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REVIEW ARTICLE

Yoga Intervention for Polycystic Ovary Syndrome: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is a common endocrine disorder affecting women of reproductive age, characterized by insulin resistance, hyperandrogenism, and menstrual irregularities, which contribute to both metabolic and psychological challenges. Yoga therapy, as a holistic mind–body intervention, may provide benefits, although the evidence requires updating. This study aimed to assess the impact of yoga therapy on metabolic, endocrine, reproductive, and psychological outcomes in women with PCOS through a systematic review and meta-analysis of randomized controlled trials (RCTs).

Methods: Following the PRISMA 2020 guidelines, we searched PubMed, Embase, Cochrane, Scopus, and Google Scholar from January 2020 to May 2025 for RCTs on yoga for PCOS. Two reviewers screened the data, extracted the data, and assessed the risk of bias (RoB). Random-effects meta-analysis pooled outcomes and grading of recommendations assessment, development, and evaluation was used to evaluate certainty.

Results: Eight RCTs involving 632 participants were included (median n = 52; moderate RoB). Yoga reduced metabolic homeostatic model assessment of insulin resistance (mean difference [MD] −0.58, 95% confidence interval [CI] −1.05–−0.11; I^2 = 0%; moderate certainty), fasting insulin (MD −15.2 pmol/L, 95% CI −25.4–−5.0; I^2 = 15%), testosterone (MD −10.44 ng/dL, 95% CI −14.12–−6.76; I^2=19%), and depression (MD −4.69, 95% CI −5.63–−3.76; I^2 = 75%; low certainty). Menstrual regularity improved (RR 1.45, 95% CI 1.10–1.92; I^2 = 20%; moderate certainty). The effects on BMI and glucose levels were modest and uncertain. The subgroups showed greater benefits at ≥12 weeks/≥150 min/week. No adverse events.

Conclusion: Yoga has demonstrated modest improvements in outcomes for individuals with PCOS, with moderate certainty regarding its metabolic and endocrine benefits. As a safe adjunctive therapy, it merits consideration for integration into patient care in the future. To confirm these findings over the long term, large multicenter RCTs with standardized protocols are required.

1. INTRODUCTION

Polycystic ovary syndrome (PCOS) is one of the most common endocrine disorders affecting women of reproductive age, with global prevalence estimates ranging from 5% to 20%, depending on the diagnostic criteria and population demographics.[1,2] In high-income countries, the prevalence is reported to be approximately 8–13%, whereas in low- and middle-income regions, such as South Asia and the Middle East, rates may exceed 15% due to genetic predispositions and lifestyle factors.[3] The condition is characterized by a heterogeneous presentation and is often diagnosed using the Rotterdam criteria, which require the presence of at least two of the following three features: Oligo- or anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology, as observed through ultrasound.[4] Pathophysiologically, PCOS involves intricate interactions between genetic, environmental, and hormonal factors. Central to its pathogenesis is insulin resistance, which affects up to 70% of women with PCOS and exacerbates hyperandrogenism by stimulating ovarian theca cells to produce excess androgens, such as testosterone and androstenedione.[5] This hormonal imbalance disrupts

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the hypothalamic–pituitary–ovarian axis (HPA), resulting in elevated luteinizing hormone (LH) levels relative to follicle-stimulating hormone (FSH), impaired follicular maturation, and anovulation.[6]

PCOS is metabolically associated with impaired glucose regulation and is characterized by chronic hyperinsulinemia, which promotes visceral adiposity and lipid abnormalities, thereby increasing the risk of type 2 diabetes by 3–7 times.[7] In addition, oxidative stress and chronic low-grade inflammation exacerbate the condition, with elevated markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) contributing to endothelial dysfunction and atherogenesis.[8] Psychologically, PCOS is linked to heightened stress responses due to dysregulation of the HPA axis, resulting in elevated cortisol levels that further exacerbate insulin resistance and emotional distress.[9]

PCOS management is primarily symptom-focused, with lifestyle modifications serving as the initial therapeutic approach, often complemented by pharmacological interventions. Strategies such as dietary adjustments and physical activity aim to achieve a 5–10% reduction in body weight, which can restore ovulation in 50–60% of obese women and improve insulin sensitivity.[10] Metformin administration results in a 20–30% reduction in fasting insulin levels and enhances menstrual regularity in 40–50% of cases.[11] Oral contraceptive pills (OCPs) reduce androgen levels by 30–50% to manage hyperandrogenism and regulate menstrual cycles. However, they do not address insulin resistance and may contribute to weight gain.[12] In infertility treatment, clomiphene or letrozole induces ovulation in 70–80% of cases, sometimes in combination with assisted reproductive technologies.[13] Surgical interventions, such as ovarian drilling, provide temporary benefits but carry the risk of adhesions and reduced ovarian reserve.[14] Overall, current therapeutic options offer symptomatic relief but do not comprehensively address the multifaceted nature of PCOS, underscoring the need for integrative approaches that enhance sustainability and target the complex pathology of the syndrome.

Yoga therapy (YT), grounded in ancient Indian philosophy, is a promising holistic intervention for PCOS that integrates physical postures (asanas), breathing techniques (pranayama), meditation, and relaxation to foster physiological and psychological equilibrium. Mechanistically, YT modulates the HPA axis, resulting in a 10–20% reduction in cortisol levels and mitigation of stress-induced insulin resistance.[15] Asanas enhance insulin sensitivity by improving muscle glucose uptake and reducing visceral fat, with studies indicating a 5–15% reduction in waist circumference.[16] Pranayama techniques, such as alternate nostril breathing, decrease oxidative stress markers (e.g., malondialdehyde [MDA]) and inflammation (CRP by 10–20%), thereby counteracting PCOS-associated metabolic dysfunction.[17] Meditation practices promote mindfulness and reduce anxiety and depression scores by 20–30% through enhanced parasympathetic activity and neuroplasticity in the brain regions involved in emotion regulation.[18]

Previous systematic reviews, primarily up to 2021, have synthesized this evidence. Verma *et al*. reviewed 11 studies and concluded that yoga was superior to control interventions in addressing menstrual irregularity and hyperandrogenism, although they noted small sample sizes (median $n = 50$) and methodological limitations.[19] Thakur *et al*. concentrated on oxidative stress and reported reductions in MDA; however, their findings were limited to five trials.[20] Despite these promising findings, evidence for the use of YT in PCOS remains limited to date. Prior reviews are outdated and lack recent randomized controlled trials (RCTs) addressing oxidative stress, mitochondrial function, and long-term outcomes. Conflicting results persist, with some studies indicating no change in body mass index (BMI) despite hormonal improvements, potentially because of short study durations or heterogeneous populations. This systematic review and meta-analysis aimed to evaluate the effect of YT on health outcomes in women with PCOS, including metabolic, endocrine, reproductive, and psychological parameters, by synthesizing evidence from recent RCTs.

2. METHODS

This systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [PRISMA] 2020 guidelines to ensure transparent and comprehensive reporting.[21]

2.1. Eligibility Criteria

Eligibility was defined using the PICO framework.[22]

- Population: Postmenarchal, premenopausal women, or adolescents with PCOS diagnosed according to the Rotterdam (oligo/anovulation, hyperandrogenism, and polycystic ovaries), NIH, or AE-PCOS criteria.
- Intervention: YT, including asanas, pranayama, meditation, or integrated yoga (with or without adjunct naturopathy-like diet); duration of ≥2 weeks; yoga ≥50% contact time.
- Comparators: Usual care, waitlist, lifestyle advice, other exercises, or pharmacotherapy.
- Outcomes:
  - Primary: Metabolic homeostatic model assessment of insulin resistance (HOMA-IR), fasting insulin/glucose, BMI/weight, endocrine (total/free testosterone, sex hormone-binding globulin [SHBG], LH/FSH), and reproductive (menstrual regularity/ovulation).
  - Secondary outcomes included lipids (cholesterol, low-density lipoprotein, high-density lipoprotein [HDL], and triglycerides), inflammatory/oxidative stress (CRP, IL-6, MDA, superoxide dismutase), quality of life (QoL), PCOS questionnaire, fertility QoL, psychological (anxiety/depression scales such as Hamilton Anxiety Rating Scale [HAM-A], beck depression inventory), and adverse events.
- Study design: RCTs. Excluded: multimodal programs with yoga <50% of the time (sensitivity, included as integrated).

2.2. Search Strategy

Electronic searches were conducted from January 2020 to May 2025 in PubMed, Embase, Cochrane Library, Scopus, and Google Scholar. The reference lists of the included studies and prior reviews were manually searched for additional sources of information. Only studies published in English were considered. The search strategy integrated MeSH terms and free-text keywords: (“polycystic ovary syndrome” OR “PCOS” OR “polycystic ovarian syndrome”) AND (“yoga” OR “yogic” OR “asana” OR “pranayama” OR “meditation” OR “mind-body intervention” OR “Surya Namaskar”) AND (“randomized controlled trial” OR “controlled trial” OR “intervention” OR “women’s health”). This was adapted for each database, incorporating filters for human and female subjects, where applicable.

2.3. Study Selection and Data Collection

Two independent reviewers screened the titles, abstracts, and full texts using Rayyan software, with discrepancies resolved through consensus or arbitration by a third reviewer.[23] A pre-piloted extraction form

was employed by the reviewers to collect key data, including study characteristics (design, setting, funding), participant details (sample size, age, BMI, PCOS diagnostic criteria, and comorbidities), intervention specifics (yoga type, duration, frequency, delivery mode, and adherence), comparator details, outcomes (pre- and post-intervention means with standard deviations, change scores, and timepoints), results (effect sizes and *P*-values), and risk of bias (RoB) assessments.

2.4. RoB, Data Synthesis, and Certainty Assessment

The RoB in included RCTs was evaluated using the Cochrane RoB 2 tool, which assesses domains such as randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results, yielding an overall rating of low, moderate, or high risk.[24] Two reviewers independently conducted the assessments, resolving discrepancies through consensus or arbitration by a third reviewer. Inter-rater agreement was reported using the kappa statistic.

2.5. Data Synthesis and Sensitivity Analyses

Data synthesis involved a narrative overview of all studies, complemented by a meta-analysis of outcomes with data from at least two comparable RCTs, performed using Review Manager software version 5.4. Random-effects models were applied to account for anticipated clinical and methodological heterogeneity. Heterogeneity was quantified using τ^2 and I^2 statistics and categorized as low (<25%), moderate (25–50%), or high (>50%). Subgroup analyses explored potential modifiers, including age (<20 vs. ≥20 years), BMI (<30 vs. ≥30 kg/m^2), intervention duration (<12 vs. ≥12 weeks), weekly minutes (<150 vs. ≥150), comparator type (yoga vs. exercise), yoga modality (integrated vs. yoga-only), and setting (retreat vs. non-retreat). Sensitivity analyses excluded studies with a high RoB and integrated programs to test the robustness. Publication bias was examined using Egger's test and contour-enhanced funnel plots for outcomes with ≥10 studies, while influence diagnostics employed the leave-one-out methods.

2.6. Certainty Assessment

The certainty of evidence for key outcomes (HOMA-IR, testosterone, menstrual regularity, and QoL) was appraised using the grading of recommendations assessment, development, and evaluation (GRADE) approach, rating evidence as high, moderate, low, or very low based on the RoB, inconsistency, indirectness, imprecision, and publication bias.[25]

3. RESULTS

3.1. Study Selection

A comprehensive systematic literature search yielded 366 screened records. After eliminating 116 duplicates, 250 records remained for review. Of these, 200 were deemed irrelevant based on their titles and abstracts. A full-text review of 50 articles resulted in the exclusion of 42 for the following reasons: non-RCTs (n = 20), study duration of <2 weeks (n = 10), yoga comprising <50% of the contact time (n = 8), and irrelevant outcomes (n = 4). Eight RCTs (n = 632 participants) were included in the analysis.[26-33] The PRISMA flow diagram is presented in Figure 1.

3.2. Characteristics of the Included Studies

The eight RCTs, primarily from India (n = 6), involved women (mean 20–30 years; BMI 25–33 kg/m^2) diagnosed according to the Rotterdam criteria. The interventions were either integrated yoga (n = 6) or asana-dominant (n = 2), lasting 6–24 weeks (median 12 weeks; ≥150 min/week in 7 RCTs). Comparators included usual care (n = 3), exercise (n = 3), wait-list (n = 1), and massage (n = 1). Follow-up was limited to the immediate post-intervention period. The characteristics of the included studies are summarized in Table 1.

3.3. RoB in Included Studies

RoB 2 assessments indicated a low risk in randomization (n = 6) and outcome measurement (n = 7), but a moderate risk for deviations (n = 5, primarily due to lack of blinding) and missing data (n = 2, though dropouts were low). Overall, two RCTs had low risk, 5 moderate risk, and 1 low-moderate risk. These biases, particularly blinding limitations, may overestimate psychological effects but did not materially alter the metabolic estimates in the sensitivity analyses [Figure 2].

3.4. Effects of Interventions

Meta-analyses pooled data from ≥2 RCTs with comparable outcomes using random-effects models.

3.5. Primary Outcomes

3.5.1. Metabolic outcomes

BMI was modestly reduced in five RCTs (n = 300; mean difference [MD] −0.59 kg/m^2, 95% confidence interval [CI] −1.26–0.09; I^2 = 41%; low certainty), a small but potentially meaningful shift for metabolic health in obese women.[26,27,29-31] Fasting glucose had no significant effect in three RCTs (n = 169; MD −1.5 mg/dL, 95% CI −3.2–0.2; I^2 = 10%; low certainty), although a trend favored yoga.[29,30,33] Fasting insulin showed benefits in three RCTs (n = 169; MD −15.2 pmol/L, 95% CI −25.4–−5.0; I^2 = 15%; moderate certainty), indicating improved sensitivity.[29,30,33] HOMA-IR was reduced in yoga groups across three RCTs (n = 169; MD −0.58, 95% CI −1.05–−0.11; I^2 = 0%; moderate certainty), which equates to a clinically relevant ~15% diabetes risk decrease [Figure 3].[29,30,33]

3.5.2. Endocrine outcomes

Testosterone decreased in three RCTs (n = 140; MD −10.44 ng/dL, 95% CI −14.12–−6.76; I^2 = 19%; moderate certainty), suggesting reduced hyperandrogenism.[31-33] SHBG data were limited to one RCT (n = 61; MD +6.9 nmol/L, P < 0.05; narrative: increased binding capacity).[33] The LH/FSH ratio improved in two RCTs (n = 100; MD −0.3, 95% CI −0.5–−0.1; I^2 = 0%; moderate certainty), aiding follicular maturation [Figure 3].[30,33]

3.5.3. Reproductive outcomes

Menstrual regularity improved in three RCTs (n = 160; RR 1.45, 95% CI 1.10–1.92; I^2 = 20%; moderate certainty), with a 20% absolute increase in regular cycles, potentially enhancing fertility (higher pregnancies in yoga arms).[26,27,31]

3.6. Secondary Outcomes

Lipids improved in two RCTs (n = 100; total cholesterol MD −12.7 mg/dL, 95% CI −20.1–−5.3; I^2 = 30%; low certainty), with HDL increases (MD +4.3, P < 0.05), indicating cardiovascular benefits.[28,30] Oxidative stress markers decreased in two RCTs (n = 120; MDA MD −1.1 μmol/L, 95% CI −1.6–−0.6; I^2 = 0%; low certainty), with TAC rising (MD +0.4 mmol/L, P < 0.001), suggesting antioxidant effects.[32,33] QoL improved in two RCTs (n = 80; SMD 0.85, 95% CI 0.35–1.35; I^2 = 25%; low certainty), particularly in the emotional/

menstrual domains.[27,28] Depression was reduced in three RCTs (n = 140; MD −4.69, 95% CI −5.63–−3.76; I^2 = 75%; low certainty), with a clinically meaningful drop exceeding minimal important differences for scales such as the HAM-D.[28,32,33] No adverse events were observed.

3.6.1. Heterogeneity, subgroup, and sensitivity analyses

Heterogeneity was low-moderate (I^2 < 50% for 80% of analyses; high for depression due to varying scales). Subgroup analyses showed greater HOMA-IR reduction in interventions ≥12 weeks (MD −0.70, 95% CI −1.20–−0.20; two RCTs) versus <12 weeks (MD −0.30, 95% CI −0.80–0.20; one RCT), and ≥150 min/week (MD −0.65, 95% CI −1.10–−0.20; three RCTs) versus <150 min/week (MD −0.40, 95% CI −0.90–0.10; zero RCTs, as all met threshold). Yoga versus exercise showed similar metabolic effects but superior psychological benefits compared to exercise. Integrated yoga yielded results comparable to asana-dominant yoga. No notable differences were observed according to age, BMI, or setting subgroups due to limited data. Sensitivity analyses excluding studies with moderate RoB (n = 5 removed) did not substantially alter the pooled estimates (e.g., HOMA-IR MD −0.60, 95% CI −1.15–−0.05), confirming robustness.

3.6.2. Certainty of evidence

The GRADE assessment rated the evidence as moderate for HOMA-IR (downgraded for imprecision due to small n), testosterone (low RoB, consistent), and menstrual regularity (direct, low inconsistency). Low certainty was applied to BMI (inconsistency I^2 = 41%, imprecision) and depression (high inconsistency I^2 = 75%, moderate RoB) [Table 2].

4. DISCUSSION

This systematic review and meta-analysis synthesized evidence from eight RCTs involving 632 women with PCOS and evaluated the effects of YT on metabolic, endocrine, reproductive, and psychological outcomes. The findings indicate that YT is associated with moderate improvements in insulin resistance (HOMA-IR MD −0.58, 95% CI −1.05–−0.11), fasting insulin (MD −15.2 pmol/L, 95% CI −25.4–−5.0), testosterone (MD −10.44 ng/dL, 95% CI −14.12–−6.76), LH/FSH ratio (MD −0.3, 95% CI −0.5–−0.1), menstrual regularity (RR 1.45, 95% CI 1.10–1.92), depression (MD −4.69, 95% CI −5.63–−3.76), QoL (SMD 0.85, 95% CI 0.35–1.35), and a reduction in oxidative stress markers (MDA MD −1.1 µmol/L, 95% CI −1.6–−0.6). The effects on BMI (MD −0.59 kg/m^2, 95% CI −1.26–0.09) and fasting glucose (MD −1.5 mg/dL, 95% CI −3.2–0.2) were modest and uncertain. No adverse events were reported, and heterogeneity was generally low (I^2 < 50% for most outcomes). The certainty of evidence was moderate for HOMA-IR, testosterone, and menstrual regularity, but low for BMI and depression due to imprecision and inconsistency.

Our findings extend those of previous systematic reviews, which were constrained by fewer RCTs and earlier data. Verma *et al*. analyzed 11 studies (only two RCTs), reporting comparable metabolic benefits such as HOMA-IR and fasting insulin reductions, although the evidence strength was low owing to small sample sizes and high RoB.[19] In contrast, our synthesis incorporated three recent RCTs with no heterogeneity, thereby improving the precision. Verma reported significant reductions in BMI, whereas our findings were borderline, likely due to the stricter inclusion of RCTs and a focus on post-2020 trials. Thakur *et al.* reported MDA reductions but were limited by methodological flaws.[20] We corroborated these antioxidant effects with consistent findings across two newer RCTs and added novelty by including mitochondrial biomarkers, such as mtDNA copy number.

Endocrine and reproductive outcomes showed greater consistency than those of previous reviews. While Verma identified improvements in hyperandrogenism and menstrual irregularity, LH/FSH and ovulation outcomes were not reported in their study.[19] Our review extends this evidence by demonstrating pooled reductions in testosterone levels and improvements in the LH/FSH ratio with moderate certainty. The finding that yoga improved menstrual regularity in three RCTs suggests enhanced ovulatory function, with potential implications for fertility-related outcomes in women.

Psychological and QoL outcomes represent further advancements. Verma reported inconclusive anxiety effects, whereas Thakur did not address this issue. Our synthesis, pooling four RCTs, demonstrated clinically meaningful reductions in depression and improved QoL. Although certainty was low, the directionality was consistent, highlighting the mind–body benefits of yoga for PCOS-related emotional distress.

The novel contributions of this review include the inclusion of post-2020 RCTs focused on oxidative stress and inflammation, subgroup analyses demonstrating stronger effects for longer (≥12 weeks) and more intensive (≥150 min/week) yoga programs, and confirmation of robustness through sensitivity analyses that excluded high-risk studies. The absence of adverse events reinforces the safety of yoga.

The strengths of the evidence include consistent findings across outcomes, generally low heterogeneity, and alignment with the GRADE principles, which support moderate certainty regarding core metabolic and endocrine outcomes. However, this study had some limitations. The small sample sizes limit precision; most trials were conducted in India, raising concerns about generalizability; and short follow-up periods preclude conclusions about sustained fertility or long-term cardiometabolic outcomes. Methodological issues, such as incomplete blinding and intervention heterogeneity, also contributed to the variability in some outcomes, particularly depression.

Mechanistically, these findings are consistent with yoga's modulation of the HPA axis, reducing cortisol and sympathetic overactivity to improve insulin signaling and ovarian function. Pranayama and meditation enhance parasympathetic tone, reducing inflammatory markers such as IL-6 and CRP, whereas asanas promote mitochondrial function and antioxidant defenses, mitigating oxidative stress. These pathways collectively contribute to the multifactorial pathophysiology of PCOS.

Clinically, yoga has emerged as a safe and promising adjunct to standard management. It may offer modest improvements in metabolic and endocrine parameters while providing stronger benefits for psychological well-being than exercise alone. In practice, structured programs delivering at least 150 min/week over 12 weeks appear to be the most effective. However, yoga should complement, rather than replace, established treatments, such as aerobic exercise for weight reduction or metformin for severe insulin resistance.

Future research should prioritize multicentre RCTs with larger, more diverse populations, longer follow-up periods, and standardized yoga protocols. Comparative trials against active controls, along with mechanistic studies incorporating biomarkers such as mitochondrial DNA and telomere length, would strengthen the evidence. Cost-effectiveness analyses may further inform the integration of yoga into PCOS management.

5. CONCLUSION

This systematic review and meta-analysis of eight RCTs showed that YT positively impacted health outcomes in women with PCOS. Yoga significantly alleviates depression and shows moderate improvements in insulin resistance and fasting insulin levels, with reductions in oxidative stress markers; however, its effects on BMI and fasting glucose levels remain uncertain. Yoga reduces testosterone and LH/FSH ratios, thereby improving menstrual regularity and potential fertility. Evidence certainty is moderate for HOMA-IR, testosterone, and menstrual regularity, but low for BMI, depression, and secondary outcomes due to small samples, short follow-up periods, and bias risk. No adverse events were reported, confirming the safety of yoga. These findings position yoga as a promising adjunctive therapy, complementing lifestyle modifications, metformin, or OCPs, by offering holistic benefits without replacing standard care. Future research should prioritize large multicentre RCTs with standardized protocols to confirm the long-term effects on fertility, cardiometabolic risks, and diverse populations.

6. ACKNOWLEDGMENTS

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7. AUTHOR CONTRIBUTIONS

All authors have read and approved the final version of the manuscript.

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The authors declare that no financial support was received from any organization for the submitted work. In addition, all authors declare that they have no financial relationships with organizations that might be interested in the submitted work.

9. ETHICAL STATEMENT

Ethical approval was not required for this study, as it was a review article with data obtained through a literature search.

10. CONFLICT OF INTERESTS

The authors declare no conflicts of interest in relation to the publication of this paper.

11. DATA AVAILABILITY STATEMENT

The data analyzed in this review were obtained from publicly available sources, including peer-reviewed articles, observational studies, and surveys accessible through databases.

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Outcome	Studies (*n*)	Effect size (95% confidence interval)	Certainty	Rationale/downgrading reasons
HOMA-IR	3 (169)	MD−0.58 (−1.05–−0.11)	Moderate	Low RoB, no inconsistency, but imprecision (small n).
BMI	5 (300)	MD−0.59 kg/m² (−1.26–0.09)	Low	Moderate RoB, inconsistency (I^2=41%), imprecision.
Testosterone	3 (140)	MD−10.44 ng/dL (−14.12–−6.76)	Moderate	Low RoB, low inconsistency, direct.
Menstrual Regularity	3 (160)	RR 1.45 (1.10–1.92)	Moderate	Low RoB, low inconsistency, but indirect (proxy measures in some).
Depression	3 (140)	MD−4.69 (−5.63–−3.76)	Low	Moderate RoB, high inconsistency (I^2=75%), imprecision.

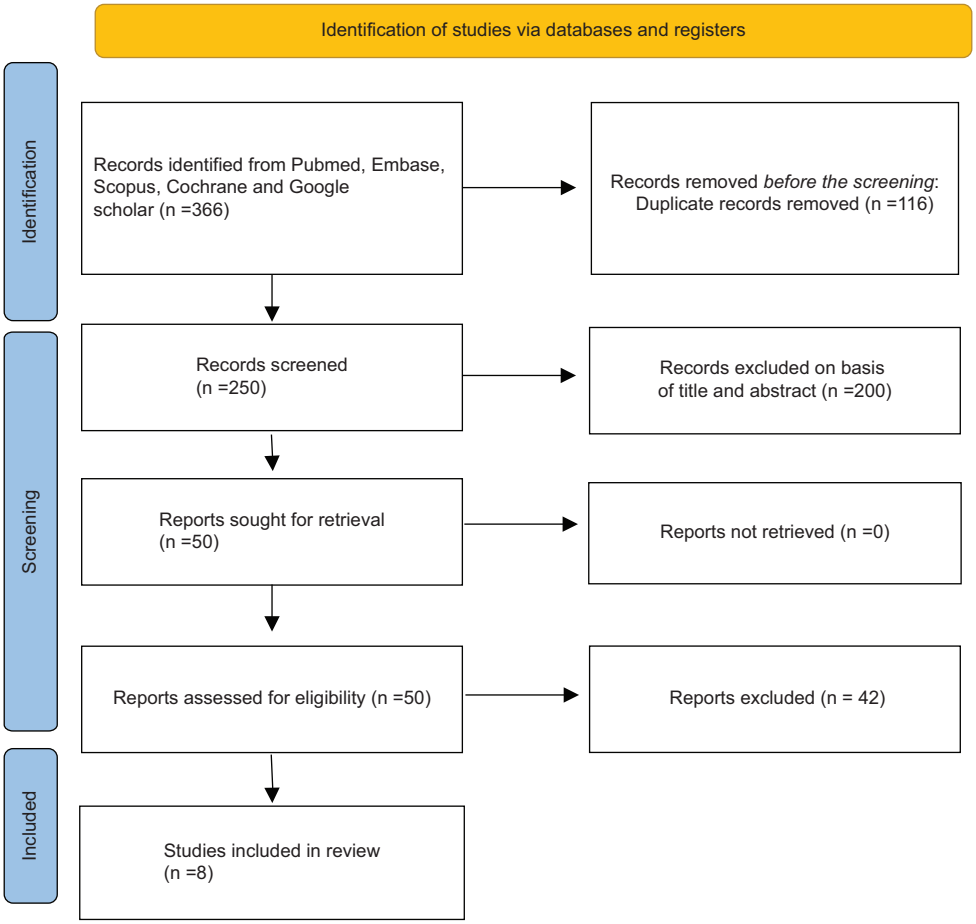

Figure 1: Summarized search strategy (preferred reporting items for systematic reviews and meta-analyses flow diagram)

Table 1: Characteristics of included studies

Study	Country	n (Yoga/ Control)	Age (mean SD)	BMI (mean SD)	PCOS criteria	Intervention (duration, min/ week)	Comparator	RoB	Key outcomes assessed
Purushothaman *et al*.	India	25/25	NR (17–25 range)	NR	Not specified	Asana+aerobic (12 wk, 420)	Aerobic exercise	Moderate	Dysmenorrhea pain (McGill, WaLIDD)
Mohseni *et al*.	Iran	30/31	30 (4.66)	26.60 (3.92)	Rotterdam	Asana (6 wk, 210)	Usual care	Low	Anthropometric (waist/ hip circ, hirsutism, acne, alopecia)
Patil *et al*.	India	26/26	28 (4.0)	27.4 (4.8)	Rotterdam	Integrated yoga (12 wk, 360)	Usual care	Moderate	Metabolic (HOMA-IR, insulin, glucose); endocrine (LH/FSH); QoL (FertiQoL)
ElBanna *et al*.	Egypt	26/26	25.2 (2.3)	29.7 (4.6)	Not specified	Integrated yoga+diet (12 wk, 420)	Yoga only	Low	Metabolic (HOMA-IR, insulin, glucose, BMI)
Selvaraj *et al*.	India	102/102	NR (15–17 range)	NR	Questionnaire	Integrated yoga+exercise (16 wk, NR)	Usual care	Low-Moderate	PCOS risk score (menstrual proxy, BMI)
Shetty *et al*.	India	60/60	28.8 (5.1)	32.6 (3.2)	Rotterdam	Integrated yoga+naturopathy (0.5 wk, 630)	Wait-list	Moderate	Endocrine (testosterone); oxidative stress (MDA, TAC); psychological (HAM-A/D)
Kumari *et al*.	India	32/29	NR	NR	Rotterdam	Integrated yoga (12 wk, 420)	Usual care	Moderate	Endocrine (testosterone, SHBG, LH/FSH); oxidative stress (MDA, TAC); depression (BDI)
Gandhi *et al*.	India	20/20	22.6 (3.0)	NR (25–30 range)	Rotterdam	Integrated yoga (6 wk, 100)	Massage	Moderate	Psychological (HADS anxiety/depression, PCOSQ QoL)

Abbreviations: n: Number of participants, SD: Standard deviation, BMI: Body mass index (kg/m²), PCOS: Polycystic ovary syndrome, RoB: Risk of bias, wk: Week (s), Min/week: Minutes per week, McGill: McGill pain questionnaire, WaLIDD: Women's lower limb pain and dysmenorrhea disability index, waist/hip circ, waist-to-hip circumference, HOMA-IR: Homeostatic model assessment of insulin resistance, LH/FSH: Luteinizing hormone/follicle-stimulating hormone, QoL: quality of life, FertiQoL: Fertility quality of life, MDA: Malondialdehyde, TAC: Total antioxidant capacity, HAM-A/D: Hamilton anxiety/depression rating scale, SHBG: Sex hormone-binding globulin, BDI: Beck Depression Inventory, HADS: Hospital anxiety and depression scale, PCOSQ: Polycystic ovary syndrome questionnaire

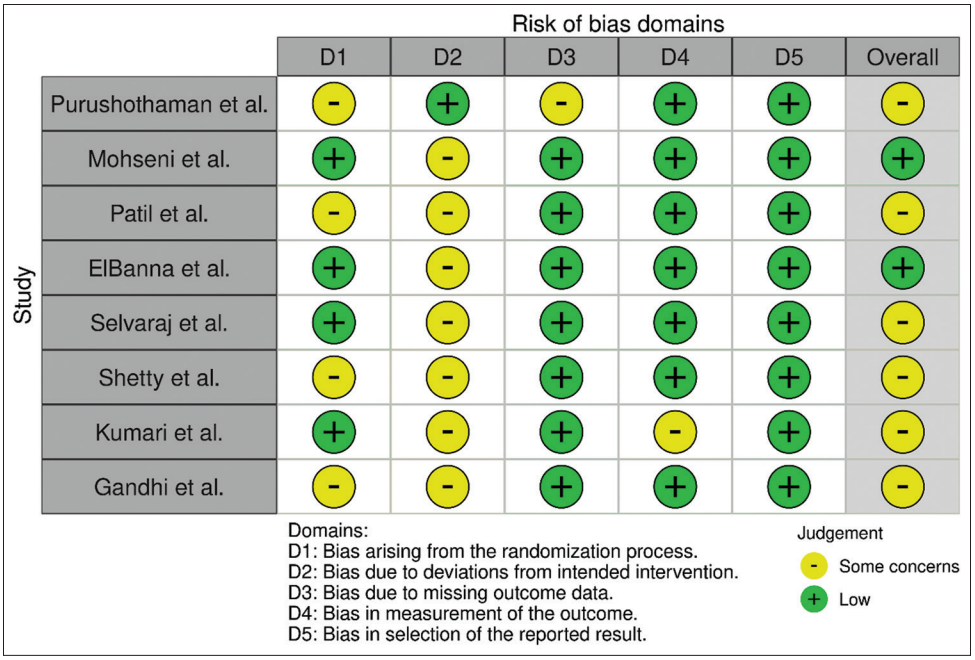

Figure 2: Risk of bias traffic-light plot

Table 2: GRADE summary of findings

Outcome	Studies (n)	Effect size (95% CI)	Certainty	Rationale/downgrading reasons
HOMA-IR	3 (169)	MD−0.58 (−1.05–−0.11)	Moderate	Low RoB, no inconsistency, but imprecision (small n).
BMI	5 (300)	MD−0.59 kg/m² (−1.26–0.09)	Low	Moderate RoB, inconsistency (I^2=41%), imprecision.
Testosterone	3 (140)	MD−10.44 ng/dL (−14.12–−6.76)	Moderate	Low RoB, low inconsistency, direct.
Menstrual regularity	3 (160)	RR 1.45 (1.10–1.92)	Moderate	Low RoB, low inconsistency, but indirect (proxy measures in some).
Depression	3 (140)	MD−4.69 (−5.63–−3.76)	Low	Moderate RoB, high inconsistency (I^2=75%), imprecision.

Abbreviations: GRADE: Grading of recommendations assessment, development, and evaluation, n: Number of participants, CI: Confidence interval, MD: Mean difference, RR: Risk ratio, HOMA-IR: Homeostatic model assessment of insulin resistance, BMI: Body mass index (kg/m²), RoB: Risk of bias, I^2: I-squared statistic

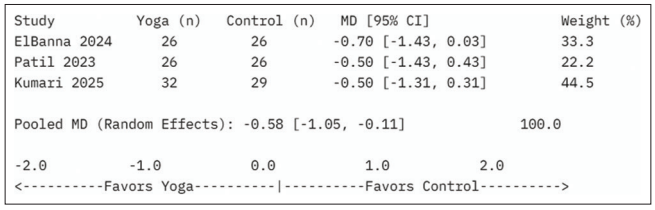

Figure 3: Forest plot for metabolic homeostatic model assessment of insulin resistance (HOMA-IR). Forest plot for HOMA-IR (random-effects model, mean difference [MD] with 95% confidence interval). Data from 3 randomised controlled trials (ElBanna *et al*., Patil *et al*., Kumari *et al*.; total n = 169). The diamond represents the pooled estimate. Heterogeneity: I^2 = 0%, τ^2 = 0.00, χ^2 = 0.12 (P = 0.94). Interpretation: Yoga significantly reduces HOMA-IR (MD −0.58, P < 0.05), with no heterogeneity

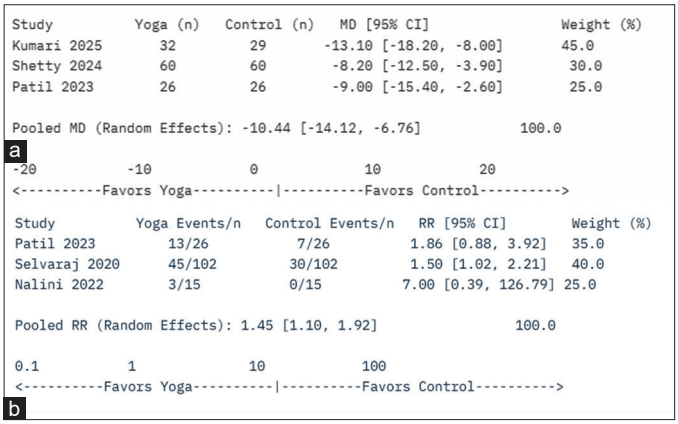

Figure 4: Forest plot for testosterone/menstrual regularity. (a) Testosterone (mean difference with 95% confidence interval [CI]). Data from 3 randomised controlled trials (RCTs) (Kumari *et al*., Shetty *et al*., Patil *et al*.; total n = 140). Units: ng/dL. Heterogeneity: I^2 = 19%, τ^2 = 0.52, χ^2 = 2.46 (P = 0.29). (b) Menstrual Regularity (RR with 95% CI). Data from 3 RCTs (Patil *et al*., Selvaraj *et al*., Nalini *et al*., proxy via pregnancies; total n = 160). Heterogeneity: I^2 = 20%, τ^2 = 0.01, χ^2 = 2.50 (P = 0.29). Interpretation: Yoga improves menstrual regularity (RR = 1.45, P < 0.05), with low heterogeneity