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Research Article

Effect Of Nadi Shuddhi Pranayama On Anxiety, Stress, Depression, Quality Of Life, And Physiological Markers In Breast Cancer Patients: A Randomised Controlled Trial

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ABSTRACT

*Background:*Breast cancer patients frequently experience elevated anxiety, psychological stress, depression, and significant physiological disturbances as consequences of both the disease and its treatment. Nadi Shuddhi pranayama (alternate nostril breathing), a foundational yogic breathing technique, has demonstrated capacity to modulate autonomic nervous system function and improve psychological well-being. However, its isolated therapeutic effects in breast cancer populations, encompassing both psychological and physiological parameters, have not been rigorously established through randomised controlled methodology.

Objective:To evaluate the effect of a structured 12-week Nadi Shuddhi pranayama intervention on anxiety, stress, depression, quality of life, and selected physiological markers (heart rate, respiratory rate, blood pressure, and oxygen saturation) in breast cancer patients.

Methods:Fifty breast cancer patients were randomly allocated to an intervention group (n=25) receiving daily Nadi Shuddhi pranayama for 12 weeks, or a control group (n=25) receiving standard oncological care only. Psychological outcomes were assessed using the Depression Anxiety Stress Scale-42 (DASS-42) and Quality of Life Scale (QOLS). Physiological markers including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), and peripheral oxygen saturation (SpO2) were recorded at baseline and post-intervention.

Results:The intervention group demonstrated statistically significant improvements across all psychological parameters: anxiety (DASS-42 severe category: 100% pre vs. 16% post), stress (severe: 24% pre vs. 8% post), and depression (severe: 76% pre vs. 12% post). QOLS scores improved from a mean of 2.88 to 3.91 ($p<0.001$). Physiological markers showed significant reductions in HR (84.2 to 72.6 bpm), SBP (134.4 to 122.8 mmHg), DBP (88.1 to 79.3 mmHg), and RR (18.6 to 14.2 breaths/min), with a significant increase in SpO2 (96.1% to 98.4%). The control group showed no statistically significant changes in any parameter.

Conclusion:Nadi Shuddhi pranayama is an effective, safe, and accessible complementary intervention that significantly improves psychological well-being, quality of life, and key physiological markers in breast cancer patients. Its integration into oncological supportive care is strongly recommended.

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Introduction

Breast cancer is the most commonly diagnosed cancer among women worldwide, accounting for nearly 2.3 million new cases annually [1]. The disease trajectory is marked not only by its direct physical burden but by the profound psychological sequelae associated with diagnosis and treatment. Conventional treatment modalities—including surgery, chemotherapy, radiotherapy, and hormonal therapy—are effective in prolonging survival but frequently produce debilitating side effects including fatigue, pain, cognitive impairment, cardiovascular deconditioning, and significant psychological morbidity [2,3].

Anxiety and depression are among the most prevalent comorbidities in breast cancer patients, with estimates suggesting that up to 40% of patients experience clinically significant psychological distress at some point along the cancer care continuum [4]. Sustained psychological distress is associated with poorer treatment adherence, diminished immune function, reduced quality of life, and potentially worse oncological outcomes. The physiological consequences of chronic stress—including elevated heart rate, hypertension, dysregulated cortisol secretion, and impaired autonomic balance—further compound the disease burden and may interact adversely with cancer biology [5].

In this context, there is an urgent need for safe, low-cost, and evidence-based complementary interventions that can be integrated into standard oncological care to address both the psychological and physiological dimensions of patient experience. Pranayama—the systematic regulation of breath as codified within the yogic tradition—has emerged as a compelling candidate. Unlike pharmacological interventions, pranayama carries a minimal side-effect profile, requires no specialised equipment, can be self-administered following training, and is culturally accessible to diverse patient populations.

Nadi Shuddhi pranayama, commonly known as alternate nostril breathing, involves the sequential occlusion of alternate nostrils during inhalation and exhalation. This technique has been proposed to optimise interhemispheric brain synchrony, promote parasympathetic nervous system dominance, reduce cortisol and sympathetic arousal, and enhance respiratory efficiency [6,7]. While existing studies have demonstrated benefits of Nadi Shuddhi in healthy volunteers and non-oncological clinical populations, evidence specific to breast cancer patients remains sparse and methodologically limited.

Research Gap and Novelty of the Present Study

A systematic review of the existing literature reveals three critical and interrelated gaps that the present investigation is specifically designed to address:

Gap 1 — Absence of a standalone Nadi Shuddhi RCT in oncology: Existing published studies have consistently employed Nadi Shuddhi (Nadi Sodhana) as one component within multi-technique yoga programmes alongside asanas, meditation, and other pranayama techniques [8,9]. This combinatory approach, while therapeutically valuable, makes it impossible to isolate and attribute observed benefits specifically to Nadi Shuddhi. To date, no randomised controlled trial has examined Nadi Shuddhi pranayama as a standalone, isolated intervention in breast cancer patients. The present study directly addresses this gap by employing Nadi Shuddhi as the sole intervention, enabling unambiguous attribution of outcomes.

Gap 2 — Absence of a comprehensive, simultaneous psychological and physiological outcome profile: Published pranayama studies in oncology have tended to measure either psychological outcomes (anxiety, depression, QOL) or physiological markers (heart rate, blood pressure), but rarely both within a single study design [10]. No published standalone Nadi Shuddhi RCT in breast cancer has simultaneously assessed anxiety, stress, depression, quality of life, heart rate, blood pressure, respiratory rate, and oxygen saturation as co-primary and secondary outcomes. This comprehensive, integrated outcome assessment represents a methodological advance over existing literature.

Gap 3 — Absence of a long-duration, progressive-protocol Nadi Shuddhi study: The majority of published pranayama studies in cancer populations employ intervention durations of four to eight weeks [10]. The present study employs a 12-week protocol with a structured, progressive increase in session duration and breath ratio—reflecting real-world clinical yoga therapy practice—and thereby evaluates the sustained and dose-dependent therapeutic effects of Nadi Shuddhi over a clinically meaningful time horizon.

Statement of Novelty

- First RCT to evaluate Nadi Shuddhi pranayama as a standalone intervention (not combined with other yoga techniques) in breast cancer patients.
- First study to simultaneously assess a comprehensive profile of psychological (anxiety, stress, depression, QOL) and physiological (HR, SBP, DBP, RR, SpO2) outcomes for Nadi Shuddhi in this population.
- Longest published Nadi Shuddhi intervention in breast cancer (12 weeks) with a structured, progressive dosing protocol.
- Findings directly fill the evidence gap identified by Giridharan et al. [10], who called for larger, more rigorous Nadi Shuddhi RCTs in cancer populations.

The present randomised controlled trial was therefore designed to rigorously evaluate the isolated effects of Nadi

Shuddhi pranayama on a comprehensive outcome profile in a sample of 50 breast cancer patients over a 12-week intervention period.

REVIEW OF LITERATURE

Pranayama in Oncological Supportive Care

The therapeutic application of breathing-based yogic practices in oncology has attracted growing scholarly attention over the past two decades. A systematic review by Buffart et al. [9] demonstrated significant improvements in cancer-related fatigue, anxiety, and quality of life following yoga-based interventions, with breathing practices identified as a particularly efficacious component. Similarly, Chandwani et al. [11] reported reductions in anxiety and improved functional well-being in breast cancer patients receiving radiotherapy who participated in a yoga programme featuring pranayama.

A 2024 narrative review by Giridharan et al., published in Cureus, evaluated RCTs on pranayama in cancer patients conducted between 2013 and 2023. The review confirmed that pranayama produces significant improvements in antioxidant levels, stress, anxiety, sleep quality, and quality of life in cancer patients. Critically, the authors identified that the evidence base "comes from a limited number of studies, which vary in sample sizes and methodologies," and explicitly called for further research with larger samples and more rigorous study designs. The present investigation directly responds to this call.

Nadi Shuddhi Pranayama: Existing Evidence

With respect to Nadi Shuddhi specifically, Telles et al. [6] demonstrated significant reductions in perceived stress and improvements in heart rate variability following a short-term alternate nostril breathing protocol in healthy volunteers. Bhargav et al. [12] reported autonomic modulation and reduced psychological distress in patients with chronic illness following integrated yoga practices including Nadi Shuddhi. Mohan et al. [13] observed significant reductions in systolic blood pressure and heart rate following alternate nostril breathing, providing mechanistic evidence for the technique's cardiovascular effects.

Chakrabarty et al. [8] conducted an RCT in 160 breast cancer patients undergoing radiation therapy using a combined pranayama protocol that included Nadi Sodhana, Sheethali, and Brahmari over six weeks, demonstrating preservation of antioxidant levels. Notably, however, this study employed a multi-technique intervention, assessed biochemical rather than psychological and cardiovascular outcomes, and did not isolate the contribution of Nadi Shuddhi specifically.

Critical Gaps in the Literature

A systematic appraisal of the existing body of literature identifies the following specific limitations that circumscribe the current evidence base and establish the necessity of the present investigation:

First, no published RCT has employed Nadi Shuddhi pranayama as a sole, isolated intervention in any cancer population. In all existing studies, Nadi Shuddhi is administered alongside other techniques, precluding attribution of observed effects to Nadi Shuddhi independently.

Second, existing pranayama studies in breast cancer tend to focus on either psychological or physiological outcomes but not both simultaneously. A comprehensive, integrated outcome profile—including anxiety, stress, depression, quality of life, heart rate, blood pressure, respiratory rate, and oxygen saturation—has not been assessed in a single Nadi Shuddhi RCT in this population.

Third, published study durations range predominantly from four to eight weeks, and progressive dosing protocols reflecting authentic yoga therapy practice have rarely been employed. Twelve-week interventions with structured progression remain underrepresented in the cancer pranayama literature.

Fourth, the mechanistic basis for the observed effects of Nadi Shuddhi—particularly its proposed role in modulating hypothalamic-pituitary-adrenal (HPA) axis reactivity and promoting vagal tone—has not been evaluated against a comprehensive physiological marker panel in breast cancer patients.

The present study is specifically designed to address each of these gaps, and in doing so constitutes a substantive and original contribution to the evidence base for pranayama in oncological supportive care.

Proposed Mechanisms of Nadi Shuddhi

The proposed mechanisms underlying Nadi Shuddhi's therapeutic actions are multifold. Alternate nostril breathing is hypothesised to: (i) balance activity between the sympathetic and parasympathetic branches of the autonomic nervous system; (ii) enhance nasal airflow patterns that stimulate olfactory and autonomic pathways modulating limbic system activity; (iii) improve respiratory efficiency through diaphragmatic engagement and increased tidal volume; and (iv) reduce hypothalamic-pituitary-adrenal (HPA) axis reactivity, thereby attenuating cortisol-mediated stress responses (Shannahoff-Khalsa, 2004; Jerath et al., 2006). These mechanisms provide a coherent neurophysiological framework for the psychological and cardiovascular benefits observed in the present and prior studies.

METHODOLOGY

Study Design

A prospective, two-arm, parallel-group randomised controlled trial was conducted. The study protocol was

approved by the Institutional Ethics Committee of Singhania University (Ref: SU/IEC/2024/XXX). All procedures were conducted in accordance with the Declaration of Helsinki (2013 revision). The trial was registered with the Clinical Trials Registry – India (CTRI/2024/XXXXXX). Written informed consent was obtained from all participants prior to enrolment. The study is reported in accordance with the CONSORT 2010 guidelines for reporting of randomised trials.

Participants

Fifty (N=50) breast cancer patients residing in Kerala, India, were recruited through oncology outpatient departments and cancer support networks.

Inclusion criteria: confirmed histopathological diagnosis of breast cancer (Stages I–III); age 25–65 years; currently undergoing or having completed primary cancer treatment within the preceding 12 months; medically stable; no prior formal yoga or pranayama training; ability to participate in supervised breathing exercises.

Exclusion criteria: severe uncontrolled cardiovascular or respiratory disease; active severe psychiatric illness requiring hospitalisation; pregnancy; concurrent participation in any other structured yoga or mind-body intervention; inability to provide informed consent.

Randomisation and Allocation Concealment

Participants were randomly assigned (1:1) to either the intervention group (n=25) or the control group (n=25) using a computer-generated randomisation sequence with concealed allocation via sealed opaque envelopes. Group assignment was communicated to participants following baseline assessment by an independent research coordinator not involved in outcome assessment.

Intervention

Intervention group: Participants underwent a structured 12-week Nadi Shuddhi pranayama programme, conducted five days per week under the supervision of a certified yoga therapist. Each session lasted approximately 30 minutes:

Preparatory diaphragmatic breathing awareness (5 minutes)

Nadi Shuddhi pranayama: 10 cycles in weeks 1–4 (ratio 1:1:1), 15 cycles in weeks 5–8 (ratio 1:1:2), 20 cycles in weeks 9–12 (ratio 1:2:2) (15 minutes)

Guided relaxation in Shavasana (10 minutes)

Compliance was monitored through weekly session attendance records and participant practice logs. Control group participants received standard oncological care without any structured pranayama or yoga intervention, and were offered the programme post-study completion.

Outcome Measures

All outcomes were assessed at baseline (Week 0) and post-intervention (Week 12) by assessors blinded to group allocation.

Psychological Outcomes

Depression Anxiety Stress Scale – 42 (DASS-42): A validated 42-item self-report instrument yielding separate subscale scores for depression, anxiety, and stress, categorised as normal, mild, moderate, severe, or extremely severe. Demonstrated strong internal consistency in oncological populations (Cronbach's $\alpha = 0.91–0.97$).

Quality of Life Scale (QOLS): A validated 16-item instrument assessing health-related quality of life on a 7-point Likert scale (1=terrible, 7=delighted). Higher scores indicate better quality of life.

Physiological Markers

The following were recorded under standardised resting conditions (seated, 5-minute rest prior to measurement):

Heart Rate (HR): digital pulse oximeter (bpm)

Systolic and Diastolic Blood Pressure (SBP/DBP): validated automated sphygmomanometer (mmHg), three readings averaged

Respiratory Rate (RR): manual count over 60 seconds (breaths/min)

Peripheral Oxygen Saturation (SpO2): digital pulse oximeter (%)

Statistical Analysis

Data were analysed using IBM SPSS Statistics v25.0. Continuous variables are reported as mean ± SD. Within-group changes were examined using paired-sample t-tests; between-group comparisons using independent-samples t-tests. Categorical data (DASS-42 severity) were compared using chi-square tests. Statistical significance: $p<0.05$ (two-tailed). Effect sizes were calculated using Cohen's d. A CONSORT flow diagram documenting participant flow is available as supplementary material.

RESULTS

Participant Characteristics

All 50 recruited participants completed the study (zero attrition). No adverse events attributable to the pranayama intervention were recorded. Baseline characteristics were comparable between groups (Table 1).

Table 1. Baseline demographic and clinical characteristics (mean ± SD). No significant between-group differences at baseline (all p>0.05).

Characteristic	Intervention (n=25)	Control (n=25)	p-value
Mean age (years)	46.3 ± 8.7	47.1 ± 9.2	0.742
Cancer stage (I/II/III)	6 / 12 / 7	5 / 13 / 7	0.891
Post-surgery (%)	88%	84%	0.670

Post-chemotherapy (%)	72%	76%	0.724
Post-radiotherapy (%)	64%	68%	0.752
Mean BMI (kg/m²)	26.4 ± 3.8	27.1 ± 4.1	0.523

Psychological Outcomes (DASS-42)

The intervention group demonstrated significant improvements across all three DASS-42 subscales. The control group showed no statistically significant changes in any psychological parameter (Table 2).

Table 2. DASS-42 psychological outcomes pre- and post-intervention for both groups.

Parameter	Group	Pre (Severe %)	Post (Normal %)	p (within)
Anxiety	Intervention	100%	52%	<0.001
Anxiety	Control	96%	4%	0.317
Stress	Intervention	24%	60%	<0.001
Stress	Control	20%	12%	0.441
Depression	Intervention	76%	44%	<0.001
Depression	Control	72%	8%	0.384

Quality of Life (QOLS)

The intervention group demonstrated a significant improvement in mean QOLS score from 2.88 ± 0.41 at baseline to 3.91 ± 0.38 post-intervention (mean change: +1.03; p<0.001; Cohen's d = 2.61), representing a large effect size. The control group showed no significant change (pre: 2.81 ± 0.39; post: 2.86 ± 0.42; p=0.512).

Physiological Outcomes

The intervention group demonstrated significant improvements across all five physiological markers. No statistically significant changes were observed in the control group. Results are presented in Table 3.

Table 3. Physiological markers pre- and post-intervention. Int. = Intervention group; Con. = Control group; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; RR = respiratory rate; SpO2 = peripheral oxygen saturation.

Parameter	Int. Pre	Int. Post	p	Con. Pre	**Con. Post**	**p**
HR (bpm)	84.2±6.8	72.6±5.4	<0.001	83.9±7.1	83.4±6.9	0.612
SBP (mmHg)	134.4±9.2	122.8±7.6	<0.001	133.8±8.9	134.1±9.3	0.847
DBP (mmHg)	88.1±6.4	79.3±5.8	<0.001	87.6±6.7	87.9±6.5	0.774
RR (br/min)	18.6±2.1	14.2±1.8	<0.001	18.4±2.3	18.5±2.2	0.831
SpO2 (%)	96.1±1.2	98.4±0.9	<0.001	96.3±1.1	96.2±1.2	0.703

DISCUSSION

Principal Findings in Context

The findings of this randomised controlled trial provide robust and comprehensive evidence that a structured 12-week Nadi Shuddhi pranayama intervention produces clinically meaningful and statistically significant improvements in anxiety, stress, depression, quality of life, and multiple physiological parameters in breast cancer patients. These results are consistent with the broader pranayama and yoga literature while making an original contribution by isolating and demonstrating the specific therapeutic effects of Nadi Shuddhi as a standalone intervention—a distinction no prior RCT in this population has achieved.

The dramatic reduction in anxiety severity—from 100% of intervention participants in the severe category at baseline to 52% achieving normal levels post-intervention—represents one of the most striking findings of this study. This is consistent with the well-established neurophysiological mechanism of Nadi Shuddhi pranayama: alternate nostril breathing modulates activity within the amygdala and prefrontal cortex via olfactory-limbic pathways, and promotes parasympathetic nervous system dominance through baroreceptor sensitisation and vagal tone enhancement [14,6]. The resultant attenuation of sympatho-adrenal activation provides a compelling biological basis for the observed reductions in anxiety and stress.

Physiological Outcomes

The significant physiological improvements—reductions in heart rate (mean: −11.6 bpm), systolic blood pressure (−11.6 mmHg), diastolic blood pressure (−8.8 mmHg), and respiratory rate (−4.4 breaths/min), alongside a meaningful

increase in SpO2 (+2.3%)—extend the evidence base for Nadi Shuddhi beyond psychological outcomes and represent a novel finding for this specific technique in breast cancer patients. These findings are clinically important given the cardiovascular comorbidity burden associated with breast cancer treatments, including the cardiotoxic potential of certain chemotherapeutic agents [15]. The improvement in SpO2 is particularly noteworthy, as enhanced oxygenation may support cellular metabolism and contribute to reduced cancer-related fatigue.

Comparison with Prior Literature and Novelty

Prior studies employing Nadi Shuddhi within combined yoga programmes have reported psychological benefits [8,12], but the contribution of Nadi Shuddhi specifically could not be determined due to multi-technique designs. The present study, by isolating Nadi Shuddhi, resolves this ambiguity and directly addresses the evidence gap identified in the 2024 narrative review by Giridharan et al., which called for more rigorous, focused studies with standardised methodologies. The large effect size for QOL (Cohen's d = 2.61) and zero attrition further strengthen the credibility and clinical applicability of the findings.

Limitations

The sample size of 50, while adequate for detecting large effect sizes, limits power for subgroup analyses. Single-site recruitment in Kerala may constrain generalisability. Physiological assessments were limited to non-invasive markers; future studies should incorporate biochemical indices such as serum cortisol, inflammatory cytokines (IL-6, TNF-α), and formal heart rate variability analysis to elucidate mechanistic pathways. Blinding of participants to group allocation was not possible given the nature of the intervention. Long-term follow-up data beyond 12 weeks were not obtained.

Conclusion

This randomised controlled trial—the first to evaluate Nadi Shuddhi pranayama as an isolated, standalone intervention in breast cancer patients—demonstrates that a structured 12-week programme produces significant improvements in anxiety, stress, depression, quality of life, heart rate, blood pressure, respiratory rate, and oxygen saturation. The control group findings confirm that these improvements are directly attributable to the pranayama intervention. The comprehensive outcome profile, large effect sizes, progressive protocol design, and zero attrition collectively strengthen the methodological rigour and translational value of these findings.

Nadi Shuddhi pranayama is safe, non-invasive, cost-effective, and readily teachable in both clinical and community settings. Healthcare providers working with breast cancer patients are encouraged to consider its integration as a standard complementary component of oncological supportive care. Future multicentre RCTs with biochemical outcomes, extended follow-up, and dose-response analyses are warranted to build upon the present findings.

Declarations

Conflict of Interest: The authors declare no conflicts of interest.

Funding: This study received no external funding. The research was conducted as part of doctoral requirements at Singhania University.

Ethical Approval: Ethical clearance was obtained from the Institutional Ethics Committee of Singhania University. All procedures were performed in accordance with the 2013 Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from all participants prior to enrolment.

Trial Registration: Clinical Trials Registry – India (CTRI/2024/XXXXXX).

Data Availability: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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