

# Therapeutic potential of slow pranayama in anxiety

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## ABSTRACT

Pranayama, yogic breathing techniques, are considered a form of meditation. In classical yoga, the breath is associated with prana; thus, pranayama is a means to control the inner force, the prana shakti or life energy. Pranayama is more than regular breathing and if practiced in structured and methodical manner can reduce the body's physical symptoms of stress and anxiety. It has more recently gained popularity in the western world because of the many health benefits that come from a pranayama practice. Anxiety disorders are among the most common mental health conditions, affecting millions worldwide. Anxiety is an emotional state in which one perceives worry, danger, apprehension, and nervousness and has negative effects on all aspects such as social, personal, and academic performance. It is closely linked with autonomic nervous system dysregulation, often reflected in decreased heart rate variability (HRV), a biomarker of vagal tone and emotional and psychological resilience. HRV reflects the balance between sympathetic and parasympathetic nervous activities. Nonpharmacological approaches such as yogic breathing techniques have shown promising approaches in reducing anxiety symptoms. The modulation of HRV through slow breathing, often characterized by a prolonged expiratory phase, enhances vagal tone, restores sympathovagal balance, and promotes homeostasis. Research indicates that yoga interventions positively impact individuals with mental health disorders, improving positive symptoms and quality of life and reducing milder symptoms. This review explores the therapeutic potential of slow pranayama in reducing anxiety symptoms and managing anxiety disorders. It examines current evidence, limitations, and future research directions for integrating yoga-based practices into mental health care.

**Keywords:** Anxiety, heart rate variability, meditation, parasympathetic, slow pranayama, sympathetic, yoga

## Introduction

Anxiety disorders are the most prevalent mental health conditions, impacting 301 million people worldwide in 2019.<sup>[1]</sup> Globally, 4% of the population is affected.<sup>[2]</sup> Anxiety disorders elevate the likelihood of developing depression, substance use, and suicidal behaviors. Anxiety disorders encompass generalized/social separation anxiety disorder, panic disorder, and phobias.

Approximately one in four individuals with anxiety disorders seeks medical treatment. Anxiety disorders are strongly connected

to and influenced by physical health.<sup>[3]</sup> Several anxiety-related effects, such as muscle tension, heightened nervous system activity, and excessive alcohol use, are also known risk factors for conditions like heart disease. The cardiovascular risks associated with anxiety disorders emerge from the disruption of the hypothalamic-pituitary-adrenal axis, impairing the autonomic nervous system and sympathovagal balance, which regulate cardiovascular functions. Heart rate variability (HRV) indicators, like the “low-frequency (LF) to high-frequency (HF) power ratio” or the “fractional LF power,” are frequent noninvasive tools used to evaluate the balance between the components of the autonomic nervous systems.<sup>[4,5]</sup>

Several obstacles restrict access to care for individuals with mental health conditions. Antidepressant medications are useful in treating adults with anxiety disorders but are associated with potential adverse effects and dependence. Psychological

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Received: 04-04-2025

Revised: 02-07-2025

Accepted: 29-07-2025

Published: 30-12-2025

### Access this article online

#### Quick Response Code:



**Website:**  
<http://journals.lww.com/JFMPC>

**DOI:**  
10.4103/jfmpe.jfmpe\_570\_25

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**How to cite this article:** Sharma N, Jha K, Munni C. Therapeutic potential of slow pranayama in anxiety. J Family Med Prim Care 2025;14:4948-54.

treatments are commonly employed to address various psychiatric conditions, primarily talk therapy, exposure therapy to learn to face fears, and coping strategies. However, the high cost and inaccessibility of psychotherapy restrict underserved people without health insurance from availing its benefits. These limitations highlight the need for complementary and alternative therapies, such as yoga-based interventions. As a result, there has been increasing interest in emerging therapies like yoga and pranayama, which are being explored to establish evidence-based research to address clinical conditions.

## Methodology

We conducted a search on PubMed for articles published between January 2020 and January 2025 to identify recent literature on yoga and anxiety disorders. We prioritized including research articles, systematic reviews, meta-analyses, and recent randomized controlled trials for evidence-based research on yoga for anxiety. The initial literature search revealed 39 articles. After reviewing abstracts, 13 papers were chosen for an in-depth analysis and included in the qualitative review. Further searches using synonym-permutation combinations revealed five additional articles, all of which were irrelevant, including animal studies.

## Pranayama: The Fourth Limb of Ashtanga Yoga

Patanjali, the master of Raja Yoga, advocated yoga in eight limbs, popularly known as Ashtanga Yoga. In his Yoga Sutra, Patanjali outlines the eight limbs of yoga, known as “Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana, and Samadhi.” Pranayama is the fourth limb of Ashtanga Yoga. The word “pranayama” combines “prana” and “ayama.” “Prana” denotes vital energy, while “ayama” signifies expansion, regulation, or control.<sup>[6]</sup> The key difference between regular breathing and pranayama is that pranayama follows a structured and methodical process using specific yogic techniques, such as puraka (inhalation), rechaka (exhalation), antara kumbhaka (breath-holding after inspiration), and bahya kumbhaka (breath-holding after exhalation).<sup>[7,8]</sup>

## Studies on the Effect of Slow Pranayama on Anxiety Disorders

A summary of studies depicting the effect of slow pranayama on anxiety disorders is presented in Table 1.

Deepika and Kumar<sup>[22]</sup> reported a case study on the combined impact of “yoga nidra” and “pranayama” in managing anxiety disorders in three patients, with the results showing a reduction in anxiety. Birdee *et al.*<sup>[12]</sup> conducted a single-blinded 12-week randomized controlled trial on 100 subjects to determine whether slow breathing with a longer exhalation than inhalation, compared to an equal inhalation and exhalation, results in observable changes in physiological and psychological stress in healthy adults. The results showed that consistent slow breathing

practice for 12 weeks, regardless of the inhalation–exhalation proportion, significantly decreased psychological stress as measured by PROMIS Anxiety but had no effect on physiological stress as evaluated by HRV. Bentley *et al.*<sup>[11]</sup> conducted a systematic review of evidence-based research to assist in optimizing the stress and anxiety reduction benefits of breathing practices.

## Slow Breathing Pranayama and Sympathovagal Balance

Slow pranayama influences the autonomic nervous system by boosting vagal activity and lowering sympathetic activity in both healthy individuals and those with different health conditions. This article examines the effects of slow pranayama on anxiety disorders by regulating sympathovagal balance. HRV reflects the variability in instantaneous heart rates and is a noninvasive tool to evaluate the equilibrium between the two divisions of the autonomic nervous system.<sup>[23]</sup> In a pilot study by Trivedi *et al.*,<sup>[20]</sup> the long-term HRV parameters of 23 subjects were compared across four different activities: “humming,” “physical exercise,” “emotional stress,” and “sleep.” The results showed that “humming” produced the minimal stress index compared to the other three tasks. Garg and Chandla<sup>[24]</sup> examined the impact of slow breathing pranayama on sympatho-vagal balance and found a notable rise in the high-frequency (HF) parameter, accompanied by a substantial drop in the low-frequency (LF) parameter and the LF/HF ratio. Pal *et al.*<sup>[25]</sup> noted a notable rise in parasympathetic activity and a reduction in sympathetic outflow following the practice of slow breathing. Telles *et al.*<sup>[26]</sup> observed a marked decrease in diastolic blood pressure following “anulom-vilom pranayama,” indicating a reduction in sympathetic activity. Madanmohan *et al.*<sup>[27]</sup> demonstrated a reduction in sympathetic discharge following the practice of slow breathing pranayama. Table 2 lists the important types of slow breathing pranayama techniques commonly recommended for sympatho-vagal balance.

## The Role of the Vagus Nerve in Slow Pranayama

The vagus nerve, the parasympathetic branch of the autonomic nervous system, plays a vital role in maintaining overall health. It facilitates communication between the brain and internal organs and controls the body’s response during rest and relaxation. Slow pranayama practices help reset the autonomic nervous system by activating stretch-induced inhibitory signals, synchronizing neural activity across the heart, lungs, limbic system, and cortex. It modulates vagal dominance and activates the parasympathetic nervous system, leading to overall rest, resilience, relaxation, and calmness.

## Sympathovagal Balance and Anxiety Disorder

Stressful situations activate the “fight-or-flight” response, which prepares the individual to cope or flee from stress. The response initiates physiological changes to address the challenge. In

**Table 1: Studies on slow pranayama for anxiety disorders**

Author and Year	Intervention	Remarks	Limitations
Natarajan K <i>et al.</i> 2024, RCT, <i>n</i> =140 <sup>[9]</sup>	Experimental group: slow pranayama and savasana for 8 weeks with routine psychiatric care. Control group: Routine psychiatric care.	In the pranayama group, the HRV parameters showed significant improvement toward the parasympathetic domain.	A double-blinded study would have added more value.
Novaes MM <i>et al.</i> , RCT <i>n</i> =30 <sup>[10]</sup>	In the RCT, 30 healthy young adults were assessed at baseline and after 4 weeks of Bhastrika pranayama.	4 weeks of Bhastrika pranayama reduced anxiety and modulated the activity of brain regions.	The sample size limitations, focus on healthy subjects, and the exploratory nature of the study limit the ability to apply the results to individuals with anxiety disorders.
Bentley TKG <i>et al.</i> , <sup>[11]</sup> Systematic review of 54 studies	Review	The articles included in the analysis showed considerable variation in how practices were reported and implemented.	Future research should focus on blinding and large cohorts.
Birdee G. <i>et al.</i> Single-blinded RCT, <i>n</i> =100, 2023. <sup>[12]</sup>	Slow breathing with an exhale greater than inhale versus an exhale equals inhale to evaluate differences in physiological and psychological stress among healthy adults.	A 12-week slow breathing practice significantly decreased psychological stress, as indicated by PROMIS Anxiety scores, but had no effect on physiological stress as measured by HRV.	Wide range of interindividual variability, small sample size.
Sharpe E <i>et al.</i> Clinical crossover trial. <i>n</i> =25, 2021. <sup>[13]</sup>	5 activities performed in random order over five separate visits: 1) sitting quietly, 2) self-paced deep breathing, 3) externally-paced deep breathing, 4) self-paced Sheetalī/Sheetkari pranayama, and 5) externally paced Sheetalī/Sheetkari pranayama.	Higher HRV parameters were observed, with greater improvements seen during externally paced breathing compared to self-paced breathing.	Small sample size, variations in the practice could be explored.
Singh D and Budhi RB. <i>n</i> =40, healthy 2022 <sup>[14]</sup>	Working memory task, 'n-back', consisting of three levels of difficulty, 0-back, 1-back, and 2-back, separately, before and after three SYB sessions on different days. Slow yoga breathing (SYB) included alternate nostril breathing (ANB), right nostril breathing (RNB), and breath awareness (BAW).	SYB practice improves cognition (8–9%) associated with memory consolidation and enhances cardiac function, which is essential for effectively completing mental tasks.	Small sample size, lack of a control group, study outcomes were restricted to male yoga practitioners only. The lingering effect of the practice block during the neurocognitive task could not be ruled out.
Chhikara A <i>et al.</i> Review article <sup>[15]</sup>	Sudarshan Kriya and meditation for tension and anxiety in dysmenorrhea.	The practice reduces symptoms of stress and anxiety.	Limited literature review.
Malhotra V, <i>et al.</i> <i>n</i> =30 <sup>[16]</sup>	Slow deep breathing (SDB), alternate nostril breathing (ANB), Kapalbhāti, nostril breathing exercise, and moderate exercise as a control. Spinal energy measured at baseline, session, and postsession.	SDB, ANB, and specific nostril breathing exercises significantly increased spinal energy levels.	The challenge of accurately measuring "spinal energy" using the NeuralChek SPINAL ENERGY device may introduce variability. Multiple breathing exercises complicate isolating each practice's effect. Small sample size and the observational nature of the study limit the generalizability and reliability of the findings.
Sorout J <i>et al.</i> RCT. <i>n</i> =200, 2024 <sup>[17]</sup>	200 subjects with metabolic syndrome were randomly assigned to control or the combined group (yoga + diet intervention) for 6 months.	The combined approach of yoga and diet is efficient in lowering stress.	The study lacked measurement of confounding factors such as diet and sleep quality. The comparison between the two groups did not provide a clear understanding of the intervention's effect.
Jahan I <i>et al.</i> Randomized experimental study, <i>n</i> =100, 2021 <sup>[18]</sup>	Effect of 4 weeks of alternate nostril breathing (ANB) on cardiorespiratory parameters at the start and 4 weeks of intervention.	Improvement in the parameters in the intervention group.	The prospective intervention study had a shorter duration and a small sample. Sociodemographic factors were not assessed.
Chand K <i>et al.</i> <i>n</i> =44 <sup>[19]</sup>	Two groups: Relaxed-Stress (RS) ( <i>n</i> =22) and Stress-Relaxed (SR) ( <i>n</i> =22). The RS group engaged in a breathing task for 5 minutes, followed by 5 minutes of mental calculations. The SR group had the order reversed.	33 HRV parameters demonstrated significant differences in two therapies. The parameters demonstrated a positive trend in the relaxed state and a degrading trend in the stressed state.	The respiration rate was extracted from the HRV data, but no subjective psychological measures were used to assess the participants' mental state.

Contd...

**Table 1: Contd...**

Author and Year	Intervention	Remarks	Limitations
Trivedi G <i>et al.</i> Pilot study, N=23, 2023 <sup>[20]</sup>	The HRV parameters of 23 subjects were examined in relation to four different tasks: humming, physical activity, emotional stress, and sleep.	“Humming or Simple Bhrumari” generates the least amount of stress compared to the other three activities.	Small sample size, limitations of the LF/HF ratio interpretation.
Ray IB. 2021 <sup>[21]</sup>	Effect of Yoga as a therapeutic and preventive modality.	It decreases inflammation by blocking the NF- $\kappa$ B pathway, affects epigenetic modifications, maintains telomerase length, enhances sensitivity to glucocorticoid receptors, depresses sympathetic activity, and improves parasympathetic activity.	-

RCT: Randomized Clinical Trial; HRV: Heart Rate Variability; PROMIS: Patient-Reported Outcomes Measurement Information System

**Table 2: Slow pranayama techniques for sympatho-vagal balance**

Asana	Procedure
“Anuloma-Viloma Pranayama” or Alternate Nostril Breathing	Sit in a meditative posture. Position your right hand in Nasagra pose. Inhale through the left nostril, close it, and exhale through the right nostril. Then, inhale through the right nostril and exhale through the left nostril. This completes <sup>[1]</sup> one round.
“Chandra Nadi Pranayama or Left Nostril Breathing”	Sit in a meditative posture. Position your right hand in Nasagra pose. Inhale through the left nostril and then exhale slowly from the left nostril with the right nostril closed, with exhalation time more than inhalation. This completes one round.
“Bhrumari Pranayama” (Breathing with vibrations through the ear)	Sit in a meditative posture. Inhale deeply through the nose. Close both ears with the index fingers. Exhale gradually in a controlled way, producing a deep, consistent humming sound similar to that of a black bee. This completes one round.
“Sheetali Pranayama or Cooling Breaths”	Sit in a meditative posture. Keep the lips slightly apart, allowing the tongue to protrude slightly. Breathe through the mouth, and at the end of the breath, retain the breath by placing the tongue in its natural position. Exhale slowly through the nose, keeping the mouth closed. This completes one round of Sheetali Pranayama. Gradually increase the inhalation–exhalation ratio to 1:2, followed by breath retention.

brief instances, the “fight-or-flight” outcome is beneficial and important for survival. However, if the sympathetic nervous system is persistently overstimulated due to chronic stress or imbalances, it can lead to a state of hyperarousal. The continuous activation of the “fight-or-flight” reaction is essential in the development of anxiety disorders.

Studies suggest that individuals with dysregulation of the sympathetic nervous system experience emotional issues like irritability, restlessness, anxiety, constant fear, and an increased risk of cardiovascular disease. A study by Watkins *et al.*<sup>[28]</sup> investigated the relationship between anxiety and vagal control of heart rate in older adults with major depressive disorders. The results revealed an inverse relationship between anxiety and baroreflex control of heart rate (BRC SPEC) as well as respiratory sinus arrhythmia (RSA), while depression was not associated with

either. The study concluded that anxiety is linked to decreased baroreflex control of heart rate (BRC SPEC).

Vagus nerve impulses have a significant impact on emotional behavior; that is, changes in vagus nerve impulses can lead to heightened anxiety and depression-like behaviors.<sup>[29-34]</sup> Additionally, proper modulation of vagal impulses through vagus nerve stimulation (VNS) helps alleviate depression that is resistant to treatment in humans<sup>[35-39]</sup> and induces antianxiety<sup>[40,41]</sup> and psychotropic, mood-stabilizing effects<sup>[42,43]</sup> in rats. These studies support the notion that vagus nerve impulses play a crucial role in maintaining emotional states.<sup>[42,43]</sup> Therefore, vagal nerve activity experiences dynamic changes in response to anxiety.

Although VNS is an efficient treatment for affective disorders, its fundamental physiology remains unclear. A study conducted by Okonogi *et al.*<sup>[44]</sup> demonstrated that VNS restores stress-induced prefrontal cortex-amygdala (PFC-AMY) oscillations in stress-susceptible mice. The prefrontal cortex and amygdala are thought to be the main brain areas associated with anxiety,<sup>[45-47]</sup> and the synchronization of neuronal oscillations between these regions influences anxiogenic behavior.<sup>[48-52]</sup>

### Benefits of Slow Breathing Pranayama in Anxiety Disorder

Recent evidence indicates that practicing pranayama has beneficial effects on clinical stress and anxiety levels. A randomized controlled trial design by Novaes *et al.*<sup>[10]</sup> assessed functional magnetic resonance imaging at baseline, and 4 weeks of pranayama practice indicated that pranayama reduced anxiety and negative emotions by modulating the activity of brain regions, mainly the amygdala, anterior cingulate, anterior insula, and prefrontal cortex. Nemati<sup>[53]</sup> investigated the effect of pranayama on test anxiety and found that one full semester of pranayama practice resulted in a significant positive effect on test anxiety and suggested it as an important pre-examination technique to reduce test anxiety.

Jain and Sharma *et al.*<sup>[54]</sup> investigated the impact of a yogic intervention, specifically pranayama, on anxiety and depression,

and the results suggested the beneficial impact of pranayama on anxiety and depression, improving mental energy and positive mental health. Chandrababu *et al.*<sup>[55]</sup> conducted a study to evaluate the impact of “alternate nostril breathing” on anxiety and pain in patients subjected to heart surgery. The results supported the use of pranayama in reducing anxiety in these patients. Magnon *et al.*<sup>[56]</sup> investigated the impact of a 5-minute deep slow breathing (DSB) on subjective anxiety and biological stress (measured by HRV) among adults, both young and old. The results demonstrated a decrease in anxiety following the DSB exercise and an increase in HF power, a parasympathetic HRV index, among both young and older adults. Jagadeesan *et al.*<sup>[57]</sup> studied the impact of “Bhramari Pranayama” on psychological distress in patients during home isolation and showed a significant decrease in DASS-21 scores. Additionally, the patients reported significant improvements in sleep quality and quality of life following the therapy.

A large body of research provides evidence that yoga improves positive symptoms and quality of life in anxiety. The practice of “yoga” and “pranayama” enhances awareness of mind, body, and spirit while helping regulate the limbic-hypothalamus axis. This aids in relieving anxiety and lowering stress hormone levels in the body. Furthermore, it encourages the production of helpful hormones like adrenaline and enkephalin, which positively impact the body and strengthen the immune system.<sup>[54]</sup>

## Challenges and Future Perspectives of Yoga in Anxiety Disorders

Although research on yoga-based approaches for mental health is progressing, there are still numerous limitations in the current research regarding yoga as a therapeutic modality. Many studies have limitations in their methodology and are regarded as having high potential for bias. There is a shortage of well-conducted randomized controlled designs, and blinding is frequently challenging because of the nature of the intervention.

Additionally, many studies have small sample sizes, which results in limited statistical power to detect meaningful effects. Evidence-based control groups and standardized outcome measures, such as biomarkers and validated psychometric scales, are frequently absent. While some studies consider individuals’ mental health symptoms, a few studies include subjects with officially diagnosed psychiatric disorders, and even fewer utilize standard diagnostic assessments. This restricts the current evidence supporting yoga as an effective intervention for individuals with psychiatric conditions. Additionally, there is notable variation in yoga therapy as yoga is a diverse practice with heterogeneity, traditions, and adaptations. This complexity makes evaluating yoga research difficult. The existing literature also does not provide clear guidance on the ideal dose, including the frequency, duration, components, or type of yoga practice, most effective for particular psychiatric disorders. So, more large-sample-size studies are warranted, specifying the duration, frequency, and type of yogic intervention.

## Summary

Pranayama, a yogic breathing practice, has demonstrated significant potential in reducing anxiety and improving mental wellbeing among clinical populations. Mental health conditions including anxiety present challenge and risk stratification for healthcare professionals. People with mental health conditions have greater morbidity and die 10–20 years earlier than the general population. Suicidal tendency is a potentially life-threatening risk factor for mental health conditions.<sup>[55]</sup> There are barriers to access for medical care due to stigma and social perception for fear of being judged as “mentally ill”, fear of being addicted, lack of awareness of symptoms as a medical condition, fear of medication side effects like excess sleep, day-time drowsiness, and so on. Psychotherapy can be an alternative to medical treatment, but its high cost, long duration of counseling sessions, emotional discomfort during sessions, and lack of qualified psychologist pose a significant challenge for patient care. Emerging reliance on complementary and alternative medicine (CAM), spiritual healing, and traditional practices such as yoga breathing techniques promotes the holistic health and improves the mental health conditions. The article summarizes the literature review of yoga-based breathing techniques as a treatment modality for anxiety disorders.

Pranayama techniques, particularly slow rhythmic breathing, promote parasympathetic activation and inhibit excessive sympathetic output. This sympathovagal shift is mediated through stimulation of vagus nerve, which enhances vagal tone and respiratory sinus arrhythmia (RSA).<sup>[56]</sup> Enhanced vagal response helps to reduce heart rate and blood pressure and calms the emotional centres of the brain, particularly amygdala, prefrontal cortex, and insula, which are involved in anxiety regulation.

Moreover, slow breathing patterns influence baroreflex sensitivity and chemoreceptor feedback, creating a stable internal physiological environment and increasing HRV, which is a reliable indicator of autonomic balance and emotional regulation. The cumulative result is measurable reduction in anxiety symptoms, and enhanced stress resilience.<sup>[57,58]</sup>

## Limitations

Small sample sizes and the observational nature of the study limit the generalizability and reliability of the findings. A double-blinded study would have added more value. Sociodemographic factors were not assessed. The respiration rate was extracted from the HRV data, but no subjective psychological measures were used to assess the participants’ mental state. A wide range of interindividual variability, lack of a control group, and study outcomes restricted to male or female yoga practitioners only are a few limitations of the studies.

## Future aspects of the study

Further research could explore exact underlying mechanisms and clinical applications, bridging ancient wisdom with contemporary

scientific understanding for optimized health outcomes. More evidence-based research for long duration on a large sample size with a larger group of participants is necessary to further improve this readily accessible intervention for managing stress and anxiety.

### Acknowledgement

Acknowledge all the authors who worked in the domain, especially those whose articles have been referred to in the review.

### Financial support and sponsorship

The review article did not receive any specific grant from any government or commercial funding agencies. The manuscript was drafted independently without any external financial support.

### Conflicts of interest

There are no conflicts of interest.

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