ORIGINAL RESEARCH PAPER

Volume - 14 | Issue - 12 | December - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

THE INFLUENCE OF YOGIC BREATHING PRACTICES ON AUTONOMIC REGULATION IN YOUNG ADULTS

Yoga

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ABSTRACT

Background: The autonomic nervous system (ANS) is pivotal for maintaining physiological homeostasis, and its imbalance is implicated in numerous stress-related disorders. Yogic breathing (pranayama) is posited to modulate ANS activity, enhancing parasympathetic tone and mitigating sympathetic dominance. **Aim:** This study aimed to evaluate the effects of an 8-week yogic breathing intervention on autonomic function parameters in healthy young adults. **Methods:** A total of 160 healthy participants (aged 18-25 years) were randomly allocated to an intervention group (n=80) or a control group (n=80). The intervention group practiced a combination of alternate nostril breathing (Nadi Shodhana) and slow diaphragmatic breathing for 30 minutes daily for 8 weeks. The control group maintained their usual daily routines. Autonomic function was assessed pre- and post-intervention using heart rate variability (HRV) analysis and a battery of standard cardiovascular reflex tests. **Results:** Post-intervention, the yoga group exhibited a significant increase in parasympathetic activity, evidenced by elevated HRV indices (e.g., mean RMSSD increased by 18%, $p<0.01$) and an improved 30:15 ratio ($p<0.05$). Significant reductions in resting heart rate (mean decrease of 6 bpm, $p<0.01$) and systolic blood pressure (mean decrease of 4 mmHg, $p<0.05$) were also observed. No significant changes were noted in any parameters within the control group. **Conclusion:** Regular practice of yogic breathing techniques significantly enhances parasympathetic modulation and improves overall autonomic balance in young adults. These findings support the incorporation of pranayama as a viable, non-pharmacological strategy for stress reduction and the promotion of autonomic health.

KEYWORDS

Yogic Breathing, Autonomic Function, Heart Rate Variability, Parasympathetic Activity, Pranayama, Young Adults, Stress Modulation.

INTRODUCTION

The Autonomic Nervous System (ANS) is a critical component of the human physiological framework, responsible for the unconscious regulation of visceral functions and the maintenance of homeostasis.[1,5] It operates through a dynamic balance between its two primary branches: the sympathetic nervous system (SNS), which mobilizes the body's resources for "fight or flight" responses, and the parasympathetic nervous system (PNS), which promotes "rest and digest" activities.[2] A state of autonomic balance is essential for health, whereas a chronic shift towards sympathetic dominance has been strongly associated with the pathogenesis of various disorders, including hypertension, anxiety, depression, and cardiovascular diseases[14,15] In contemporary society, young adults face unprecedented levels of academic, social, and professional stress, which can disrupt this delicate autonomic equilibrium, leading to increased SNS activity and reduced PNS tone.[2,7] This underscores the need for effective, accessible, and non-pharmacological interventions to foster resilience and autonomic health in this demographic. Yogic breathing practices, known collectively as *pranayama*, are a cornerstone of traditional yoga and have gained significant scientific interest for their potential to modulate the ANS. Techniques such as alternate nostril breathing (Nadi Shodhana) and slow diaphragmatic breathing are believed to stimulate the vagus nerve-the primary nerve of the PNS-thereby increasing vagal tone and promoting a state of physiological calm.[10,4] Heart Rate Variability (HRV), a non-invasive marker of cardiac autonomic regulation, is a widely accepted tool for assessing this modulation, where higher HRV is indicative of robust parasympathetic activity and better adaptability. [6,12]

While previous studies have demonstrated the benefits of multi-component yoga on stress and ANS function[9], there is a research gap regarding rigorous, randomized controlled trials that focus specifically on a structured, stand-alone yogic breathing protocol in a homogeneous cohort of healthy young adults. Most existing studies either combine pranayama with physical postures (asanas) and meditation, or have smaller sample sizes, making it difficult to isolate the unique contribution of breath control. Therefore, this study aims to systematically investigate the hypothesis that an 8-week regimen of selected yogic breathing techniques, devoid of other yogic elements, will significantly enhance parasympathetic activity and improve autonomic balance, as measured by HRV and standard cardiovascular reflex tests.

MATERIALS AND METHODS

Study Design

This study employed a prospective, randomized controlled trial design. Participants were randomly assigned to either an intervention group (yogic breathing) or a control group using computer-generated random numbers (block randomization, block size of 4). Assessors were blinded to group allocation. The study was conducted between January and April 2025.

Participants

A total of 160 healthy young adults (80 males and 80 females), aged 18–25 years, were recruited from a university population through flyers and online announcements. The sample size was calculated a priori using G*Power (version 3.1.9.7) with an effect size (f) of 0.25, an alpha level of 0.05, and 90% power for an ANOVA repeated-measures within–between interaction, yielding a required sample of 158. Eligible participants were those aged 18–25 years with a sedentary or moderately active lifestyle, defined as engaging in less than 150 minutes of moderate-intensity exercise per week according to WHO guidelines, and willing to comply with the 8-week study protocol. Individuals were excluded if they had a history of cardiovascular, respiratory, or metabolic disorders; practiced yoga or meditation regularly in the preceding six months; used medications affecting autonomic nervous system function (e.g., beta-blockers); smoked; or had any condition that could impair normal respiratory manoeuvres. Ethical approval was obtained from the Institutional Ethics Committee and written informed consent was obtained from all participants before enrollment.

Intervention

Intervention Group:

Participants attended supervised group sessions 5 days a week for 8 weeks, following a standardized protocol adapted from established yoga literature (Sovik & Bhavanani, 2016). Each 30-minute session, conducted in a quiet, well-ventilated hall, comprised:

1. Slow Diaphragmatic Breathing (10 minutes):
Participants were instructed to breathe slowly and deeply at a rate of 6-8 breaths per minute, guided by a metronome, with an emphasis on abdominal expansion during inhalation and gentle contraction during exhalation while sitting in a comfortable cross-legged position (Sukhasana).

2.Alternate Nostril Breathing (Nadi Shodhana) (20 minutes):
Participants practiced this technique in a comfortable seated posture. They used the right thumb to close the right nostril and the right ring finger to close the left nostril, following a pattern of inhalation through

the left, exhalation through the right, inhalation through the right, and exhalation through the left, completing one cycle. The breathing was smooth and without strain.

Control Group:
Participants were instructed to maintain their usual daily routines and refrain from starting any new exercise or stress-management programs during the study period. To control for attention, they were offered a single wellness lecture at the end of the study.

Outcome Measures:
All assessments were conducted in a quiet, temperature-controlled (22-24°C) laboratory between 8:00 and 10:00 AM, following an overnight fast (10-12 hours) and abstinence from caffeine, alcohol, and strenuous exercise for 24 hours.

Heart Rate Variability (HRV):
A 5-minute electrocardiogram (ECG) was recorded in a supine position using a Biopac MP150 system. Data were analyzed using Kubios HRV Standard software (version 3.5.0). Time-domain (SDNN, RMSSD) and frequency-domain (LF power [0.04-0.15 Hz], HF power [0.15-0.4 Hz], LF/HF ratio) indices were analyzed following the standards set by the Task Force (1996). RMSSD and HF power were designated as primary markers of parasympathetic activity.

Cardiovascular Reflex Tests:
Conducted as per Ewing's battery (Ewing et al.)[3].
1. Deep Breathing Test (DBT): Expiratory-to-inspiratory (E: I) ratio was calculated from six breathing cycles at 6 breaths/minute.
2. Valsalva Ratio: The ratio of the longest R-R interval after the maneuver to the shortest R-R interval during forced exhalation at 40 mmHg for 15 seconds.
3. 30:15 Ratio: The ratio of the R-R interval at the 30th beat to the R-R interval at the 15th beat after standing from a supine position.
4. Blood Pressure Response: Systolic blood pressure response to standing and isometric handgrip (30% maximum voluntary contraction for 2 minutes) was measured.

Statistical Analysis
Data were analyzed using SPSS statistics version 26.0 (IBM Corp., Armonk, NY, USA). Normality of data distribution was assessed using the Shapiro-Wilk test. Descriptive data are presented as mean ± standard deviation (SD). Within-group comparisons (pre- vs. post-intervention) were performed using paired sample t-tests for normally distributed data and Wilcoxon signed-rank tests for non-normal data. Between-group comparisons of change scores (post-pre) were made using independent sample t-tests or Mann-Whitney U tests. A p-value of < 0.05 was considered statistically significant.

RESULT
All 160 participants completed the study, and their data were included in the final analysis (CONSORT flow diagram provided as Supplementary Figure 1). The baseline characteristics of the participants were comparable between the two groups, confirming successful randomization (Table 1).

Table 1: Baseline Characteristics Of The Study Participants (Mean ± SD)

Characteristic	Intervention Group (n=80)	Control Group (n=80)	p-value
Age (years)	21.5 ± 1.7	21.3 ± 1.9	0.48
Gender (M/F)	40/40	40/40	1.00
BMI (kg/m²)	22.1 ± 2.3	21.8 ± 2.5	0.41
Resting Heart Rate (bpm)	74.2 ± 6.1	73.8 ± 5.9	0.67
Systolic BP (mmHg)	122.5 ± 7.3	121.8 ± 6.9	0.52
Diastolic BP (mmHg)	78.4 ± 5.2	77.9 ± 5.6	0.55

Post-intervention, the yoga group demonstrated significant improvements in key autonomic parameters compared to the control group (Table 2).

Table 2: Pre- And Post-intervention Autonomic Function Parameters (Mean ± SD)

Parameter	Group	Pre-Intervention	Post-Intervention	p-value (Within Group)
Resting HR (bpm)	Yoga	74.2 ± 6.1	68.1 ± 5.4	<0.01
	Control	73.8 ± 5.9	74.0 ± 6.2	0.82
Systolic BP (mmHg)	Yoga	122.5 ± 7.3	118.4 ± 6.5	<0.05
	Control	121.8 ± 6.9	122.1 ± 7.1	0.78
RMSSD (ms)	Yoga	32.5 ± 8.4	38.4 ± 9.1	<0.01
	Control	33.1 ± 7.9	32.8 ± 8.3	0.75
HF Power (ms²)	Yoga	355 ± 102	448 ± 121	<0.01
	Control	362 ± 98	358 ± 105	0.80
LF/HF Ratio	Yoga	1.8 ± 0.5	1.6 ± 0.4	0.07
	Control	1.7 ± 0.6	1.8 ± 0.5	0.71

Table 3: Results from Cardiovascular Reflex Tests (Mean ± SD)

Parameter	Group	Pre-Intervention	Post-Intervention	p-value (Within Group)
30:15 Ratio	Yoga	1.28 ± 0.11	1.35 ± 0.12	<0.05
	Control	1.27 ± 0.10	1.26 ± 0.11	0.65
Valsalva Ratio	Yoga	1.45 ± 0.15	1.51 ± 0.16	0.08
	Control	1.47 ± 0.14	1.46 ± 0.15	0.74
Deep Breathing Test (E:I Ratio)	Yoga	1.32 ± 0.09	1.38 ± 0.10	<0.05
	Control	1.31 ± 0.08	1.30 ± 0.09	0.58

Heart Rate Variability and Resting Parameters
As shown in Table 2, the yoga group demonstrated a highly significant increase in parasympathetic HRV indices. The RMSSD increased by 18.2% (p<0.01), and High-Frequency (HF) power increased by 26.2% (p<0.01). Concurrently, resting heart rate decreased significantly by 6.1 bpm (p<0.01), and systolic blood pressure decreased by 4.1 mmHg (p<0.05). The LF/HF ratio showed a decreasing trend, though it was not statistically significant (p=0.07). No significant changes were observed in the control group.

Cardiovascular Reflex Tests
The results from the cardiovascular reflex tests are detailed in Table 3. The 30:15 ratio and the Expiratory-to-Inspiratory (E: I) ratio from the Deep Breathing Test showed a significant improvement in the yoga group (p<0.05). The Valsalva ratio also improved, but the change did not reach statistical significance (p=0.08). No significant changes were observed in the control group for any of these parameters.

DISCUSSION
This randomized controlled trial provides clear evidence that an 8-week structured practice of yogic breathing techniques significantly enhances cardiovagal function and autonomic balance in healthy young adults. The intervention group exhibited marked improvements in primary parasympathetic markers (as shown in Tables 2 and 3), including HRV indices and specific cardiovascular reflexes, alongside beneficial reductions in resting heart rate and systolic blood pressure, with no such changes observed in the control group.

The most compelling findings from our study are the significant increases in time-domain (RMSSD) and frequency-domain (HF power) HRV parameters, as shown in Table 2. RMSSD and HF power are considered the gold-standard non-invasive measures of cardiac vagal tone.[10] The 18% increase in RMSSD and 26% increase in HF power unequivocally demonstrate enhanced parasympathetic nervous system (PNS) activity. This was clinically corroborated by the significant reduction in resting heart rate, a direct consequence of increased vagal inhibition on the sinoatrial node. The improvement in the 30:15 ratio and E:I ratio (Table 3) further solidifies this conclusion, as these tests specifically assess the PNS's ability to modulate heart rate in response to postural change and respiration, respectively. Our results are strongly aligned with a growing body of research on yogic breathing. A study by Bhimani et al. (2011)[1] reported a 22% increase in HF power following 12 weeks of Nadi Shodhana, a finding very consistent with our 26% increase over 8 weeks. Similarly, research by Telles et al. (2014)[13] demonstrated that slow breathing techniques led to a significant increase in RMSSD and a decrease in resting heart rate in healthy volunteers, mirroring our observations. The modest but significant reduction in systolic blood pressure observed in our study (Table 2) also finds support in the work of Pal et al. (2021)[8], who documented similar reductions in pre-hypertensive individuals following pranayama practice, attributing it to reduced sympathetic vasomotor tone. The non-significant change in the Valsalva ratio, a test requiring strong, coordinated vagal activation and recovery, has also been reported in other short-to-medium-term studies (Saoji et al., 2019)[9], suggesting it may require a longer intervention duration or more intensive training to manifest significant change.

The autonomic shifts observed can be explained by several interconnected physiological mechanisms. The slow, deep, and rhythmic nature of diaphragmatic and alternate nostril breathing stimulates pulmonary stretch receptors (Herring-Barrier reflex), sending afferent signals via the vagus nerve to the nucleus of the solitary tract (NTS) in the brainstem.[6] This leads to increased vagal efferent activity and inhibition of sympathetic outflow, resulting in bradycardia and increased HRV. Furthermore, the focused attention and controlled respiration involved in pranayama are believed to modulate higher brain centers, including the prefrontal cortex and amygdala, leading to a down-regulation of the hypothalamic-pituitary-adrenal (HPA) axis and a subsequent reduction in sympathetic tone.[12] The improvement in the 30:15 ratio specifically indicates enhanced vagal baroreflex sensitivity, allowing for a more rapid and appropriate parasympathetic response to orthostatic stress.

Clinical Significance

The findings hold significant clinical relevance. Yogic breathing presents a low-cost, accessible, and non-pharmacological strategy for improving autonomic tone, which is a cornerstone of resilience against stress-related disorders such as anxiety, hypertension, and cardiovascular disease.[15] Incorporating these practices into the daily routines of young adults could serve as a powerful primary prevention tool. However, this study has limitations. The participants were healthy, limiting generalizability to clinical populations. The intervention combined two techniques, preventing the isolation of each technique's individual effect. The lack of long-term follow-up means the persistence of benefits is unknown. Future research should include longer-term studies, dose-response analyses, and investigations in populations with diagnosed autonomic dysfunction.

CONCLUSION

This study conclusively demonstrates that a stand-alone, regular practice of yogic breathing techniques is an effective strategy for enhancing parasympathetic activity and promoting autonomic balance in young adults. Given the rising prevalence of stress-related disorders, these practices offer a powerful, evidence-based tool for primary prevention and health promotion.

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