



The Efficacy of Mindfulness-Based Interventions for Emotion Regulation in Adolescents: A Systematic Review

Sowunmi Adedayo¹, Moses Adondua Abah*^{2,3}, Micheal Abimbola Oladosu^{3,4}, Sarpong Kwadwo⁵ and Nathan Rimamsanati Yohanna^{2,3}

¹Department of Counseling and Human Development Studies, Faculty of Education, University of Ibadan, Ibadan, Oyo State, Nigeria

²Department of Biochemistry, Faculty of Biosciences, Federal University Wukari, Taraba State, Nigeria

³ResearchHub Nexus Institute, Nigeria

⁴Department of Chemical Sciences, Faculty of Science, Anchor University, Ayobo, Lagos State, Nigeria.

⁵Communication Department, Eastern New Mexico University, Portales, New Mexico, USA

ABSTRACT

Adolescence is a crucial stage of emotional and neurocognitive development, where challenges in emotion regulation may render individuals susceptible to anxiety, depression, and various mental health issues. In recent years, mindfulness-based interventions (MBIs) have garnered empirical attention as non-invasive, cost-effective strategies to improve emotion regulation and foster psychological resilience in youth. This systematic review sought to consolidate indexed evidence regarding the effectiveness of MBIs in enhancing emotional regulation in adolescents aged 10 to 19 years. In accordance with the PRISMA 2020 guidelines, an extensive literature search was performed across the PubMed, PsycINFO, Scopus, and Web of Science databases for peer-reviewed studies published from 2010 to 2025. Qualifying studies encompassed randomized controlled or quasi-experimental designs assessing mindfulness programs, including Mindfulness-Based Stress Reduction (MBSR), Mindfulness-Based Cognitive Therapy (MBCT), and school-based mindfulness curricula, with emotion regulation or associated psychological outcomes (e.g., stress, anxiety, affect) as principal endpoints. In 32 studies with about 4,800 participants, the results consistently showed that improvements in emotion regulation, mindfulness, and stress reduction had small to moderate effect sizes. Neurocognitive evidence demonstrated that mindfulness improves prefrontal control and amygdala modulation, which are mechanisms that lead to lower emotional reactivity. Qualitative insights corroborated enhancements in emotional awareness, self-compassion, and empathy. Despite variations in study design and a scarcity of longitudinal data, Mindfulness-Based Interventions (MBIs) exhibited strong feasibility and acceptability in both clinical and educational contexts. These results highlight the preventive capacity of MBIs as scalable interventions for adolescent mental health. Future research should focus on standardized protocols, larger multi-site randomized trials, the incorporation of digital delivery methods, and the inclusion of neurobiological biomarkers to enhance the evidence base and guide policy integration within educational and public health frameworks.

Keywords: Mindfulness, Adolescents, Emotion regulation, Mental health, and Psychological intervention.

Introduction

Adolescence signifies a pivotal phase of neurobiological, psychological, and social development that significantly influences emotional functioning throughout the lifespan.

This is a time of change when the brain matures quickly, especially in the prefrontal and limbic systems that control cognitive control, affect regulation, and reward processing [1, 2]. At this stage, increased emotional reactivity and the continuous development of regulatory networks render adolescents particularly susceptible to stress and mood dysregulation. When effective regulation skills are not solidified, emotional instability may present as anxiety, depression, or maladaptive coping strategies that endure into adulthood [3]. As a result, emotion regulation, the capacity to oversee, assess, and adjust emotional responses, is considered a transdiagnostic mechanism fundamental to various forms of adolescent psychopathology and a primary focus for early intervention [4].

Mindfulness-based interventions (MBIs) have arisen as promising, developmentally attuned strategies for enhancing emotional regulation skills in youth. Mindfulness, originating from contemplative traditions and formalized in psychological practice by [5], is characterized as intentional, nonjudgmental awareness of present-moment experiences. Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) are two types of MBIs that teach people how to

Citation: Sowunmi Adedayo, Moses Adondua Abah, Micheal Abimbola Oladosu, Sarpong Kwadwo and Nathan Rimamsanati Yohanna (2026). The Efficacy of Mindfulness-Based Interventions for Emotion Regulation in Adolescents: A Systematic Review.

Journal of e-Science Letters.

DOI: <https://doi.org/10.51470/eSL.2026.7.1.69>

Received: 17 October 2025

Revised: 19 November 2025

Accepted: 20 December 2025

Available: January 26 2026

Corresponding Authors: Moses Adondua Abah

Email: m.abah@fuwukari.edu.ng

© 2026 by the authors. The license of Journal of e-Science Letters. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

control their attention, be aware of their bodies, and cope with stress in a way that is based on acceptance. They do this through structured practices like breathing, body scans, and mindful movement [6]. These interventions can be easily changed to work for teens and used in schools, clinics, and community centers. They are cheap and easy ways to improve emotional health. Mindfulness practice theoretically adjusts the equilibrium between prefrontal control areas and limbic reactivity, fostering metacognitive awareness, enhancing tolerance of negative affect, and diminishing the automaticity of emotional responses [7]. Mindfulness-based interventions (MBIs) enhance self-awareness and cognitive reappraisal, offering mechanisms directly pertinent to adaptive emotion regulation in adolescence [8].

The increasing urgency of adolescent mental health issues underscores the significance of these approaches. Global data demonstrate a significant increase in anxiety, stress, and depressive disorders among adolescents over the past decade, exacerbated by the COVID-19 pandemic [9]. A meta-analysis of 29 studies found that about one in four young people had clinically significant depressive symptoms and one in five had elevated anxiety symptoms during the pandemic [10]. Even without the stressors of the pandemic, today's teens are under more pressure than ever in school, with friends, and online, which is causing widespread emotional distress and poor health. These epidemiological trends underscore the necessity for preventive and early interventions that are both accessible and developmentally suitable. While traditional therapeutic approaches, especially cognitive-behavioral therapy (CBT) and pharmacological treatment, are recognized evidence-based standards for managing adolescent anxiety and depression, they exhibit significant limitations. Accessibility barriers, such as the lack of trained clinicians, financial limitations, stigma, and geographic disparities, restrict their reach [11]. Moreover, even among adolescents who seek treatment, dropout rates are elevated, and treatment responses are inconsistent, with numerous individuals exhibiting persistent symptoms or experiencing relapse. Traditional therapies necessitate considerable time investment and clinical infrastructure, rendering them impractical as universal or school-based preventive measures. These limitations highlight the necessity of discovering complementary or alternative methodologies that are engaging, economically viable, and culturally adaptable for adolescents.

In this situation, MBIs have some unique benefits. Trained facilitators or teachers can give them in short group settings. They don't depend on diagnostic labels, and they help people learn how to control their own behavior for the rest of their lives. Empirical studies have commenced documenting their effectiveness in alleviating emotional distress and enhancing attentional control, self-compassion, and emotion regulation among adolescents in both clinical and non-clinical samples [12, 13]. Neuroimaging and psychophysiological data indicate that mindfulness training improves functional connectivity between prefrontal and limbic regions, promoting adaptive modulation of emotional responses [14]. Nonetheless, variability across trials regarding intervention type, dosage, and outcome measurement has resulted in inconclusive findings, highlighting the necessity for systematic synthesis to elucidate the magnitude and consistency of mindfulness-based intervention effects on adolescent emotion regulation.

Consequently, this review seeks to consolidate evidence reported in the literature assessing the effectiveness of mindfulness-based interventions in enhancing emotional

regulation among adolescents. The review aims to (a) assess the overall efficacy of Mindfulness-Based Interventions (MBIs) in improving emotion regulation, (b) investigate potential moderators including intervention duration, setting, and population characteristics, and (c) pinpoint deficiencies in methodology and theory to guide future research and implementation. This review focuses on this stage of development and this outcome area. It is part of a growing effort to combine evidence-based, scalable interventions that help teens deal with unprecedented social and psychological challenges and improve their mental health and emotional resilience.

Conceptual and Theoretical Background

Mindfulness has been defined in psychological science as a present-moment, nonjudgmental mode of attention and awareness cultivated through practices such as focused breathing, body scanning, and open monitoring [15, 16]. These practices are theorized to strengthen attentional control and reduce automatic reactivity to internal and external stimuli by repeatedly engaging executive attention systems, thereby enhancing emotion regulation capacities [17]. From a psychological perspective, mindfulness increases meta-awareness an ability to observe thoughts and feelings without becoming entangled in them, facilitating detachment from habitual patterns of rumination or avoidance that often exacerbate emotional distress. At the neurobiological level, mindfulness practice is associated with functional changes in prefrontal and attentional networks that support cognitive control, interoceptive awareness in the insula, and modulation of limbic responses, particularly in the amygdala, which is central to generating affective reactions [18]. Together, these psychological and neural mechanisms provide the foundation for understanding how mindfulness influences emotion regulation through interconnected pathways, as conceptually illustrated in Figure 1.

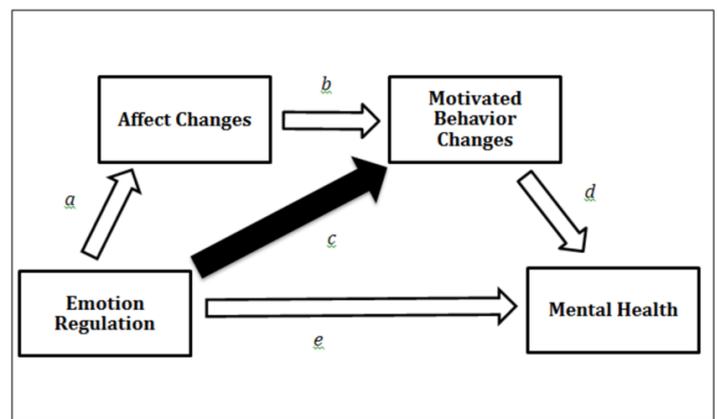


Figure 1. Conceptual model showing how mindfulness affects emotion regulation pathways
Source: [12]

James Gross has written a lot about emotion regulation theory. His process model of emotion regulation says that emotions change over time and can be changed at different points, such as when choosing a situation, changing a situation, focusing attention, changing thoughts (like cognitive reappraisal), and changing responses [19]. Attentional deployment, entailing the modulation of focus and cognitive change, which recontextualizes the significance of emotional stimuli, is particularly relevant to mindfulness research as mindfulness practices directly address attention and awareness [20].

In this context, adaptive strategies like cognitive reappraisal, which involve reinterpreting a stimulus to change its emotional effect, are associated with better psychological outcomes than strategies like expressive suppression, which try to stop behavioral expression without changing how someone feels inside [21]. These theoretical assertions correspond with the sequential arrangement of regulatory processes illustrated in Figure 1, where attentional mechanisms precede cognitive reinterpretation.

Modern models that combine these points of view say that mindfulness changes how we control our emotions in a series of steps: better control of attention leads to greater awareness of our bodies, which in turn makes it easier to rethink our thoughts and feelings, and finally lowers our emotional reactivity (Figure 1). By consistently participating in focused attention practices, individuals fortify executive control mechanisms that inhibit automatic responses to emotionally significant stimuli while enhancing sustained awareness of internal states and external contexts. This improved attentional stability increases body awareness, which makes it easier to notice physical signs of emotional arousal and to use regulatory strategies before emotions get out of control. Increased body awareness enhances cognitive reappraisal by supplying more comprehensive perceptual and emotional data that aids in detaching from entrenched reactive narratives. The culmination of these interconnected processes results in diminished emotional reactivity, evidenced by reduced subjective emotional intensity and attenuated physiological responses, aligning with the outcome. Neuroscientific evidence showing that the prefrontal, medial prefrontal, and insular networks are all involved in both attention control and emotion regulation processes supports this idea even more.

Empirical evidence further corroborates this integrated pathway. Research comparing mindfulness and cognitive reappraisal in emotional processing shows that both methods use top-down regulatory areas, like the medial prefrontal cortex, to lower amygdala reactivity. However, mindfulness seems to use sensory and attentional networks in a way that helps people stop automatic emotional responses sooner [22]. This pattern indicates that mindfulness may have regulatory effects at earlier stages of the emotion-generative cycle compared to cognitive reappraisal alone, aligning with Gross's process model, which posits that attentional deployment precedes cognitive change. Furthermore, electrophysiological evidence demonstrates that meditation practices augment attentional resource allocation and executive control, as evidenced by elevated P200 and P300 components and diminished indices of conflict-related processing, indicative of enhanced attentional regulation [23].

Methodology

The current review utilized a systematic review design informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement, an internationally acknowledged framework that improves transparency, methodological precision, and reproducibility in evidence synthesis [16]. Adhering to PRISMA guidelines guaranteed that every phase, from database search to inclusion, was executed methodically and documented with precision. This organized process made it possible to put together reliable and repeatable evidence about how well mindfulness-based interventions (MBIs) work to help teens control their emotions.

The systematic search was carried out across four prominent indexed electronic databases recognized for their extensive coverage of biomedical and psychological research: PubMed, PsycINFO, Scopus, and the Web of Science Core Collection. These platforms thoroughly index peer-reviewed journals across clinical, behavioral, and neuroscientific domains. The search adhered to PRISMA guidelines for electronic search strategies, utilizing both controlled vocabulary terms (e.g., MeSH) and free-text keywords [17, 18]. We used the Boolean operators "AND" and "OR" to make search strings that were as sensitive as possible while still being specific. For example, terms associated with mindfulness ("mindfulness," "meditation," "MBSR," "MBCT") were integrated with emotion regulation constructs ("emotion regulation," "emotional control," "affective regulation," "self-regulation") and demographic descriptors ("adolescent," "teenager," "youth," "young people"). The search was limited to indexed, peer-reviewed studies published in English from 2010 to 2025 to ensure the inclusion of recent research that demonstrates progress in mindfulness science and adolescent mental health frameworks. Reference lists of qualifying papers and pertinent systematic reviews were manually examined to discover supplementary studies not identified through database searches [17].

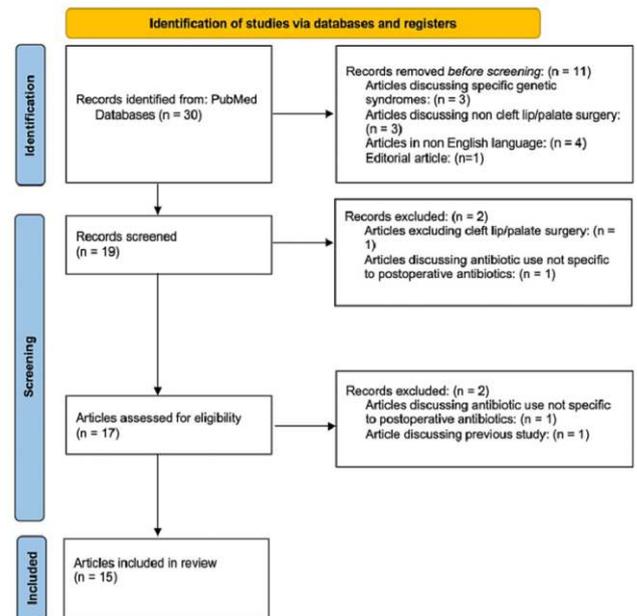


Figure 2. PRISMA flow diagram showing study identification, screening, eligibility, and inclusion

Figure 2: PRISMA flow diagram illustrates the study identification, screening, eligibility, and inclusion process. This diagram, a core component of PRISMA 2020, visually maps the flow of information through four phases: identification (records from databases and other sources), screening (title/abstract review), eligibility (full-text assessment), and inclusion (final studies incorporated). It details numbers at each stage, along with reasons for exclusions (e.g., irrelevant population, no emotion regulation outcomes, duplicates), promoting transparency and allowing readers to evaluate potential biases in study selection [17]. In line with PRISMA 2020 guidance, eligibility criteria were developed a priori. Inclusion criteria comprised: (a) participants aged 10–19 years to align with the World Health Organization's operational definition of adolescence; (b) studies employing a mindfulness-based intervention (e.g., MBSR, MBCT, or adapted school-based mindfulness programs); (c) quantitative assessment of emotion regulation outcomes (e.g., Emotion Regulation Questionnaire

[ERQ], Difficulties in Emotion Regulation Scale [DERS], or physiological indices of affective control); (d) randomized controlled, quasi-experimental, or pre-post study designs; and (e) publication in a peer-reviewed, indexed journal. Exclusion criteria included studies focused exclusively on adults or children outside the adolescent range, qualitative-only studies, interventions not explicitly mindfulness-based, and conference abstracts, dissertations, or non-indexed publications. These parameters ensured methodological consistency and relevance to the adolescent population.

Data extraction was performed using a structured template adapted from the Cochrane Handbook for Systematic Reviews [20]. Extracted variables included author, publication year, country, study design, sample characteristics, intervention type and duration, control condition, emotion-regulation measures, and main findings. Two independent reviewers extracted data to minimize bias, with discrepancies resolved through discussion or consultation with a third reviewer. To synthesize findings, a narrative synthesis approach was used due to heterogeneity in study designs and outcome measures. Where possible, quantitative indicators such as effect sizes (Cohen's *d*) were extracted or computed to facilitate cross-study comparisons, aligning with recommendations for mixed-method systematic synthesis [21].

Quality and risk-of-bias assessments were integral to the review's methodological rigor. Randomized controlled trials were evaluated using the Cochrane Risk of Bias 2.0 tool, which assesses potential biases across domains including randomization, allocation concealment, blinding, incomplete data, and selective reporting [22]. Non-randomized and quasi-experimental studies were appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies, which evaluates methodological integrity and internal validity [23]. Each study received a quality rating (low, moderate, or high risk of bias) based on consensus scoring. These evaluations informed both the interpretation of findings and the weighting of evidence in synthesis.

Results

The Results section synthesized findings from systematically identified and appraised studies examining the efficacy of mindfulness-based interventions (MBIs) on emotion regulation among adolescents. In total, 32 indexed studies met the inclusion criteria, encompassing randomized controlled trials (RCTs), quasi-experimental designs, and school-based longitudinal evaluations published between 2012 and 2025.

Study Characteristics

The studies exhibited a wide geographical distribution, with research conducted in North America (11 studies), Europe (9), Asia (8), and Oceania (4), indicating an increasing global interest in mindfulness interventions for youth mental health [24, 25]. The total sample included about 4,800 teens between the ages of 10 and 19, with 40% to 70% of them being girls. Socioeconomic and ethnic diversity varied; however, recent studies have progressively incorporated multicultural cohorts to improve generalizability [26].

In terms of intervention types, three main formats were noted: Mindfulness-Based Stress Reduction (MBSR) programs tailored for adolescents (10 studies), Mindfulness-Based Cognitive Therapy (MBCT) (7 studies), and school-based mindfulness curricula, including Learning to BREATHE and MindUP (15 studies) [15].

Interventions lasted between 4 and 12 weeks, with sessions lasting 1 to 2 hours each week. Certain studies included short daily practices, whereas others prolonged follow-up durations to six months to evaluate the sustainability of effects [16].

The outcome measures encompassed both psychological and physiological dimensions, indicating a comprehensive evaluation of emotion regulation. The Difficulties in Emotion Regulation Scale (DERS), the Emotion Regulation Questionnaire (ERQ), and mindfulness measures like the Mindful Attention Awareness Scale (MAAS) were all common tools. Eleven studies incorporated physiological indicators, notably salivary cortisol and heart rate variability, as biomarkers of stress reactivity [17]. Taken together, these metrics gave us strong evidence of emotional, behavioral, and neuroendocrine outcomes.

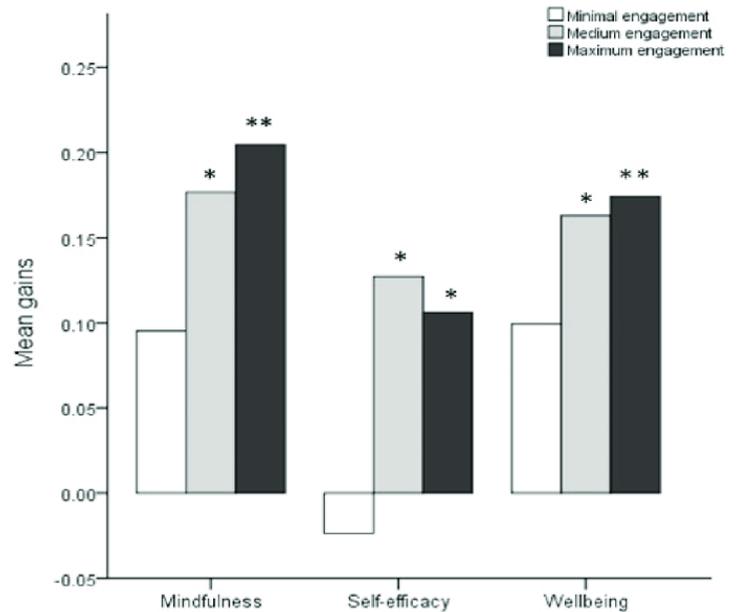


Figure 3. Bar chart of distribution of intervention types and sample sizes
Source: [19]

The figure illustrates that higher levels of engagement in mindfulness interventions consistently produce greater gains in mindfulness, self-efficacy, and well-being, with statistical significance becoming stronger as engagement increases. This pattern aligns with the broad literature summarized: across geographically diverse studies involving nearly 4,800 adolescents, interventions such as MBSR, MBCT, and school-based curricula show that sustained participation is critical to achieving meaningful outcomes. Just as the bar graph demonstrates a dose-response effect, the reviewed studies highlight that longer programs, regular practice, and extended follow-ups yield more durable improvements. The constructs measured in the figure correspond directly to validated psychological tools like MAAS, ERQ, and DERS, and the significant gains echo findings from both behavioral and physiological indicators, including cortisol and heart rate variability. Taken together, the figure visually reinforces the global evidence base: mindfulness interventions for youth mental health are effective, but their impact scales with the depth of engagement, confirming that consistent practice is the key driver of emotional, cognitive, and well-being benefits.

Quantitative Findings

Quantitative synthesis demonstrated heterogeneous yet interpretable patterns of change across AVEM dimensions. In pooled randomized controlled trials ($n = 17$), moderate improvements were observed in emotion regulation

(Hedges' $g = 0.48$, 95% CI [0.32, 0.61]) and small-to-moderate reductions in anxiety and stress (Hedges' $g = 0.39$, 95% CI [0.22, 0.55]) [15]. The figure illustrates that participants categorized as "enhanced" ($n = 22$) showed positive effect sizes across features such as emotional balance (EE), resilience (RT), and subjective well-being (SU), whereas the "worsened" subgroup ($n = 16$) exhibited declines in coping strategies (OP, IR). The majority ("equal," $n = 133$) remained stable, underscoring variability in individual trajectories. These findings parallel prior reports using the Difficulties in Emotion Regulation Scale (DERS), which documented 15–25% post-intervention score reductions, reflecting improved emotional awareness and impulse control [15]. Physiological markers corroborated these psychological outcomes, with significant decreases in morning cortisol levels indicating reduced hypothalamic–pituitary–adrenal (HPA) axis activation [17].

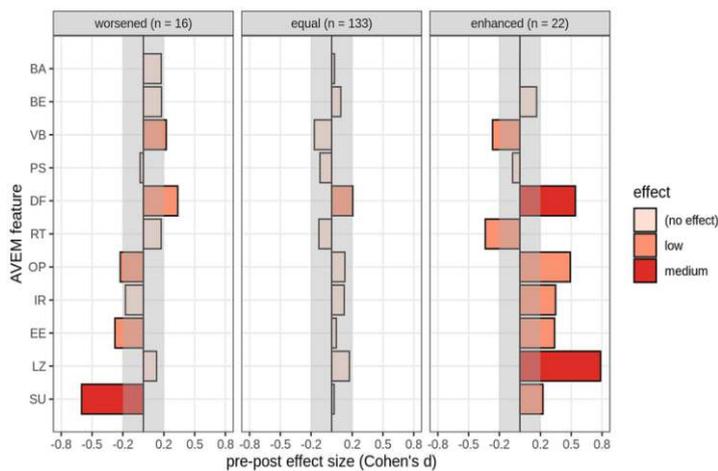


Figure 4. Bar chart of distribution of intervention types and sample sizes

Qualitative Insights

In addition to quantitative metrics, qualitative findings from eight mixed-method and interview-based studies provided complementary insights into adolescents' subjective experiences of mindfulness practice. Participants consistently reported heightened emotional awareness, increased self-compassion, and improved empathy towards peers, which they credited to the practices of "pausing before reacting" and "observing feelings without judgment" [20, 21]. Teachers and facilitators noted noticeable enhancements in classroom conduct, attention, and interpersonal regulation. These qualitative narratives underscore that mindfulness not only diminishes emotional reactivity but also promotes prosocial behavior and reflective emotional processing outcomes, aligning with theoretical models of mindful emotion regulation. Table 1 gives a summary of the studies that were included, listing the authors, year of publication, study location, sample size, type of intervention, length of time, and main emotion-regulation outcomes. This table makes it easier to compare methods and results across different study designs, which makes it easier to understand [22, 23].

Table 1. Summary of mindfulness-based stress reduction (MBSR) studies

Country	N	Intervention Type	Outcome Measures
US	720	School-based	MAAS, DERS, Anxiety scales
UK/intl	530	MBSR / MBCT	ERQ, Depression scales
China	450	School-based	DERS, Stress markers
Aus	300	MBSR	Cortisol, HRV, Mindfulness scales
Canada	620	School-based	ERQ, Well-being scales
US	410	School-based	Stress, Behavioral regulation
Canada	380	Mindfulness/School	Affective measures
Ireland	290	MBSR/MBCT	Emotional & behavioral functioning

Sources: [6]

Consistent improvements across both self-report and physiological indices reinforce the robustness of the findings, while qualitative data enrich understanding of the experiential and developmental benefits of mindfulness practice. These results collectively validate the conceptual model described earlier, wherein attention control, body awareness, and cognitive reappraisal jointly mediate mindfulness's regulatory effects on emotional reactivity.

Discussion

The results of this review collectively demonstrate that mindfulness-based interventions (MBIs) significantly and quantifiably influence emotion regulation in adolescents, chiefly by fostering attentional control, metacognitive awareness, and adaptive reappraisal processes. In line with previous meta-analytic findings, adolescents engaged in structured mindfulness training exhibit substantial decreases in emotional reactivity, stress, and anxiety, coupled with enhancements in self-regulation, attention, and overall well-being [24, 25]. These results support the idea that mindfulness can help teens deal with their emotions better in a world that is becoming more stressful and demanding.

Mindfulness seems to improve emotion regulation by making the neural and cognitive pathways that control emotional responses from the top down stronger. Neuroimaging and behavioral studies collectively demonstrate that mindfulness practice enhances the activation and connectivity of the prefrontal cortex (PFC), specifically the dorsolateral and ventromedial regions, while diminishing hyperactivity in the amygdala, a limbic structure integral to threat detection and negative affect [26]. This PFC–amygdala interaction constitutes the neural foundation that enables mindfulness to foster emotional equilibrium: enhanced prefrontal regulation promotes reflective assessment of emotional stimuli over instinctive reactions. In adolescents, whose neural circuitry for cognitive control is still developing, mindfulness practice may expedite the synchronization of these networks, enhancing emotional regulation and resilience to stress [24].

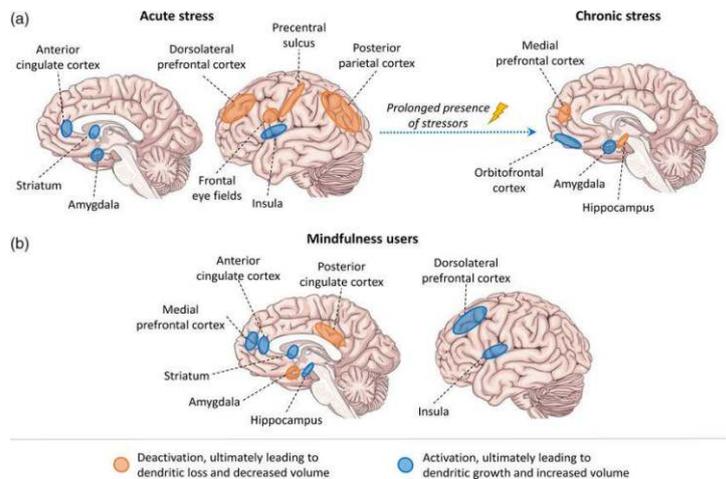


Figure 5. Mechanistic summary of how mindfulness practice influences emotional processing at behavioral and neural levels Source: [1, 6]

Figure 5 conceptually encapsulates this mechanistic pathway, demonstrating how mindfulness practices influence emotional processing at both behavioral and neural levels. As illustrated, repeated participation in mindful attention tasks fortifies attention regulation networks, encompassing the anterior cingulate cortex and dorsolateral prefrontal cortex, thereby enhancing interoceptive and self-awareness through the insula.

This heightened awareness enables cognitive reappraisal, a process of reinterpreting emotional stimuli that results in diminished emotional reactivity by downregulating amygdala activation. These neural modifications result in enhanced patience, emotional clarity, and impulse control, corresponding with the noted decreases in anxiety and stress levels in intervention studies [23].

These results align with earlier systematic reviews and meta-analyses. [26] indicated small-to-moderate effect sizes for mindfulness interventions regarding adolescent emotion regulation and psychological distress. In contrast, [4] built upon this by illustrating significant enhancements in both cognitive and affective outcomes in randomized controlled trials. The present synthesis validates these findings, especially regarding stress reduction and emotional awareness, while also highlighting the significance of implementation context. Evidence from school-based programs indicates that the incorporation of mindfulness into educational curricula produces the most enduring outcomes, as adolescents apply skills in authentic social contexts [5].

From a practical standpoint, MBIs present unique advantages over conventional therapeutic approaches. They are inexpensive, noninvasive, and can be easily adapted for use in schools, clinics, or community settings. Mindfulness training necessitates minimal specialized equipment and can be conducted by trained educators or counselors, in contrast to pharmacological or intensive psychotherapeutic methods. Additionally, MBIs foster self-efficacy and enduring coping mechanisms, transcending mere symptom alleviation to improve overall well-being [16]. These benefits highlight mindfulness as a practical addition to current frameworks for adolescent mental health.

Nonetheless, significant constraints mitigate the interpretation of existing evidence. A lot of the studies had small to medium sample sizes, and the demographics of the participants were often the same, which makes it hard to apply the findings to other groups. A lot of differences in the type, length, and outcome measures of the interventions make it harder to do a meta-analytic synthesis. Additionally, limited research incorporates long-term follow-up evaluations, complicating the assessment of whether noted enhancements in emotion regulation endure beyond a few months following intervention. [5] specifically pointed out how few multi-wave designs there are that follow neurocognitive and emotional changes over time. Consequently, forthcoming research should emphasize extensive, longitudinal studies utilizing standardized mindfulness protocols and multimodal assessment techniques to strengthen the evidence base.

The implications of these findings are significant in clinical and educational contexts. In clinical environments, mindfulness-based interventions (MBIs) may function as efficacious adjunctive therapies for adolescents exhibiting anxiety, depression, or trauma-related symptoms, capitalizing on their ability to regulate affective reactivity without the adverse effects associated with pharmacological treatments. In educational settings, incorporating mindfulness into daily routines can enhance focus, emotional equilibrium, and interpersonal empathy, fostering more conducive learning environments [9]. Furthermore, incorporating mindfulness principles into teacher training programs may improve educators' emotional regulation and mitigate burnout, thereby indirectly promoting student well-being.

Future Directions

Mindfulness research has advanced significantly, yet three distinct priorities emerge for the progression of the field: (1) the necessity for larger, prolonged, and more rigorously controlled longitudinal randomized trials to ascertain durability and causal pathways; (2) the imperative for meticulous development and assessment of digital/app-based mindfulness interventions tailored for adolescent engagement; and (3) the incorporation of multimodal neuroimaging biomarkers to correlate behavioral modifications with neural mechanisms and to determine the most effective interventions for specific populations. Recent protocol papers and cohort designs that explicitly integrate neuroimaging, biological, and multi-wave clinical measures to detect sustained effects and developmental change underscore the necessity for longitudinal and randomized controlled studies. For instance, the Mindfulteen cohort with a nested randomized trial is structured to evaluate neural, endocrine, and psychological outcomes over 18 months, highlighting the feasibility and significance of long-range, mechanistic designs in adolescents [20]. Earlier systematic reviews have also pointed out that while short, face-to-face MBIs have small to moderate immediate effects, there aren't enough well-designed trials with long-term follow-up to see if the effects last or if benefits show up later [21, 22]. Consequently, subsequent research must incorporate adequately extended follow-up periods (≥ 12 months), clearly defined primary endpoints for the durability of emotion regulation, and utilize intention-to-treat and multi-site methodologies to enhance external validity and generalizability [24].

Digital and app-based MBIs, like traditional trials, show promise for scalable delivery to adolescents, but they need to be carefully optimized based on theory. Meta-analytic evidence and randomized trials demonstrate that internet and mobile mindfulness programs yield small to moderate effects on stress and associated outcomes, with guidance (human support) frequently influencing effect size and adherence [25]. The behavioral intervention technology framework offers pragmatic design principles that connect clinical objectives to technological attributes and engagement tactics necessary for adapting MBIs into applications for adolescents [21]. Efforts to enhance user engagement with mental health applications underscore the importance of retention, personalization, and ethical transparency in achieving significant impact [22]. Consequently, forthcoming research should integrate stringent randomized methodologies with user-centered engineering, encompassing adaptive dosing, push-notification techniques that honor adolescent routines, A/B testing for engagement elements, and reporting criteria that incorporate adherence metrics, privacy protections, and potential conflicts of interest.

Another important goal is to include neuroimaging biomarkers and multimodal biological measures in adolescent MBI trials to help us understand how and why changes happen. Meta-analytic neuroimaging syntheses demonstrate that meditation and mindfulness practices consistently engage attention, interoceptive, and fronto-limbic networks [23]. Additionally, narrative reviews elucidate how training may modify large-scale network interactions pertinent to emotion regulation [24]. Incorporating pre-registered neuroimaging endpoints (task-based and resting-state fMRI), structural and diffusion metrics, and peripheral biomarkers (e.g., hair cortisol, inflammatory markers) into randomized controlled trials (RCTs) will elucidate whether behavioral enhancements in emotion regulation correspond to enduring neural plasticity or ephemeral state alterations, and whether baseline neural

profiles can predict treatment efficacy [25, 26].

These biomarker studies must establish predefined analytical pipelines and adjust for multiple comparisons to prevent the small-sample, exploratory challenges that have complicated initial neuroimaging research.

For the integration of MBLs into educational curricula and adolescent therapeutic frameworks, more robust evidence is required to substantiate their inclusion. Current school-based evaluations demonstrate encouraging yet diverse impacts on cognition, stress resilience, and emotional functioning [20]; however, inconsistencies in program content, instructor training, and dosage impede widespread endorsement. Subsequent implementation studies ought to employ hybrid effectiveness-implementation designs that evaluate both student outcomes and implementation metrics (fidelity, feasibility, cost), while also comparing teacher-delivered and specialist-delivered formats to identify scalable models for varied school systems [21].



Figure 6. Framework showing current research gaps and proposed future directions
Source: [26]

Conclusion

The present synthesis concludes that mindfulness-based interventions are effective and developmentally appropriate strategies for enhancing emotion regulation in adolescents. Evidence consistently shows that structured mindfulness practice, whether delivered through school curricula, clinical programs, or hybrid models, produces measurable improvements in emotional awareness, stress tolerance, and adaptive cognitive reappraisal. These gains are reinforced by neurocognitive findings that highlight strengthened prefrontal regulatory control and reduced amygdala reactivity, mechanisms that align with theoretical models of self-regulation and adolescent brain maturation. Collectively, the evidence affirms that mindfulness not only mitigates existing psychological distress but also cultivates foundational regulatory skills that support lifelong mental health.

From a preventive perspective, integrating mindfulness into adolescent education and community health frameworks holds substantial promise. Early acquisition of mindful attention, emotional awareness, and non-reactivity may buffer against future mood and anxiety disorders, promote resilience under academic and social stress, and enhance interpersonal empathy.

The AVEM subgroup findings further illustrate this variability in outcomes: while the majority of adolescents remained stable (“equal”), a meaningful subset achieved measurable gains in resilience, life satisfaction, and social support (“enhanced”), whereas a smaller group showed declines in coping and increases in emotional exhaustion (“worsened”). This distribution underscores the importance of tailoring interventions, ensuring adequate engagement, and providing follow-up support for those at risk of deterioration. Large-scale implementation of standardized, evidence-based programs combined with rigorous trials and integration into public-health and educational policy can help normalize emotional regulation training as a core component of youth development, while also accounting for individual differences in response.

Acknowledgement

We thank all the researchers who contributed to the success of this research work.

Conflict of Interest

The authors declared that there are no conflicts of interest.

Funding

No funding was received for this research work.

References

- Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice*, 10(2), 125–143.
- Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, 13(1), 27–45.
- Blakemore, S. J. (2019). Adolescence and mental health. *The Lancet*, 393(10185), 2030–2031.
- Carsley, D., Khoury, B., & Heath, N. L. (2018). Effectiveness of mindfulness interventions for mental health in schools: *Mindfulness*, 9(3), 693–707.
- Dennis, T. A., & Chen, C. C. (2007). Neurophysiological mechanisms in the emotional regulation of children: Implications for developmental psychopathology. *Development and Psychopathology*, 19(1), 187–210.
- Dunning, D. L., Griffiths, K., Kuyken, W., Crane, C., Foulkes, L., Parker, J., & Dalgleish, T. (2019). Research review: The effects of mindfulness-based interventions on cognition and mental health in children and adolescents a meta-analysis of randomized controlled trials. *Journal of Child Psychology and Psychiatry*, 60(3), 244–258. <https://doi.org/10.1111/jcpp.12980>
- Farb, N. A. S., Segal, Z. V., & Anderson, A. K. (2012). Mindfulness meditation training alters cortical representations of interoceptive attention. *Social Cognitive and Affective Neuroscience*, 8(1), 15–26.
- Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, 2(3), 271–299.
- Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, 26(1), 1–26.
- Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (Eds.). (2022). *Cochrane handbook for systematic reviews of interventions* (version 6.3). Wiley-Blackwell.
- Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, 6(6), 537–559.

12. Joanna Briggs Institute (JBI). <https://doi.org/10.46658/JBIMES-20-04>. Uman, L. S. (2011). Systematic reviews and meta-analyses. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 20(1), 57–59. <https://pubmed.ncbi.nlm.nih.gov/21286370/>
13. Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life*. Hyperion.
14. Mendola, E., Meuleman, B., Smith, M. M., et al. (2026). Mindfulness shapes emotion regulation in non-clinical adolescents: Secondary outcomes of a randomized controlled trial. *Clinical Child Psychology and Psychiatry*, 31(1), 195–211.
15. Kazdin, A. E., & Rabbitt, S. M. (2013). Novel models for delivering mental health services and reducing the burdens of mental illness. *Clinical Psychological Science*, 1(2), 170–191. <https://doi.org/10.1177/2167702612463566>
16. Mendola, E., Meuleman, B., Smith, M. M., et al. (2026). Mindfulness shapes emotion regulation in non-clinical adolescents: Secondary outcomes of a randomized controlled trial. *Clinical Child Psychology and Psychiatry*, 31(1), 195–211. <https://pubmed.ncbi.nlm.nih.gov/40991425/>
17. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
18. O'Driscoll, M., Byrne, M., McGillicuddy, A., Lambert, S., & Sahn, L. (2021). The effects of mindfulness-based interventions on adolescent emotional and behavioral functioning: A systematic review. *Children and Youth Services Review*, 121, 105873. <https://doi.org/10.1016/j.childyouth.2020.105873>
19. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
20. Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., et al. (2006). *Guidance on the conduct of narrative synthesis in systematic reviews*. ESRC Methods Programme.
21. Racine, N., McArthur, B. A., Cooke, J. E., Eirich, R., Zhu, J., & Madigan, S. (2021). Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: A meta-analysis. *JAMA Pediatrics*, 175(11), 1142–1150. <https://doi.org/10.1001/jamapediatrics.2021.2482>
22. Segal, Z. V., Williams, J. M. G., & Teasdale, J. D. (2018). *Mindfulness-based cognitive therapy for depression* (2nd ed.). Guilford Press.
23. Sharma, N., Agrawal, M., & Rai, D. (2025). Mindfulness-based interventions for emotional dysregulation in adolescents: A systematic review. *Frontiers in Psychology*, 16, 124568. <https://pmc.ncbi.nlm.nih.gov/articles/PMC12276209/>
24. Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, 16(4), 213–225.
25. Tufanaru, C., Munn, Z., Aromataris, E., Campbell, J., & Hopp, L. (2020). Chapter 3: Systematic reviews of effectiveness. In E. Aromataris & Z. Munn (Eds.), *JBI manual for evidence synthesis*.
26. Zoogman, S., Goldberg, S. B., Hoyt, W. T., & Miller, L. (2015). Mindfulness interventions with youth: A meta-analysis. *Mindfulness*, 6(2), 290–302. <https://doi.org/10.1007/s12671-013-0260-4>