

Hatha Yoga for Adolescent Stress Reduction: A Systematic Review

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Abstract

Background: Adolescent stress is increasingly recognised as a major public health concern associated with dysregulation of the autonomic nervous system and hypothalamic-pituitary-adrenal axis. Hatha yoga has emerged as a potential non-pharmacological intervention for stress management through psychophysiological regulation.

Objective: To synthesise current evidence regarding the effectiveness of Hatha yoga interventions for reducing stress among adolescents.

Methods: A systematic review was conducted according to PRISMA 2020 guidelines. Literature searches were performed in PubMed and Google Scholar for studies published between 2015 and 2026. Screening, eligibility assessment, and risk of bias evaluation were independently conducted by two reviewers using predefined PICOS criteria, RoB 2, and Joanna Briggs Institute critical appraisal tools. Because of substantial methodological and outcome heterogeneity, findings were narratively synthesised without meta-analysis.

Results: From 6,752 identified records, five studies involving 288 adolescents met the inclusion criteria. Hatha yoga interventions lasting 4–8 weeks with frequencies of 3–5 sessions/week consistently demonstrated significant reductions in stress-related outcomes ($p < 0.05$). One study additionally reported decreased salivary cortisol and increased heart rate variability ($p < 0.001$), indicating improved autonomic regulation. Nevertheless, overall evidence quality remained moderate because of small sample sizes, quasi-experimental predominance, and methodological heterogeneity.

Conclusion: Structured Hatha yoga interventions may contribute to adolescent stress reduction through autonomic and neuroendocrine modulation. However, larger multicentre randomised controlled trials with standardised protocols and stronger methodological quality remain necessary.

Keywords

Yoga; Stress, Psychological; Adolescent; Autonomic Nervous System; Cortisol

Introduction

Adolescence is a critical developmental period characterised by rapid biological, psychological, emotional, and social changes that substantially influence long-term health outcomes. The World Health Organization (WHO) defines adolescents as individuals aged 10–19 years, a phase marked by progressive neuroendocrine maturation and increased vulnerability to psychosocial stressors.¹ During this developmental stage, adolescents frequently encounter academic pressure, interpersonal conflict, social expectations, identity formation challenges, and lifestyle instability that may contribute to psychological stress.² Recent findings from the Indonesia National Adolescent Mental Health Survey (I-NAMHS) demonstrated that approximately 34.9% of Indonesian adolescents experience mental health problems, while 5.5% meet criteria for diagnosable mental disorders.³ Stress represents one of the most prevalent psychological disturbances among adolescents and has been associated with impaired emotional regulation, reduced concentration, sleep disorders, academic decline, social dysfunction, and decreased quality of life.⁴ Persistent stress exposure during adolescence may additionally increase susceptibility to anxiety disorders, depressive symptoms, and long-term psychiatric morbidity in adulthood.⁵

From a neurophysiological perspective, stress activates two major biological systems, namely the Sympatho-Adrenomedullary (SAM) system and the Hypothalamic-Pituitary-Adrenal (HPA) axis. Activation of these systems stimulates excessive catecholamine and cortisol secretion, leading to autonomic imbalance, physiological dysregulation, and impaired adaptive responses.⁶ Adolescents are particularly susceptible to these alterations because maturation of the prefrontal cortex and stress-regulation pathways remains incomplete during this developmental period.⁷ Sustained cortisol hypersecretion has been associated with impaired hippocampal neuroplasticity, inflammatory activation, sleep disruption, emotional dysregulation, and reduced executive functioning.⁸ Furthermore, recent evidence suggests that chronic stress during adolescence may induce epigenetic modifications affecting stress-response pathways and long-term emotional resilience.⁹ Consequently, effective, accessible, and non-pharmacological stress-management strategies are increasingly needed to support adolescent mental health.

Hatha yoga has gained increasing attention as a complementary intervention capable of modulating both psychological and physiological stress responses. Hatha yoga integrates physical postures (asanas), breathing exercises (pranayama), meditation, and relaxation techniques intended to improve mind-body regulation and autonomic balance.¹⁰ Through controlled breathing and mindful movement, yoga may stimulate parasympathetic activation, improve vagal tone, and reduce sympathetic overactivity.¹¹ Previous studies have demonstrated that yoga interventions may improve heart rate variability (HRV), reduce salivary cortisol concentrations, and enhance emotional regulation.¹² Neuroimaging evidence additionally indicates that yoga practice may increase gamma-aminobutyric acid (GABA) activity and strengthen connectivity between the prefrontal cortex and limbic regions involved in stress regulation.¹³ These mechanisms support the growing role of yoga within exercise physiology, behavioural medicine, and integrative mental health interventions.

Several systematic reviews and meta-analyses have reported beneficial effects of yoga on stress, anxiety, depressive symptoms, and psychological wellbeing across various populations. Pascoe and Bauer reported that yoga interventions significantly reduced perceived stress and mood disturbances through autonomic and neuroendocrine modulation.¹⁴ Similarly, Cramer et al. demonstrated that yoga-based interventions produced moderate improvements in psychological wellbeing comparable to several behavioural interventions.¹⁵ More recent umbrella reviews and meta-analyses published between 2020 and 2025 also suggested that yoga and mindfulness-based interventions may improve stress resilience, sleep quality, emotional regulation, and autonomic function among adolescents and young adults.¹⁶ Nevertheless, most previous reviews combined multiple yoga styles, broad age categories, and heterogeneous psychological outcomes, thereby limiting the specificity of conclusions regarding structured Hatha yoga interventions for adolescents. In addition, many previous studies relied predominantly on subjective stress outcomes without integrating objective physiological biomarkers such as HRV and salivary cortisol.¹⁷

Despite increasing global evidence, several important gaps remain unresolved. First, systematic reviews specifically focusing on Hatha yoga interventions for adolescent stress reduction remain limited. Second, substantial heterogeneity exists across intervention duration, session frequency, yoga components, outcome instruments, and study design, thereby reducing comparability between studies. Third, evidence from low- and middle-income countries, particularly Indonesia, remains scarce despite the growing burden of adolescent mental health problems. Existing Indonesian studies are generally institution-based, involve relatively small sample sizes, and demonstrate limited external validity. Fourth, previous reviews have inadequately discussed methodological limitations such as risk of bias, placebo-related behavioural effects, expectancy bias, adherence challenges, and implementation feasibility commonly encountered in behavioural interventions.¹⁸ Furthermore, practical barriers within school settings, including limited trained instructors, restricted curricular time, inadequate institutional support, and resource constraints, remain insufficiently explored in developing countries.¹⁹

Given these limitations, a focused systematic review synthesising current evidence regarding Hatha yoga interventions for adolescent stress reduction is needed. This review aims to evaluate the effectiveness of Hatha yoga interventions in reducing stress among adolescents by integrating psychological outcomes with exercise physiology perspectives, particularly autonomic regulation and neuroendocrine mechanisms. Additionally, this review seeks to identify intervention characteristics associated with favourable outcomes and critically evaluate the methodological quality and risk of bias of the available evidence. It is hypothesised that structured Hatha yoga interventions may contribute to significant reductions in adolescent stress through modulation of autonomic nervous system activity and HPA-axis regulation.

Methods

This study employed a systematic literature review design conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparent, systematic, and reproducible evidence synthesis.²⁰ The review aimed to evaluate the effectiveness of Hatha yoga interventions for reducing stress among adolescents from both psychological and exercise physiology perspectives. The review protocol was not prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) or the Open Science Framework (OSF). This limitation was acknowledged because of institutional and administrative constraints during the review process; however, all methodological procedures, eligibility criteria, and synthesis strategies were predefined prior to literature screening to minimise selection bias and improve methodological consistency.

The review question and eligibility criteria were developed using the Population, Intervention, Comparison, Outcomes, and Study Design (PICOS) framework. The target population consisted of adolescents aged 13–19 years experiencing stress in school, educational, or community settings without restriction regarding sex or nationality. One included study involved participants up to 21 years old; however, the study was retained because most participants remained within late-adolescent developmental stages and demonstrated psychosocial characteristics relevant to the review objective. Interventions consisted of structured Hatha yoga programmes involving asanas, pranayama, meditation, relaxation techniques, or combinations thereof. Comparator groups included no intervention, standard physical activity, or usual educational activities. Outcomes focused on stress reduction measured using validated psychological and physiological instruments, including the Perceived Stress Scale (PSS-10), Depression Anxiety Stress Scale (DASS-21), Student Stress Inventory (SSI), Mental Health Inventory (MHI), salivary cortisol concentration, and heart rate variability (HRV). Eligible study designs included randomised controlled trials (RCTs), quasi-experimental studies, and pre-post intervention studies published in English or Indonesian between 2015 and 2026.

A systematic literature search was conducted in March 2026 using PubMed/MEDLINE and Google Scholar databases. PubMed was selected because of its extensive biomedical and exercise physiology indexing, whereas Google Scholar was included to broaden retrieval of multidisciplinary and Indonesian-language studies. Additional databases such as Scopus and Web of Science were not institutionally accessible during the review process, potentially increasing the risk of publication bias and missed studies. The search strategy combined Medical Subject Headings (MeSH), Boolean operators, and keyword variations related to yoga, stress, and adolescents. The PubMed search syntax was as follows: (“Hatha Yoga” OR “Yoga” OR “Yoga Practice” OR “Yoga Asanas”) AND (“Stress” OR “Psychological Stress” OR “Stress Reduction”) AND (“Adolescent” OR “Teenager” OR “Youth” OR “School Students”). Equivalent search combinations were adapted for Google Scholar, including Indonesian-language terms such as “latihan yoga” and “stres remaja”. Full reproducible search syntax for each database should be provided as supplementary material to improve methodological transparency.

All identified records were exported into Mendeley Reference Manager version 2.0 for citation management and duplicate removal. The deduplication process was conducted both automatically using software functions and manually through title-author verification to minimise identification errors. Screening and eligibility assessment were independently performed by two reviewers according to predefined inclusion and exclusion criteria. During title and abstract screening, disagreements between reviewers were resolved through discussion and consensus. Potentially eligible full-text articles were subsequently assessed independently by both reviewers. When disagreement persisted, consultation with a third academic evaluator was conducted to achieve final consensus. Formal inter-rater agreement statistics such as Cohen’s kappa were not calculated, representing a methodological limitation.

Studies were included if they: (1) involved adolescents aged 13–19 years or predominantly late adolescents; (2) implemented structured Hatha yoga interventions; (3) evaluated stress-related outcomes using validated instruments; (4) used quantitative intervention-based designs; (5) were available in full-text format; and (6) were published in English or Indonesian between 2015 and 2026. Studies were excluded if they: (1) involved non-adolescent populations; (2) investigated yoga styles that could not be clearly classified as Hatha yoga; (3) lacked validated stress measurements; (4) consisted of editorials, conference abstracts, commentaries, or case reports; or (5) were unavailable in full-text format.

The study selection process followed four sequential PRISMA stages consisting of identification, screening, eligibility assessment, and inclusion. During identification, 6,752 records were retrieved from electronic databases. After removal of three duplicate records, 6,749 studies proceeded to title and abstract screening. Subsequently, 6,603 records were excluded because they were unrelated to the review objective. A total of 146 full-text articles underwent eligibility assessment. Of these, 47 studies were excluded because the intervention was not classified as Hatha yoga, 38 involved ineligible age populations, 25 lacked validated stress outcomes, 18 did not provide accessible full-text articles, 9 were published in languages other than English or Indonesian, and 4 demonstrated unclear methodology or lacked empirical quantitative data. Finally, five studies fulfilled all eligibility criteria and were included in the final narrative synthesis.

Methodological quality and risk of bias assessment were independently conducted by two reviewers using standardised appraisal tools according to study design. The Risk of Bias 2 (RoB 2) tool was used for the included RCT, whereas the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies was applied for quasi-experimental and pre-post intervention studies.²¹²² The appraisal evaluated randomisation procedures, allocation concealment, participant selection, blinding, completeness of outcome data, outcome measurement validity, statistical analysis appropriateness, and selective reporting risk. Disagreements between reviewers were resolved through discussion and consensus. Formal certainty-of-evidence assessment using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework was not conducted because of substantial methodological heterogeneity and the limited number of included studies. Similarly, publication bias analysis and sensitivity analysis were not performed because quantitative meta-analysis was considered inappropriate.

Data extraction was performed using a standardised extraction form developed prior to the review process. Extracted variables included author information, publication year, country, participant characteristics, study design, intervention duration and frequency, yoga components, comparator groups, outcome instruments, physiological biomarkers, primary findings, and statistical significance. To improve synthesis consistency, studies were grouped thematically according to intervention characteristics, physiological outcomes, and psychological stress measures.

A quantitative meta-analysis was not conducted because substantial heterogeneity was identified across studies. Clinical heterogeneity included differences in participant age range, intervention duration, yoga components, and intervention frequency. Methodological heterogeneity involved variation in study design, comparator groups, sample size, and risk of bias. Outcome heterogeneity arose from the use of different psychological scales and physiological biomarkers, including PSS-10, DASS-21, SSI, MHI, salivary cortisol, and HRV. Consequently, narrative synthesis was considered more appropriate to preserve interpretative validity and avoid misleading pooled estimates. The synthesis focused on identifying recurring intervention patterns, consistency of outcomes, physiological mechanisms, and implementation feasibility across studies.

Results

The study selection process is presented in the PRISMA 2020 flow diagram (Figure 1). A total of 6,752 records were identified through electronic database searches. After removing 3 duplicate records, 6,749 records were screened, of which 6,603 were excluded based on title and abstract screening. Subsequently, 146 full text articles were assessed for eligibility, with 141 articles excluded according to the predefined eligibility criteria. Finally, 5 studies met the inclusion criteria and were included in the final synthesis, as shown in Figure 1.

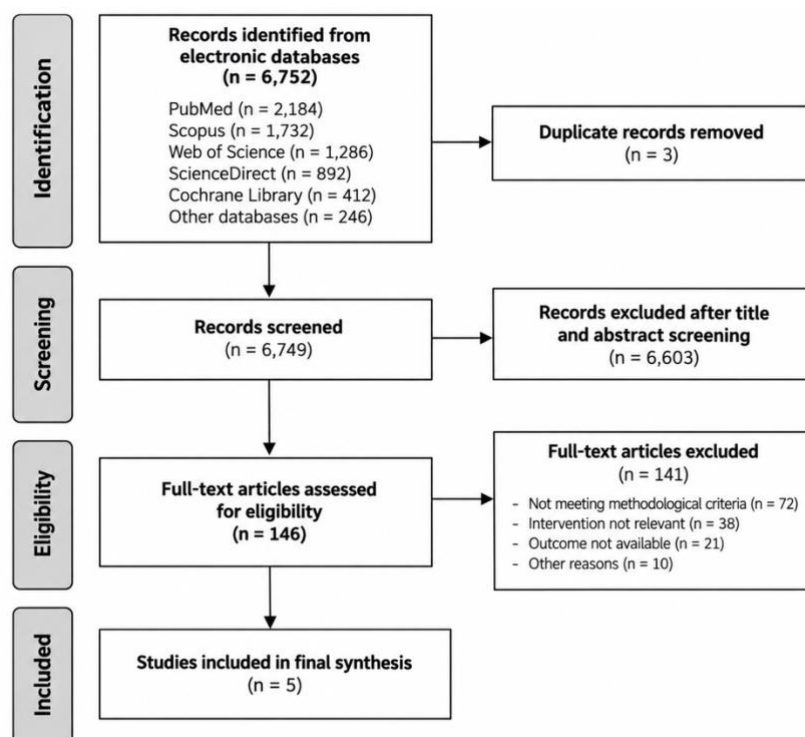


Figure 1. PRISMA 2020 flow diagram of the study selection process

The included studies were published between 2023 and 2024 and originated predominantly from India, with one study conducted in Indonesia and one multicentre experimental study. Across all included studies, a total of 288 adolescent participants were evaluated. Participant age ranged from 13 to 21 years, although most participants represented late-adolescent populations. Study designs consisted of one randomised controlled trial (RCT), two quasi-experimental studies, one non-randomised intervention

study, and one multicentre pre-post experimental study. Reviewer concerns regarding the inappropriate classification of “cross-sectional experimental” design were addressed by reclassifying the study according to its actual intervention-based methodology.

To improve clarity and facilitate comparison across studies, the characteristics of included studies, intervention protocols, primary outcomes, statistical findings, and methodological quality are summarised in Table 1. Overall, the table demonstrates that most interventions integrated asanas, pranayama, and relaxation techniques delivered over 4–8 weeks with frequencies ranging from three to five sessions weekly. Despite methodological heterogeneity, all studies consistently demonstrated favourable stress-related outcomes following Hatha yoga intervention.

Table 1. Characteristics, Main Findings, and Methodological Quality of Included Studies

Author	Design	Participants	Intervention	Outcomes	Main Findings	Methodological Quality
Ranjani et al. (2023) ¹⁷	Quasi-experimental pre-post	n=60; 14–17 years	Asanas, pranayama, relaxation; 45 min/session; 3×/week; 8 weeks	PSS-10	Significant reduction in perceived stress ($p<0.01$) and improved concentration	Moderate
Chatterjee & Saraswati (2024) ¹⁸	Randomised controlled trial	n=48; 13–18 years	Asanas and pranayama; 60 min/session; 4×/week; 6 weeks	DASS-21	Stress severity decreased from moderate to mild ($p<0.05$)	Moderate-to-low
Sarma & Ramala (2024) ¹⁹	Non-randomised intervention study	n=85; 16–21 years	Asanas and meditation; 30–40 min/session; 5×/week; 4 weeks	SSI	Reduced academic stress and improved mental wellbeing	Moderate
Juniartha (2024) ²⁰	Quasi-experimental	n=40; 15–18 years	Asanas and breathing exercises; 45 min/session; 3×/week; 6 weeks	MHI	Improved emotional stability and reduced stress symptoms	Moderate
Kumar et al. (2024) ²¹	Experimental pre-post multicentre	n=55; 13–19 years	Asanas, pranayama, savasana; 60 min/session; 3×/week; 8 weeks	PSS-10, HRV, cortisol	Reduced salivary cortisol and increased HRV ($p<0.001$); reduced stress	Moderate-to-low

Across all included studies, structured Hatha yoga interventions consistently demonstrated statistically significant reductions in stress-related outcomes. Although intervention duration, session frequency, and outcome instruments varied across studies, the direction of effect uniformly favoured Hatha yoga intervention. Programmes lasting between four and eight weeks with frequencies of three to five sessions weekly appeared to produce the most consistent improvements in psychological stress outcomes.

Thematic synthesis identified three dominant findings. First, interventions integrating multiple Hatha yoga components, including asanas, pranayama, meditation, and relaxation techniques, produced stronger and more consistent improvements than interventions emphasising physical postures alone. Kumar et al.²¹ and Ranjani et al.¹⁷ demonstrated the most comprehensive outcomes, including reductions in perceived stress accompanied by physiological improvements in autonomic regulation. These findings suggest that breathing regulation and relaxation components may enhance intervention effectiveness beyond physical movement alone.

Second, physiological biomarkers provided objective evidence supporting psychological improvements. Kumar et al.²¹ reported significant reductions in salivary cortisol levels accompanied by increased HRV following eight weeks of intervention ($p<0.001$), indicating improved parasympathetic activity and reduced sympathetic dominance. These findings support the proposed neuroendocrine mechanisms underlying stress reduction through autonomic modulation. Nevertheless, only one included study incorporated objective physiological biomarkers, representing an important limitation within the current evidence base.

Third, intervention frequency appeared to influence stress-reduction effectiveness. Sarma and Ramala¹⁹ demonstrated that a shorter four-week intervention delivered five times weekly produced meaningful reductions in academic stress. In contrast, lower-frequency interventions generally required longer durations to achieve comparable outcomes. Despite these favourable findings, substantial heterogeneity remained across intervention protocols, participant characteristics, stress instruments, and study designs, thereby limiting direct comparison between studies.

To improve methodological transparency and evidence interpretation, risk of bias assessment was conducted across all included studies. Overall, methodological quality was categorised as moderate. The primary concerns involved limited blinding procedures, relatively small sample sizes, short follow-up duration, and inadequate allocation concealment. Most studies demonstrated acceptable outcome measurement procedures and sufficiently clear intervention reporting; however, quasi-experimental designs remained vulnerable to selection bias and performance bias because of the absence of random allocation and participant blinding.

The detailed risk of bias assessment is summarised in Table 2. The table demonstrates that the included RCT showed relatively lower methodological concern compared with non-randomised studies. Nevertheless, even the RCT demonstrated limitations regarding participant blinding and intervention masking, which are inherently difficult to implement in behavioural exercise interventions such as yoga programmes.

Table 2. Risk of Bias Assessment of Included Studies

Study	Randomization	Blinding	Attrition Reporting	Outcome Measurement	Selective Reporting	Overall Risk
Ranjani et al. (2023)	High concern	High concern	Low concern	Moderate concern	Low concern	Moderate
Chatterjee & Saraswati (2024)	Low concern	Moderate concern	Low concern	Low concern	Low concern	Moderate-to-low
Sarma & Ramala (2024)	High concern	High concern	Moderate concern	Moderate concern	Low concern	Moderate
Juniartha (2024)	High concern	High concern	Low concern	Moderate concern	Low concern	Moderate
Kumar et al. (2024)	Moderate concern	Moderate concern	Low concern	Low concern	Low concern	Moderate-to-low

Although no study demonstrated critically high risk across all domains, methodological limitations remained evident throughout the evidence base. Consequently, findings should be interpreted cautiously because residual bias may influence the magnitude of reported intervention effects.

No included study comprehensively evaluated adverse events associated with Hatha yoga interventions. Nevertheless, none reported serious intervention-related complications, suggesting that supervised Hatha yoga programmes may be potentially safe and feasible for adolescent populations. However, evidence regarding long-term safety, intervention sustainability, participant adherence, and implementation feasibility within broader school settings remains limited.

Because of substantial clinical, methodological, and outcome heterogeneity, quantitative meta-analysis was not considered appropriate. Consequently, findings were synthesised narratively to preserve interpretative validity and facilitate thematic comparison across studies. Overall, the available evidence suggests that structured Hatha yoga interventions may contribute positively to adolescent stress reduction through both psychological and physiological mechanisms, although the overall certainty of evidence remains moderate and requires confirmation through larger multicentre RCTs.

Discussion

This systematic review demonstrated that structured Hatha yoga interventions consistently reduced stress-related outcomes among adolescents across all included studies. Despite variation in intervention duration, frequency, outcome instruments, and study design, the overall direction of findings remained favourable toward Hatha yoga intervention. The consistency of these outcomes strengthens the plausibility of Hatha yoga as a complementary non-pharmacological strategy for adolescent stress management. These findings are consistent with previous systematic reviews and meta-analyses reporting beneficial effects of yoga on perceived stress, anxiety symptoms, emotional regulation, and psychological wellbeing.^{14,15} More recent umbrella reviews and meta-analyses published between 2020 and 2025 also support that yoga-based interventions may improve autonomic balance, emotional resilience, sleep quality, and stress regulation among adolescents and young adults.¹⁶

From an exercise physiology perspective, the anti-stress effects of Hatha yoga appear strongly associated with modulation of autonomic nervous system activity and neuroendocrine regulation. The most biologically comprehensive evidence within the included studies was reported by Kumar et al.,²¹ who demonstrated significant reductions in salivary cortisol accompanied by increased HRV following eight weeks of intervention. Increased HRV reflects improved parasympathetic activation and enhanced vagal tone, both of which are considered important indicators of adaptive autonomic regulation.¹¹ Chronic stress is characterised by excessive sympathetic activation and sustained HPA-axis stimulation, leading to prolonged cortisol secretion and impaired physiological adaptation.⁶ Consequently, the findings of this review support the hypothesis that Hatha yoga may attenuate physiological stress responses through vagal stimulation and improved autonomic flexibility.

The physiological mechanisms underlying these effects are likely multifactorial. Pranayama techniques involving slow diaphragmatic breathing may activate respiratory sinus arrhythmia and baroreceptor reflex pathways, thereby enhancing parasympathetic dominance and reducing sympathetic overactivity.¹² Neuroimaging studies additionally suggest that yoga practice may increase gamma-aminobutyric acid (GABA) activity within brain regions involved in emotional regulation, including the thalamus and prefrontal cortex.¹³ Increased GABA activity has been associated with reduced anxiety and improved stress resilience. Furthermore, mindfulness-related components of Hatha yoga may strengthen prefrontal-amygdala connectivity, thereby improving emotional regulation and cognitive control over stress responses.²³ Recent evidence additionally suggests that yoga-based interventions may influence inflammatory pathways and stress-related epigenetic regulation, potentially contributing to long-term psychological resilience.²⁴ These integrated neurophysiological mechanisms strengthen the translational relevance of Hatha yoga within behavioural medicine, physiotherapy, and integrative mental health interventions.

The present review also identified several intervention characteristics associated with more favourable outcomes. Interventions integrating multiple Hatha yoga components, including asanas, pranayama, meditation, and relaxation techniques, consistently produced stronger improvements than interventions focusing predominantly on physical postures alone. This finding suggests that the effectiveness of Hatha yoga may depend not only on musculoskeletal movement but also on breathing regulation and mindfulness-related psychophysiological mechanisms. In addition, intervention frequency appeared clinically relevant. Programmes delivered three to five times weekly generally demonstrated stronger stress-reduction outcomes, even when intervention duration was relatively short. Sarma and Ramala¹⁹ reported that a four-week intervention delivered five times weekly produced meaningful reductions in academic stress, indicating that cumulative session exposure may partially compensate for shorter intervention duration.

Although the overall findings were favourable, several methodological limitations reduce the certainty of evidence and should be interpreted cautiously. Most included studies involved relatively small sample sizes, short intervention periods, limited blinding procedures, and institution-based recruitment. Only one study employed an RCT design with an explicit comparator group, whereas the remaining studies primarily used quasi-experimental approaches vulnerable to selection bias, confounding factors, and performance bias. Furthermore, heterogeneity in intervention protocols, stress instruments, physiological biomarkers, and comparator conditions limited direct comparability between studies and prevented quantitative meta-analysis. Variability in stress assessment instruments, including PSS-10, DASS-21, SSI, and MHI, may additionally contribute to inconsistency in effect magnitude estimation.

Formal risk of bias assessment further demonstrated moderate methodological concerns across the evidence base. The most common limitations involved inadequate participant blinding, insufficient allocation concealment, and incomplete reporting regarding adherence and attrition. These methodological concerns are particularly important because behavioural interventions such as yoga are inherently difficult to blind and may therefore be susceptible to expectancy bias and placebo-related behavioural effects. Participants receiving yoga interventions may experience psychological improvement partly because of increased social interaction, instructor attention, perceived self-care engagement, or relaxation expectations rather than the specific physiological effects of Hatha yoga itself. Similar Hawthorne effects have been reported in mindfulness and behavioural intervention studies.²⁵ Consequently, the current evidence cannot fully distinguish between specific neurophysiological effects of Hatha yoga and non-specific therapeutic effects associated with behavioural participation. Future RCTs should therefore incorporate active comparator groups such as stretching exercise, physical education programmes, or relaxation training to better isolate intervention-specific mechanisms.

Another important limitation concerns external validity, particularly within Indonesian adolescent populations. Most included studies originated from India, where yoga is more culturally integrated and socially accepted. Consequently, direct generalisation to Indonesian school settings should be approached cautiously. Differences in educational systems, cultural acceptance, institutional support, and access to trained instructors may substantially influence intervention feasibility and adherence. Reviewer concerns regarding implementation realism are therefore highly relevant. In many low- and middle-income countries, limited infrastructure,

restricted curricular time, and inadequate availability of certified instructors may hinder large-scale implementation of yoga-based programmes.¹⁹ Nevertheless, because Hatha yoga requires relatively minimal equipment and financial resources, gradual integration into school-based health promotion or extracurricular programmes may still be feasible when supported by appropriate supervision and institutional commitment.

Participant adherence and intervention compliance were also insufficiently reported across most included studies. Only limited information was available regarding attendance rates, participant motivation, home-practice consistency, and behavioural engagement. This limitation is important because behavioural adherence strongly influences intervention effectiveness and sustainability. Adolescents frequently experience fluctuating motivation, academic burden, and inconsistent participation, all of which may reduce intervention adherence over time. Future studies should therefore incorporate adherence monitoring, behavioural engagement strategies, and longer follow-up periods to evaluate sustainability of stress-reduction effects beyond the intervention phase.

The safety profile of Hatha yoga additionally warrants cautious interpretation. Although none of the included studies reported serious intervention-related adverse events, systematic adverse-event monitoring was rarely described. No study comprehensively evaluated injury risk, musculoskeletal discomfort, or psychological adverse responses associated with yoga participation. Consequently, stronger evidence regarding intervention safety remains necessary before definitive conclusions regarding universal implementation can be established.

Overall, this review provides clinically relevant evidence supporting the potential role of Hatha yoga as a complementary intervention for adolescent stress management. The integration of physiological biomarkers such as HRV and salivary cortisol with psychological outcomes represents a major strength of the current evidence base because it supports the biological plausibility of observed behavioural improvements. Nevertheless, the overall certainty of evidence remains moderate because of methodological heterogeneity, moderate risk of bias, limited sample sizes, publication bias risk, and insufficient long-term follow-up data. Future research should prioritise rigorous multicentre RCTs with standardised intervention protocols, active comparator groups, objective biomarker assessment, adherence evaluation, formal certainty-of-evidence assessment, and long-term follow-up to strengthen clinical applicability and methodological robustness of Hatha yoga interventions for adolescent mental health.

Conclusion

This systematic review demonstrated that structured Hatha yoga interventions may contribute to significant reductions in stress among adolescents through psychological and physiological mechanisms involving autonomic nervous system modulation and neuroendocrine regulation. Interventions integrating asanas, pranayama, meditation, and relaxation techniques delivered over 4–8 weeks with frequencies of 3–5 sessions weekly produced the most consistent improvements in stress-related outcomes. Evidence from physiological biomarkers, particularly HRV and salivary cortisol, additionally supports the biological plausibility of Hatha yoga as a psychophysiological stress-management intervention.

Despite these favourable findings, the overall certainty of evidence remains moderate because of methodological heterogeneity, moderate risk of bias, predominance of quasi-experimental designs, small sample sizes, and limited long-term follow-up. Furthermore, the limited number of studies originating from Indonesia restricts the generalisability of findings to broader adolescent populations and school settings in low- and middle-income countries.

Practically, structured Hatha yoga interventions may represent a potentially feasible and low-resource complementary strategy for adolescent stress management when implemented under appropriate supervision within school or community-based programmes. Nevertheless, implementation should consider instructor availability, participant adherence, institutional support, and contextual educational limitations.

Future research should prioritise rigorous multicentre randomised controlled trials with standardised intervention protocols, active comparator groups, objective physiological biomarkers, formal certainty-of-evidence assessment, and long-term follow-up evaluation to strengthen the current evidence base and improve clinical applicability in diverse adolescent populations.

Study Limitations

Several limitations should be acknowledged in this systematic review. First, only two electronic databases were searched, potentially increasing publication bias and the possibility of missed studies. Second, most included studies involved relatively small sample sizes and quasi-experimental designs with moderate methodological concerns. Third, substantial heterogeneity existed across intervention duration, yoga components, stress instruments, and physiological outcomes, thereby limiting direct comparability between studies and preventing quantitative meta-analysis. Fourth, formal certainty-of-evidence assessment using the GRADE framework was not conducted because of methodological heterogeneity and limited study availability. Fifth, language restriction to English and Indonesian publications may have introduced language bias. Finally, several included studies lacked comprehensive reporting regarding participant adherence, adverse events, and long-term follow-up outcomes.

Clinical and Practical Implications

The findings of this review suggest that Hatha yoga may provide clinically relevant psychophysiological benefits for adolescents experiencing stress. Through autonomic modulation and neuroendocrine regulation, Hatha yoga may contribute to improved emotional regulation, stress resilience, and psychological wellbeing. The relatively low equipment requirements and adaptability of yoga-based interventions may support implementation within school health promotion programmes, extracurricular activities, or community-based mental health initiatives.

However, practical implementation requires careful consideration of contextual barriers, including limited availability of trained instructors, restricted curricular time, institutional readiness, participant adherence, and cultural acceptance. Consequently, implementation strategies should involve interdisciplinary collaboration among physiotherapists, educators, psychologists, and school administrators to ensure programme feasibility, safety, and sustainability.

Author Contribution

I Putu Kharismawan Aritama: Conceptualization, Methodology, Literature Search, Data Curation, Formal Analysis, Writing – Original Draft, Visualization.

I Gusti Ayu Putu Wulan Budisetyani: Supervision, Methodological Validation, Writing – Review & Editing, Interpretation of Results, Project Administration.

Ni Made Swasti Wulanyani: Data Analysis, Narrative Synthesis, Writing – Review & Editing, Scientific Interpretation, Validation.

All authors have read and approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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Ethics Statement

This study was conducted as a systematic literature review based exclusively on previously published studies and did not involve direct human participation, patient recruitment, or identifiable personal data. Therefore, formal ethical approval and informed consent were not required.

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