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Impact of a Yoga Protocol Combining Bhramari Pranayama and Chakra Meditation on Stress Perception, Sleep, Quality of Life, and Neuroendocrine Status in Peri-menopausal Women A Randomized Controlled Trial

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ABSTRACT:

Background: The perimenopausal transition is a demanding phase marked by heightened psychological strain, reduced life quality, disturbed sleep, and disrupted neuroendocrine function. Although hormone replacement therapy remains the standard medical option, there is expanding interest in mind-body approaches as complementary strategies. Still, well-designed randomized trials examining the joint effects of Bhramari Pranayama and Chakra Meditation on combined psychological and hormonal outcomes in this population remain scarce.

Objective: To assess how a 12-week yoga program built around Bhramari Pranayama and Chakra Meditation affects perceived stress, quality of life, sleep, severity of menopausal symptoms, and fasting serum cortisol in peri-menopausal women.

Methods: This single-blind, two-arm, parallel randomized trial recruited 80 peri-menopausal women (40–55 years) at [Institution]. Participants were assigned either to a yoga arm (n=40; combined Bhramari Pranayama and Chakra Meditation, 45 minutes daily, five days weekly, for 12 weeks) or a control arm (n=40; usual care, no structured intervention). The two primary endpoints were the Perceived Stress Scale (PSS-10) and

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the WHOQOL-BREF; secondary endpoints included the Pittsburgh Sleep Quality Index (PSQI), the Menopause Rating Scale (MRS), and fasting serum cortisol, measured at entry and at week 12. Repeated-measures ANOVA was applied under an intention-to-treat framework.

Results: Of the 80 women enrolled, 74 (37 in each arm) completed the trial, an attrition rate of 7.5%. PSS scores fell substantially in the yoga arm (22.45±4.12 at baseline to 14.32±3.67 at week 12; $p<0.001$; Cohen's $d=2.08$), whereas the control arm changed little (21.89±3.98 to 20.76±4.21; $p=0.162$). Every WHOQOL-BREF domain improved in the yoga arm (all $p<0.001$), with the psychological domain showing the biggest gain (48.6±10.1 rising to 61.3±9.4; partial $\eta^2=0.24$). Global PSQI scores fell from 9.86±2.87 to 5.43±2.12 in the yoga arm ($p<0.001$). MRS totals dropped sharply, from 24.67±5.34 to 15.43±4.21 ($p<0.001$; partial $\eta^2=0.26$). Fasting cortisol declined in the yoga arm (18.92±4.56 to 13.67±3.89 μg/dL; $p<0.001$) with no meaningful shift among controls. Every Group×Time interaction reached significance ($p<0.01$), with medium-to-large effect sizes throughout.

Conclusion: Over 12 weeks, this combined Bhramari Pranayama–Chakra Meditation program produced meaningful gains in stress levels, life quality, sleep, menopausal symptom burden, and cortisol regulation among peri-menopausal women. The results lend support to structured yoga programs as a viable complementary option for addressing the combined psychological and hormonal strain of this life stage.

1. INTRODUCTION

Perimenopause marks a major bio-psycho-social shift in the reproductive lifespan of women, generally unfolding between the ages of 40 and 55 as ovarian hormone output becomes erratic on the path toward menopause [1]. Lasting anywhere from four to ten years, this window commonly brings a mix of vasomotor, physical, emotional, and urogenital complaints that meaningfully erode day-to-day functioning and general wellbeing [2]. Projections from the World Health Organization suggest that close to 1.5 billion women worldwide will have reached post-menopausal status by 2030, which highlights why effective care during this transition matters from a public-health standpoint [3].

Mental and emotional strain during perimenopause is drawing growing clinical attention [4]. Population data suggest that somewhere between 45% and 68% of women in this phase report clinically meaningful stress levels, and 40–60% describe worsening quality of life spanning physical, psychological, social, and environmental dimensions [5]. As estradiol and progesterone decline, the hypothalamic-pituitary-adrenal (HPA) axis is thrown off balance, producing irregular cortisol patterns, heightened reactivity to stressors, and weakened neuroendocrine stability [6]. These hormonal disturbances feed into sleep problems affecting an estimated 39–47% of peri-menopausal women, setting up a self-reinforcing loop among stress, poor sleep, and reduced quality of life [7].

Standard treatment for perimenopausal complaints centers on hormone replacement therapy (HRT) and selective serotonin reuptake inhibitors (SSRIs) [8]. Although these can relieve vasomotor complaints, HRT is linked to recognized risks — thromboembolic events, breast cancer, and cardiovascular complications — especially with extended use [9]. Drug-based treatments, moreover, tend to leave the broader psychosocial dimensions of perimenopause — stress, quality of life, and sleep disruption — largely unaddressed [10]. This gap in care has fueled interest in integrative, evidence-supported approaches capable of addressing the fuller range of needs peri-menopausal women experience.

Yoga, a mind-body discipline with roots stretching back some 5,000 years in India, has become a widely studied complementary option for menopausal symptom management thanks to its effects across multiple physiological systems [11]. Two techniques within the yogic tradition — Bhramari Pranayama (the "humming bee" breath) and Chakra Meditation (meditation centered on the body's energy centers) — are mechanistically distinct yet potentially complementary [12]. Bhramari Pranayama pairs slow nasal exhalation with an audible hum, a practice believed to stimulate the vagus nerve, shift

autonomic balance toward parasympathetic dominance, and engage limbic structures via sound resonance in the sinus cavities [13,14]. Chakra Meditation, rooted in the concept of energy centers running along the spine, uses guided visualization and breath awareness to engage the prefrontal cortex, dampen amygdala responsiveness, and strengthen interoceptive awareness [15].

There is a plausible neurobiological case for pairing these two practices. Bhramari Pranayama has been associated with improved vagal tone, reduced sympathetic drive, lowered salivary cortisol, and increased alpha-wave activity on EEG recordings [16–19]. Chakra Meditation, built around progressive body-awareness and visualization, has separately shown benefits for psychological wellbeing, stress appraisal, and emotion regulation [20]. Together, the two practices may act on distinct arms of the stress-response system at once — Bhramari Pranayama via bottom-up vagal signaling, and Chakra Meditation via top-down cortical regulation of limbic and HPA-axis activity.

Even with an expanding evidence base connecting yoga to menopausal symptom relief, important gaps persist. Many studies rely on broad, undifferentiated yoga routines without isolating the distinct contributions of specific pranayama or meditation techniques. Few trials, moreover, have tracked stress, quality of life, sleep, symptom severity, and an objective neuroendocrine marker together within one cohort using validated tools [21–23]. The scarcity of adequately powered, methodologically sound randomized trials continues to constrain how confidently this evidence can inform clinical guidance.

Against this backdrop, the present randomized controlled trial was designed to examine how a structured 12-week program combining Bhramari Pranayama and Chakra Meditation affects perceived stress (PSS-10), quality of life (WHOQOL-BREF), sleep (PSQI), menopausal symptom severity (MRS), and fasting serum cortisol among peri-menopausal women. We anticipated that participants receiving the yoga program would show significantly greater gains across every outcome relative to those receiving routine care, with effect sizes of clinical relevance.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This prospective, single-blind, parallel two-arm randomized controlled trial took place in Chennai, India, from September through November 2025. Ethical clearance was granted by the Institutional Ethics Committee (Approval No: MAHER/IEC/PhD/113/APRIL25), and the trial was registered with the Clinical Trial Registry of India (CTRI/2025/08/093425). Conduct followed the 2013 revision of the Declaration of Helsinki, and reporting adhered to the CONSORT 2010 guidelines.

2.2 Participants

2.2.1 Inclusion Criteria

Eligible participants were women aged 40–55 in the peri-menopausal stage per STRAW+10 criteria, reporting menstrual cycle irregularity (a swing of ≥7 days in cycle length, or ≥2 missed cycles within the preceding year), willing to commit to the full 12-week protocol, capable of giving written informed consent, and cleared by the study physician as physically able to undertake yoga practice.

2.2.2 Exclusion Criteria

Women were excluded for surgical menopause or premature ovarian failure; recent (within six months) or ongoing use of hormone replacement therapy, psychotropic medication, or corticosteroids; a diagnosed psychiatric condition per DSM-5; uncontrolled thyroid or adrenal disease; an existing yoga or meditation practice exceeding two sessions weekly over the prior six months; chronic pain or musculoskeletal conditions incompatible with yoga; or enrollment in another clinical trial within the previous three months.

2.3 Sample Size Calculation

The required sample size was determined in advance with G*Power 3.1, based on the PSS-10 as the primary endpoint. Using an anticipated Cohen's d of 0.65 drawn from prior literature, 80% power, a two-tailed alpha of 0.05, and a projected 15% attrition rate, the calculation indicated a need for at least 40 participants per arm (n=80 overall) [24].

2.4 Randomization and Blinding

Group allocation (1:1) used a computer-generated randomization sequence with block sizes of four, prepared by a statistician independent of the study team. Sequentially numbered, sealed, opaque envelopes preserved allocation concealment. Given the nature of the intervention, blinding participants and yoga instructors was not possible; however, those assessing outcomes and the statistician conducting the analysis remained unaware of group assignment.

2.5 Intervention

2.5.1 Yoga Intervention Group

Women in the yoga arm followed a structured 12-week program led by a certified yoga therapist with over a decade of clinical teaching experience, comprising 45-minute sessions held five days a week. Each session opened with a brief prayer and centering period (3 minutes), followed by light warm-up stretches (5 minutes), Bhramari Pranayama with Shanmukhi Mudra — ten cycles, with exhalation duration progressively extended from 5 to 15 seconds across the 12 weeks (15 minutes) — guided Chakra Meditation moving sequentially through the seven primary energy centers alongside synchronized breathing and mantra repetition (17 minutes), and a closing relaxation period in Shavasana (5 minutes). Session attendance logs and weekly phone check-ins tracked adherence, and participants also kept a home-practice diary.

2.5.2 Control Group

Women assigned to the control arm continued their usual daily routines and any standard medical care already in place, and were asked not to begin any new exercise, yoga, meditation, or relaxation regimen during the study window. To support retention, these participants were offered the yoga program once the trial concluded.

2.6 Outcome Measures

2.6.1 Primary Outcomes

Perceived Stress Scale (PSS-10): This 10-item self-report tool, developed by Cohen and colleagues in 1983, captures how strongly recent life circumstances are experienced as stressful. Responses use a 5-point scale (0 = never to 4 = very often), producing a total score from 0 to 40, where higher values reflect greater perceived stress; ranges of 0–13, 14–26, and 27–40 correspond to low, moderate, and high stress respectively. Internal consistency in Indian samples has been reported between 0.82 and 0.91 (Cronbach's alpha) [25].

WHO Quality of Life-BREF (WHOQOL-BREF): This 26-item WHO-developed self-report instrument covers four domains — Physical Health (7 items), Psychological Health (6 items), Social Relationships (3 items), and Environment (8 items) — along with two general items on overall quality of life and health satisfaction. Each domain is rescaled to 0–100, with higher scores denoting better quality of life. Reliability in Indian populations has been reported at 0.68–0.82 across domains [26].

2.6.2 Secondary Outcomes

Pittsburgh Sleep Quality Index (PSQI): A 19-item self-report measure covering the past month's sleep, producing seven component scores — subjective quality, latency, duration, habitual efficiency, disturbances, medication use, and daytime dysfunction — each rated 0–3, summing to a global score of 0–21; scores above 5 indicate poor sleep. Reported sensitivity and specificity for distinguishing poor from good sleepers are 89.6% and 86.5% respectively [27].

Menopause Rating Scale (MRS): An 11-item self-report tool spanning somatic-vegetative (4 items: hot flushes, cardiac complaints, sleep difficulty, joint/muscle discomfort), psychological (4 items: low mood, irritability, anxiety, exhaustion), and urogenital (3 items: sexual difficulties, bladder issues, vaginal dryness) domains. Items are scored 0–4, giving a total range of 0–44, with higher totals reflecting more severe symptoms [28].

Serum Cortisol: Fasting blood samples (5 mL) were drawn between 7 and 9 a.m. to control for diurnal variation, with cortisol quantified via electrochemiluminescence immunoassay (Cobas e411, Roche Diagnostics, Mannheim, Germany). The morning reference range used was 6.2–19.4 μg/dL, with intra- and inter-assay coefficients of variation below 5% and 7% respectively.

2.7 Statistical Analysis

Analyses were run in IBM SPSS Statistics v26.0 and R v4.3.1. The Shapiro-Wilk test and Q-Q plots were used to check normality. Baseline group comparisons used independent-samples t-tests for continuous data and chi-square tests for categorical data. The core analysis was a 2×2 (Group × Time) repeated-measures ANOVA with Bonferroni-corrected post-hoc tests, alongside paired t-tests for within-group change. Effect sizes were reported as Cohen's d for within-group comparisons and partial eta-squared for interaction effects. Pearson correlations examined relationships among outcomes. The primary analytic approach was intention-to-treat with last-observation-carried-forward imputation, supported by a per-protocol analysis. Statistical significance was set at a two-tailed $p<0.05$, with Benjamini-Hochberg correction applied for multiple comparisons.

3. RESULTS

3.1 Participant Flow and Baseline Characteristics

Of 128 women screened, 80 satisfied eligibility criteria and were randomized in equal numbers to each arm. Six participants did not complete the study: three from the yoga arm (two relocated or had competing family obligations, one withdrew due to time constraints) and three from the control arm (all lost to follow-up). This left 37 participants per arm at study end, for an overall retention of 92.5%; the CONSORT flow is depicted in Figure 1.

Figure 1. CONSORT 2010 flow diagram depicting enrollment, allocation, follow-up, and analysis.

Table 1 shows that baseline demographic and clinical variables did not differ meaningfully between arms (all $p>0.05$), consistent with successful randomization. Across the full sample, mean age was 47.1±3.3 years and mean BMI was 26.2±3.0 kg/m², and starting scores on all outcome measures were similar between groups.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Yoga Group (n=40)	Control Group (n=40)	p-value
Age (years)	47.32 ± 3.21	46.89 ± 3.45	0.567
BMI (kg/m²)	26.45 ± 3.12	25.98 ± 2.87	0.489
Years since LMP	2.34 ± 1.12	2.56 ± 1.23	0.421
Parity	2.1 ± 0.8	2.0 ± 0.9	0.612
Education (years)	14.2 ± 2.8	13.9 ± 3.1	0.654
Employed, n (%)	28 (70.0%)	26 (65.0%)	0.631
Married, n (%)	34 (85.0%)	32 (80.0%)	0.556
PSS Score	22.45 ± 4.12	21.89 ± 3.98	0.534
WHOQOL-BREF Total	53.62 ± 8.34	53.18 ± 7.92	0.812
PSQI Global Score	9.86 ± 2.87	9.54 ± 2.74	0.612
Serum Cortisol (µg/dL)	18.92 ± 4.56	18.45 ± 4.23	0.634
MRS Total Score	24.67 ± 5.34	23.89 ± 5.12	0.512

Values expressed as Mean ± SD or n (%); p-values from independent t-test or chi-square test.

3.2 Adherence

Average session attendance among yoga-arm participants was 87.3±8.2% (range 72–98%), with 89.2% reaching at least 80% adherence. Home-practice diaries recorded an average of 3.2±1.1 extra sessions per week beyond scheduled classes. No intervention-related adverse events were recorded at any point in the trial.

3.3 Primary Outcome: Perceived Stress Scale (PSS-10)

Women in the yoga arm showed a marked drop in PSS scores, from 22.45±4.12 at baseline to 14.32±3.67 at 12 weeks — an 8.13-point average decline (36.2%; t=8.94, p<0.001, Cohen's d=2.08). The control arm's change was far smaller and not statistically significant (21.89±3.98 to 20.76±4.21; average decline 1.13 points, 5.2%; t=1.42, p=0.162). At 12 weeks, the between-group gap was substantial (mean difference 6.44 points; t=7.32, p<0.001, Cohen's d=1.63), and the Group×Time interaction from repeated-measures ANOVA was significant with a large effect (F[1,72]=53.67, p<0.001, partial η^2=0.43) (Table 2, Figure 2).

Table 2. Perceived Stress Scale (PSS-10) Scores: Within-Group and Between-Group Comparisons

Variable	Pre Mean±SD	Post Mean±SD	Mean Diff.	t-value	Cohen's d	p-value
Yoga Group	22.45 ± 4.12	14.32 ± 3.67	-8.13	8.94	2.08	<0.001***
Control Group	21.89 ± 3.98	20.76 ± 4.21	-1.13	1.42	0.28	0.162
Between-group (Post)			-6.44	7.32	1.63	<0.001***

****p<0.001; Cohen's d: small (0.2), medium (0.5), large (0.8)*

Figure 2. PSS-10 scores in Yoga and Control groups pre- and post-intervention. Error bars = SD. **p<0.001 (within-group paired t-test).*

A large majority of yoga-arm participants — 83.8% (31/37) — moved from the moderate-stress category (PSS 14–26) into the low-stress range (PSS 0–13) by study end, versus just 10.8% (4/37) of controls (χ^2=39.67, p<0.001).

3.4 Primary Outcome: WHOQOL-BREF

All four WHOQOL-BREF domains improved significantly in the yoga arm, while the control arm showed no significant shifts (Table 3, Figure 3). Gains were largest in the Psychological domain (+12.7 points; F[1,72]=22.31, p<0.001, partial η^2=0.24), followed by Physical Health (+12.4 points; F=18.45, p<0.001, partial η^2=0.21), Overall QOL (+9.9 points; F=19.78, p<0.001, partial η^2=0.22), Social Relationships (+8.5 points; F=12.67, p<0.001, partial η^2=0.15), and Environment (+5.8 points; F=8.92, p=0.004, partial η^2=0.11).

Table 3. WHOQOL-BREF Domain Scores: Group Comparisons with Repeated Measures ANOVA

Domain	Yoga Pre	Yoga Post	Ctrl Pre	Ctrl Post	F-value	Eta²	p
Physical Health	52.4±9.2	64.8±8.7	51.8±8.9	53.2±9.1	18.45	0.21	<0.001***
Psychological	48.6±10.1	61.3±9.4	49.1±9.8	50.4±10.2	22.31	0.24	<0.001***
Social Relations	55.2±11.3	63.7±10.1	54.7±10.8	55.9±11.2	12.67	0.15	<0.001***
Environment	58.3±8.7	64.1±8.2	57.9±8.4	58.6±8.9	8.92	0.11	0.004**
Overall QOL	53.6±8.3	63.5±7.9	53.2±7.9	54.3±8.4	19.78	0.22	<0.001***

Values as Mean±SD (transformed 0–100 scale); F = Group×Time interaction; ***p<0.01,*** p<0.001*

Figure 3. WHOQOL-BREF domain scores for Yoga and Control groups pre- and post-intervention. ** denotes significant Group×Time interaction (p<0.001).*

3.5 Secondary Outcome: Sleep Quality (PSQI)

Every PSQI component score improved in the yoga arm, with the largest gains in subjective sleep quality and sleep latency (Table 4). Global PSQI fell from 9.86±2.87 to 5.43±2.12 in the yoga arm (a 44.9% improvement; p<0.001), compared with a modest, non-significant change among controls (9.54±2.74 to 8.97±2.91; p=0.312). The Group×Time interaction was significant (F[1,72]=21.56, p<0.001, partial η^2=0.23). By study end, 75.7% (28/37) of yoga-arm participants had reached good sleep quality (PSQI ≤5), up from 16.2% (6/37) at baseline, versus only 18.9% (7/37) among controls at 12 weeks.

Table 4. Pittsburgh Sleep Quality Index Component and Global Scores

PSQI Component	Yoga Pre	Yoga Post	Ctrl Pre	Ctrl Post	F	p
Subjective Sleep Quality	1.89±0.72	0.97±0.56	1.82±0.68	1.73±0.71	14.23	<0.001***
Sleep Latency	1.76±0.81	0.89±0.62	1.68±0.77	1.59±0.82	11.87	<0.001***
Sleep Duration	1.43±0.69	0.78±0.54	1.38±0.65	1.32±0.69	9.45	0.003**
Habitual Efficiency	1.21±0.73	0.65±0.52	1.16±0.71	1.08±0.74	7.89	0.006**
Sleep Disturbances	1.54±0.61	0.86±0.49	1.49±0.58	1.42±0.63	10.34	0.002**
Use of Sleep Medication	0.67±0.82	0.32±0.47	0.62±0.79	0.58±0.81	3.45	0.067
Daytime Dysfunction	1.36±0.71	0.96±0.58	1.39±0.69	1.25±0.73	4.12	0.046*
Global PSQI Score	9.86±2.87	5.43±2.12	9.54±2.74	8.97±2.91	21.56	<0.001***

F = Group×Time interaction from repeated measures ANOVA; p<0.05, **p<0.01,** *p<0.001*

3.6 Secondary Outcomes: Serum Cortisol and Menopause Rating Scale

Fasting cortisol dropped from 18.92±4.56 to 13.67±3.89 μg/dL in the yoga arm (a 27.8% reduction; p<0.001), with no comparable change among controls (18.45±4.23 to 17.86±4.67; 3.2%; p=0.423). This Group×Time interaction was significant (F[1,72]=16.78, p<0.001, partial η^2=0.19).

MRS total scores fell substantially in the yoga arm, from 24.67±5.34 to 15.43±4.21 (a 37.5% reduction; p<0.001), with significant gains across all three subscales — somatic (-3.45 points; p<0.001), psychological (-3.54 points; p<0.001), and urogenital (-2.25 points; p<0.001). Controls showed only minor, non-significant change on every MRS subscale. The MRS Group×Time interaction produced the largest effect size observed in the study (F[1,72]=24.56, p<0.001, partial η^2=0.26) (Table 5, Figure 4).

Table 5. Serum Cortisol and Menopause Rating Scale: Within-Group and Interaction Effects

Variable	Pre Mean±SD	Post Mean±SD	Mean Diff.	F-value	Eta²	p-value
Cortisol - Yoga	18.92±4.56	13.67±3.89	-5.25			<0.001***
Cortisol - Control	18.45±4.23	17.86±4.67	-0.59			0.423
Cortisol (Group×Time)				16.78	0.19	<0.001***
MRS Total - Yoga	24.67±5.34	15.43±4.21	-9.24			<0.001***
MRS Total - Control	23.89±5.12	22.56±5.45	-1.33			0.198
MRS (Group×Time)				24.56	0.26	<0.001***
Somatic - Yoga	9.12±2.45	5.67±1.98	-3.45			<0.001***
Somatic - Control	8.89±2.34	8.43±2.56	-0.46			0.312
Psychological - Yoga	8.43±2.67	4.89±1.87	-3.54			<0.001***
Psychological - Ctrl	8.21±2.54	7.76±2.71	-0.45			0.387
Urogenital - Yoga	7.12±2.12	4.87±1.76	-2.25			<0.001***
Urogenital - Control	6.79±1.98	6.37±2.13	-0.42			0.289

F and Eta² reported for Group×Time interaction; **p<0.001,** p<0.01*

3.7 Repeated Measures ANOVA Summary

Table 6 collects the Group×Time interaction results across every outcome. All reached significance at $p<0.01$, with effect sizes spanning medium (Environment domain, partial $\eta^2=0.11$) to large (PSS, partial $\eta^2=0.43$), pointing to the intervention's broad reach across multiple psychological and neuroendocrine domains at once.

Table 6. Summary of Repeated Measures ANOVA: Group × Time Interaction Effects for All Outcome Variables

Outcome Variable	Source	df	F	p	Partial Eta²	Effect Size
PSS	Group×Time	1, 72	53.67	<0.001***	0.43	Large
WHOQOL Physical	Group×Time	1, 72	18.45	<0.001***	0.21	Large
WHOQOL Psychological	Group×Time	1, 72	22.31	<0.001***	0.24	Large
WHOQOL Social	Group×Time	1, 72	12.67	<0.001***	0.15	Large
WHOQOL Environment	Group×Time	1, 72	8.92	0.004**	0.11	Medium
PSQI Global	Group×Time	1, 72	21.56	<0.001***	0.23	Large
Serum Cortisol	Group×Time	1, 72	16.78	<0.001***	0.19	Large
MRS Total	Group×Time	1, 72	24.56	<0.001***	0.26	Large

Partial Eta² interpretation: small (0.01), medium (0.06), large (0.14); ***p<0.01,*** p<0.001*

3.8 Correlation Analysis

Pearson correlations run on post-intervention change scores uncovered meaningful relationships among the outcomes (Figure 5). Reductions in PSS tracked closely with gains in WHOQOL-BREF Psychological ($r=-0.71$, $p<0.001$) and Physical Health ($r=-0.62$, $p<0.001$) domains, and with reductions in MRS ($r=0.61$, $p<0.001$) and PSQI ($r=0.58$, $p<0.001$). Change in serum cortisol correlated moderately with change in PSS ($r=0.52$, $p<0.001$) and MRS ($r=0.47$, $p<0.01$), pointing toward a shared underlying pathway connecting stress perception, cortisol regulation, and menopausal symptom expression.

4. DISCUSSION

This trial offers solid evidence that a 12-week program combining Bhramari Pranayama and Chakra Meditation meaningfully improves perceived stress, quality of life, sleep, menopausal symptom severity, and cortisol levels among peri-menopausal women. Effect sizes fell consistently in the medium-to-large range across every measure, with the strongest effects seen for perceived stress (partial $\eta^2=0.43$) and menopausal symptoms (partial $\eta^2=0.26$). These outcomes carry practical significance and add to existing literature by showing the broad psycho-neuroendocrine benefit of a clearly defined, repeatable yoga protocol in this population.

The 36.2% drop in PSS scores among yoga-arm participants, with a within-group Cohen's d of 2.08, ranks among the largest stress-reduction effects reported for yoga interventions in menopausal populations to date. It surpasses the pooled effect reported by Cramer et al. (2018) in their systematic review of yoga for menopausal symptoms (SMD: -0.64, 95% CI: -0.89 to -0.39), and fits with the idea that combining pranayama and meditation may outperform either technique used alone [29]. That 83.8% of yoga-arm participants moved from moderate to low stress categories is clinically meaningful, given that sustained moderate-to-high stress during perimenopause has separately been linked to faster cardiovascular aging, cognitive decline, and elevated risk of major depression [30].

Several converging mechanisms may explain the observed stress reduction. Bhramari Pranayama engages vagal afferents through laryngeal and pharyngeal mechanoreceptors during the humming exhalation, activating the nucleus tractus solitarius and, in turn, modulating the central autonomic network [31]. This bottom-up vagal input appears capable of dampening amygdala reactivity, strengthening prefrontal regulation of emotional responses, and blunting cortisol reactivity to psychosocial stress [32]. Chakra Meditation, meanwhile, works through top-down attentional mechanisms — focused visualization and body awareness engaging the dorsolateral prefrontal cortex and anterior cingulate cortex, regions central to stress appraisal and emotion regulation [33].

The significant improvement across all four WHOQOL-BREF domains reflects a broad-based enhancement in quality of life. The Psychological domain's leading gain (+12.7 points, partial η^2=0.24) stands out, since psychological complaints tend to be among the most persistent and distressing features of perimenopause. This mirrors the conclusion of Ramos et al. (2024), whose meta-analysis identified psychological wellbeing as the WHOQOL-BREF domain most responsive to yoga among midlife women [34].

Differences across domains offer some mechanistic insight. Strong gains in Physical Health and Psychological domains likely reflect direct physiological benefit from better autonomic regulation and cortisol normalization, whereas the smaller Environment domain improvement may be an indirect consequence of improved coping skills, social engagement, and a stronger sense of control over one's surroundings [35]. The comparatively modest gain in Social Relationships may reflect that this domain depends more on external interpersonal circumstances that an individual-level intervention is less able to shift.

The 44.9% improvement in global PSQI scores — with 75.7% of yoga-arm participants reaching good sleep quality by study end — represents a substantial shift for a group known to have high rates of sleep disturbance. Sleep disruption in perimenopause typically stems from an interplay of vasomotor symptoms (night sweats), hormone-driven changes in sleep architecture, and psychological contributors such as anxiety, rumination, and hyperarousal [36]. The yoga intervention appears to touch several of these mechanisms at once: the parasympathetic activation from Bhramari Pranayama may lower pre-sleep hyperarousal, while the mindfulness component of Chakra Meditation may ease the cognitive-emotional patterns that sustain insomnia [37].

Notably, the largest PSQI component gains were in subjective sleep quality ($F=14.23$, $p<0.001$) and sleep latency ($F=11.87$, $p<0.001$), suggesting the intervention's chief sleep benefit works through reduced pre-sleep arousal rather than a direct change in sleep architecture. This is consistent with the arousal-reduction account of yoga's sleep effects proposed by Khalsa (2021), in which lower sympathetic activation and reduced bedtime cortisol drive the improvement [38].

The 27.8% fall in serum cortisol in the yoga arm gives objective, biochemical support to the subjective stress findings. Its correlation with the change in PSS ($r=0.52$, $p<0.001$) suggests that at least part of the perceived-stress benefit stems from HPA-axis normalization. The magnitude of this cortisol reduction (mean decrease: 5.25 µg/dL) is clinically notable and larger than what most yoga trials in non-menopausal groups have reported, hinting that peri-menopausal women — whose HPA axis is already somewhat dysregulated at baseline — may gain disproportionately from yoga practice [39,40].

The links between cortisol normalization and gains in sleep quality ($r=0.44$, $p<0.01$) and menopausal symptoms ($r=0.47$, $p<0.01$) reinforce the idea that cortisol functions as a central mediator in this psycho-neuroendocrine response. Elevated cortisol is known to disturb sleep by heightening arousal circuits and suppressing melatonin production, and to worsen vasomotor symptoms via effects on hypothalamic thermoregulatory thresholds. Bringing cortisol back toward normal through yoga practice may therefore represent one key pathway by which several symptom domains improve together [41].

The 37.5% decline in MRS totals — improved across somatic, psychological, and urogenital subscales alike — indicates a broad easing of menopausal symptom burden. The MRS interaction effect was the second largest in the study (partial η^2=0.26), underscoring the intervention's clinical impact. The psychological subscale showed the biggest absolute drop (-3.54 points), in keeping with the intervention's predominantly psychological mechanisms; but meaningful gains in somatic (-3.45 points) and urogenital (-2.25 points) symptoms point to additional peripheral pathways, potentially involving autonomic regulation of vasomotor activity and strengthened pelvic-floor tone through the breathing practices.

The correlation findings (Figure 5) sketch a coherent picture linking these outcomes into an integrated psycho-neuroendocrine model. The strongest relationships were between PSS and WHOQOL-BREF Psychological domain ($r=-0.71$) and between PSS and MRS ($r=0.61$), suggesting that reduced perceived stress may be a central driver linking better quality of life, sleep, and menopausal symptoms. The moderate cortisol correlations add biochemical weight to this model, indicating that subjective stress relief runs alongside measurable neuroendocrine change.

The effect sizes reported here exceed those in much of the prior yoga-perimenopause literature. Several factors could account for this: the specific pairing of Bhramari Pranayama with Chakra Meditation (targeting complementary neurophysiological routes), a relatively long 12-week duration, strong adherence (87.3%), and a structured, progressively escalating protocol.

Recent meta-analytic work by Wang et al. (2025) and Gangadharan et al. (2024) similarly notes that standardized, protocol-specific yoga programs delivered at adequate dose outperform loosely defined, mixed yoga programs — consistent with the approach used here [42,43].

Strengths and Limitations

This study's strengths include its randomized design, use of validated instruments, inclusion of an objective biochemical marker (serum cortisol), reasonable sample size with low attrition (7.5%), rigorous intention-to-treat analysis, and a clearly specified, reproducible protocol. Tracking several psycho-neuroendocrine outcomes together in one cohort also allowed correlational analysis that single-outcome studies cannot offer.

Some limitations should be noted. The single-center design constrains generalizability. Blinding of participants and instructors was not achievable given the intervention's nature. The control arm received usual care rather than an active comparator such as aerobic exercise or relaxation training, which limits how confidently the observed effects can be attributed specifically to the yoga components rather than to general effects of attention or group participation. Long-term durability of benefit beyond the 12-week window was not examined. A single fasting cortisol measurement offers only a partial view of HPA-axis function; serial sampling or diurnal cortisol profiling would have given a fuller neuroendocrine picture. Finally, sleep was assessed only via self-report (PSQI), without objective measures such as polysomnography or actigraphy.

CONCLUSION

This randomized controlled trial shows that a 12-week program combining Bhramari Pranayama and Chakra Meditation delivers meaningful improvements in perceived stress, quality of life across all WHOQOL-BREF domains, sleep quality, menopausal symptom severity, and serum cortisol among peri-menopausal women. Given the medium-to-large effect sizes observed across every outcome, the absence of adverse events, and strong adherence, this structured protocol appears to be a safe and accessible complementary option for addressing the combined psychological and hormonal burden of perimenopause. Further multi-center trials incorporating active comparator arms, extended follow-up, objective sleep assessment, and more detailed neuroendocrine profiling would help clarify both the efficacy and the underlying mechanisms of this intervention.

DECLARATIONS

Ethical Approval This study received approval from the Institutional Ethics Committee (Approval No: MAHER/IEC/PhD/113/APRIL25) and was conducted per the 2013 revision of the Declaration of Helsinki. Written informed consent was secured from all participants before enrollment.

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Conflicts of Interest The authors declare no conflicts of interest.

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Data Availability Statement Datasets generated and analyzed during this study are available from the corresponding author upon reasonable request.

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