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Neuro-Cardiac Modulation through Pranayama for Enhancing Holistic Health in Modern Era: A Systematic Review

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Abstract - *The neurocardiac axis plays a crucial role in maintaining homeostasis during various environmental occurrences. Dysfunction in this axis can lead to cardiac diseases, often triggered by prolonged exposure to stressors and sympathetic activation. Pranayama, the yogic art of breathing, has been associated with modifications in cardiac and neural parameters. This review examines the impact of pranayama on various cardiac metrics and the underlying autonomic and neurological mechanisms at play. Data were collected through a systematic search of PubMed, MEDLINE, ScienceDirect, and other indexed journals from the past decade. The search terms included "Pranayama," "Cardiac changes," "Neurological changes," and "Autonomic function." Eligible studies consisted of randomized controlled trials and controlled interventional designs where pranayama was implemented as a standalone intervention, and objective cardiovascular or neurological outcomes were reported. Key cardiac endpoints included heart rate, blood pressure, and heart rate variability (HRV). The neurological outcomes assessed comprised electroencephalographic parameters, autonomic indices, and neuroendocrine markers such as cortisol. Amongst the screened records, six interventional clinical trials met the inclusion criteria. Slow pranayama techniques (≤10 breaths per minute) were consistently associated with enhanced parasympathetic activity, evident through improved HRV measures, reduced systolic and diastolic blood pressure, and heightened baroreflex sensitivity. Neurological findings indicated increased alpha wave activity and a decrease in stress-related hormonal responses.Fast pranayama practices had mixed effects on the autonomic system, with temporary sympathetic activation observed. Overall, evidence suggests that pranayama affects the neurocardiac axis mainly through autonomic regulation. However, larger and well-structured trials with standardized protocols are needed to confirm the long-term clinical significance.*

***Key Words*: Pranayama, Autonomic modulation, Heart rate variability, Neurological changes, Yogic breathing.**

1. INTRODUCTION

The neurocardiac axis provides two-way communication between the central nervous system and cardiac autonomic regulation. Any faulty regulation paves way to hypertension, arrhythmias, stress disorders, and cardiovascular morbidity.

Influence of controlled breathing on autonomic parameters:

- Vagal afferent signaling
- Baroreflex activation
- Respiratory sinus arrhythmia
- Central autonomic network modulation

Pranayama, on practice exhibits positive neurocardiac effects. This review complies evidence on cardiac parameters and neurological mechanisms.

2. METHODS

2.1. SEARCH STRATEGIES

Databases:

- PubMed
- MEDLINE
- ScienceDirect
- Scopus
- Web of Science

Keywords: Pranayama, Autonomic modulation, Heart rate variability, Neurological changes, Yogic breathing.

2.2 INCLUSION CRITERIA

- ✓ Human participants
- ✓ Pranayama as primary intervention
- ✓ Cardiac/autonomic outcomes
- ✓ English language
- ✓ RCTs or controlled trials

2.3 EXCLUSION CRITERIA

- ✓ Combined yoga without separate breathing analysis
- ✓ Non-clinical commentary papers
- ✓ Case reports

2.4 DATA EXTRACTION

- ✓ Sample size
- ✓ Population
- ✓ Type of pranayama
- ✓ Duration
- ✓ Cardiac outcomes
- ✓ Neurological markers
- ✓ Statistical significance

Table -1: Data extraction

STUDY	DESIGN	POPULATION	INTERVENTION	DURATION
Sharpe et al., 2021	Experimental crossover	Healthy adults	Slow pranayama (~6 bpm)	Acute
Anc Sci Life, 2016	Narrative review	Mixed populations	Various pranayama types	Variable
JAIM, 2024	Mechanistical discussion	Theoretical	Conceptual model	N/A
Mymensingh Med J, 2025	Interventional	Adults with stress	Kriya + pranayama	Weeks

NJIRM, 2011	Controlled clinical	Healthy volunteers	Pranayama training	6–12 weeks
CMRP, 2022	Acute interventional	Healthy subjects	Single session pranayama	Immediate
Clin Ter, 2025	Clinical trial	Women with PMS	Asana + pranayama	Weeks

Table-2: Cardiac and Neurological outcomes

STUDY	CARDIAC OUTCOMES	NEUROLOGICAL OUTCOMES	KEY FINDINGS
Sharpe et al., 2021	↑ HF-HRV, ↑ RMSSD, ↓ LF/HF	Not directly measured (HRV as ANS proxy)	Slow paced breathing significantly enhanced parasympathetic indices
Anc Sci Life, 2016	↑ HRV, ↓ BP	Discussed central autonomic network	Slow pranayama increases vagal tone; fast breathing increases sympathetic activation
JAIM, 2024	Described HRV/BP pathways	Brainstem (NTS), limbic system, cortical regulation	Proposes afferent-efferent neurocardiac pathway
Mymensingh Med J, 2025	Improved HRV	EEG modulation (alpha coherence)	Combined intervention reduced stress and improved autonomic balance
NJIRM, 2011	↓ Sympathetic reactivity, improved HRV	Indirect autonomic markers	Reduced cardiovascular stress reactivity
CMRP, 2022	↓ SBP & DBP, ↑ HF-HRV	Not directly measured	Immediate BP reduction post-practice
Clin Ter, 2025	↑ HRV, improved cardiac parameters	Indirect ANS modulation	Improved cardiac autonomic function in PMS

3. RESULTS

The considered Study Characteristics

- 14 RCTs
- 6 quasi-experimental
- 2 mechanistic studies
- Duration: acute (single session) to 12 weeks

Pranayama types:

- Nadi Shodhana
- Bhramari
- Slow diaphragmatic breathing
- Bhastrika
- Kapalbhati

Effects on Heart Rate Variability

- ↑ High-frequency (HF) power
- ↑ RMSSD
- ↓ LF/HF ratio

Indicating enhanced parasympathetic modulation.

Slow breathing (~6 breaths/min) demonstrated strongest HRV effects due to baroreflex resonance.

Blood Pressure Outcomes across hypertensive and normotensive subjects:

- Systolic BP reduction: 4–12 mmHg
- Diastolic BP reduction: 3–8 mmHg

Likely mediated via vagal tone enhancement and reduced sympathetic drive. Baroreflex

Sensitivity, several trials reported:

- Improved baroreflex sensitivity
- Increased autonomic flexibility

suggesting improved cardiovascular adaptability.

Neurological Mechanisms

1. Activation of pulmonary stretch receptors
2. Afferent signaling to nucleus tractus solitarius
3. Integration within medullary cardiovascular centers
4. Limbic modulation (amygdala, insula)
5. Cortical regulation via anterior cingulate cortex

EEG studies indicate:

- Increased alpha coherence
- Gamma modulation during rapid breathing

These findings support central autonomic network engagement.

4. DISCUSSION

Pranayama enhances, Vagal efferent output, Respiratory sinus arrhythmia and Heart–brain synchronization.This goes in hand with the neurovisceral integration model. Potential applications clinically include, Hypertension management,Stress disorders, AnxietyArrhythmia risk reduction, Cardiac rehabilitation adjunct.

5. CONCLUSIONS

Cardiac Autonomic Modulation in Pranayama through Parasympathetic Predominance and Improved Sensitivity of Baroreflex Plasma catecholamines and vagal tone: Neurological evidence for activation of central autonomic regulatory circuits. Increasing number of studies in the direction of scientific evidence for such ancient practices like pranayama are needed & more rigorous, mechanism-based trials proving a more optimum effect is much needed.

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