

## Meditation Practices and Stress Reactivity: A Comprehensive Exploration of Psychological, Physiological, and Neurobiological Dimensions

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### ABSTRACT

Psychological stressors have the potential to induce distress, leading to autonomic arousal and the activation of stress responses. Prolonged or persistent stress can disrupt the feedback mechanisms of the stress response, resulting in increased cortisol levels and pro-inflammatory cytokines. These physiological changes may contribute to damage in brain regions responsible for mood and emotion regulation. Our hypothesis posits that the extent of the stress response to psychological stressors is influenced by various modifiable psychological processes, such as an individual's level of self-compassion, dispositional mindfulness, inclination to ruminate, and attentional bias. Moreover, we suggest that the impact of psychological stressors on the stress response can be mitigated by influencing these psychological processes. Meditation practices, we propose, have the potential to decrease stress and enhance mood by reducing stress reactivity at psychological, physiological, and neurobiological levels. This concept is explored in detail in our narrative review.

**Keywords:** Brain; Meditation; Stress; Autonomic nervous system

### INTRODUCTION

Stressors encompass situations that pose a threat to a goal, whether it be the preservation of physical safety (physical stressors) or psychological well-being, involving aspects related to work, home, and personal circumstances [1,2]. Distress, characterized by negative psychological responses such as anxiety, sadness, and frustration, emerges in reaction to these threats [1]. Whether real or perceived, stressors can disturb homeostasis or well-being, triggering a comprehensive stress response, even without a tangible physical threat. Notably, athletes anticipating competitions commonly exhibit emotional and physiological responses, correlating with heightened cortisol levels. The Autonomic Nervous System (ANS), comprising the Sympathetic Nervous System (SNS) and Parasympathetic Nervous System (PNS) [3], regulates the activation of a stress response [3]. The SNS initiates the 'fight-flight-freeze' response in dangerous situations, while also influencing pro-inflammatory cytokine production. Once the threat subsides, the PNS, primarily governed by the vagus nerve [4], initiates the 'rest and digest' response, restoring the body to equilibrium. Simultaneously, the Hypothalamic-Pituitary-Adrenal (HPA) axis activates, releasing

cortisol to fulfill various metabolic functions, including maintaining blood sugar levels during stress.

Cortisol, at a certain concentration, activates glucocorticoid receptors, terminating the stress response through negative feedback control [5]. However, chronic exposure to stress, including psychological stressors, can disrupt this delicate feedback mechanism, leading to glucocorticoid resistance and increased inflammation, potentially contributing to mental disorders like depression. Depression is associated with altered immune-endocrine interaction, heightened pro-inflammatory cytokines, and a flattened cortisol circadian rhythm. Excess corticosteroids from chronic stress can damage the brain, affecting regions involved in mood regulation, such as the hippocampus and prefrontal cortex, leading to atrophy. Depression is linked to increased pro-inflammatory cytokines, and inflammation-induced cellular apoptosis in brain regions regulating mood. Meditation, with various definitions and classifications, has shown associations with improved mental health across diverse populations. This article proposes that meditation practices alleviate distress from psychological stressors by influencing key psychological processes, thereby

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altering the relationship with stressors. The suggested reduction in distress is associated with decreased autonomic arousal, mitigated stress response activation, and diminished long-term activation in brain regions linked to rumination and mood regulation. The study aims to contribute to existing literature by concurrently exploring the impact of mindfulness on psychological, physiological, and neurobiological outcomes in the context of stress regulation and its implications for mood, particularly depression. The narrative review focuses on meta-analytic and systematic review studies of meditation, aiming to unravel its mechanisms of action and identify populations that may benefit the most.

## MATERIALS AND METHOD

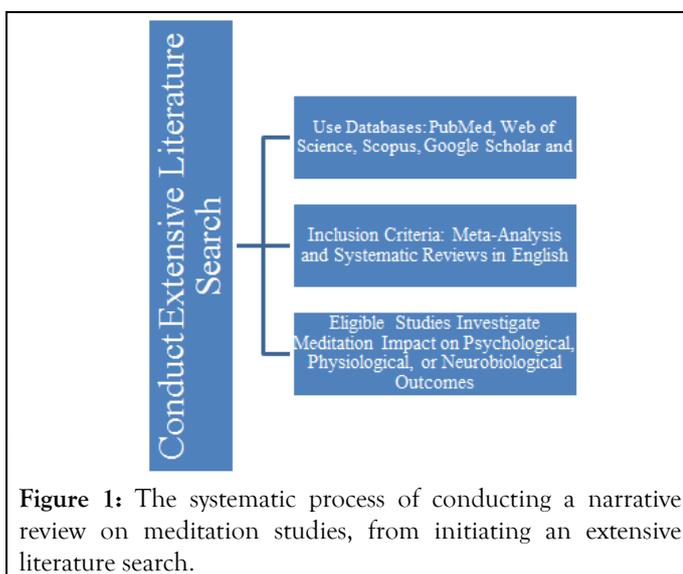
Our objective was to conduct a narrative review of meta-analytic and systematic studies encompassing various meditation forms (Figure 1). The review focused on exploring the psychological and/or biological mechanisms that link meditation practices with mood, particularly emphasizing those associated with the stress response [6]. This comprehensive examination included investigations into:

**Psychological processes:** Examining aspects such as self-compassion, dispositional mindfulness, rumination, exposure, meta-cognition, and attention.

**Physiological processes:** Investigating the impact on the autonomic nervous system, including parameters like heart rate, blood pressure, cytokines, and cortisol.

**Neurobiological processes:** Analyzing the influence on brain structure and function.

A sole author conducted an extensive literature search using databases such as PubMed, Web of Science, Scopus, and Google Scholar. Additionally, a panel of experts contributed to refining the literature search. Inclusion criteria comprised meta-analysis and systematic reviews. The search terms encompassed terms like "mindful" "meditate" "psych" "neuro" "stress" "autonomic" "mental illness" "mental health" "cytokine" and "endocrine." Only studies published in English were considered.



Systematic reviews and meta-analyses were deemed eligible if they investigated the impact of meditation practices on physiological, psychological, or neurobiological outcomes across diverse populations. Quality assessments of the included studies were not conducted, resulting in the inclusion of all eligible articles. Data were categorized based on the specific outcome under examination, which included psychological processes, physiological processes, and neurobiological processes.

Mindfulness, defined as non-judgmental awareness of the present moment, has been studied extensively in relation to psychological and physiological outcomes. Galante and colleagues found that kindness-based meditation increased mindfulness in a meta-analysis of 22 Randomized Controlled Trials (RCTs). Similarly, mindfulness mediated symptoms of depression, stress, anxiety, mood states, quality of life, and anger expression in diverse populations practicing OM (Omkaara) meditations. The impact of meditation on psychological health is evident in various contexts, such as health care professionals experiencing reduced burnout, depression, anxiety, and stress. Mindfulness is associated with reduced psychological distress, enhancing self-regulation of emotions and behaviors. Higher self-compassion, cultivated through meditation, is linked to improved psychological health [7]. The practice of mindfulness, particularly in OM studies, has been shown to increase self-compassion.

The psychological skills developed through meditation, like self-compassion, are associated with decreased self-reported stress, altering individuals' reactions to psychological stressors. For instance, high self-compassion buffers against anxiety following stressors in individuals with elevated symptoms of depression. Self-compassion may improve psychological health by decreasing avoidance and rumination, contributing to lower symptoms of depression and stress. Rumination, repetitive negative thinking, is a process strongly influenced by meditation. OM meditation has been found to mediate symptoms of depression, stress, anxiety, and global psychopathological symptoms. Meditation's ability to shift attention from ruminative thoughts to the present moment decreases distress associated with rumination. High self-compassion has been shown to mitigate the negative correlation between rumination and symptoms of depression and anxiety.

Exposure, prolonged observation of thoughts and emotions without avoidance, is suggested to occur during mindfulness practice, contributing to decreased psychological stress. Meditation, including Mindfulness Based Stress Reduction (MBSR), has been associated with increased exposure and decreased depression, anxiety, and stress. Metacognitive awareness, the ability to decenter from thoughts and emotions, protects against depression relapse. Although limited studies assess the impact of meditation on metacognition, MBSR has been shown to increase metacognition in patients in remission from major depression. Meditation practices positively influence attention capacity across various populations. Mindfulness meditation, in particular, has been associated with enhanced decision-making and cognitive processes related to attention. Meditation contributes to a decrease in autonomic arousal, impacting psychological processes and physiological responses to

stressors [8,9]. Strong evidence supports the positive effects of meditation, especially concentrative and TM (Trademark) forms, on blood pressure. OM meditation decreases resting heart rate, and its impact on heart rate variability remains inconclusive. Studies on the influence of meditation on inflammatory proteins like CRP, IL-6, and TNF- $\alpha$  show mixed results. Meditation, particularly FA-based, has demonstrated the ability to decrease cortisol levels, contributing to stress reduction.

Persistent stress-induced cortisol release can lead to structural changes in the brain, affecting regions important for emotional regulation and mood. Meditation practices, including mindfulness, have been associated with changes in brain structure and function, particularly in the Default Mode Network (DMN). Mindfulness practices reduce DMN activity and alterations in DMN are linked to mental disorders like depression. Meditation influences brain regions such as the medial prefrontal cortex, rostralateral prefrontal cortex, anterior/midcingulate cortex, and orbitofrontal cortex, leading to morphological changes and enhanced emotional regulation. These structural changes indicate increased self-monitoring and better regulation of negative emotions.

## RESULTS AND DISCUSSION

This narrative literature review serves as a valuable contribution to the growing body of research, illuminating the concurrent effects of meditation practices on stress reactivity from psychological, physiological, and neurobiological perspectives. The observed positive impacts on mood are likely the result of influencing stress reactivity through multiple interconnected pathways. By comprehensively exploring the intricate relationship between meditation and well-being, this review highlights the potential of these practices to foster holistic health. Meditation's influence extends across various dimensions, impacting both psychological processes and physiological markers [10]. The psychological realm encompasses aspects such as self-compassion, rumination, exposure, metacognition, and attention. These processes play an important role in shaping an individual's psychological response and relationship with stressors. The positive alterations observed in these psychological dimensions suggest that meditation-based practices have the potential to enhance an individual's overall psychological well-being, contributing to improved stress resilience and adaptive coping mechanisms.

On the physiological front, meditation practices influence key markers of stress reactivity, including changes in blood pressure, heart rate, cortisol levels, and possibly inflammatory proteins. The ability of meditation to modulate these physiological responses has been observed across diverse populations of adults. Acute and chronic stress, often accompanied by elevated corticosteroids, can have detrimental effects on the brain, particularly in regions associated with mood and emotion regulation, such as the hippocampus and prefrontal cortex. In contrast, meditation practices are linked to structural and functional changes in these brain regions, providing a potential mechanism for the observed improvements in mood outcomes. The bidirectional interaction among psychological, physiological,

and neurobiological effects represents a complex and interconnected web that warrants further exploration. Understanding how these dimensions interact and influence each other is important for unraveling the full spectrum of meditation's impact on holistic well-being. Future research should aim to delve into the nuances of these interactions, considering the dynamic nature of stress reactivity and its modulation through meditation practices.

Diversity in meditation forms, populations, and training lengths introduces a rich tapestry of variables that can influence outcomes. The current state of research indicates varying amounts of evidence supporting different forms of meditation for distinct clinical conditions. For instance, Mindfulness-Based Cognitive Therapy (MBCT) shows strong evidence as a depression relapse prevention strategy, while its efficacy for bipolar disorder treatment is less robust. This underscores the need for future investigations to scrutinize the differences between various meditation forms in diverse populations. Exploring the nuanced impact of meditation on mood outcomes in different contexts will contribute to a more refined understanding of its therapeutic potential. A critical aspect that warrants attention is the consideration of potential detrimental effects of meditation, particularly in specific circumstances and for certain individuals. While case reports exist describing severe symptoms induced by certain meditation forms, such incidents are often associated with intensive retreats and have not been reported following evidence-based mindfulness interventions. Nonetheless, the possibility of subjective distress and functional impairment emphasizes the need for informed meditation practices. Teachers and practitioners should possess a deep understanding of the theoretical and mechanistic foundations of meditation, allowing them to explain its relevance, anticipate difficulties that may arise, and guide individuals through managing challenges.

## CONCLUSION

The study underscores the importance of considering self-esteem, both in its general and nuanced dimensions, as a significant determinant in the prevalence and intensity of internet addiction among adolescents. As digital technologies continue to play a central role in the lives of young individuals, this research provides a foundation for developing customized strategies aimed at fostering healthier online behaviors and supporting adolescents in navigating the challenges of the digital age.

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