Original Article

Mindfulness-based breathing techniques:
A scoping review of recent research trends and future directions

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Abstract
The aim of this study was to systematically map recent original research on mindfulness-based breathing techniques (MB) using a scoping review approach, with a focus on identifying research trends and gaps. Literature searches were conducted using PubMed and PsycINFO, targeting studies published between 2020 and 2025. Studies involving healthy adults and examining MB as a standalone intervention were included, resulting in a final sample of 20 articles that met the eligibility criteria. Across the studies included, a wide range of outcomes—psychological, cognitive, and physiological—were assessed, reflecting a multidimensional approach to evaluating the effects of MB. While the findings generally suggested beneficial effects, some studies did not employ direct measures of mindfulness states. Therefore, although the observed outcomes may be attributable to mindfulness processes, caution is warranted in interpreting these effects. Regarding intervention characteristics, common core processes were identified, including non-judgmental attention to the breath and the refocusing of attention when distracted. However, variability was observed in practice duration and implementation settings. Notably, many studies employed relatively short-duration interventions, suggesting potential advantages in terms of feasibility and applicability, particularly for beginners and in educational or clinical contexts. Despite these promising findings, important limitations were identified. In particular, the sustainability of effects and optimal intervention conditions remain insufficiently examined. Future research should aim to clarify the definition and structural components of MB, ensure the appropriate selection of outcome measures, and adopt longitudinal study designs integrating both qualitative and quantitative approaches. Addressing these issues will contribute to a more comprehensive understanding of the mechanisms and applications of mindfulness-based breathing techniques.

Key words
mindfulness, breathing technique, short-duration technique, isolated technique, scoping review

1. Introduction

Mindfulness has gained attention as a psychological intervention with broad effects on psychological and physiological aspects, and its practice is expanding across multiple domains including healthcare, education, and industry (Benavides-Gil et al., 2024; Ong et al., 2024; Shahbaz and Parker, 2022). Particularly in the medical field, mindfulness-based interventions (MBIs) have been consistently reported to improve stress responses, burnout, and emotional regulation in studies targeting healthcare professionals and medical students (Joseph and Jose, 2024; Kaisti et al., 2024; Wang et al., 2023). Furthermore, recent studies have demonstrated beneficial effects not only on these psychological outcomes but also on behavioural and psychosocial indicators such as psychological symptoms like depression and anxiety, inappropriate eating behaviours, physical activity levels, and internet addiction (Fendel et al., 2024; Kao et al., 2025; Preissner et al., 2025). Furthermore, findings regarding physiological underpinnings, such as neurobiological mechanisms (Calderone et al., 2024) and effects on the endocrine system (Vargas-Uricoechea et al., 2024), are accumulating, advancing our understanding of the mechanisms of action of MBIs.

On the other hand, many MBIs are composed of multiple techniques, and concerns have been raised about the heterogeneity of intervention content and the low comparability between studies (Bolognino et al., 2023; Lopes et al., 2024; Preissner et al., 2025; Renshaw, 2020). Precisely because they are composite interventions, it is difficult to identify which specific components contribute to the observed effects. Theoretical challenges regarding the efficacy mechanisms of MBIs are therefore thought to remain. Furthermore, the diversity of techniques and the associated learning efforts have been noted as factors that can make sustained practice difficult for beginners and lead to dropout (Hitomi, 2025; Miyoshi and Taniguchi, 2024).

Given these challenges, research focusing on single techniques holds significant importance for understanding the mechanisms of MBIs and refining interventions. Recent studies have shown that mindfulness breathing (MB) dem-

onstrates improvements in mood and reductions in respiratory rate compared to mindfulness meditation (Balban et al., 2023), suggesting that even single techniques can yield certain effects. MB is considered a useful approach because it is easier to standardize conditions than interventions combining multiple elements, and that supports to facilitate comparative verification across studies. Therefore, organizing findings specifically targeting MB is particularly meaningful, given its status as a single technique and the potential for its effectiveness.

However, existing review studies primarily focus on composite MBIs, with few reviews systematically organizing the effects or methodological characteristics of MB alone. There are few comprehensive findings examining which outcomes MB influences, the degree of variation in practice procedures, or how practice duration and frequency affect efficacy. This gap is considered a significant impediment to both the theoretical understanding and practical application of MB. Given this background, systematically surveying existing literature to clarify the accumulation of research, existing gaps, commonalities and diversity in methodology, as well as effectiveness and limitations, is critically important. It provides a foundation for identifying future research directions and practical applications for MB, holding substantial academic significance. Furthermore, focusing on recent studies is expected to enable an accurate grasp of current research trends, implementation time tendencies, and commonalities in practice conditions. Therefore, this study aimed to clarify the trends and gaps in existing research by conducting a scoping review targeting recent studies on MB.

2. Methods

This study focuses on MB, aiming to systematically organize its methodological characteristics, effects, and limitations. Based on this objective, participants were limited to healthy adults to exclude the potential influence of disease or symptoms on intervention effects and to ensure interpretive consistency. Furthermore, studies incorporating complex mindfulness practices that included techniques other than breathing techniques (e.g., yoga, body scan, meditation) were excluded from this review because they did not evaluate MB practice alone.

Scoping review methodology was employed to minimize bias and ensure objectivity in literature selection. A scoping review concisely summarizes key concepts, information sources, and types of available literature and evidence within a specific research field, enabling a comprehensive grasp of existing knowledge while identifying knowledge gaps and challenges (Hitomi et al., 2024).

2.1 Eligibility criteria (PCC: population, concept, context) and literature selection criteria

In this study, MB refers not to respiratory regulation techniques, such as diaphragmatic breathing or paced breathing primarily aimed at regulating respiratory rate or ventilation volume, but rather to practices centered on attention to breathing positioned within the mindfulness framework. The authors use terms such as mindfulness, mindful breathing, breath-focused attention, and meditation to describe these practices. The "mindfulness effect" in this study refers to all observable changes in psychological, cognitive, physiological, and neurological indicators that may result from interventions involving attention to breathing positioned as mindfulness practice. This refers to practices that go beyond mere breath regulation and encompass non-judgmental attention to the breath and the process of bringing attention back to it through a variety of techniques. Therefore, we limited the scope to practices explicitly identified as mindfulness in the literature. Even if the name of the breathing technique differed, we adopted it as MB if it was documented as a mindfulness practice. Conversely, even yoga breathing techniques widely practiced as MB were excluded if studies did not explicitly state they were practiced within a mindfulness context.

2.2 PCC

- Population: Healthy adults
- Concept: Interventions and practices involving mindful breathing, one of the mindfulness techniques
- Context: Education, workplace, general community settings, etc.
- Study Period: 5 years (January 1, 2020 to June 18, 2025)

2.3 Literature selection criteria

Eligibility criteria:

1. Participants are healthy adults
2. The study must explicitly describe MB as the intervention method (even if the name differs, techniques using breathing methods that clearly demonstrate the effects of mindfulness are considered MB interventions) and must be a practice centered on attention to breathing.
3. Original research articles
4. Full text must be downloadable

Exclusion criteria:

1. Studies with ambiguous or unclear descriptions of MB (those not explicitly mentioning mindfulness effects)
2. Studies including composite mindfulness practices (e.g., yoga, body scan, meditation) as interventions
3. Conference proceedings, society journals, case reports, or case studies
4. Studies primarily focused on verifying effects for specific

diseases or symptoms

2.4 Screening procedure

In the primary screening, eligibility criteria were assessed based on paper titles and abstracts; papers where eligibility could not be clearly determined were included. In the secondary screening, full texts were obtained and examined in detail. Final selection was made after discussion by two researchers in both stages.

2.5 Search method

In this study, based on the objective of comprehensively examining the psychological and physiological effects of MB in healthy adults, we conducted a literature search using PubMed, which represents the fields of medicine and life sciences, and PsycINFO, which represents the field of psychology. The search included literature published up to June 18, 2025. Since mindfulness has been reported to broadly influence psychological, emotional, and stress-related indicators, this review targeted literature containing keywords related to psychological health, including stress, anxiety, mental health, and well-being. The search terms were developed based on these keywords and finalized through discussion between two researchers to ensure validity.

- PubMed Search Terms:
  ("mindful breathing" OR "mindfulness breathing" OR "breath awareness")
  AND ("intervention" OR "practice" OR "training")
  AND ("mental health" OR "stress" OR "anxiety" OR "well-being")
  NOT ("review" OR "meta-analysis")
  AND ("2020/01/01"[Date - Publication] : "2025/6/18"[Date - Publication])
- PsycINFO search query
  AB("mindful breathing" OR "mindfulness breathing" OR "breath awareness") AND
  AB("intervention" OR "practice" OR "training") AND
  AB("mental health" OR "stress" OR "anxiety" OR "well-being") AND
  NOT AB("review" OR "systematic review" OR "scoping review" OR "meta-analysis") AND
  PY >= 2020

The search yielded 195 articles, with 115 from PubMed and 82 from PsycINFO, and 22 duplicate articles. In the primary screening, based on article titles and abstracts, 21 articles met the eligibility criteria. In the secondary screening, full texts of these 21 articles were obtained and discussed. As a result, 20 articles met the inclusion criteria. The process of these results is shown in a flowchart based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) (Figure 1). For these 20 articles, the following items were organized separately: Study Objective, Study Design, Participants, Breathing Technique Details, Main Outcomes, and Conclusion/Implications (Table 1).

3. Results

This study targeted 20 original research articles on MB. Each article was organized based on the perspectives of Study Objective, Study Design, Participants, Breathing Technique Details, Main Outcomes, and Conclusion/Implications,

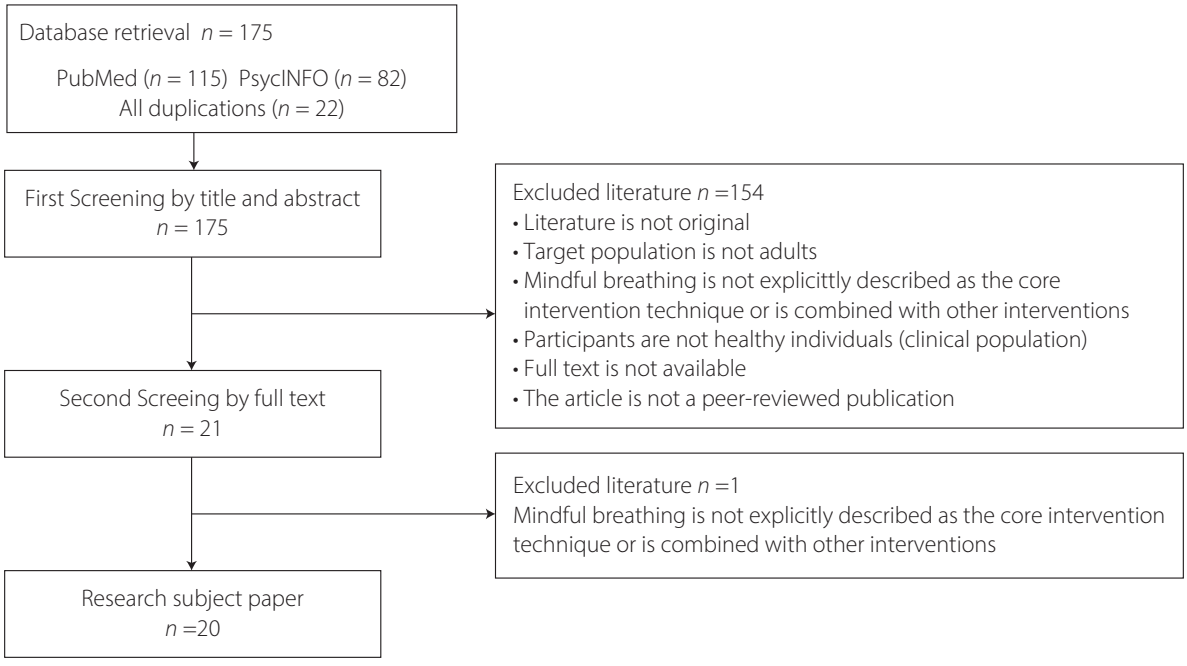

Figure 1: PRISMA flowchart search results and literature selection process for this study

Table 1: Summary of included studies (n = 20) in the scoping review

ID	Authors (Year)	Title	Journal	Study Objective	Study Design	Participants	Breathing Technique Details
1	Brahmi, M., Soni, D., & Kumar, J. (2025)	Neurobehavioural Exploration of Breath-counting & Breath-awareness in Novice Indian Meditators: A Naturalised Ānāpānasati-based Paradigmatic Approach	Annals of Neurosciences	This study investigates the effects of Anapanasati breathing meditation on electroencephalographic (EEG) changes and self-reported mindfulness states in novice meditators following cognitive effort. The primary objectives are to evaluate (1) changes in neural oscillations across three stages (Resting State: RS, Breath Counting: BC, Breath Focusing: BF) and (2) the relationship between neural and subjective variables during the BC stage.	Within-group comparative study	89 Indian novice meditators (mean age 24.6 years; 82 men, 7 women)	The breathing technique consisted of three stages based on the Buddhist Ānāpānasati. RS: 5 minutes of resting with eyes closed. BC: 5 minutes of counting breaths while increasing concentration. BF: 8–10 minutes of continuously focusing on the breath. Frequency: One session (approximately 20 minutes) was conducted once.
2	Li, E., Cheng, W., Yuan, H., & Gao, X. (2025)	Protecting young women's body image from appearance-based social media exposure: A comparative study of self-compassion writing and mindful breathing interventions	Journal of Psychosomatic Research	This study compares the protective effects of 5 minutes of self-compassion writing and mindful breathing against the negative effects of exposure to idealized body images on social media on body image and emotional well-being, and verifies their effectiveness, particularly among young women with high tendencies toward self-objectification.	Randomized Controlled Trial (RCT)	107 healthy female college students aged 17–25 (mean age 20.81 years)	The mindful breathing group performed a single 5-minute guided breathing meditation session. Participants were instructed to focus their attention on their breathing and bodily sensations and followed an audio guide (recorded by a female mindfulness instructor) without background noise. The session was conducted individually in a laboratory setting.
3	Natarajan, A., Emir-Farinas, H., & Su, H.-W. (2023)	Mindful breathing as an effective technique in the management of hypertension	Frontiers in Physiology	To examine the short- and medium-term changes in systolic and diastolic blood pressure resulting from 15 minutes of mindful breathing (6 breaths per minute) daily, and to explore its potential application in hypertension management	Quasi-experimental study	1,918 Fitbit users (adults residing in the U.S. or Canada, capable of self-measuring blood pressure, and smartwatch owners)	A 15-minute mindfulness breathing session once daily (breathing rate: 6 breaths/min = 5-second inhalation + 5-second exhalation) via an app on a Fitbit device, continued for 28 days. Timing of inhalation and exhalation was guided by an animated guide.
4	Togo, E. (2024)	Time Series Data Analysis of Mindfulness Breathing Method Using Electroencephalogram	SAGE Open Nursing	To evaluate the effects of Mindful Breathing Meditation on mental stress in university students using time-series data analysis of electroencephalogram (EEG) signals	Randomized Controlled Trial (RCT)	20 healthy college students (10 per group, mean age: 21.5 ± 0.9 years, no prior mindfulness experience)	A 5-minute Mindful Breathing Meditation session based on Kabat's MBSR (using an audio guide). Includes attention to breathing, awareness of bodily sensations, and refocusing of attention. The intervention was conducted only once.
5	Ng, H. H., Wu, C. W., Hsu, H. C., Huang, C. M., Hsu, A. L., Chao Y. P., Jung, T. P., & Chuang, C. H. (2024)	Neurological Evidence of Diverse Self-Help Breathing Training With Virtual Reality and Biofeedback Assistance: Extensive Exploration Study of Electroencephalography Markers	JMIR Formative Research	To examine differences in the neurobiological mechanisms of various breathing training techniques (mindful breathing, guided breathing, breath counting) in an environment integrating VR and BF using EEG.	Within-group comparative study	Of the 53 young adults recruited from two universities in northern Taiwan, 2 were excluded due to data outliers, resulting in a final sample of 51 participants (26 men, 25 women; mean age 22.7 ± 2.5 years)	Three types: Mindful breathing, Guided breathing, and Breath counting. Each technique was performed in a VR environment, utilizing real-time biofeedback (BF) of respiration, heart rate, and EEG. Each session lasted 6 minutes. Participants experienced all four conditions once each.
6	Wagner, M., & Wieczorek, A. (2024)	Ego-depletion and motor skill performance under pressure—experimental effects of a short term virtual-reality based mindfulness breathing meditation with integrated biofeedback	Scientific Reports	The effects of VR-based mindfulness breathing meditation (VRMMB) on motor skill performance under pressure in a state of ego depletion is examined. Its effectiveness as a means of restoring self-control resources is evaluated.	Within-group comparative study	Experiment 1: 18 experienced basketball players (20 free throws) Experiment 2: 16 experienced soccer players (20 penalty kicks, 4 targets)	A biofeedback-based meditation game that guides diaphragmatic breathing. The virtual environment changes in response to exhalation, promoting attention to breathing. Conducted for 15 minutes. (Performed only once per condition)
7	Natarajan, A. (2022)	Heart rate variability during mindful breathing meditation	Frontiers in Physiology	Heart rate variability (HRV) during mindfulness breathing meditation is analyzed and the validity of a new quantitative indicator of parasympathetic activity (ABI) is analyzed.	Observational study	8 Chi meditators, 4 Kundalini Yoga meditators, 14 metronome breathers, 11 healthy controls (during sleep), 9 triathletes (during sleep)	Chi meditation, Kundalini Yoga meditation Respiratory rate: 3-10 breaths/min (during meditation), 10-20 breaths/min (during sleep or controlled breathing) Average per session: 11-57 minutes; duration and posture not specified
8	Vieth, E., & von Stockhausen, L. (2023)	Effects of short mindful breathing meditations on executive functioning in two randomized controlled double-blinded experiments	Acta Psychologica	To investigate the effects of short-term mindful breathing meditation on executive functions (inhibition, updating, and shifting).	Randomized controlled trial	Experiment 1: 96 participants (74 women, 1 non-binary person, mean age 23.5 years) Experiment 2: 69 participants (57 women, 1 non-binary person, mean age 22.0 years) Adults aged 18 years or older who had not engaged in regular meditation or mindfulness practice in the past three months	Mindfulness breathing meditation based on Kabat-Zinn (1990). Focusing attention on the breath, observing and accepting thoughts and emotions, and bringing attention back to the breath when it wanders. Experiment 1: Audio-guided sessions of 10, 15, and 20 minutes were conducted three times over a 5-day period. Experiment 2: Audio-guided 20-minute sessions were conducted four times over a 5-day period.
9	Konrad, A. C., Engert, V., Albrecht, R., Dobel, C., Döring, N., Haueisen, J., Klimecki, O., Sandbothe, M., & Kanske, P. (2023)	A multicenter feasibility study on implementing a brief mindful breathing exercise into regular university courses	Scientific Reports	To verify the feasibility of introducing short-duration Mindful Breathing Meditation into regular university classes and to examine its immediate and sustained effects on the psychological state of students and instructors	Observational study	325 university students and 14 instructors (6 universities).	3-4-minute Mindful Breathing Meditation based on MBCT. (1) Observe current physical and mental state, (2) Focus attention on breathing, (3) Observe physical and mental state again. Conducted every other week at the start of class.
10	Bortolla, R., Galli, M., Spada, G. E., & Maffei, C. (2022)	Mindfulness Effects on Mind Wandering and Autonomic Balance.	Applied Psychophysiology and Biofeedback	To examine the psychological and physiological effects of mindfulness-based breathing observation on mind wandering, heart rate variability, and emotional states in untrained participants	Within-group comparative study	28 Italian university students (all female, mean age 24.44 years) who were beginners at meditation	Performed mindfulness breathing observation (10 minutes) Focused on breathing; when thoughts wandered, returned attention to the breath No details provided on posture or duration

ID	Main Outcomes	Conclusion/Implications
1	Electroencephalography (EEG) Amsterdam Resting-State Questionnaire (ARSQ) Breath Counting Features (BCF)	It was suggested that meditation techniques designed to heighten awareness of the breath promote "present-centric control." In particular, breath counting is considered an effective training method for beginners to bring their attention back to the "here and now." Furthermore, it was suggested that appropriately adjusting cognitive workload and arousal levels is important for maximizing the effects of meditation.Furthermore, changes in brain waves, such as alpha, theta, and gamma waves, indicated neurophysiological mechanisms that support these psychological and cognitive changes. On the other hand, this study has several limitations. First, there was no control group, so the effects of the intervention could not be directly compared.Second, the majority of participants were male. Third, because this study employed a cross-sectional design, the long-term effects of meditation remain unclear. Furthermore, since self-report measures were used, the possibility that subjective bias influenced the results cannot be ruled out.
2	Objectified Body Consciousness Scale (OBCS) Body Image States Scale (BISS) Single-Item Positive Emotion Measure Single-Item Negative Emotion Measure"	Both self-compassion writing and mindfulness breathing demonstrated effectiveness in preventing the decline in body image caused by exposure to appearance-focused social media, through the enhancement of mindfulness. However, self-compassion writing showed more pronounced improvements.This difference stems from the fact that while breathing exercises focus on "non-judgmental attention to the present moment," writing fosters "self-compassion" and "empathic understanding," thereby alleviating self-criticism and negative self-evaluation and promoting the reconstruction of a positive body image.In particular, for individuals with a high tendency toward self-objectification, breathing exercises alone were insufficient to sufficiently alleviate "self-criticism" and "obsession with appearance," whereas writing was effective in restoring a "self-encouraging perspective." Furthermore, both interventions enhanced emotional well-being through body image, suggesting that improvements in body image contribute to emotional stability. Limitations include the fact that the interventions were short-term (5 minutes per session) and that the participants were limited to young women.
3	Systolic and diastolic blood pressure Association with age, gender, hypertension status, and antihypertensive medication use; dose-response relationship based on duration of practice	A decrease in systolic and diastolic blood pressure was observed immediately after performing the mindfulness breathing technique, demonstrating a short-term reduction in blood pressure and an improvement in resting blood pressure with continued practice. These changes are thought to result from the autonomic nervous system being regulated as the rhythms of breathing, heart rate, and blood pressure synchronize, creating a state of "resonance" or "coherence."No significant differences in the degree of blood pressure reduction were observed based on age or gender; however, the effects tended to vary depending on the presence of hypertension and the use of antihypertensive medications. On the other hand, limitations include the fact that blood pressure measurements were self-reported, as well as issues such as the number of measurements, sample bias, and the short duration of the study. Future research should focus on interventions incorporating exercise and the verification of long-term effects.
4	Electroencephalography (EEG)	During rest (with eyes closed) following Mindful Breathing Meditation, a trend toward an increase in the proportion of alpha waves over time was observed. Results from autocorrelation and partial autocorrelation suggested that EEG activity fluctuates in a non-linear and time-dependent manner rather than remaining constant. This indicates that even brief breathing interventions may influence neural activity, demonstrating the utility of evaluation methods using time-series data.
5	EEG band power Effective connectivity Connectivity flow between brain regions Respiratory signals Heart rate	Significant changes in EEG band power were observed in the Breath Counting and Guided Breathing conditions compared to the resting state. In contrast, no significant differences were observed in the Mindful Breathing condition. Breath Counting involved internal attention (counting one's own breaths) and was associated with an increase in overall alpha band power, whereas Guided Breathing involved external attention (synchronizing with VR imagery) and showed a tendency toward decreased alpha band power in the central frontal region.This suggests that internal and external attention activate different brain networks, which may be integrated in the anterior cingulate cortex. Connectivity analysis revealed that the right frontal, central, and occipital regions exerted major influence during the breath-counting and guided breathing conditions; in particular, the increased frontal–parietal connectivity in the alpha band is thought to reflect the maintenance of internal attention and resistance to external interference.This connectivity is also associated with the attention network, suggesting coordination between internal and external attention. In mindful breathing, EEG changes were small among beginners; as shown in previous studies, changes in high-frequency EEG may appear after more than 8 weeks of training. Since this study employed a cross-sectional design, long-term neurological changes could not be evaluated, and because the subjects were limited to beginners, the responses of experienced practitioners remain unknown. Future research should verify long-term effects by integrating VR-compatible open-access breathing training software and EEG biofeedback, as well as conduct studies with larger sample sizes.
6	Motor skill performance Ego depletion check (subjective rating scale)	Mindfulness breathing meditation was shown to potentially mitigate performance decline caused by ego depletion. Even after ego depletion induced by the Stroop task, the group that practiced mindfulness breathing maintained higher accuracy in the basketball and soccer tasks compared to the control group. These results suggest that mindfulness breathing may support performance under stress through attention control and emotional regulation.On the other hand, a limitation of this study is that the participants were limited to young adults with prior exercise experience, and factors such as prior mindfulness experience and individual differences were not adequately controlled. Overall, mindfulness breathing meditation may reduce psychological fatigue in situations requiring concentration and self-control, thereby contributing to the maintenance of performance.
7	HRV metrics Respiratory rate	The Autonomic Balance Index (ABI) reflects the intensity of Respiratory Sinus Arrhythmia (RSA) and is an effective quantitative indicator of parasympathetic activity.Root Mean Square of Successive Differences (RMSSD) is biased toward high-frequency components and is therefore not suitable for slow breathing. ABI is independent of respiratory rate and is a promising indicator for capturing autonomic balance during meditation. In the Chinese Chi meditation group and the Kundalini Yoga meditation group, ABI increased significantly, and respiratory rate decreased significantly.The Low Frequency/High Frequency ratio (LF/HF ratio) is not considered an appropriate indicator under low respiratory rates, and ABI is thought to be more reliable. On the other hand, ABI also has several limitations. Its accuracy may decrease when there are large fluctuations in respiratory rate or when it is influenced by low-frequency components such as blood pressure fluctuations (Mayer waves). Additionally, caution is required because RSA itself is weak during daily activities and in older adults, making calculation difficult.
8	Inhibition: Continuous Performance Test-II (CPT-II) Updating: N-Back Task (1- to 3-back) Shifting: Number-Letter Task	Short-term mindfulness breathing meditation did not demonstrate specific effects on inhibition, updating, or shifting. There were also no significant differences compared to Progressive Muscle Relaxation (PMR), and the effects may be attributable to the restoration of attentional resources through relaxation. Even when training duration and frequency were increased, the effects were limited, suggesting that the effects of short-term interventions may be transient and do not accumulate.Future research should employ experience sampling methods to capture momentary state changes and conduct longer-term longitudinal studies. Additionally, limitations such as gender imbalance, the influence of prior meditation experience, the diversity of measurement indicators, and inconsistencies in theoretical frameworks were noted.
9	Presence Composite Score (concentration, alertness, energy, presence) Stress Composite Score (stress, mental distraction) Mood, motivation for class (pre-class and post-class)	The study demonstrated that a brief mindfulness breathing exercise at the beginning of class has an immediate positive effect on students' psychological state.Regardless of individual characteristics or instructor factors, improvements in presence, stress reduction, and increased motivation were confirmed, suggesting the usefulness of this practice as a simple intervention in educational settings. On the other hand, methodological challenges remain, such as reliance on self-report measures, the lack of verification regarding long-term effects and impacts on learning outcomes, and the limited control conditions. Future research should include multifaceted evaluations incorporating physiological indicators and learning outcomes, as well as verification of sustained intervention effects.
10	Amsterdam Resting-State Questionnaire (ARSQ) Positive and Negative Affect Schedule (PANAS) Heart Rate Variability (HRV: RSA, RMSSD, SDNN) Heart Rate (HR) Mindfulness in Object-Distracted Questionnaire (MODQ) Mindful Attention Awareness Scale (MAAS) Five-Factor Mindfulness Questionnaire (FFMQ)	Mindfulness-based breath observation was shown to reduce state mind-wandering and increase HRV in novices, suggesting it may contribute to improved autonomic nervous system balance. Although no direct changes in emotions themselves were observed, an association was found between state mindfulness during the task and positive emotions, supporting short-term effects related to attention control and emotional regulation. On the other hand, no improvement in trait mindfulness was measured, so conclusions regarding long-term changes cannot be drawn. Due to limitations such as the small sample size consisting solely of women, the absence of a comparison group, and the lack of measurement of breathing rate, future studies involving experienced practitioners and clinical groups are required.

ID	Authors (Year)	Title	Journal	Study Objective	Study Design	Participants	Breathing Technique Details
11	Quek, F. Y. X., Majeed, N. M., Kothari, M., Lua, V. Y. Q., Ong, H. S., & Hartanto, A. (2021)	Brief Mindfulness Breathing Exercises and Working Memory Capacity: Findings from Two Experimental Approaches	Brain Sciences	To examine the effects of short-term Mindful Breathing Meditation on working memory capacity using two different experimental methods	Study 1: Within-subjects design Study 2: Between-subjects design	Study 1: 82 university students in Singapore (71.95% female) Study 2: 424 MTurk participants in the U.S. (mean age approximately 43 years, 56.25% female)"	15-minute guided audio session of mindfulness breathing meditation Instructions to focus on abdominal movements and the sensation of breathing, and to concentrate on the present moment In the control condition, an audio track encouraging free-flowing thoughts (mind wandering) was used A listening confirmation (content description) was conducted after each session
12	Chotipanich, C., Tepmongkol, S., Wongsawat, Y., & Jantarato, A. (2021)	Alterations of Regional Cerebral Glucose Metabolism Using 18F-Fluorodeoxyglucose PET/CT and EEG Analysis During Mindfulness Breathing in Anapanasati Meditation: A Preliminary Analysis	World Journal of Nuclear Medicine	To examine the effects of mindful breathing during Anapanasati meditation on regional cerebral glucose metabolism and EEG activity, compared to a normal conscious state	Within-group comparative study	Six healthy right-handed adults (2 men, 4 women, ages 31–67) with meditation experience ranging from 1 month to 50 years	Mindful breathing through Ānāpānasati meditation. Participants sat in a quiet room with their eyes closed, focusing their awareness on their breath. After detecting the meditative state via EEG, FDG was injected. Participants focused on their breath for 30 minutes while FDG was taken.
13	Cruz, M. V., Jamal, S., Wahl, C., & Sethuraman, S. C. (2024)	Investigating the Impact of Mindful Breathing Meditation on Brain Waves: A Study on Young Adults	Neuropsychological Trends	To investigate the neurophysiological effects of mindful breathing meditation on the brain waves of young adults using EEG, and to clarify changes in brain waves and classification accuracy before and after meditation.	Intra-group comparative study	15 young adults (11 males, 4 females, ages 17-25)	Mindful breathing meditation, a form of Dharana meditation that focuses attention on the breath, was performed. Binaural beats (alpha wave frequency) were used concurrently during meditation. The sessions were conducted in a seated position, with 1-minute EEG measurements taken before and after meditation, divided into four sessions.
14	Bolognino, S. J., Renshaw, T. L., & Phan, M. L. (2023)	Differential effects of mindful breathing and loving kindness meditations: a component analysis study	Advances in Mental Health	To examine the individual and combined effects of Mindful Breathing Meditation (MBM) and Loving-Kindness Meditation (LKM) based on treatment process variables and mental health outcomes.	Randomized controlled tria (RCT)	52 undergraduate psychology students enrolled at a university in the southeastern United States Ages 18-22, 75% female, 78.8% white.	Four conditions: MBM, LKM, MBM+LKM, and relaxation. Participants self-administered 10-minute guided audio meditations for each condition over a 2-week period. Audio recordings featured the same narrator and structure. MBM and LKM were based on MBSR/MBCT and LKM literature.
15	Goldberg, S. B., Flook, L., Hirshberg, M. J., Davidson, R. J., & Schaefer, S. M. (2021)	Brief breath awareness training yields poorer working memory performance in the context of acute stress	Stress	To examine the effects of short-term breathing meditation, compassion meditation, and gratitude meditation on working memory under acute stress, compared to an attention control condition. Based on the stress buffering hypothesis and Monitor and Acceptance Theory, to clarify the effects of different meditation methods on cognitive function.	Randomized between-groups comparative study	162 college students enrolled at a university in the Midwestern United States (mean age 19.3 years) 63.6% female, 74.7% White, 83.3% meditation novices Participants were native English speakers aged 18 years or older"	Each group performed either a 12-minute guided audio meditation or an attention task. The Breathing group practiced meditation focusing on breath sensations; the Compassion group repeated phrases expressing compassion toward self and others; the Gratitude group created and reflected on a list of things for which they were grateful; and the Attention Control group described and visualized spatial details of their home.
16	Hu, X. S., Beard, K., Sherbel, M. C., Nascimento, T. D., Petty, S., Pantzlaff, E., Schwitzer, D., Kaciroti, N., Maslowski, E., Ashman, L. M., Feinberg, S. E., DaSilva, A. F. (2021)	Brain mechanisms of virtual reality breathing versus traditional mindful breathing in pain modulation: Observational functional near-infrared spectroscopy study	Journal of Medical Internet Research	To compare the analgesic effects and underlying brain mechanisms of breathing techniques based on abstract interoceptive sensations with those based on exteroceptive sensations induced by VR.	Intergroup Comparative Study	40 healthy adults (21 women, mean age 28 years	One-week intervention. Breathing exercises were performed in the laboratory on the first and seventh days, with participants practicing MB at home for the five days in between. VRB group: Performed VR breathing exercises using visual and auditory stimuli of a 3D lung synchronized with breathing. TMB group: Performed abstract mindfulness-based breathing exercises. Each session lasted 10 minutes. Participants sat in a dental chair. Home practice was performed three times daily (upon waking, at noon, and before bedtime).
17	Shao, H., Ren, G., Li, Y., Wang, M., Shen, Y., Li, R., & Ding, X. (2024)	The effects of one-session mindfulness meditation on mind wandering	Current Psychology	To examine the effects of a single mindfulness meditation session on mind wandering in relation to task duration and the characteristics of mind wandering	Randomized controlled trial	56 university students (28 in each group) Ages 18-32 No prior meditation experience Gender ratio: 68% female, 32% male in both groups	A 15-minute guided mindfulness breathing meditation. Conducted in a seated position. Participants were instructed not to control their breathing rate, to direct their attention to the sensation of breathing, and to return their attention to their breath whenever it wandered. The control group listened to unrelated news audio for 15 minutes.
18	Wright, S. L., Bach, E., Bryson, S. P., Schaller, S., & Wright, D. (2025)	Using an App-Based Mindfulness Intervention: A Mixed Methods Approach	Cognitive and Behavioral Practice	An exploration of the effects of a short-term, app-based mindfulness intervention using the Apple Watch on depression, anxiety, and coping skills, as well as user experience and barriers. The study focuses particularly on subjective experiences and psychological changes following two weeks of continuous use of a 5-minute breathing exercise.	Mixed-methods study	9 participants (ages 23-43, mean 32, 6 women)	Participants used the "Mindfulness" (formerly "Breathe") app pre-installed on the Apple Watch. They performed a 5-minute breathing exercise once daily for 2 weeks. The breathing rate was set to 6 breaths per minute, and participants followed visual cues. The exercise was self-guided and conducted at home.
19	Hunt, M., Rajagopal, T., Cerecino, F., & O'Neil, M. (2021)	Mindful Versus Diaphragmatic Breathing: Spirituality Moderates the Impact on Heart Rate Variability	Mindfulness	To compare the effects of Mindful Breathing Meditation and diaphragmatic breathing on physiological stress indicators (HRV, respiratory rate, and lung capacity) and to examine whether spirituality moderates these effects	Randomized controlled trial	48 psychology students at the University of Pennsylvania (27 in the diaphragmatic breathing group, 21 in the Mindful Breathing Meditation group)	Mindful Breathing Meditation: Directing non-judgmental attention to the sensation of breathing. Reference to religious background Diaphragmatic Breathing Technique: Correcting chest breathing to consciously perform deep, slow abdominal breathing Both groups received video instruction and practiced at home for one week. Participants wore Hexoskin while seated to measure respiration and heart rate
20	Uberoi, P., Smitherman, A., Aden, J., Park, G., & Jellison, F. (2020)	Incorporation of Mindfulness Exercises to Reduce Anxiety During Urodynamic Testing: A Randomized Single-Blind Controlled Pilot Trial	The Journal of Alternative and Complementary Medicine	To examine the effectiveness of Mindful Breathing Meditation in reducing anxiety during urodynamic testing	Randomized controlled trial (RCT)	27 adults aged 18 years or older	Mindfulness group: Participants performed a 10-minute mindfulness breathing exercise under the guidance of a psychologist, following a standardized script. Control group: Participants waited for 10 minutes in a quiet, empty room.

ID	Main Outcomes	Conclusion/Implications
11	Study 1: Working memory assessment using the Operation Span Task (OSPAN) Study 2: Working memory assessment using the Symmetry Span Task (A composite task involving symmetry judgment and spatial memory, evaluated by partial correct response scores) Exploratory outcomes: Stress (average of 3 items: stress, worry, calmness), present-moment absorption	In both studies, no clear effect of breathing meditation on improving working memory was observed. In Study 1, performance was higher in the control condition, and in Study 2, Bayesian statistics supported the null hypothesis.Short-term breathing meditation may be insufficient to enhance the attention and concentration required for complex cognitive tasks. Previous studies have shown that long-term meditation training has a positive effect on cognitive function; this study suggests the limitations of short-term interventions and the need for future verification using long-term and diverse cognitive measures. Given limitations such as the constraints of online experiments and the simplicity of operational checks, more rigorous designs are required in the future.
12	Regional cerebral glucose metabolism (18F-FDG PET/CT) Detection of the meditative state via electroencephalography (EEG) (increased alpha wave activity in the frontal lobe)	During Ānāpānasati meditation, a significant increase in glucose metabolism in the right posterior cingulate cortex and an increase in alpha wave activity in the frontal region were observed. These changes suggest the activation of brain circuits involved in the feelings of well-being, tranquility, self-control, and mood stability associated with meditation. Brain activity patterns vary depending on the depth of meditation and individual differences, and statistical power is limited due to the very small sample size (n=6).Furthermore, results may vary depending on individual meditation proficiency, age differences, and quantitative analysis methods. Given these challenges, this study serves as an initial preliminary report indicating neurophysiological effects; future research will require an increased sample size, improved analytical methods, and comparisons based on proficiency levels.
13	EEG-based brainwave classification (Delta, Theta, Low Alpha, High Alpha, Low Beta, High Beta) and changes in alpha wave power	The results suggest that mindful breathing meditation leads to an increase in alpha waves and may have a positive impact on brain functions related to relaxation, concentration, and attention control. Furthermore, EEG classification using machine learning and deep learning showed changes in classification accuracy before and after meditation, with accuracy decreasing slightly after meditation. This may be attributed to subtle and highly variable post-meditation EEG changes, the short duration of the measurement, and the influence of binaural beats and external factors.Furthermore, as this study was a short-term experiment, a key limitation is that the long-term effects of sustained meditation practice and the stability of brain function remain unclear. Future research should track the effects of meditation practice over a longer period and establish evaluation methods that account for individual differences and the influence of the measurement environment. Additionally, verification involving diverse age groups and levels of meditation experience is necessary, which is expected to enhance the generalizability of the neurophysiological effects of Mindful Breathing Meditation.
14	Avoidance and Fusion Questionnaire for Youth–Short Form (AFQ-Y8) Mindful Attention Awareness Scale–Short Form (MAAS-5) UCLA Loneliness Scale – Revised Positive and Negative Affect Schedule (PANAS) Self-Compassion Scale – Short Form (SCSSF) Santa Clara Brief Compassion Scale (SCBCS) Generalized Anxiety Disorder 7-item Scale (GAD-7) Center for Epidemiological Studies Depression Scale (CES-D) Satisfaction with Life Scale (SWLS) Treatment Integrity Calendar Log Abbreviated Acceptance Rating Profile (AARP) Demographics Questionnaire	Both MBM and LKM demonstrated efficacy on more treatment process and mental health indicators than the relaxation condition. The effects of the two were generally similar, and the combined condition (MBM + LKM) did not show any additional effects. Although statistical significance was limited, differences between conditions were suggested from the perspectives of descriptive statistics and effect sizes, indicating that standalone interventions with MBM and LKM may be beneficial even in the short term. The sample consisted of college students in the southeastern United States, with biases in age, gender, and race. Furthermore, the intervention period was short (2 weeks) and the daily practice time was low (10 minutes per day), so the effects of longer-term or more intensive interventions remain unclear.Outcomes were measured solely using self-report scales, and the lack of assessments incorporating physiological or behavioral measures is another limitation. Furthermore, since no control group was established solely for measurement purposes, the influence of changes due to the passage of time or the placebo effect cannot be ruled out. Finally, because the sample size was relatively small, there may have been insufficient statistical power to detect subtle differences between conditions.
15	Operation Span Task (OSPAN) Positive and Negative Affect Schedule (PANAS)	The breathing meditation group showed a greater decline in working memory performance following acute stress compared to the other groups. The compassion, gratitude, and attention control groups showed improved OSPAN performance, suggesting that short-term breathing meditation may not have a stress-buffering effect.Since breathing meditation requires concentration, it may deplete self-control resources under stress and negatively impact cognitive function. A mismatch between attention to internal stimuli (breathing) and attention to external stimuli (OSPAN) is also considered a contributing factor. Future studies should include the introduction of a fully passive control group, the assessment of subjective experiences, and the measurement of the mental load and acceptability of meditation.
16	Pain threshold following thermal stimulation of the face (quantitative sensory testing) Changes in brain activity and inter-cortical connectivity measured by functional near-infrared spectroscopy (fNIRS) PANAS (Positive and Negative Affect Schedule) McGill Pain Questionnaire (pain assessment) Heart rate variability (HRV)	In both groups, pain thresholds significantly increased after one week of breathing practice, but the neural mechanisms underlying this effect differed. In the TMB group, functional connectivity between the aPFC, PMC, and S1 increased, and pain evaluation was suppressed via interoceptive sensory processing and attentional control. In contrast, in the VRB group, activation of the visual and auditory cortices predominated, and reduced connectivity with S1 indicated an analgesic effect mediated by exteroceptive sensory processing. These results suggest that TMB represents an "introspective analgesic mechanism" emphasizing internal attention and contextual evaluation, while VRB represents an "extroverted analgesic mechanism" mediated by sensory immersion.One limitation is that the VRB group may not have experienced the same level of immersion during the home practice period as they did in the laboratory, potentially leading to an underestimation of the effect. Future studies should conduct a re-examination in a more realistic environment using smartphone-compatible portable VR devices.
17	SART (Sustained Attention to Response Task): CEs (incorrect responses to target stimuli), OEs (no responses to non-target stimuli), RTCV (reaction time coefficient of variation) Thought Probe (self-report of attentional state) PANAS (Positive and Negative Affect Schedule) Neuroticism Scale of the Big Five Personality Traits	A single session of mindfulness breathing (15 minutes) improved response accuracy in the Sustained Attention to Response Task and reduced the frequency of subjective mind wandering. Significant differences were observed particularly in OEs, RTCV, and the Thought Probe.The effects were influenced by task duration; while no significant differences were observed for 5-minute sessions, clear effects were confirmed for sessions of 10 minutes or longer. The intervention effects were shown to be sustainable for 20 minutes, confirming their stability. However, limitations include inconsistencies among indicators, task difficulty, intervention format, and the limited scope of the target population. Future research should address these issues by adjusting task difficulty, comparing intervention formats, expanding the target population, conducting pre-measurements of mindfulness characteristics, and controlling for the placebo effect.
18	Coping Self-Efficacy Scale Generalized Anxiety Disorder 7-item scale (GAD-7) Patient Health Questionnaire-9 (PHQ-9)	A statistically significant improvement in coping skills was observed, but changes in depression and anxiety were not significant. Qualitative analysis identified themes related to subjective positive experiences (changes in thinking, relaxation, enjoyment, physical changes) and the importance of personalization (adjusting usage time, setting reminders). On the other hand, barriers to use (timing of reminders, length of exercise sessions) were also reported. When healthcare professionals introduce this app, it is considered effective to emphasize personalization strategies and explain the basic elements of mindfulness. Additionally, for those who do not own an Apple Watch, alternative methods such as visual and auditory timers, nature sounds, haptic feedback, and HRV biofeedback may also be useful. However, this study had a small sample size and targeted the general adult population with mild levels of anxiety and depression rather than a clinical group, so there are limitations to the generalizability of the results. Furthermore, usage frequency was based on self-reports, leaving challenges in accurately determining the actual "dose" of practice. Future research is needed to elucidate the relationship between the "dose" of breathing techniques and their "effects."
19	Heart rate variability (HRV measured by SDNN) Respiratory rate, tidal volume Beliefs and Values Scale	Both breathing techniques resulted in a decrease in respiratory rate and an increase in tidal volume. Diaphragmatic breathing significantly improved HRV, while mindfulness breathing improved HRV only in participants with high spirituality. Diaphragmatic breathing was consistently more effective for participants with low spirituality, suggesting that spirituality is a personal characteristic that moderates the effects of breathing interventions. Limitations include the small sample size and the fact that the study was conducted on a limited population of selected college students in the United States, so caution is required regarding generalizability. Furthermore, the intervention consisted of a single session, a short-term approach, and thus did not fully capture the sustained effects or long-term changes associated with mindfulness practice.The evaluation metrics were limited to physiological stress responses, and the psychological and cognitive effects of mindfulness interventions were not examined. Furthermore, the reasons why individuals with low spirituality are less responsive to mindfulness breathing remain speculative, and the fact that underlying attitudes and cultural factors were not directly measured also presents a challenge.
20	State-Trait Anxiety Inventory – 6-item version (STAI-6) Visual Analogue Scale (VAS) Physical and emotional discomfort following urodynamic testing (UDS questionnaire)	Although no statistically significant differences were observed in the reduction of anxiety or pain, fear scores were significantly lower in the MBSR-BE group. Furthermore, participants who reported feeling the strongest emotional distress were found only in the control group. This suggests that even brief mindful breathing practice may improve the emotional experience associated with invasive medical examinations. However, caution is required in interpreting these results due to the small sample size and the possibility of a "pseudo-mindfulness effect" in the control group resulting from prayer or napping. Larger, well-controlled trials are needed in the future.

with the overview presented in Table 1.

3.1 Study objective

The primary objective was to clarify the effects of short-term interventions on psychological, cognitive, behavioral, and physiological outcomes. Studies on psychological and cognitive outcomes evaluated effects on executive function, working memory, mind wandering, and self-awareness (ID: 6, 8, 9, 10, 11, 15, 17, 20). For physiological outcomes, indicators such as EEG, heart rate variability, blood pressure, regional brain metabolism, and analgesic effects were used, aiming to clarify the autonomic nervous system and neurophysiological effects of breathing techniques (ID: 1, 3, 4, 5, 7, 10, 12, 13, 16). Behavioral outcomes reported effects on task performance, and the feasibility of introducing breathing techniques using digital devices and applications were also examined (ID: 6, 16, 18). Furthermore, some studies aimed to compare these techniques with other meditation or breathing methods (ID: 2, 14, 15, 19).

3.2 Study design

Quantitative studies using experimental methods predominated. Specifically, randomized controlled trials (RCTs), within-group comparative studies, and between-group comparative studies were frequently employed, with designs evaluating pre- and post-intervention effects or intergroup differences being prominent. Observational studies were also cited, albeit to a limited extent (ID: 7, 9). Furthermore, only one study employed a mixed-methods approach integrating both qualitative and quantitative aspects (ID: 18), indicating an overall tendency toward quantitative research.

3.3 Participants

The experiment participants were primarily university students and young adults, with a majority of female participants, and the studies were conducted mainly with individuals who had no prior meditation experience (ID: 1, 2, 4, 5, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20). Some interventions also targeted adults based on specific activities, such as Fitbit users or those with sports experience (ID: 3, 6). Research that targeting middle-aged and older adults was limited (ID: 12, 18).

3.4 Breathing technique details

The elements of focusing attention on the breath and returning attention to the breath when it wanders were commonly identified across many studies. Additionally, breathing methods explicitly incorporating awareness of bodily sensations, thoughts, and emotions were primarily adopted in studies based on MBSR or MBCT. However, diversity was observed in implementation methods and intervention formats. Types of breathing techniques used included: step-by-step breathing based on Ānāpānasati meditation (ID: 1, 12), breath counting (ID: 3, 5), Dharana meditation (ID: 13), diaphragmatic breathing (ID: 19), and Chi meditation or Kundalini Yoga meditation (ID: 7). Interventions were conducted in settings such as laboratories, VR environments, online applications, and home practice, utilizing diverse guidance methods including audio, video, and biofeedback (ID: 2, 3, 4, 5, 6, 8, 11, 14, 15, 16, 17, 18). Additionally, some studies set up multiple conditions for comparison, including breathing meditation conditions alongside conditions involving compassion or gratitude recall, and attention control tasks. The duration of MB sessions ranged from 3 to 57 minutes, with many studies employing interventions lasting approximately 10 to 15 minutes. Implementation frequency varied from single sessions to continuous interventions over several weeks. Overall, MB demonstrated a trend toward simplified practice, with many designs enabling implementation in short durations and over brief periods.

3.5 Main outcomes

Many studies evaluated outcomes by combining psychological, physiological, cognitive, and behavioral measures.

Psychological outcomes included emotion and mood (PANAS, Single-Item Emotion Measures), stress and anxiety (GAD-7, PHQ-9,STAI-6, Coping Self-Efficacy), attention and mindfulness traits (MAAS, FFMQ, MODQ), and measures of loneliness and self-compassion (UCLA Loneliness Scale, Self-Compassion Scale) were used (ID: 2, 10, 14, 15, 16, 17, 18).

Physiological outcomes included heart rate variability (HRV), respiratory rate, blood pressure, and brain activity measures (EEG, fNIRS, PET/CT), assessing the relationship between breathing techniques and autonomic nervous system activity or neural activity (ID: 1, 3, 4, 5, 7, 10, 12, 13, 16, 19).

Cognitive and behavioral outcomes utilized attention tasks, executive function tasks, working memory tasks, motor skill performance, and pain thresholds (ID: 6, 11, 16, 17). Subjective experiences, perceived usefulness of the intervention, and motivation to continue were also measured (ID: 6, 19). These multi-domain indicators were often combined with psychological and physiological measures.

3.6 Conclusion/Implications

In MB practice, "attention to breathing" is positioned as one of the central elements. Numerous studies have shown that breathing promotes concentration on the present moment and is associated with improvements in attention control and emotional regulation. Specifically, techniques such as breath counting, Ānāpānasati meditation, and breathing interventions using applications on wearable devices (Fitbit) were considered effective as attention refocusing training for beginners (ID: 1, 3, 5, 12).

Physiological changes reported include decreased blood

pressure, increased heart rate variability, and improved autonomic nervous system balance. These were interpreted as resulting from synchronization of breathing, heart rate, and blood pressure, and a shift toward parasympathetic dominance (ID: 3, 5, 7, 10, 16, 19). Furthermore, EEG changes observed included increased alpha, theta, and gamma waves, along with altered activity in the cingulate cortex and prefrontal cortex. These findings suggested associations with neural substrates related to relaxation and attention control (ID: 1, 4, 5, 12, 13).

Psychologically and behaviorally, the studies were examined for association with improved self-awareness, emotional stability, stress reduction, and enhanced well-being (ID: 2, 6, 9, 10, 18). When implemented for short durations in adult education settings, enhanced presence and concentration were reported, with expectations that it contributes to restoring self-control and maintaining performance (ID: 9). Conversely, it was also noted that acute stress may potentially cause a decline in working memory (ID: 15). Regarding pain relief, MB was shown to be involved in behavioral changes mediated through sensory processing and emotional regulation (ID: 16). Traditional breathing meditation was associated with an introverted analgesic mechanism, while VR breathing techniques were linked to an extroverted analgesic mechanism, suggesting the potential involvement of different neural pathways.

Regarding limitations in each study, the following trends were observed. Some studies discussed the absence of control groups or control conditions, and the inability to directly compare intervention effects with non-intervention conditions or other psychological manipulations (ID: 1, 9, 10, 12, 13, 14, 15, 17, 19, 20). The possibility of insufficiently controlling for the effects of time passage, expectancy effects, and non-specific relaxation effects was mentioned (ID: 8, 13, 17, 14). Furthermore, a common limitation cited was the prevalence of studies based on short-term interventions or single-time point measurements, resulting in insufficient verification of the sustained effects of meditation practice or long-term changes (ID: 1, 2, 3, 5, 8, 9, 10, 11, 12, 13, 14, 19). Some studies had small sample sizes or were preliminary, leading to limited statistical power (ID: 5, 8, 10, 12, 14, 18, 19, 20). Participants tended to be skewed toward university students and young adults, with reported biases in regional/cultural backgrounds and gender ratios, limiting the generalizability of results (ID: 1, 2, 3, 5, 6, 8, 10, 12, 13, 14, 17, 18, 19). Furthermore, many studies focused on meditation beginners, emphasizing the feasibility of introducing a single technique like MB for novices (ID: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20). Furthermore, some studies relied on self-reporting for practice duration, frequency, and outcome measures, and it was noted that the influence of subjective bias could not be completely eliminated (ID1, 3, 9, 14, 18).

4. Discussion

4.1 Purpose and background of this study

This study aimed to explore, through a scoping review focused specifically on MBIs, which aspects regarding implementation methods, outcome measures, and interpretation of effects remain insufficiently organized. Conventional MBIs encompass diverse techniques, including MBSR, MBCT, the Raisin Exercise, Body Scan, and Sitting Meditation. These programs are not only diverse in technique but are also typically conducted several times per week for 30-60 minutes per session over an 8-week period, requiring a certain learning period and sustained practice. Consequently, they present a high barrier to entry for beginners. In contrast, MB, being a single technique, is relatively simple and allows for shorter practice sessions. Its homogeneity also makes it suitable for comparisons across studies and systematic organization. However, few reviews have specifically focused on MB to date, and findings regarding its composition, implementation methods, and effects remain insufficiently organized. Therefore, this study targeted 20 original research papers published within the past five years, using June 18, 2025, as the literature search cutoff date. It organized findings focusing on the technique's composition, implementation methods, and effects. Below, the literature obtained from the perspective of Study Objective, Breathing Technique Details, Study Design, Participants, Main Outcomes, and the Conclusion/Implications section of each study are examined.

4.2 Study objective

Many of the extracted studies focused on psychological, cognitive, behavioral, and physiological outcomes, indicating an attempt to evaluate various effects from multiple angles. This objective setting reflects the comprehensive and integrative nature of mindfulness interventions, suggesting an effort to verify effects broadly rather than limiting the scope to a single aspect. The necessity for such multidimensional evaluation likely stems from mindfulness's multifaceted nature. It encompasses multiple cognitive processes—attention control, memory restructuring, inhibition, and switching (Vago, et al, 2019)—and comprises multiple techniques such as breath meditation, body scan, and yoga (Carmody and Baer, 2008). Each study is based on the recognition that it is difficult to capture the fundamental characteristics of mindfulness interventions, including MB, with a single indicator. Consequently, it can be interpreted that evaluation frameworks combining multiple outcomes—psychological, cognitive, behavioral, and physiological—have been adopted. This suggests that even interventions focusing solely on breathing techniques demonstrate that the concept of mindfulness is not simple,

and a multifaceted approach is essential for appropriately evaluating its effects.

On the other hand, regarding MB techniques, it became clear that despite being standalone MB interventions, the implementation methods, research settings, and task designs varied widely. This likely reflects the research objectives, which focused on the breathing technique while also seeking to verify how differences in practice conditions influence ease of learning and mindfulness effects. Regarding the time required for the technique, MB-only interventions in the extracted literature were generally conducted in about 10 to 15 minutes. While some ranged from 3 to 57 minutes, all were characterized by being short-duration, sustainable, and easy to introduce. This likely reflects the adoption of more user-friendly intervention formats to verify learning continuity and the applicability of the practice.

4.3 Breathing technique details

While specific implementation methods showed some consistency across studies, various approaches were adopted regarding how attention was directed to breathing, practice duration, posture, and supplementary elements. Techniques were implemented in diverse formats, including those based on Buddhist Ānāpānasati, MBSR/MBCT-derived breathing methods, biofeedback-based techniques, and breathing exercises in VR environments. The designs were primarily focused on being short-duration and easy to introduce. Common across studies were fundamental processes: non-judgmental attention to the breath, observation of thoughts and emotions, and refocusing attention when it wanders.

However, session duration and frequency showed considerable variation. While most studies employed brief interventions lasting only a few minutes, some set relatively long sessions lasting up to 57 minutes. Frequency also ranged widely, from single sessions to ongoing practice spanning several weeks. However, overall, the majority of studies employed short-duration, short-term interventions, with research based on prolonged or high-frequency practice being limited. Considering this distribution, it suggests a research tendency within MB studies: while diverse intervention conditions have been attempted as part of theoretical and practical exploration, verification has primarily focused on highly feasible short-duration interventions, likely due to considerations of participant effort and dropout risk. Furthermore, diverse approaches were employed regarding implementation settings, devices used, and the presence or absence of audio guidance. While using the same breathing technique, methodological attempts to more accurately verify MB's effects were developed across studies. These approaches likely reflect an exploratory intent to examine how implementation conditions and the quality of experience influence outcomes. However, studies comparing the outcomes of mindfulness practice in simulated natural environments versus actual natural environments have shown that stress reduction was greater in actual natural settings (Choe et al., 2021). This suggests that implementation conditions, such as the equipment or auxiliary elements used for breathing techniques, can also cause some variation in participants' experiences and effects. Therefore, when verifying and comparing the effects of MB, it is considered important to methodologically organize not only the form of the breathing technique itself but also to explicitly state additional conditions such as implementation time, frequency, and environment.

4.4 Breathing technique details

Regarding study design, quantitative research was predominant, with many studies employing pre- post-comparisons or RCTs. Designs focused primarily on verifying the psychological effects of MB through quantitative research, while qualitative studies focusing on experiential aspects or subjective understanding were limited. Qualitative research has been reported as particularly important for understanding the mechanisms of action and individual differences in the effects of mindfulness interventions that quantitative research cannot fully capture, by clarifying participants' subjective experiences and learning processes (Langer et al., 2020). ID: 19 suggests that individual characteristics such as beginner status, gender, and level of spirituality may influence intervention effects. This suggests that visualizing the insights and emotional changes participants experience during the intervention can reveal internal processes and context-dependent changes that quantitative research alone cannot capture. This approach can deepen our understanding of individual differences and context-dependence in intervention effects.

4.5 Participants

Participants in the reviewed literature were primarily university students and young adults, with a tendency toward a higher proportion of women. Given that MB is a relatively simple and accessible technique, there is value in using it to examine feasibility and initial effects among beginners with limited mindfulness practice experience. However, this participant composition also indicates potential limitations when generalizing MB effects to other age groups or occupational sectors. Furthermore, reports indicate that individual characteristics such as prior meditation experience and spirituality may influence intervention acceptance and physiological responses (ID: 19). It has been suggested that beginners may experience initial reactions like sympathetic nervous system activation and depletion of attentional resources (ID: 16; Vieth and von Stockhausen, 2023). These findings suggest that considering participants' experience levels is necessary when

interpreting MB's effects.

4.6 Main outcomes

Multiple domains of outcomes—psychological, physiological, cognitive, and behavioral—were employed, reflecting attempts to evaluate MB effects from multiple angles. In the psychological domain, emotional regulation; in the cognitive domain, attentional control; and in the physiological domain, autonomic indicators—all were introduced based on verifying MB's short-term effects.

However, while some studies comprehensively evaluated multiple domains such as psychological, physiological, and cognitive aspects, others focused only on limited indicators, resulting in inconsistencies in research objectives and outcome selection. Furthermore, some studies did not incorporate the MAAS or FFMQ, which are tools for measuring "mindfulness," a core concept of MB. For example, ID: 19 compared MB with HRV during diaphragmatic breathing. This study positions MB as a mindfulness practice and diaphragmatic breathing as a base breathing technique. While it demonstrates improved HRV with diaphragmatic breathing, it does not evaluate diaphragmatic breathing itself as a mindfulness practice. Therefore, this study cannot determine the relative effectiveness of mindfulness as an MB intervention. Furthermore, in mindfulness, the possibility of a disconnect between subjective experience and objective physiological indicators cannot be ruled out. According to Verdonk, et al. (2021), their findings indicate that changes in physiological indicators do not necessarily directly reflect improvements in mindfulness. Additionally, in the ID: 10 study, while mind-wandering representing thoughts about others, the future, or visual imagery decreased with MB, and increased parasympathetic activity was observed, no pre- post-comparison was conducted using trait mindfulness scales such as the FFMQ. Therefore, further verification is needed to determine whether the intervention itself improved mindfulness traits. Furthermore, it is important to note that the observed changes in autonomic nervous system activity cannot be distinguished as being due to mindfulness processes specific to MB or influenced by factors such as changes in breathing pace or non-specific relaxation. In other words, while relaxation primarily refers to a passive state of parasympathetic activation, MB involves an active process of controlling attention. Therefore, future research needs to employ experimental designs with appropriate control groups to clearly distinguish between these two distinct effects. It should be noted that this interpretation is not a challenge unique to the ID: 19 report but rather a challenge inherent to MB intervention studies as a whole.

Given the above, there has been a tendency to adopt diverse outcomes and seek a multifaceted understanding of MB. Moving forward, refining intervention effects is anticipated through selecting outcomes aligned with verifying MB's efficacy and validating appropriateness.

4.7 Findings and implications from included studies

This study revealed methodological limitations such as variability in measurement indicators, small sample sizes, and uncontrolled sequence effects. It also highlighted uncertainties regarding the transience and sustainability of effects in short-term interventions. Furthermore, the relationship between implementation duration/frequency and effects remains insufficiently examined, making it an important future research topic. Diversifying participants and incorporating qualitative approaches are considered key directions for future research.

On the other hand, mindfulness-based interventions show potential as versatile techniques in education and self-care domains through promoting psychological well-being, regulating the autonomic nervous system, and influencing cognitive function. To explicitly capture their multifaceted value, it is crucial to accurately assess whether changes induced by the intervention genuinely reflect a mindful state (Van Dam et al., 2018). Regarding methodological challenges, findings from qualitative research focusing on practitioners' experiences highlight their importance, exemplified by Maekawa (2017). While MB practice was confirmed to heighten awareness of breathing and provide experiences of turning attention inward, comments such as "I found it harder to breathe when I focused on it," "I wondered if my own way was okay," and "I dislike staying still and felt the urge to move my body was disruptive" were also raised, suggesting potential difficulties with the technique and the emergence of evaluative thinking.

This indicates that verifying the MB criteria and developing methods accessible to everyone are key future challenges. Van Dam et al. (2018) point out methodological diversity and definitional ambiguity in mindfulness research. Our findings suggest this is no exception even when focusing solely on MB. Indeed, specific breathing technique procedures and adaptations vary, leading to differences in how breathing techniques are conceptualized and experienced across the literature. Furthermore, participant composition—including individual characteristics such as age, gender, occupation, and meditation experience—may influence intervention acceptability and physiological responses. Therefore, standardization to enhance validity and reliability, along with verification of techniques tailored to subject characteristics, is required.

4.8 Limitations of this study

This study has several methodological limitations. First, limiting the literature to the past five years excludes classical findings and long-term trends. Second, the literature search was limited to the two major databases, PubMed and

PsycINFO, excluding other interdisciplinary databases. Third, the search was restricted to English-language literature, excluding studies in other languages. Due to these methods, relevant studies on MB may have been omitted, leaving room for improvement in terms of comprehensiveness.

Another limitation is that the definition and implementation procedures of MB vary across studies, and no established comparable outcome measures exist. Furthermore, most studies are cross-sectional, resulting in insufficient evidence regarding the long-term effects and habituation of MB.

5. Conclusion

This study aimed to organize recent research on MB and clarify its research trends and challenges.

Multiple domains—psychological, cognitive, physiological—were used as MB outcomes, demonstrating multifaceted effects even with brief interventions. However, some studies lacked direct measures of mindfulness states, requiring cautious interpretation of whether observed effects stemmed from "mindfulness."

While MB techniques share common basic processes, such as non-judgmental attention to breathing and refocusing attention, considerable variation exists in practice duration, frequency, posture, and implementation settings. Practice duration is often relatively short, yet psychological, cognitive, and physiological effects have been confirmed even with brief interventions. This low practice effort is an advantage, enhancing the potential for introduction among beginners and in clinical and educational settings. However, the sustainability of effects and optimal intervention conditions remain insufficiently explored, requiring further verification in future research.

Considering the above, future research should focus on clarifying the definition and practice structure of MB, appropriately selecting outcome measures, and adopting longitudinal research designs that integrate qualitative and quantitative approaches. Addressing these challenges is expected to deepen our understanding of MB's mechanisms of action.

References

Balban, M. Y., Neri, E., Kogon, M. M., Weed, L., Nouriani, B., Jo, B., Holl, G., Zeitzer, J. M., Spiegel, D., and Huberman, A. D. (2023). Brief structured respiration practices enhance mood and reduce physiological arousal. *Cell Reports Medicine*, Vol. 4, No. 1, 100895.

Benavides-Gil, G., Martínez-Zaragoza, F., Fernández-Castro, J., Sánchez-Pérez, A., and García-Sierra, R. (2024). Mindfulness-based interventions for improving mental health of front-line healthcare professionals during the COVID-19 pandemic: A systematic review. *Systematic Reviews*, Vol. 13, No. 1, 160.

Bolognino, S. J., Renshaw, T. L., and Phan, M. L. (2023). Differential effects of mindful breathing and loving kindness meditations: A component analysis study. *Advances in Mental Health*, Vol. 21, No. 2, pp. 129-149.

Bortolla, R., Galli, M., Spada, G. E., and Maffei, C. (2022). Mindfulness effects on mind wandering and autonomic balance. *Applied Psychophysiology and Biofeedback*, Vol. 47, No. 1, pp. 53-64.

Brahmi, M., Soni, D., and Kumar, J. (2025). Neurobehavioural exploration of breath-counting & breath-awareness in novice Indian meditators: A naturalised Ānāpānasati-based paradigmatic approach. *Annals of Neurosciences*, Vol. 32, pp. 1-13.

Calderone, A., Latella, D., Impellizzeri, F., de Pasquale, P., Famà, F., Quartarone, A., and Calabrò, R. S. (2024). Neurobiological changes induced by mindfulness and meditation: A systematic review. *Biomedicines*, Vol. 12, No. 11, 2613.

Carmody, J. and Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine*, Vol. 31, No. 1, pp. 23-33.

Choe, E. Y., Jorgensen, A., and Sheffield, D. (2021). Examining the effectiveness of mindfulness practice in simulated and actual natural environments: Secondary data analysis. *Urban Forestry & Urban Greening*, Vol. 66, 127414.

Chotipanich, C., Tepmongkol, S., Wongsawat, Y., and Jantarato, A. (2021). Alterations of regional cerebral glucose metabolism using 18F-fluorodeoxyglucose positron-emission tomography/computed tomography and electroencephalography analysis during mindfulness breathing in Anapanasati meditation: A preliminary analysis. *World Journal of Nuclear Medicine*, Vol. 20, No. 3, pp. 273-280.

Cruz, M. V., Jamal, S., Wahl, C., and Sethuraman, S. C. (2024). Investigating the impact of mindful breathing meditation on brain waves: A study on young adults. *Neuropsychological Trends*, Vol. 35, pp. 19-44.

Fendel, J. C., Vogt, A., Brandtner, A., and Schmidt, S. (2024). Mindfulness programs for problematic usage of the internet: A systematic review and meta-analysis. *Journal of Behavioral Addictions*, Vol. 13, No. 2, pp. 327-353.

Goldberg, S. B., Flook, L., Hirshberg, M. J., Davidson, R. J., and Schaefer, S. M. (2021). Brief breath awareness training yields poorer working memory performance in the context of acute stress. *Cognition & Emotion*, Vol. 35, No. 5, pp. 1009-1017.

Hitomi, T. (2025). Current trends and new developments in mindfulness research: Proposing a mindfulness breathing technique with ultrasound imaging feedback. *Precision Medicine*, Vol. 8, No. 4, pp. 337-340.

Hitomi, T., Iwasaki, Y., Sekikawa, Y., and Yachi, C. T. (2024). The new potential and prospects of leisure activities of older

adults individuals during the COVID-19 pandemic in Japan on health-span from the perspective of a scoping review. *Studies in Science and Technology*, Vol. 13, No. 2, pp. 115-122.

Hu, X.-S., Beard, K., Sherbel, M. C., Nascimento, T. D., Petty, S., Pantzlaff, E., Schwitzer, D., Kaciroti, N., Maslowski, E., Ashman, L. M., Feinberg, S. E., and DaSilva, A. F. (2021). Brain mechanisms of virtual reality breathing versus traditional mindful breathing in pain modulation: Observational functional near-infrared spectroscopy study. *Journal of Medical Internet Research*, Vol. 23, No. 10, e27298.

Hunt, M., Rajagopal, T., Cerecino, F., and O'Neil, M. (2021). Mindful versus diaphragmatic breathing: Spirituality moderates the impact on heart rate variability. *Mindfulness*, Vol. 12, No. 11, pp. 2743-2753.

Joseph, A. and Jose, T. P. (2024). Coping with distress and building resilience among emergency nurses: A systematic review of mindfulness-based interventions. *Indian Journal of Critical Care Medicine*, Vol. 28, No. 8, pp. 785-792.

Kaisti, I., Kulmala, P., Hintsanen, M., Hurtig, T., Repo, S., Paunio, T., Miettunen, J., Halt, A. H., and Jääskeläinen, E. (2024). The effects of mindfulness-based interventions in medical students: A systematic review. *Advances in Health Sciences Education*, Vol. 29, No. 1, pp. 245-271.

Kao, T. A., Ling, J., Alanazi, M., Atwa, A., and Liu, S. (2025). Effects of mindfulness-based interventions on obesogenic eating behaviors: A systematic review and meta-analysis. *Obesity Reviews*, Vol. 26, No. 3, e13860.

Konrad, A. C., Engert, V., Albrecht, R., Dobel, C., Döring, N., Haueisen, J., Klimecki, O., Sandbothe, M., and Kanske, P. (2023). A multicenter feasibility study on implementing a brief mindful breathing exercise into regular university courses. *Scientific Reports*, Vol. 13, No. 1, 7908.

Langer, Á. I., Medeiros, S., Valdés-Sánchez, N., Brito, R., Steinebach, C., Cid-Parra, C., Magni, A., and Krause, M. (2020). A qualitative study of a mindfulness-based intervention in educational contexts in Chile. *International Journal of Environmental Research and Public Health*, Vol. 17, No. 18, 6927.

Li, E., Cheng, W., Yuan, H., and Gao, X. (2025). Protecting young women's body image from appearance-based social media exposure. *Journal of Psychosomatic Research*, Vol. 192, 112121.

Lopes, A., Sampaio, R., and Tavares, I. (2024). Pain, mindfulness, and placebo: A systematic review. *Frontiers in Integrative Neuroscience*, Vol. 18, 1432270.

Maekawa, M. (2017). Effects of mindful breathing on depression in Japanese university students. *Waseda Rilas Journal*, Vol. 5, pp. 23-35.

Miyoshi, T. and Taniguchi, J. (2024). Section 3: Various practices in medical education and healthcare institutions – mindfulness. *Medical Education of Japan*, Vol. 55, No. 4, pp. 319-326.

Natarajan, A. (2022). Heart rate variability during mindful breathing meditation. *Frontiers in Physiology*, Vol. 13, 1017350.

Natarajan, A., Emir-Farinas, H., and Su, H.-W. (2023). Mindful breathing as an effective technique in the management of hypertension. *Frontiers in Physiology*, Vol. 14, 1339873.

Ng, H.-Y. H., Wu, C.-W., Hsu, H.-C., Huang, C.-M., Hsu, A.-L., Chao, Y.-P., Jung, T.-P., and Chuang, C.-H. (2024). Neurological evidence of diverse self-help breathing training with virtual reality and biofeedback assistance. *JMIR Formative Research*, Vol. 8, e55478.

Ong, N. Y., Teo, F. J. J., Ee, J. Z. Y., Yau, C. E., Thumboo, J., Tan, H. K., and Ng, Q. X. (2024). Effectiveness of mindfulness-based interventions on the well-being of healthcare workers. *General Psychiatry*, Vol. 37, No. 3, e101115.

Preissner, C. E., Vilier, L., Bertelsmann, N. C., Beckers, K., de Ruijter, D., de Vries, H., and Oenema, A. (2025). Effectiveness of unstandardized mindfulness interventions. *BMC Public Health*, Vol. 25, No. 1, 1705.

Quek, F. Y. X., Majeed, N. M., Kothari, M., Lua, V. Y. Q., Ong, H. S., and Hartanto, A. (2021). Brief mindfulness breathing exercises and working memory capacity. *Brain Sciences*, Vol. 11, No. 2, 175.

Renshaw, T. L. (2020). Mindfulness-based intervention in schools. In *Promoting mind-body health in schools* (pp. 145-160). American Psychological Association.

Shahbaz, W. and Parker, J. (2022). Workplace mindfulness. *Human Resource Management Review*, Vol. 32, No. 3, 100849.

Shao, H., Ren, G., Li, Y., Wang, M., Shen, Y., Li, R., and Ding, X. (2024). The effects of one-session mindfulness meditation on mind wandering. *Current Psychology*, Vol. 43, No. 47, pp. 35811-35820.

Togo, E. (2024). Time series data analysis of mindfulness breathing method using electroencephalogram. *Sage Open Nursing*, Vol. 10, 23779608231226073.

Togo, E., Yamamoto, Y., Muramatsu, A., and Mizuno, Y. (2021). Effects of mindfulness on EEG during task performance. *Journal of Nursing Science and Engineering*, Vol. 9, pp. 47–59.

Uberoi, P., Smitherman, A., Aden, J., Park, G., and Jellison, F. (2020). Incorporation of mindfulness exercises to reduce anxiety during urodynamic testing. *Journal of Alternative and Complementary Medicine*, Vol. 26, No. 1, pp. 74-75.

Vago, D. R., Gupta, R. S., and Lazar, S. W. (2019). Measuring cognitive outcomes in mindfulness-based intervention research. *Current Opinion in Psychology*, Vol. 28, pp. 143-150.

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., Meissner, T., Lazar, S. W., Kerr, C. E., Gorchov, J., Fox, K. C. R., Field, B. A., Britton, W. B., Brefczynski-Lewis, J. A., and Meyer, D. E. (2018). Mind the hype. *Perspectives on Psychological Science*, Vol. 13, No. 1, pp. 36-61.

Vargas-Uricoechea, H., Castellanos-Pinedo, A., Urrego-Noguera, K., Vargas-Sierra, H. D., Pinzón-Fernández, M. V., Barceló-Martínez, E., and Ramírez-Giraldo, A. F. (2024).

Mindfulness-based interventions and the hypothalamic-pituitary-adrenal axis. *Neurology International*, Vol. 16, No. 6, pp. 1552-1584.

Verdonk, C., Trousselard, M., Di Bernardi Luft, C., Medani, T., Billaud, J. B., Ramdani, C., Canini, F., Claverie, D., Jaumard-Hakoun, A., and Vialatte, F. (2021). The heartbeat evoked potential does not support strong interoceptive sensibility in trait mindfulness. *Psychophysiology*, Vol. 58, No. 10, e13891.

Vieth, E. and von Stockhausen, L. (2023). Effects of short mindful breathing meditations on executive functioning. *Acta Psychologica*, Vol. 239, 104006.

Wagner, M. and Wieczorek, A. (2024). Ego-depletion and motor skill performance under pressure. *Scientific Reports*, Vol. 14, No. 1, 17541.

Wang, Q., Wang, F., Zhang, S., Liu, C., Feng, Y., and Chen, J. (2023). Effects of mindfulness-based interventions on stress and burnout in nurses. *Frontiers in Psychiatry*, Vol. 14, 1218340.

Wright, S. L., Bach, E., Bryson, S. P., Schaller, S., and Wright, D. (2025). Using an app-based mindfulness intervention. *Cognitive and Behavioral Practice*, Vol. 32, No. 2, pp. 258-269.

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