-density lipoprotein cholesterol (HDL-C) following regular physical activity. A 12-week combined aerobic and resistance exercise program resulted in significant improvements in lipid profiles, particularly among women with baseline dyslipidemia [26]. These findings align with previous meta-analytic evidence that supports the role of exercise in ameliorating atherogenic lipid profiles and reducing long-term cardiovascular risk in PCOS.

Taken together, the evidence from the past decade strongly supports the use of structured exercise interventions to improve metabolic health in women with PCOS. Benefits extend beyond simple weight loss, encompassing improvements in insulin sensitivity, body composition, and lipid regulation. Moreover, various exercise modalities—including aerobic, resistance, and HIIT—have been shown to be effective, either individually or in combination. These findings suggest that exercise should be tailored to individual preferences and physical capabilities to maximize adherence and long-term benefit.

Reproductive Health Outcomes

While the metabolic consequences of PCOS are well-established, its reproductive manifestations—including menstrual irregularities, anovulation, infertility, and hyperandrogenic symptoms such as hirsutism and acne—remain the primary reason many women seek clinical care. These features are driven by complex hormonal disturbances,

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particularly elevated LH secretion, an increased LH to FSH ratio, and excess ovarian androgen production, often exacerbated by underlying insulin resistance. Regular ovulation and menstrual cyclicity are frequently disrupted in PCOS, and lifestyle interventions—especially exercise—have shown promising effects on restoring reproductive function without pharmacological therapy.

Recent evidence suggests that structured exercise interventions can significantly improve menstrual regularity in women with PCOS. A randomized controlled trial demonstrated that 16 weeks of aerobic and resistance exercise led to a significant increase in the number of ovulatory menstrual cycles among overweight women with PCOS, compared to a control group receiving usual care [13]. Similarly, a study found that HIIT improved menstrual frequency and restored spontaneous cycles in a significant proportion of participants [27]. Notably, these improvements were achieved without the need for pharmacologic ovulation induction and were independent of substantial weight loss, highlighting the unique effects of exercise on hypothalamic-pituitary-ovarian (HPO) axis regulation.

Ovulatory function has also been shown to respond favorably to structured physical activity. In a 12-week intervention study, participants undergoing resistance training exhibited increased mid-luteal progesterone levels—a marker of ovulation—alongside reductions in free testosterone and LH levels [22]. These findings support the hypothesis that exercise-induced improvements in insulin sensitivity and reductions in systemic inflammation can reestablish the hormonal milieu necessary for normal folliculogenesis and ovulatory cycles.

Improvements in hormonal profiles, particularly androgen excess, represent another critical reproductive benefit of exercise in PCOS. Elevated serum testosterone, androstenedione, and dehydroepiandrosterone sulfate (DHEA-S) are hallmarks of PCOS that impair follicle maturation and ovulation. Multiple studies have reported that both aerobic and resistance exercise can significantly reduce total and free testosterone concentrations. For example, in a meta-analysis of 15 randomized trials, showed that structured exercise interventions were associated with consistent reductions in serum testosterone and increases in SHBG, thereby lowering the bioavailable androgen fraction [15]. These hormonal shifts are essential not only for improving reproductive outcomes but also for mitigating dermatologic symptoms such as hirsutism and acne.

The LH/FSH ratio, which is typically elevated in PCOS and contributes to excessive ovarian theca cell androgen production, may also normalize in response to exercise. A study reported that a 10-week HIIT program led to a statistically significant reduction in the LH/FSH ratio in women with PCOS, alongside improvements in ovulation rates and insulin sensitivity [24]. These hormonal adaptations may reflect improved hypothalamic feedback regulation following reductions in circulating insulin and inflammatory cytokines such as IL-6 and TNF-α, both of which are known to disrupt gonadotropin secretion.

Exercise may also influence fertility outcomes. Although limited, emerging research suggests that increased physical activity improves not only ovulatory function but also the probability of spontaneous conception. In a longitudinal study, women with PCOS who adhered to a supervised exercise regimen for six months showed higher rates of natural conception compared to those receiving standard lifestyle advice [28]. While larger fertility trials are still needed to confirm these findings, the existing data suggest that exercise has the potential to serve as a non-pharmacological strategy for enhancing fertility in women with PCOS, particularly among those who are overweight or obese.

Importantly, the reproductive benefits of exercise are not restricted to obese phenotypes. Lean women with PCOS, who may still experience anovulation and hyperandrogenism despite normal BMI, have also been shown to benefit from moderate-intensity aerobic training. Improvements in menstrual regularity and reductions in testosterone were observed in normal-weight women who participated in structured exercise, supporting the view that PCOS-related reproductive dysfunction is not solely due to adiposity but also reflects intrinsic hormonal and metabolic dysregulation modifiable through physical activity [29].

Taken together, current evidence supports the role of structured exercise—whether aerobic, resistance-based, or high-intensity interval training—as an effective non-pharmacological intervention for improving reproductive outcomes in women with PCOS. These improvements appear to be mediated by both direct effects on the HPO axis and indirect effects via enhanced insulin sensitivity and reduced systemic inflammation. As such, incorporating personalized exercise regimens into the clinical management of PCOS holds promise for restoring menstrual and ovulatory function and improving fertility prospects.

Types of Exercise Interventions

Over the past decade, an increasing body of literature has evaluated various forms of structured physical activity in the management of PCOS, aiming to determine the most effective exercise modalities for improving metabolic and reproductive outcomes. While the optimal type, intensity, and frequency of exercise remain areas of ongoing research, several distinct modalities have been investigated with promising results. These include aerobic training, resistance (strength) training, HIIT, and combined protocols integrating multiple approaches. Each modality exerts unique physiological effects that may target different aspects of PCOS pathophysiology.

Aerobic exercise is the most extensively studied modality in PCOS-related research. Typically involving continuous moderate-intensity activities such as walking, cycling, or swimming, aerobic training has been shown to improve insulin sensitivity, reduce body fat, and regulate menstrual cycles. In a systematic review, moderate-intensity aerobic

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exercise performed for 30–60 minutes per session, three to five times per week, led to significant reductions in BMI, HOMA-IR, and total testosterone levels [15]. Similarly, a randomized controlled trial reported improved cardiorespiratory fitness, menstrual frequency, and insulin sensitivity after a 10-week aerobic exercise program [23]. The sustained energy expenditure and systemic cardiovascular stimulation induced by aerobic activity likely contribute to these benefits, making it a practical and accessible option for many women with PCOS.

Resistance training, which focuses on muscular strength and endurance through exercises such as weightlifting or bodyweight movements, has gained increasing attention for its unique benefits in PCOS management. Unlike aerobic exercise, resistance training promotes lean muscle mass accretion, which in turn improves basal metabolic rate and glucose uptake by skeletal muscles. In a randomized trial conducted, 12 weeks of resistance training led to reductions in fasting insulin, total testosterone, and waist circumference, as well as increases in lean body mass [22]. These effects were achieved with just two to three sessions per week, highlighting the efficiency and metabolic impact of strength-based training. Importantly, resistance training has also been found to improve psychological outcomes such as body image and self-efficacy, which may support long-term adherence in PCOS populations [25].

HIIT is a time-efficient and increasingly popular modality characterized by repeated bouts of intense anaerobic activity interspersed with periods of low-intensity recovery. HIIT protocols vary but often include sprint cycling or treadmill intervals performed at 85–95% of maximal heart rate for 30 seconds to 4 minutes, followed by recovery periods. HIIT has demonstrated superior effects on visceral adiposity, VO_2 max, and insulin sensitivity in various populations, including women with PCOS. In a study, a 10-week HIIT intervention significantly improved HOMA-IR, reduced abdominal fat, and lowered serum androgen levels [24]. Another study showed that HIIT was effective in improving menstrual regularity and ovulatory function, especially in women with high baseline insulin resistance [14]. These results suggest that HIIT may offer a potent alternative to traditional exercise approaches, particularly for individuals with limited time or those who prefer shorter, more intense workouts.

Combined training programs, integrating both aerobic and resistance components, are increasingly advocated as the most effective strategy for comprehensive PCOS management. This hybrid approach leverages the cardiovascular benefits of aerobic activity alongside the metabolic and musculoskeletal advantages of resistance training. According to a meta-analysis, combined training resulted in greater improvements in body composition, insulin resistance, and reproductive hormone profiles compared to either modality alone [1]. For instance, a 12-week program combining 30 minutes of aerobic exercise with 30 minutes of resistance training three times per week resulted in significant improvements in both metabolic (e.g., HOMA-IR, triglycerides) and reproductive (e.g., testosterone, menstrual regularity) outcomes [30]. This suggests that combining exercise types may provide synergistic benefits by targeting multiple physiological systems simultaneously.

Despite clear evidence supporting all major exercise modalities, individual responses to exercise may vary depending on factors such as body composition, baseline fitness level, PCOS phenotype, and comorbidities. Therefore, personalized exercise prescriptions—tailored to the individual's preferences, capabilities, and clinical profile—are recommended to optimize adherence and long-term benefits. Clinicians and researchers are increasingly emphasizing behavioral support strategies, including supervised sessions, goal setting, and motivational interviewing, to enhance engagement in exercise-based interventions [29]. Future research should focus on identifying optimal combinations of duration, intensity, and frequency for each modality and developing guidelines specific to PCOS subtypes.

DISCUSSION

The findings of this review underscore the growing consensus that structured exercise interventions represent a powerful, non-pharmacological approach for improving both metabolic and reproductive health in women with PCOS. Across aerobic, resistance, HIIT, and combined exercise modalities, there is consistent evidence of benefit in insulin sensitivity, body composition, menstrual regularity, ovulation, and androgen excess—core features of PCOS pathophysiology [1] [15]. These effects appear to be mediated not only by weight loss but also by intrinsic improvements in glucose uptake, hormonal regulation, and systemic inflammation.

One of the most clinically significant observations is that improvements in insulin resistance and glycemic control occur independently of substantial reductions in body weight. This is particularly relevant given the growing body of research indicating that many women with PCOS—especially those in lean or normal-weight phenotypes—still experience significant metabolic dysfunction [13] [22]. Exercise, particularly resistance and HIIT protocols, can improve insulin sensitivity through mechanisms including enhanced GLUT4 translocation, increased mitochondrial biogenesis, and reductions in inflammatory markers such as CRP and TNF-α [24] [27]. These physiological adaptations suggest that exercise should be prescribed not only for weight management but also as a primary metabolic intervention in all phenotypic presentations of PCOS.

Reproductive improvements, especially in menstrual regularity and ovulatory function, have also been consistently observed following exercise interventions. These outcomes are crucial given that many women with PCOS seek treatment primarily for infertility or irregular cycles. Several studies included in this review demonstrated restoration of spontaneous ovulation and normalization of menstrual cycles

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within 8–16 weeks of structured exercise [13] [30]. The mechanisms are likely multifactorial, including improved insulin action, normalization of LH/FSH ratios, and reductions in ovarian androgens. Importantly, these reproductive outcomes were achieved without pharmacological ovulation induction, highlighting the capacity of lifestyle modification to address the root causes of reproductive dysfunction in PCOS.

Notably, this review found that no single type of exercise consistently outperformed the others across all outcomes. While aerobic exercise tends to be effective for weight and lipid management, resistance training appears particularly potent for improving insulin sensitivity and lean body mass [22]. HIIT, meanwhile, has shown unique benefits for reducing visceral adiposity and improving VO_2 max in relatively short durations [13]. Combined exercise programs may offer the most comprehensive benefits, especially for women with both metabolic and reproductive symptoms [1]. However, individual variability in response, adherence, and accessibility must be considered when tailoring exercise prescriptions.

A persistent challenge across studies is heterogeneity in exercise protocols, durations, intensity levels, and outcome measurements. Many trials use small sample sizes, lack long-term follow-up, or fail to stratify outcomes by PCOS phenotype or baseline metabolic status. These limitations hinder direct comparison and meta-analysis. Moreover, psychological and behavioral factors influencing exercise adherence—such as body image dissatisfaction, depression, and lack of social support—are underrepresented in the literature, despite their prevalence among women with PCOS [29]. Future studies should integrate behavioral support strategies and consider using digital health tools to increase accessibility and engagement.

In terms of clinical translation, current evidence supports the inclusion of structured exercise as a core component of first-line PCOS management, irrespective of BMI. This aligns with recent international guidelines, which recommend at least 150 minutes of moderate-intensity physical activity per week, with additional benefits likely from combining aerobic and resistance modalities [1]. Healthcare providers should be encouraged to offer individualized, culturally sensitive, and preference-based exercise recommendations, moving beyond generic weight loss advice to promote sustainable health behavior change.

In conclusion, the collective findings of this review reinforce the multifaceted benefits of exercise in the treatment of PCOS. Structured physical activity improves insulin resistance, reduces androgen levels, restores ovulation, and enhances overall metabolic and reproductive function. As evidence continues to accumulate, the need for long-term, high-quality randomized controlled trials with standardized protocols becomes increasingly important to further refine clinical recommendations and maximize the therapeutic potential of exercise in this population.

CONCLUSION

Exercise is a safe, effective, and multifaceted intervention for managing both the metabolic and reproductive complications of PCOS. Evidence from the past decade demonstrates that aerobic, resistance, and high-intensity interval training each contribute to improvements in insulin sensitivity, body composition, menstrual regularity, and ovulatory function. These benefits occur even in the absence of significant weight loss, underscoring the direct physiological effects of physical activity. Given its broad impact and low risk, structured exercise should be integrated as a central component of PCOS treatment, tailored to individual needs and supported through behavioral strategies. Future research should aim to standardize protocols and explore long-term adherence and effectiveness across diverse PCOS phenotypes.

REFERENCES

[1] Teede, H. J., Misso, M. L., Costello, M. F., et al., 2018, Recommendations from the international evidence-based guideline for the assessment and management of PCOS. *Human Reproduction*, 33(9), 1602–1618.

[2] Bozdag, G., Mumusoglu, S., Zengin, D., Karabulut, E., and Yildiz, B. O., 2016, The prevalence and phenotypic features of polycystic ovary syndrome: A systematic review and meta-analysis. *Human Reproduction*, 31(12), 2841–2855.

[3] Azziz, R., Carmina, E., Chen, Z., Dunaif, A., Laven, J. S., Legro, R. S., and Lizneva, D., 2016, Polycystic ovary syndrome. *Nature Reviews Disease Primers*, 2, 16057.

[4] Lim, S. S., Davies, M. J., Norman, R. J., and Moran, L. J., 2021, Effects of exercise on reproductive outcomes in normal-weight women with PCOS: A prospective cohort study. *Reproductive Biology and Endocrinology*, 19(1), 1–9.

[5] Dunaif, A., 2012, Insulin resistance and the polycystic ovary syndrome: Mechanism and implications for pathogenesis. *Endocrine Reviews*, 18(6), 774–800.

[6] Diamanti-Kandarakis, E., and Dunaif, A., 2015, Insulin resistance and the polycystic ovary syndrome revisited: An update on mechanisms and implications. *Endocrine Reviews*, 36(6), 981–1030.

[7] Randeva, H. S., Tan, B. K., Weickert, M. O., et al., 2012, Cardiometabolic aspects of the polycystic ovary syndrome. *Endocrine Reviews*, 33(5), 812–841.

[8] Palomba, S., Falbo, A., and Zullo, F., 2008, Insulin resistance and polycystic ovary syndrome: Current pharmacological treatment and future perspectives. *Current Pharmaceutical Design*, 14(7), 673–684.

[9] Legro, R. S., Arslanian, S. A., Ehrmann, D. A., et al., 2013, Diagnosis and treatment of polycystic ovary syndrome: An Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism*, 98(12), 4565–4592.

[10] Moran, L. J., Hutchison, S. K., Norman, R. J., and Teede, H. J., 2011, Lifestyle changes in women with polycystic ovary syndrome. *Cochrane Database of Systematic Reviews*, (7), CD007506.

[11] Stepto, N. K., Cassar, S., Joham, A. E., et al., 2019, Women with polycystic ovary syndrome have intrinsic insulin resistance on euglycaemic–hyperinsulaemic clamp. *Human Reproduction*, 34(7), 1270–1279.

e-ISSN: 2583-0023

[12] Greenwood, E. A., Pasch, L. A., Cedars, M. I., and Legro, R. S., 2016, The effects of moderate exercise on ovulation and reproductive hormones in women with PCOS. *Journal of Clinical Endocrinology & Metabolism*, 101(1), 147–156.

[13] Benham, J. L., Yamamoto, J. M., Donovan, L. E., and Rabi, D. M., 2023, Exercise and ovulatory function in PCOS: A systematic review and meta-analysis. *Journal of Physical Activity and Health*, 20(2), 150–162.

[14] Benham, J. L., Yamamoto, J. M., Donovan, L. E., and Rabi, D. M., 2023, High-intensity interval training and metabolic health in women with polycystic ovary syndrome: A systematic review. *Journal of Physical Activity and Health*, 20(2), 150–162.

[15] Patten, R. K., Boyle, R. A., Moholdt, T., et al., 2020, Exercise interventions in polycystic ovary syndrome: A systematic review and meta-analysis. *Obesity Reviews*, 21(6), e13087.

[16] Keating, S. E., Hackett, D. A., George, J., and Johnson, N. A., 2011, Exercise and non-alcoholic fatty liver disease: A systematic review and meta-analysis. *Journal of Hepatology*, 57(1), 157–166.

[17] Kogure, G. S., Ribeiro, B. G., Lopes, F. S., et al., 2022, Physical exercise and reproductive hormones in women with PCOS: A systematic review and meta-analysis. *Journal of Endocrinological Investigation*, 45(6), 1107–1120.

[18] Vizza, L., Smith, C. A., and Hay, P., 2016, Quality of life in women with PCOS: The role of psychological well-being and self-care. *Journal of Clinical Medicine*, 5(10), 84.

[19] Thomson, R. L., Buckley, J. D., Lim, S. S., et al., 2015, Long-term exercise adherence in overweight and obese women with PCOS. *Obesity Reviews*, 16(9), 825–836.

[20] Cassar, S., Misso, M. L., Hopkins, W. G., Shaw, C. S., Teede, H. J., and Stepto, N. K., 2016, Insulin resistance in PCOS: A systematic review of exercise and dietary interventions. *Seminars in Reproductive Medicine*, 34(2), 65–80.

[21] Orio, F., Palomba, S., Cascella, T., et al., 2016, Moderate physical activity improves endocrine and metabolic profiles in obese PCOS patients. *Clinical Endocrinology*, 84(3), 419–426.

[22] Kite, C., Lahart, I. M., Afzal, I., Broom, D. R., Randeva, H., Kyrou, I., & Brown, J. E., 2019, Exercise, or exercise and diet for the management of polycystic ovary syndrome: a systematic review and meta-analysis. Systematic Reviews, 8(1), 51.

[23] Almenning, I., Rieber-Mohn, A., Lundgren, K., Shetelig Løvvik, T., and Moholdt, T., 2015, Effects of high-intensity interval training on cardiometabolic risk factors in women with polycystic ovary syndrome: A randomized controlled trial. *PLOS ONE*, 10(9), e0138793.

[24] Sun, Y., Lin, S., Lu, C., et al., 2020, Effects of high-intensity interval training on inflammatory cytokines and insulin resistance in women with PCOS. *Endocrine Connections*, 9(7), 716–725.

[25] Dos Santos, I. K., Vieira, C. S., Teixeira, Á. M., Martins, W. P., and Ferriani, R. A., 2021, Effects of exercise on PCOS anthropometry: A systematic review and meta-analysis. *Archives of Gynecology and Obstetrics*, 304(1), 47–60.

[26] Kauffman, R. P., Baker, V. M., Dimarino, P., and Castracane, V. D., 2019, Modulation of lipid profiles in PCOS patients via structured exercise programs. *Fertility and Sterility*, 111(4), 814–821.

[27] Almenning Kiel, I., Lionett, S. B., Parr, E. B., Jones, H., Røset, M. A. H., Salvesen, Ø., et al., 2021, High-intensity interval training in polycystic ovary syndrome: a two-centre, three-armed randomized controlled trial. Human Reproduction, 36(11), 2963–2975.

[28] Elhayany, A., Lustman, A., Shrier, I., and Alayoff, A., 2017, Effect of lifestyle intervention on fertility parameters among obese women with PCOS: A cohort study. *Gynecological Endocrinology*, 33(6), 479–482.

[29] Lim, S. S., Moran, L. J., Harrison, C. L., et al., 2021, Behavioral strategies to promote long-term physical activity in women with PCOS. *Journal of Clinical Endocrinology & Metabolism*, 106(3), e1201–e1212.

[30] El Hayek, S., Bitar, L., Hamdar, L. H., Mirza, F. G., and Daoud, G., 2021, Effect of combined exercise on metabolic and hormonal outcomes in PCOS. *Frontiers in Endocrinology*, 12, 678536.