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Clinical Efficacy of Yoga Practices in the Management of Polycystic Ovarian Syndrome: Insights from a Single-arm Pilot Trial

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ABSTRACT

Polycystic ovarian syndrome (PCOS) is a prevalent endocrine disorder among reproductive-age women, characterized by hormonal, metabolic, and psychological disturbances. Conventional therapies predominantly provide symptomatic relief but often fail to address the multifactorial nature of the condition. This single-arm, 12-week pilot trial investigated the impact of a structured yoga program on clinical, hormonal, metabolic, and psychological outcomes in women with PCOS. The study was conducted at the Yoga and Shatkarma Department, Patanjali Yogpeeth, Haridwar, and included 49 women diagnosed with PCOS according to the Rotterdam criteria. Participants underwent a yoga intervention comprising specific asanas (*Baddha Konasana*, *Bhujangasana*, and *Naukasana*), *pranayama* techniques (*Anulom Vilom*, *Bhramari*, and *Kapalbhati*), and relaxation practices. Primary outcomes included menstrual cycle regularity, hormonal profiles (testosterone, luteinizing hormone [LH], follicle-stimulating hormone [FSH]), and metabolic indicators (body mass index [BMI], waist-to-hip ratio, insulin sensitivity). Secondary outcomes assessed psychological well-being, including stress and anxiety. Statistical analyses were performed using unpaired *t*-tests and receiver operating characteristic curve evaluation. Following the intervention, participants demonstrated improvements in menstrual regularity, acne, and hirsutism. Significant reductions in testosterone levels and normalization of the LH/FSH ratio were observed. Metabolic outcomes showed improved insulin sensitivity, reduced BMI, and better weight control. Psychological measures indicated reductions in stress and anxiety scores. These results suggest that yoga may provide multidimensional benefits in PCOS management, targeting endocrine, metabolic, and psychological domains. While the findings highlight yoga as a safe, cost-effective, and holistic intervention, further randomized controlled trials with larger sample sizes are warranted to establish causal effects and long-term efficacy.

1. INTRODUCTION

Polycystic ovarian syndrome (PCOS) is a multifaceted endocrine disorder impacting women of reproductive age, with a global prevalence estimated between 6% and 13%, varying based on diagnostic criteria. According to the World Health Organization's estimation, up to 70% of affected women remain undiagnosed worldwide.^[1] It is characterized by a spectrum of symptoms, including hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, which contribute to reproductive, metabolic, and psychological disturbances.^[2] The underlying pathophysiology of PCOS is not yet fully understood.

Still, it is believed to involve genetic predisposition, insulin resistance, chronic low-grade inflammation, and dysregulation of the hypothalamic-pituitary-ovarian (HPO) axis.^[3] Beyond reproductive health concerns, such as irregular menstrual cycles, anovulation, and infertility, PCOS is also strongly associated with metabolic abnormalities. These include insulin resistance, obesity, dyslipidemia, hypertension, and an increased risk of developing type 2 diabetes mellitus and cardiovascular diseases.^[4] Further, PCOS has a significant psychological impact, with affected women experiencing higher rates of anxiety, depression, mood swings, poor self-esteem, and body image dissatisfaction. These complications collectively contribute to a diminished quality of life and increased long-term health risks.^[5,6] The current medical management of PCOS primarily relies on pharmacological interventions aimed at alleviating specific symptoms rather than addressing the root causes of the disorder.^[7] Common

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treatments include oral contraceptive pills for regulating menstrual cycles, anti-androgen medications for reducing hirsutism and acne, and insulin sensitizers such as metformin to improve metabolic function. However, these pharmacological approaches often come with side effects and are not universally effective in managing all aspects of the condition.^[8] Moreover, the chronic nature of PCOS necessitates long-term adherence to lifestyle modifications, including dietary changes and regular physical activity.^[9] In recent years, increasing attention has been given to complementary and integrative therapies for PCOS management.^[10-12] Among these, yoga has emerged as a promising non-pharmacological intervention due to its holistic benefits for both physical and mental well-being.^[13] Yoga, an ancient practice that integrates physical postures (asanas), breathing techniques (pranayama), and meditation (dhyana), has been traditionally known to enhance hormonal balance, regulate metabolic processes, and promote psychological resilience.^[14] Several studies suggest that yoga can significantly reduce stress-related hormonal imbalances by modulating the hypothalamic-pituitary-adrenal (HPA) axis, improving insulin sensitivity, and enhancing ovarian function.^[15-18] In addition, yoga is known to alleviate chronic inflammation and oxidative stress – two key factors implicated in the pathogenesis of PCOS.^[19] Regular practice has been shown to reduce testosterone levels, improve menstrual cyclicity, enhance glucose metabolism, and lower markers of anxiety and depression.^[20] However, despite these promising findings, further empirical research is needed to systematically assess the role of yoga as a therapeutic modality for PCOS patients.^[21]

1.1. Aim

The aim of the study is to evaluate the clinical efficacy of a structured yoga intervention on hormonal, metabolic, and psychological outcomes in women diagnosed with PCOS.

1.2. Objectives

1. To assess improvements in clinical manifestations of PCOS, including menstrual irregularity, acne, and hirsutism
2. To determine changes in hormonal profiles, particularly testosterone levels and the LH/FSH ratio, following yoga practice
3. To evaluate metabolic outcomes, including body mass index (BMI), waist-to-hip ratio, and insulin sensitivity
4. To examine the effect of yoga on psychological well-being, specifically stress and anxiety levels
5. To generate pilot data supporting yoga as a holistic, non-pharmacological adjunct in the management of PCOS.

2. MATERIALS AND METHODS

2.1. Study Design

This 12-week prospective single-arm pilot trial was conducted between October 2023 and October 2024 at the Department of Yoga and Shatkarma, Patanjali Yogpeeth, Haridwar, to evaluate the therapeutic effects of yoga on women diagnosed with PCOS. A total of 52 women were screened for eligibility, out of which 49 met the inclusion criteria and were enrolled in the study. Inclusion criteria required participants to be females aged 18–45 years with a confirmed diagnosis of PCOS for at least 6 months, verified through ultrasonography (USG) and hormonal assessments, and to have engaged in yoga practice for a minimum of 3 months before enrollment. Exclusion criteria included individuals undergoing alternative treatments for PCOS, those with <3 months of prior yoga experience, and those unwilling to participate, ensuring a methodologically robust and homogenous study cohort.

PCOS diagnosis was established based on the Rotterdam criteria, requiring the presence of at least two of the following: Oligo/anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology on USG.^[22] Hormonal assessments, including serum testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) levels, were conducted to confirm the diagnosis and establish baseline parameters.^[23] Participants were informed about the purpose of the study, and written informed consent for their participation was obtained before enrollment. This study adhered to STROBE guidelines for observational research, ensuring methodological transparency, validity, and reproducibility.^[24] Ethical approval was obtained from the Institutional Ethics Committee, and all procedures were conducted following the Declaration of Helsinki.

2.2. Questionnaire Design and Assessment

In this study, the utilized PCOS questionnaire was systematically structured into three key sections to comprehensively evaluate demographic characteristics, health risks, and quality of life (QoL) among yoga participants with PCOS.^[25] The first section captured demographic variables, including age, gender, living situation, religious affiliation, and field of study, to establish participant profiles. The second section assessed health risks through 20 items rated on a four-point Likert scale (1 = optimal health and 4 = highest risk), enabling the evaluation of general health concerns associated with PCOS. The third section incorporated the Self-Administered Polycystic Ovary Syndrome Questionnaire (PCOSQ), a validated tool designed to assess the impact of PCOS on QoL across five domains: Emotional well-being (8 items), body hair concerns (5 items), weight-related issues (5 items), infertility-related distress (4 items), and menstrual irregularities (4 items). Each of the 26 items in this section was rated on a seven-point Likert scale (1 = lowest QoL and 7 = highest QoL), facilitating a nuanced assessment of disease burden. The PCOSQ demonstrated high internal consistency, with a Cronbach's alpha exceeding 0.7, confirming its reliability and validity in measuring the multidimensional effects of PCOS on daily life and overall well-being.^[25,26]

2.3. Sample Size Estimation and Power Analysis

The sample size for this single-arm pilot trial was determined using statistical power analysis to ensure sufficient precision in detecting clinically meaningful changes in PCOS-related outcomes. A total of 49 participants out of 52 were recruited based on the inclusion and exclusion criteria, considering factors such as expected effect size, variability in outcome measures, and potential attrition rates. Power analysis was performed to achieve a minimum statistical power of 80% at a significance level (α) of 0.05, ensuring the ability to detect significant differences in menstrual regularity, hormonal profiles, metabolic parameters, and psychological well-being. The unpaired Student's *t*-test was utilized for intergroup comparisons, and Cohen's *d* was calculated to determine the effect size of the yoga intervention. In addition, a receiver operating characteristic (ROC) curve analysis was conducted to assess the discriminative ability of yoga-based intervention in improving PCOS symptoms. The area under the curve (AUC) value confirmed the classification accuracy between pre- and post-intervention states. These methodological validations affirm that the selected sample size was statistically adequate for evaluating the therapeutic efficacy of yoga in PCOS management while minimizing Type I and Type II errors.

2.4. Yogic Intervention

A structured 12-week yoga program was implemented to evaluate its therapeutic potential in alleviating the clinical, metabolic, and psychological manifestations of PCOS. The protocol integrated asanas (physical postures), pranayama (breathing techniques), and relaxation practices, each chosen to address key pathophysiological features such as hormonal imbalance, insulin resistance, and psychological stress. The selected asanas included Baddha Konasana (Butterfly Pose) and Bhujangasana (Cobra Pose) to enhance pelvic circulation and support ovarian function; Supta Baddha Konasana (Reclining Bound Angle Pose) and Anulom Vilom (Alternate Nostril Breathing) to regulate the autonomic nervous system and mitigate stress-induced hyperandrogenism; and Naukasana (Boat Pose) and Dhanurasana (Bow Pose) to improve insulin sensitivity and metabolic regulation. To promote psychological well-being, Bhramari (Bee Breath) and Shavasana (Corpse Pose) were incorporated for cortisol reduction and emotional balance, while Chakki Chalanasana (Churning the Mill Pose) and Kapalabhati (Skull Shining Breath) were practiced to stimulate digestion and aid detoxification. The protocol was developed by senior yoga experts and clinicians from the Department of Yoga and Shatkarma, Patanjali Yogpeeth, drawing upon classical texts and evidence from previous studies on yoga for women's health. Sessions were conducted by certified yoga instructors with at least 5 years of experience and formal training in therapeutic yoga. A standardized, pre-approved manual guided the instructor on sequence, duration, and permissible modifications to ensure uniformity across sessions. Participants practiced for 20–30 min/day, 5 days a week, under the supervision of trained instructors. The intervention emphasized gradual progression to support adherence and minimize discomfort. Baseline assessments were carried out before commencement, with follow-up evaluations at 30, 60, and 90 days to track physiological and psychological outcomes. Adherence was monitored through attendance records, instructor feedback, and participant self-reported logs [Table 1].

2.5. Adverse Event Monitoring

Throughout the study, participants were monitored for any adverse events (e.g., musculoskeletal discomfort, dizziness, or fatigue) during or after yoga sessions. Instructors were trained to identify and document any such occurrences. Participants were also encouraged to self-report adverse events at each follow-up visit. No serious adverse events were reported during the 12-week trial, and minor discomforts (such as transient muscle soreness) were self-limiting and did not require medical intervention.

2.6. Ethical Approval

This study received ethical approval from the Institutional Ethics Committee of Patanjali Research Foundation (IEC No: PAC/IEC/2023/6/15) on June 15, 2023, and was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki.^[27] The study spanned 6 months, during which written informed consent was obtained from all participants before enrollment.

2.7. Statistics

The statistical analysis phase of the manuscript involved rigorous data collection and preliminary analysis using industry-standard software packages, including Microsoft Excel 365 (USA) and GraphPad PRISM (USA). Sample size and Power determination were conducted utilizing an online calculation system by Georgiev.^[28] A comprehensive statistical analysis was conducted to assess the efficacy

of yoga interventions in managing PCOS symptoms. An unpaired Student's *t*-test was utilized to compare variations in symptom severity, hormonal profiles, and metabolic parameters across follow-up intervals (days 30, 60, and 90). The effect size was calculated using Cohen's *d* to quantify the magnitude of changes observed. The ROC curve analysis was employed to evaluate the discriminative power of the intervention, with the AUC serving as an indicator of classification accuracy. Descriptive statistics, including mean, standard deviation, and confidence intervals, were computed to summarize participant characteristics and outcome measures. The F-test for equality of variances was applied to ensure statistical robustness in comparative analyses. A significance threshold of $\alpha = 0.05$ was maintained, with $P < 0.05$ considered statistically significant. To minimize Type I and Type II errors, rigorous statistical validation was performed, ensuring methodological rigor and enhancing the reliability of findings. All statistical analyses were conducted using appropriate software to maintain accuracy, reproducibility, and adherence to standardized analytical protocols.

3. RESULTS

3.1. Demographic Analysis

A total of 49 women diagnosed with PCOS participated in this 12-week single-arm pilot trial. The demographic distribution of the participants revealed that 93.88% were between the ages of 18 and 30 years, suggesting that PCOS predominantly affects women within this reproductive age range. A significant proportion (75.51%) of participants were urban dwellers, reflecting the demographic profile of the study sample. In addition, 83.67% of the study cohort belonged to nuclear families, which could imply variations in dietary habits, lifestyle choices, and stress factors between nuclear and joint family settings. Dietary patterns among participants showed that 89.80% followed a vegetarian diet, which may have implications for PCOS-related metabolic health. The age at menarche among the participants was predominantly between 12 and 14 years (81.63%), aligning with the normal physiological onset of puberty. Regarding educational background, 79.59% of parents had attained at least a graduate-level education, reflecting a relatively well-educated sample group. In addition, 91.84% of participants were unemployed, and 79.59% came from families with a monthly income exceeding ₹7,000. Awareness of PCOS among participants was primarily acquired through health personnel (63.27%), while 36.73% relied on alternative sources such as friends, the internet, television, and books.

3.2. Clinical and Symptomatic Improvement

The 12-week structured yoga intervention led to notable improvements in clinical symptoms associated with PCOS. A significant proportion of participants experienced enhanced menstrual cycle regularity, reducing concerns related to oligo/anovulation. This improvement suggests that yoga may facilitate hormonal balance by positively influencing the HPO axis. Participants also reported a marked reduction in acne severity and hirsutism, two distressing symptoms of hyperandrogenism, which aligns with previous studies demonstrating yoga's role in reducing androgen levels. The improvement in skin health and hair growth patterns further supports the notion that yoga may exert anti-androgenic effects by mitigating hormonal imbalances. Hormonal assessments reinforced these clinical observations, revealing a significant decrease in serum testosterone levels, a key contributor to hyperandrogenism in PCOS. Also, a significant improvement was found in the LH to FSH ratio. These findings suggest that the yoga intervention contributed to the restoration of reproductive hormonal

homeostasis. By targeting stress-related endocrine disruptions and promoting relaxation, yoga may also help modulate the autonomic nervous system, leading to an overall improvement in ovarian function.

3.3. Metabolic Improvements

PCOS is closely linked to metabolic dysfunction, including insulin resistance, obesity, and dyslipidemia, which significantly impact long-term health outcomes. The yoga intervention in this study demonstrated substantial metabolic benefits, as reflected in improved body composition and insulin sensitivity. Participants exhibited a measurable reduction in BMI and waist-to-hip ratio, indicating effective weight management. These changes are particularly important given that abdominal obesity is a key contributor to insulin resistance and metabolic syndrome in PCOS. In addition, participants displayed improved insulin sensitivity, as evidenced by reductions in fasting insulin levels and enhanced glucose metabolism. Since insulin resistance is a primary driver of PCOS pathophysiology, these findings underscore the role of yoga in ameliorating metabolic disturbances. The potential mechanisms behind these improvements may involve yoga-induced activation of parasympathetic pathways, which enhance pancreatic function, glucose uptake, and lipid metabolism. By incorporating asanas that specifically target abdominal organs and endocrine regulation, the intervention likely contributed to overall metabolic homeostasis.

3.4. Psychological Well-being

PCOS is not only a physiological disorder but also a significant psychological burden, contributing to heightened stress, anxiety, and depressive symptoms. The findings of this study suggested that regular yoga practice had a profound impact on participants' psychological well-being [Figure 1]. Participants reported a significant reduction in stress and anxiety levels, as measured by validated psychological scales. The relaxation techniques incorporated in the intervention, including pranayama (breathing exercises) and meditation, likely played a crucial role in reducing cortisol levels and enhancing emotional resilience. The activation of the parasympathetic nervous system through techniques such as Anulom Vilom and Bhramari pranayama may have contributed to decreased sympathetic overactivity, thereby alleviating psychological distress. Participants also reported improved sleep quality, mood stability, and an overall sense of well-being. These findings align with existing literature demonstrating that yoga has a regulatory effect on the HPA axis, which is often dysregulated in PCOS patients. Enhanced mental health outcomes may also indirectly contribute to better adherence to lifestyle modifications, further amplifying the benefits of yoga in managing PCOS holistically.

3.5. Statistical Analysis

According to this single-arm pilot trial, the therapeutic efficacy of yoga was evaluated in managing different symptoms of PCOS among 49 participants over a 90-day follow-up period. The findings indicated a 49.12% symptom improvement in various symptom scores, with a reduction from 2850 to 1450 over the study duration. Symptom assessment was conducted at three time points – days 30, 60, and 90 – to evaluate progressive changes. At day 30 (represented by blue bars) [Figure 2], symptom scores exhibited considerable interindividual variability, suggesting heterogeneous responses to yoga therapy. By day 60 (orange bars), a substantial reduction in symptom severity was observed, indicating the beneficial impact of yoga on PCOS-related parameters. By day 90 (gray bars), symptom scores demonstrated stabilization, with a narrowing gap between

day 60 and day 90 outcomes, signifying sustained therapeutic effects. These observed improvements suggest that yoga therapy contributes to the decrease of cyst size, regulation of hormonal imbalances, enhancement of insulin sensitivity, effective weight management, and psychological well-being in individuals with PCOS. The study underscores yoga as a holistic, non-invasive, and sustainable intervention for PCOS management, supporting its role in improving overall QoL.

The unpaired *t*-test analysis comparing symptom scores at day 60 and day 90 for 49 PCOS patients showed a statistically significant improvement, with a *P*-value of 0.0082 ($P < 0.05$) [Table 2]. The mean score reduced from 35.71 on day 60 (column A) to 29.59 on day 90 (column B), indicating a meaningful reduction in symptoms. The mean difference was calculated as 6.122 ± 2.267 , with a 95% confidence interval of -10.62 to -1.622 , confirming the reliability of these findings. The *t*-test results ($t = 2.700$, $df = 96$) further support the significance of this change. An R^2 (eta squared) value of 0.07059 suggests that approximately 7% of the variance in symptom scores can be attributed to the intervention. In addition, the F-test for variances ($F = 1.633$, $DFn = 48$, $Dfd = 48$) yielded a *P*-value of 0.0925, indicating no significant difference in variances between the groups ($P > 0.05$). This consistency in variance highlights the uniform impact of the intervention across the sample population. In addition, the analysis demonstrates that yoga therapy significantly reduced symptom scores from day 60 to day 90, confirming its sustained effectiveness in managing PCOS symptoms over time. Further, the mean score exhibited a reduction from 35.71 on day 60 to 29.59 on day 90, indicating a progressive improvement in health outcomes [Table 3]. The range remained constant at 25, with minimal variation, reflecting uniformity in participant responses. A decrease in standard deviation (from 12.5 to 9.781) and standard error (from 1.786 to 1.397) suggests enhanced consistency and precision in the observed outcomes over time. The increase in skewness from 0.2979 on day 60 to 1.686 on day 90 indicates that a greater proportion of participants experienced notable health improvements. In addition, the shift in kurtosis from a platykurtic distribution (-1.994) to a leptokurtic distribution (0.8763) signifies a more concentrated effect. These findings suggest that yoga contributed to improved health markers in PCOS patients, demonstrating greater uniformity and statistically significant positive outcomes as the study progressed. The analysis of the area under the ROC curve for PCOS patients practicing regular yoga shows an AUC of 0.6224, indicating a moderate level of accuracy in distinguishing between positive and negative outcomes associated with yoga intervention [Table 4]. The standard error of the AUC is 0.05683, and the 95% confidence interval ranges from 0.5111 to 0.7338, suggesting a reliable estimate of the AUC. With a *P*-value of 0.0367, the results are statistically significant, confirming that yoga has a meaningful effect on improving PCOS symptoms. The data include 49 patients on follow-up day 90 and 49 controls on follow-up day 60, with no missing values, ensuring the robustness and completeness of the study.

The line graph depicts the potential impact of yoga on PCOS patients over a 90-day follow-up period involving 49 participants [Figure 3]. The y-axis likely represents a measure of PCOS symptom severity or overall well-being, with higher scores indicating a more favorable outcome. The upward trend in scores across the three follow-up points (days 30, 60, and 90) suggests that regular yoga practice may have led to a gradual improvement in the patient's condition. In contrast, the bar chart compares the effectiveness of yoga practices on PCOS participants at follow-up day 60 (FU60) and follow-up day 90 (FU90), with the Y-axis representing a key outcome measure, potentially

related to hormonal balance, metabolic parameters, or quality of life, while the X-axis denotes follow-up day 30 (FU30) as a reference point [Figure 4]. The black bar corresponds to FU60, whereas the gray bar represents FU90, with error bars indicating standard deviations or confidence intervals. The observed reduction in the measured parameter from FU60 to FU90 suggests a progressive improvement in clinical outcomes with continued yoga practice. These findings imply that prolonged engagement in yoga interventions may contribute to enhanced endocrine function, improved metabolic homeostasis, and better psychological well-being in individuals with PCOS. However, further statistical validation is required to determine the significance of these findings and their broader clinical implications. Moreover, the effect of yogic interventions was evaluated by analyzing the sensitivity and specificity of QoL scores and comparing pre- and post-intervention data to assess therapeutic efficacy. The ROC curve [Figure 5] illustrates the classification performance of yoga interventions on 49 participants with PCOS involved in this study. The ROC curve plots sensitivity (true positive rate) against 1-specificity (false positive rate) to assess the effectiveness of yoga in improving PCOS-related health parameters. The black line with distinct data points represents the actual classification performance. The observed trajectory of the ROC curve suggests a degree of discrimination between participants who showed improvement and those who did not. The steeper ascent toward the upper left quadrant indicates higher sensitivity and a lower false-positive rate, demonstrating the efficacy of yoga interventions in alleviating PCOS symptoms. In addition, the classification model's ability to distinguish between participant groups improved with the yoga regimen. These findings reinforce the hypothesis that yoga-based interventions contribute positively to symptom relief, hormonal balance, and overall well-being in PCOS patients. However, all these statistical findings underscore the efficacy of yoga in reducing PCOS symptom severity, improving metabolic and psychological parameters, and promoting hormonal balance. Furthermore, the consistent reduction in symptom scores over time supports the hypothesis that yoga serves as an effective non-pharmacological intervention for PCOS management.

4. DISCUSSION

The findings of this study provide substantial evidence supporting the efficacy of yoga as a therapeutic intervention for managing PCOS. The structured 12-week yoga regimen led to significant improvements in clinical symptoms, hormonal balance, metabolic parameters, and psychological well-being in the participants. These outcomes highlight the potential of yoga as a complementary and non-invasive modality in PCOS management, addressing both physiological and psychological aspects of the disorder. The clinical improvements observed in this study were particularly notable in terms of menstrual cycle regularity, acne severity, and hirsutism, which are some of the most distressing symptoms experienced by women with PCOS. The findings showed that participants who practiced yoga consistently over 12 weeks experienced improved menstrual regularity, reduced severity of acne, and decreased hirsutism. These benefits are likely mediated through hormonal regulation, as evidenced by significant reductions in serum testosterone levels and an improved LH-to-FSH ratio. This suggests that yoga may facilitate hormonal equilibrium, thereby enhancing ovarian function and alleviating hyperandrogenism. The observed hormonal changes are consistent with previous research, indicating that yoga has a modulating effect on the HPO axis, contributing to the normalization of reproductive hormone levels in PCOS patients. The metabolic benefits observed in this study are equally significant, as PCOS is strongly associated with insulin resistance and metabolic

dysfunction. The study demonstrated that participants experienced a reduction in BMI, waist-to-hip ratio, and an overall improvement in insulin sensitivity. These metabolic improvements may be attributed to the practice of specific yoga postures that stimulate pancreatic function, enhance glucose metabolism, and promote weight management. Regular yoga practice is known to enhance insulin receptor sensitivity and reduce fasting insulin levels, which are crucial factors in mitigating the risk of metabolic disorders such as type 2 diabetes and cardiovascular diseases in PCOS patients. Given the high prevalence of insulin resistance among women with PCOS, the positive impact of yoga on metabolic health underscores its potential as an effective intervention for long-term disease management. Psychological distress, including anxiety, depression, and emotional instability, is another critical aspect of PCOS that significantly affects quality of life. The present study demonstrated a substantial reduction in stress and anxiety levels among participants, suggesting that yoga serves as an effective tool for enhancing psychological well-being. Breathing techniques such as Anulom Vilom (Alternate Nostril Breathing) and Bhramari (Bee Breath) are known to activate the parasympathetic nervous system, thereby reducing sympathetic overactivity and lowering cortisol levels. Since chronic stress and elevated cortisol levels are implicated in exacerbating PCOS symptoms, the relaxation and mindfulness components of yoga may play a pivotal role in breaking the cycle of stress-induced hormonal imbalance. In addition, improved psychological well-being may enhance adherence to lifestyle modifications, further amplifying the benefits of yoga in managing PCOS holistically. The results of this study align with previous research demonstrating the effectiveness of yoga in PCOS management. For instance, several studies highlight the efficacy of yoga and holistic interventions in managing PCOS by improving endocrine, metabolic, and psychological parameters. Yoga has been shown to reduce free testosterone,^[29] LDL and triglycerides,^[30] and hirsutism and body circumference.^[31] It also improves weight, ovarian cysts, menstrual regularity, and emotional well-being.^[32] Lifestyle interventions, including yoga, significantly lower PCOS risk in adolescents^[33] and enhance metabolic markers such as glucose and insulin sensitivity.^[34] Compared to conventional exercise, yoga yields greater reductions in anti-Müllerian, LH, testosterone, and hirsutism.^[35] Kayakalpa practice supports hormonal balance and menstrual regularity^[36] while yoga enhances autonomic function.^[37] Ayurvedic interventions, including Vamana Karma and Siddha medicine, also show benefits in hormonal balance and menstrual health.^[38,39] In addition, yoga effectively reduces depression in some PCOS patients.^[40] Collectively, these findings emphasize yoga and holistic therapies as valuable adjuncts in PCOS management, addressing hormonal, metabolic, and psychological health. Furthermore, the findings of the present study further corroborate these reports, adding to the growing body of evidence supporting the integration of yoga into PCOS treatment regimens. The therapeutic effects of yoga on PCOS can be attributed to multiple physiological and biochemical mechanisms. One potential mechanism involves the regulation of the HPA axis, which plays a crucial role in stress response and hormone regulation. By reducing chronic stress responses, yoga may help in lowering excess androgen production, thereby improving symptoms such as hirsutism and acne. Furthermore, the practice of asanas enhances circulation to the pelvic region, promoting ovarian health and facilitating hormonal balance. In addition, yoga is known to reduce systemic inflammation and oxidative stress, both of which are key contributors to PCOS pathogenesis. By improving autonomic nervous system function and reducing inflammatory markers, yoga may provide long-term benefits in managing PCOS symptoms. Despite the promising findings, this study has certain limitations that

should be acknowledged. As a single-arm pilot trial, it lacks a control group, which limits the ability to definitively establish causation. In addition, the sample size, although statistically adequate, may not be representative of the broader PCOS population. The observed improvements directly align with the predefined outcome measures of clinical symptoms, hormonal profiles, metabolic parameters, and psychological well-being, highlighting yoga's multidimensional role in PCOS management. Future research should focus on randomized controlled trials (RCTs) with larger sample sizes and extended follow-up periods to assess the long-term efficacy of yoga in PCOS management. Furthermore, further investigations into the specific biochemical pathways influenced by yoga will provide deeper insights into its therapeutic mechanisms.

5. CONCLUSION

This single-arm pilot trial suggests that yoga may provide supportive benefits for women with PCOS, with observed improvements in clinical symptoms, hormonal profiles, metabolic parameters, and psychological well-being. However, these results should be regarded as preliminary due to the small sample size and the absence of a control group, which limit causal inference. Larger, well-designed RCTs are needed to validate these findings, establish efficacy, and clarify the long-term role of yoga as an adjunctive, non-pharmacological approach to PCOS management.

6. LIMITATIONS OF THE STUDY

The lack of a control group, small sample size ($n = 49$), self-reported data, and short duration (12 weeks) limit the generalizability and long-term assessment. Future studies should use randomized trials with larger, diverse populations and extended follow-ups. As this was a single-arm pilot trial without a control group, causal inference is limited, and findings should be considered preliminary and hypothesis-generating.

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8. AUTHORS' CONTRIBUTIONS

All authors made equal contributions to the conception, design, and execution of this article.

9. FUNDING SOURCE

None

10. ETHICAL APPROVALS

This study was approved by the Institutional Ethics Committee at Patanjali Research Foundation (IEC No: PAC/IEC/2023/6/15) on June 15, 2023, and was conducted following the Declaration of Helsinki. The study lasted 6 months, and written informed consent was obtained from all participants.

11. CONFLICTS OF INTEREST

All authors declare that they have no conflict of interest.

12. DATA AVAILABILITY

This manuscript is original, and all data are available solely for review purposes through the principal investigators.

13. PUBLISHER'S NOTE

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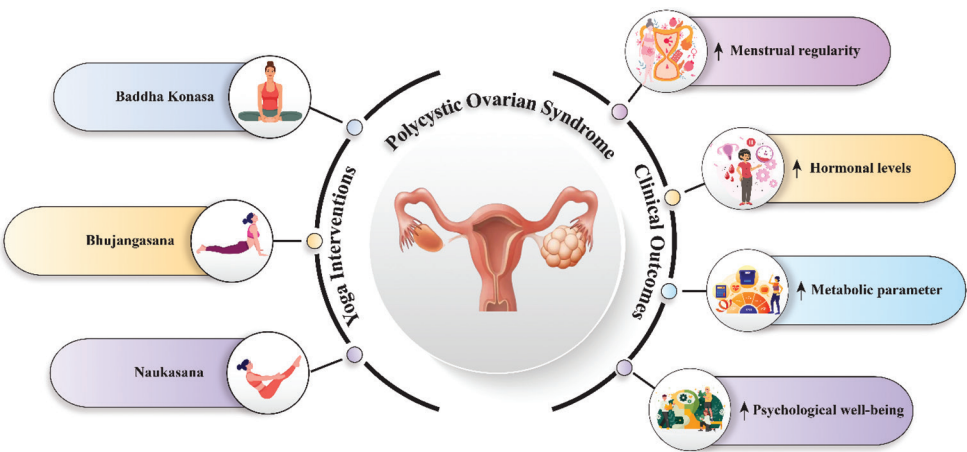


Figure 1: Clinical outcomes resulting from targeted yoga interventions in participants with polycystic ovarian syndrome

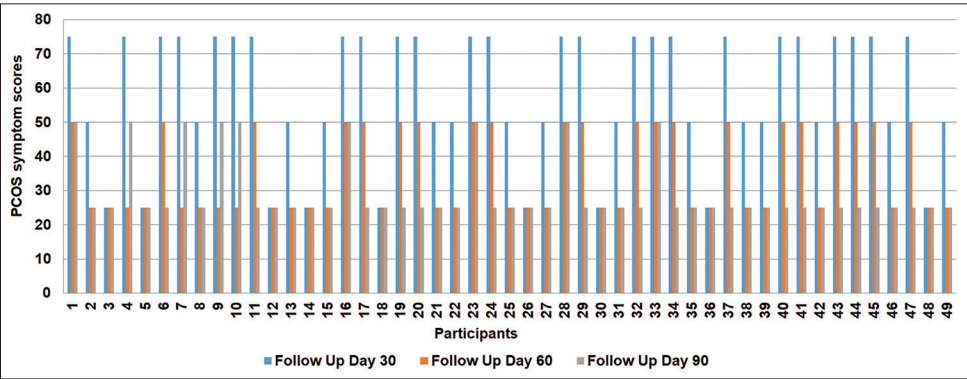


Figure 2: Effects of yoga practices on polycystic ovarian syndrome patients at different follow-up intervals, showing changes in symptom scores (menstrual irregularity, acne, and hirsutism)

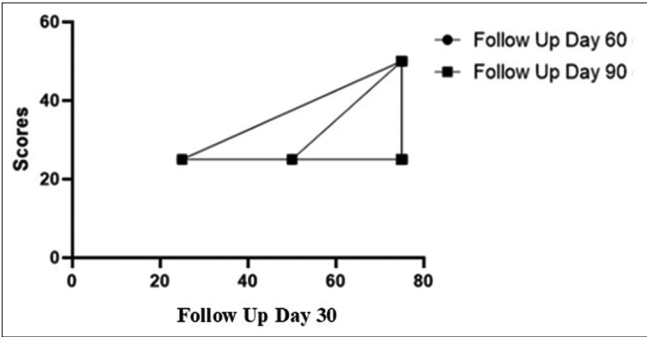


Figure 3: Line graph showing progressive improvement in overall polycystic ovarian syndrome symptom severity scores across follow-up intervals (days 30, 60, and 90)

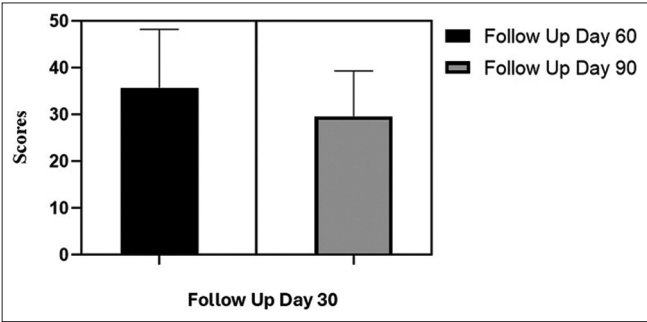


Figure 4: Effect of yoga on hormonal and metabolic outcome measures (testosterone, luteinizing hormone/follicle-stimulating hormone ratio, body mass index, and insulin sensitivity) in polycystic ovarian syndrome participants comparing follow-up day 60 and follow-up day 90, with error bars

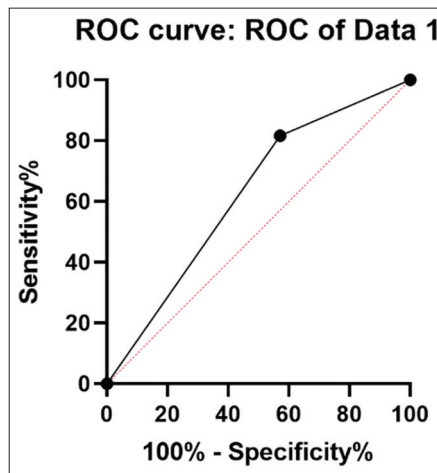


Figure 5: Receiver operating characteristic curve of pre- and post-yoga intervention data depicting sensitivity and specificity of quality of life (polycystic ovary syndrome questionnaire domains: Emotional well-being, body hair, weight concerns, infertility distress, menstrual irregularities)

Table 1: Structured yoga asanas and pranayama prescribed for PCOS participants during the 90-day observation period, targeting hormonal, metabolic, and psychological outcomes

Yoga practices	Description	Theoretical/Proposed Benefits in PCOS Management
Baddha Konasana (Butterfly Pose)	Seated posture with soles of feet together	May improve pelvic circulation; traditionally suggested to support reproductive health
Bhujangasana (Cobra Pose)	Backward bending posture	Potential role in improving posture and abdominal tone; believed to aid ovarian function
Naukasana (Boat Pose)	Core-strengthening posture	May enhance abdominal strength and metabolic regulation; suggested to support insulin sensitivity
Dhanurasana (Bow Pose)	Back-bending posture	Traditionally considered to stimulate abdominal organs and digestion; may help in metabolic balance
Supta Baddha Konasana (Reclining Bound Angle Pose)	Restorative lying posture	Promotes relaxation and parasympathetic activity; believed to reduce stress-related hormonal imbalance
Anulom Vilom (Alternate Nostril Breathing)	Pranayama technique	May calm the nervous system and reduce stress, indirectly supporting hormonal regulation
Bhramari (Bee Breath)	Pranayama with humming exhalation	Suggested to reduce anxiety and promote relaxation
Kapalbhati (Skull Shining Breath)	Rapid breathing practice	Traditionally believed to stimulate digestion and detoxification
Chakki Chalanasana (Churning the Mill Pose)	Seated circular trunk rotation	May enhance spinal flexibility and aid digestion
Shavasana (Corpse Pose)	Deep relaxation posture	Supports stress reduction, relaxation, and overall well-being

Table 2: Unpaired Student's *t*-test analysis of PCOS symptom severity scores (menstrual irregularity, acne, hirsutism) following yoga intervention

Analysis	
Column B	Follow-Up Day 90
vs.	
Column A	Follow-Up Day 60
Unpaired t-Test	
P value	0.0082**
Significantly different (p<0.05)?	Yes
One- or two-tailed <i>P</i> value?	Two-tailed
t, df	t=2.700, df=96
Differences	
Mean of Column A	35.71
Mean of Column B	29.59
Difference between means (B-A) ± SEM	-6.122±2.267
95% Confidence Interval	-10.62 to -1.622
R-squared (eta squared)	0.07059
F-Test to compare variances	
F, DFn, Dfd	1.633, 48, 48
P value	0.0925
Significantly different (p<0.05)	No
Data analysed	
Sample Size, Column A	49
Sample Size, Column B	49

Table 3: Descriptive statistical analysis of clinical, hormonal, metabolic, and psychological outcome measures across different follow-up intervals

Parameters	Follow Up Day 60	Follow Up Day 90
Number of values	49	49
Minimum	25	25
Maximum	50	50
Range	25	25
5% Percentile	25	25
95% Percentile	50	50
Mean	35.71	29.59
Std. Deviation	12.5	9.781
Std. Error of Mean	1.786	1.397
Skewness	0.2979	1.686
Kurtosis	-1.994	0.8763

Table 4: Area under the ROC curve (AUC) for PCOS participants with regular yoga practice, based on QoL (PCOSQ) scores

Area	0.6224
Std. Error	0.05683
95% confidence interval	0.5111 to 0.7338
p-value	0.0367
Data	
Controls (Follow-Up Day 60)	49
Patients (Follow-Up Day 90)	49
Missing Controls	0
Missing Patients	0