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Role of Yoga Practices on Academic Stress with Reference to Neurophysiological Mechanisms: A Review Study

Hemant Kumar Kaushik[1], Chintaharan Betal[2], Ishan Chauhan[3]

[1]Research Scholar, Dept. Naturopathy and Yoga, HNB Garhwal A Central University, Srinagar, Uttarakhand.
[2]Assistant Professor, Dept. Naturopathy and Yoga, HNB Garhwal University (A Central University), Srinagar, Uttarakhand.
[3]Research Scholar, Dept. Naturopathy and Yoga, HNB Garhwal A Central University, Srinagar, Uttarakhand.

Corresponding Author: Dr. Chintaharan Betal

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ABSTRACT

Academic stress is now a significant challenge for students, impacting their performance, emotional regulation, cognitive functions and psychological as well as physiological well-being. Various conventional techniques like psychotherapy, counselling and Cognitive Behavioural Therapy (CBT), have been used and applied to remove the problem but no effective results have been achieved so far. Yoga, on the other hand, is recognized as a practical approach to stress management, its neurobiological mechanisms in the academic context are less explored so far. This review study investigated the effects of yoga on the brain and nervous system which have been conceived as a prime factor in reducing academic stress. Key mechanisms included the modulation of the Hypothalamic–Pituitary–Adrenal (HPA) axis, reduced cortisol secretion, increased serotonin and elevated brain-derived neurotrophic factor (BDNF), all of which support neuroplasticity, memory and cognitive flexibility, which is essential for academic success under stressful situation. The findings suggested that yoga practices such as asana, pranayama and meditation have positively influenced and thereby slowed down the mechanisms of stress. Asanas improve autonomic balance, pranayama regulates the HPA axis and meditation enhances mindfulness and thus promotes the cognitive regulation and self-control capacity of students. The study of neuroimaging, biochemical and electrophysiological studies also highlighted that yoga is an evidence-based intervention that improves stress resilience, mental efficiency and academic performance in students. Therefore, the study concluded that Yoga practices are the most potent and promising tool to alleviate academic stress.

Keywords: *Academic Stress, Yoga, Neurophysiology, HPA axis, Neuroplasticity, Biochemical*

INTRODUCTION

Academic stress is one of the most significant challenges faced by students in contemporary educational systems. Academic stress can be defined as the psychological and physiological response to academic pressures that exceed an individual's adaptive capacity. [1] Studies show that a large number of school and college students experience high levels of academic stress, with the percentage ranging from 30% to 70%, depending on their age and the type of educational setting. [2]. Chronic exposure to academic stress

adversely affects mental and physical health. Neurocognitive research shows that excessive stress impairs attention, memory, and executive functioning, while psychological studies highlight its role in increased anxiety, emotional dysregulation, and even depressive symptoms. Prolonged stress further disrupts the HPA axis, elevating cortisol levels and resulting in fatigue, sleep disturbances, and reduced academic performance [3].

Academic stress refers to the physical and mental strain that students experience when the demands of academic pressures exceed their ability to cope with them. It extends beyond exams and encompasses factors such as heavy workloads, peer and parental expectations, time management issues, procrastination, a lack of self-control, and intense competition within modern education systems [4]. The causes of academic stress are varied. Examinations and continuous assessments lead to worry, frustration, and performance pressure, while heavy workloads result in fatigue and less free time. Competition among peers and the pressure to meet societal or familial expectations intensify stress. These constant stressors create a cycle that significantly harms student well-being.

From a physiological perspective, academic stress activates the HPA axis, which leads to elevated cortisol secretion. Prolonged activation of this system disrupts homeostasis and contributes to autonomic imbalance - often characterized by heightened sympathetic activity and reduced parasympathetic regulation. This imbalance manifests as headaches, sleep disturbances, gastrointestinal discomfort and lowered immunity in students [5]. Psychologically, academic stress is strongly associated with anxiety, depression, irritability, and impaired concentration. Neurocognitive studies reveal that chronic stress compromises attention span, working memory, and executive functioning, directly impacting academic performance [6]. Furthermore, long-term exposure to stress without adequate coping mechanisms may predispose students to burnout, substance use and other maladaptive behaviours. Thus, academic stress is not merely an academic concern but a multidimensional health issue with far-reaching implications for students' cognitive, emotional and physiological development.

Many conventional techniques, such as psychotherapy, counselling and Cognitive Behavioural Therapy (CBT), have been used [7]and applied to remove the problem of academic stress, but no practical results have been achieved so far. Therefore, many intellectuals, social scientists and yoga therapists are turning their attention to spiritual practices such as asana, pranayama and meditation, which aim to refine both the mind and body. These spiritual practices are known as yoga as they unite the body, breath, mind and consciousness.

The word "Yoga" comes from the Sanskrit root "yuj," meaning "to unite" or "to join" [8]. Yoga is the union of body, mind and consciousness. It is an ancient psycho-spiritual practice that originated in India thousands of years ago. It is not just a form of physical exercise, but a deep spiritual and mental discipline aimed at achieving unity among the body, mind and soul. Recently, yoga has emerged as a holistic 'mind–body medicine' that includes (Yoga Sutra-II/29) Yama (social disciplines), Niyama (personal disciplines), Asanas (physical postures), Pranayama (breathing practices), Pratyahara (sensual control), Dharna (concentration), Dhyana (meditation) and Samadhi (absorption of consciousness in the self). Unlike conventional stress-management techniques, yoga simultaneously targets physiological arousal, emotional regulation and cognitive clarity, making it particularly relevant for students to remain free from academic stress. Its growing acceptance in clinical and educational settings is supported by evidence demonstrating reductions in stress levels, improved autonomic balance and enhanced mental well-being [9,10].

REVIEW OF LITERATURE

In Patanjali's Yoga Sutras, Yoga is defined as the cessation of the fluctuations of the mind- *"yogahcittavṛtti-nirodhaḥ/"* (YogaSutra-I/2). These fluctuations often happen due to the nine '*Antaraya*s' (obstacles*)*and five'*kleshas'(afflictions)*mentioned in the yoga sutras of Patanjali (Yoga Sutra/I/30 and II/1). Maharishi Patanjali also described the avidya (ignorance) as the source of all these fluctuations and distractions into the path of one's own journey. If these fluctuations are not alleviated, they lead to Citta-vikṣepa (mental distraction), as mentioned in Yoga Sutra(I/30), which conveys how one falls into the pit of mental disturbance, further leading to stress thathinders mental clarity and spiritual practice. These fluctuations represent an agitated and distracted state of mind.

Sage Patanjali has outlined several ways to overcome and master these *Vrittis* (thought waves), *Anataryas,* and *Kleshas*. Among these, Patanjali's Ashtanga Yoga (Sutra 2.29) provides an eight-limbed system to guide the practitioner toward mental clarity and self-realization, which obviously rectifies stress and helps one overcome mental afflictions. The eight limbs include Yama (ethical disciplines), Niyama (self-purification), Asana (postures), Pranayama (breath control), Pratyahara (withdrawal of senses), Dharana (concentration), Dhyana (meditation), and Samadhi (enlightenment). These limbs work together to purify the body, prana (vital energy), mind, and consciousness, which ultimately leads to physio-psychological well-being and spiritual awakening [11].

In the Bhagavad Gita, yoga is depicted as a comprehensive practice that promotes mental well-being, emotional balance and spiritual growth. The Bhagavad Gita presents yoga not only as a physical discipline but also as a holistic approach to achieving mental equanimity and tranquillity. It has outlined various forms of yoga, such as Karma, Bhakti and Janayoga, all of which aim to purify the mind and cultivate mental clarity and equanimity. With this reference, Verse 2.48 describes, *"samatvamyoga uchchyate," which* means that yoga is defined as the path of equanimity (mental balance), where one remains undisturbed by the pairs of opposites [12].

In the text Hatha yoga pradipika, yoga is presented as a holistic practice that involves the purification of the body and mind to achieve higher states of consciousness and spiritual realization. The text describes four means of attaining enlightenment: Asana, Kumbhaka (pranayama), Mudra, and Nadanusandhan, each offering specific techniques for advancing in the practice of yoga. These means explore various aspects of Hatha Yoga, each of which contributes to mental clarity, physical well-being, and spiritual development. The Hath yoga pradipeeka mentioned that when prana (vital energy) moves, the mind also remains unsteady, but when the movement of prana becomes still, the mind also attains the state of motionlessness. By this (steadiness of prana), the yogi attains steadiness and hence one should restrain one's breath -

"calevatecalamcittamniscaleniscalambhavet
yogi sthānutvamapnotitatovāyūmnirodhayet ||" (H.P.-II/2) [13]

In Gheranda Samhita, Savasana is mentioned as a means of removing fatigue and gives relief to the mind: - *"uttanamsavavatbhumanusayanamtusavasanam/*
savasanamsramaharamcittavisrantikarakam // (Gheranda Samhita-II/19)

Gheranda Samhita also stated that by the practice of pranayama, diseases are destroyed, sakti(energy) is awakened and the mind experiences bliss and the practitioner become happy(V/57).

In the Yoga Vasistha, the concepts of Aadhi (mental afflictions or disturbances) and Vyadhi (physical illness or disease) are discussed in relation to the human condition. The text highlights the connection between the mind and body,

emphasizing how mental disturbances can lead to physical ailments and vice versa. Yoga is presented as the remedy for Aadhi, aiming to bring both mental and spiritual peace. The text suggests that the practice of Yoga is not only for physical health but for mental and emotional healing, leading to liberation [14]. Apart from this, many other ancient texts describe Yoga as a solution to practical life problems.

Yoga is a traditional mind–body discipline that combines Asana (physical postures), Pranayama (breathing practice) and Dhyana(meditation) [9]. Each of these components plays a distinct role in stress regulation: asanas promote muscular relaxation and improve physical endurance [15], and pranayama regulates respiratory and autonomic balance [16]. At the same time, meditation enhances self-awareness and emotional stability [17]. Together, they create a comprehensive system for managing both physiological and psychological stress [18]

Besides the above-mentioned textual references, the findings of modern scientific research also support the efficacy of yoga in the management of stress, anxiety, depression and other mental sicknesses. The general benefits of yoga in stress management are widely supported by research [19]. Regular practice promotes relaxation by reducing sympathetic arousal and enhancing parasympathetic activity, thereby restoring autonomic balance [20]. Psychologically, yoga facilitates emotional regulation, improves attention and concentration, and cultivates resilience against stress-induced mood fluctuations [21]. Neurobiological evidence suggests that yoga functions as an effective stress management through its modulation of neurotransmitter systems and neurotrophic factors. Yoga practice has been associated with increased levels of gamma-aminobutyric acid (GABA), which enhances inhibitory control within neural circuits and reduces anxiety [22], as well as elevated serotonergic activity that contributes to mood stabilization and emotional resilience. Furthermore, yoga has been shown to upregulate the Brain-Derived Neurotrophic Factor (BDNF) [23], a key mediator of neuroplasticity, memory consolidation and cognitive flexibility [24]. This is particularly significant in the context of stress, as chronic activation of the HPA axis and elevated cortisol typically suppresses the expression of BDNF, impairing hippocampal and prefrontal cortical functioning [25, 26]. By counteracting these effects, yoga not only restores neurotrophic support but also promotes adaptive neural remodelling, thereby enhancing attention, working memory, and academic performance under pressure [27]. Collectively, these findings underscore the neuroprotective role of yoga in mitigating stress-related neurobiological dysfunction and fostering cognitive resilience in demanding educational environments [28].

Yoga is particularly relevant for students as they navigate the challenges of academic life. Unlike pharmacological or purely cognitive interventions, yoga offers a low-cost, non-invasive, and holistic approach that simultaneously targets body, breath, and mind. Incorporating yoga into daily routines can not only help students cope with academic pressure but also improve memory, learning efficiency and overall well-being. Educational settings that integrate yoga into their curriculum have reported better classroom behaviour, improved focus, attention and a healthier psychological climate among students [29].

Yoga practices, especially slow, diaphragmatic pranayama and meditation asanas, shift the ANS toward parasympathetic dominance [30]. This is reflected in heart rate variability (HRV) indices, e.g., higher Root Mean Square of Successive Differences (RMSSD) and high-frequency power, indicating improved vagal tone and baroreflex sensitivity [31]. Slow breathing exercises, like those in pranayama, improve HRV and enhance cardiorespiratory synchronization. This results in respiratory sinus arrhythmia (RSA), where the heart rate increases during

inhalation and decreases during exhalation. Slow breathing at a rate of six breaths per minute (0.1 Hz) maximizes RSA and HRV, which are linked to better autonomic regulation [32]. By increasing parasympathetic (vagal) tone and reducing sympathetic dominance, slow breathing helps relieve stress, anxiety, and depression. It also improves mood, neuroendocrine function and autonomic balance, contributing to overall health and resilience [33].

Thus, the above review of literature confirmed the impact of yoga on stress management, anxiety regulation and other psychophysiological ailments; emphasizing its neurophysiological mechanisms and its potential to improve students' resilience and well-being. Considering the aforementioned positive effects of yoga practices on various psychophysiological parameters, the investigators undertook the present study.

Objectives of the Study

The main objectives of this review study were as follows:

1. To analyse the concept of *academic stress* and its underlying *neurophysiological mechanisms*, including the role of the autonomic nervous system, hypothalamic–pituitary–adrenal (HPA) axis and brain neurotransmitters.
2. To review the existing literature on *yoga practices*, including asanas, pranayama, meditation and relaxation techniques and their scientifically documented effects on the nervous system, endocrine systems as well as the brain.
3. To examine how yoga-based interventions modulate *stress-related neurophysiological responses*, such as cortisol secretion, heart rate variability (HRV) and brain wave patterns in the context of students facing academic pressure.
4. To explore the *mind–body connection* established through yoga and its probable effect to restore emotional stability, memory, concentration and cognitive performance during periods of academic stress.
5. To identify the gaps in current research and propose directions for *future empirical studies* on the integration of yoga into educational and stress-management frameworks.

METHODOLOGY

This theoretical review study employed a systematic approach to analyse the existing literature on the role of yoga practices in managing academic stress, with an emphasis on neurophysiological mechanisms. The findings of relevant studies were collected from databases such as PubMed, Scopus, Google Scholar and ResearchGate using keywords like "yoga," "academic stress," "neurophysiology", "HPA axis", "Neurotransmitter," and "students." Research focusing on yogic practices (asana, pranayama and meditation) and their effects on stress-related physiological responses such as autonomic balance, cortisol regulation, and brainwave activity was included. The selected studies were examined through a 'thematic analysis' to identify recurring neurobiological patterns and theoretical insights, thereby forming an integrated framework that explains how yoga influences stress modulation and enhances academic performance.

Physiological and Neurophysiological Effects of Yoga Practices in Managing Academic Stress

The findings of several studies have highlighted the positive effects of HPA axis regulation through yoga practices. Studies have confirmed that chronic academic stress upregulates the HPA axis, thereby elevating cortisol levels and disrupting circadian rhythms [5]. Regular practice of Yoga has been shown to play a significant role in regulating the HPA axis. Studies indicated that regular yoga practice reduces cortisol levels and increases the secretion of neurohormones such as oxytocin, which help counteract the effects of stress [34]. Figure-1 clarified the neuro-physiological

pathways and effect of academic stress on students.

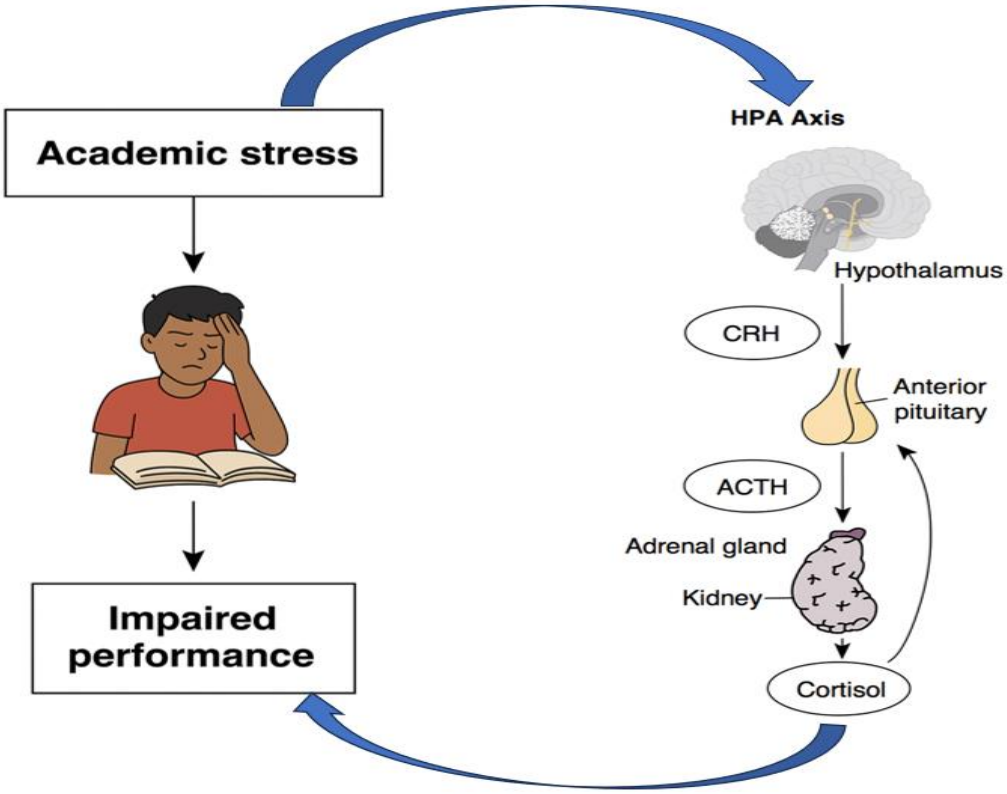

Fig.-1, physiological and neuro-physiological function and effect of academic stress.

Studies have confirmed that yoga practices have a profound impact on neurotransmitter modulation, a process involved in regulating arousal and mood development. GABA (Gamma-Aminobutyric Acid), which is the primary inhibitory neurotransmitter in the central nervous system (CNS), is also linked to anxiolysis and improved inhibitory control, supporting emotional regulation under academic pressure [35]. Studies have shown that Yoga practices have a profound positive effect on serotonin secretion, thereby enhanced mood stability, resilience and well-being. The findings also suggested that Yoga interventions regulate and control the secretion of catecholamines (e.g., norepinephrine/epinephrine), which reflects reduced sympathetic drive and hyperarousal. Together, these mechanisms create a neurochemical milieu that counters anxiety and supports sustained attention and working memory [36].

The findings of many scientific studies highlighted the positive effects of yoga practice on Brain Functioning (Neuroimaging& Neuroplasticity). In these studies, the functional MRI studies of meditative and breath-focused practices were the essential components of yoga practice, which showed the following results:

- **Enhanced prefrontal cortex (PFC) engagement** (dorsolateral/ventromedial regions) and anterior cingulate activity are enabling top-down regulation of attention and emotion [37].
- **Reduced amygdala hyperreactivity** to stress cues are consistent with better threat appraisals and diminished reactivity. Complementary findings (e.g., increased alpha/theta EEG power) are also aligned with relaxed alertness—a state favourable for learning and memory consolidation [38].
- **Enhance the activation of Neuroplasticity -** Neuroplasticity is the brain's capacity to reorganize by creating new neural pathways

throughout life, involving both structural and functional adjustments. Neuroplasticity plays a key role in how the brain responds to stressors [39]. Regular yoga practice can stimulate the growth of new neural pathways, improve cognitive functions and help the brain to better manage stress [40]. This enhancement of neuroplasticity supports the brain's ability to adapt to academic pressures by fostering emotional resilience and cognitive flexibility [27]. Yoga has also been linked to increased activity in the hippocampus and prefrontal cortex regions, which are critical for memory, decision-making and stress regulation. Through these neurophysiological changes, yoga can help in mitigating the adverse effects of academic stress, enhancing focus and fostering mental as well as physical well-being (table-1).

Table 1. Neurophysiological Mechanisms of Yoga with reference to Academic Stress Regulation.

Neurophysiological Mechanism	Yoga Practices	Impact on Academic Stress	Evidence
Autonomic Nervous System (ANS)	Pranayama (Breathing practices), Asanas (physical posture)	Balances the sympathetic and parasympathetic systems, reducing anxiety and stress [16, 20, 22].	Increased HRV and parasympathetic activation after yoga. [30,32].
HPA Axis Regulation	Pranayama, Meditation	Lowers cortisol levels, reducing stress-induced fatigue and improving mood [34]	Decreased cortisol levels were observed in yoga practitioners. [34]
Neurotransmitter Modulation	Asanas, Pranayama and Meditation	Enhances GABA and serotonin, improving emotional regulation and reducing anxiety [22-24]	Increased GABA and serotonin post-yoga, leading to better emotional control [22-24].
Neuroplasticity & Cognitive Function	Asanas, Meditation, Pranayama	Enhances memory, attention, and cognitive flexibility under stress [24,27]	Functional MRI studies have shown increased activity in the prefrontal cortex after yoga [37].
Emotional Regulation	Meditation, Pranayama	Improves emotional resilience and reduces test anxiety [17,18].	Improved mood and emotional regulation after consistent yoga practice [17,18,35,36].
Working Memory & Executive Function	Asanas, Pranayama, Meditation	Enhances cognitive flexibility, working memory, and focus under academic pressure [27]	Improved working memory and executive function in students practicing yoga [27].

Neuroplasticity, the brain's ability to form new neural pathways, plays a key role in stress response [39]. Studies found that regular yoga practice stimulates the neuroplasticity, enhances cognitive function and improves the capability of stress management. It enhances emotional pliability and mental flexibility, aiding adaptation to academic pressures. Yoga also increases activity in the hippocampus and prefrontal cortex, improves memory, decision-making and stress regulation, which helps to reduce academic stress and thus, promote mental and physical well-being [40, 41].

DISCUSSION

This review study highlighted the significant role of yoga in mitigating academic stress by modulating neurophysiological mechanisms. Academic stress is a well-documented challenge for students, negatively impacted the cognitive functions, emotional stability and academic performance. Chronic exposure to stress activated the HPA axis, leading to elevated cortisol levels andimpairing cognitive functions such as attention, memory and executive functioning, as noted by Lupien et al. (2009) [41]. These findings are consistent with researches those were

showing that chronic stress contributes to anxiety, depression and other mental health issues, and thereby, further degrading the academic outcomes.

Yoga, as a mind-body practice, has gained traction as an effective, non-pharmacological intervention to alleviate stress. It integrates asanas (physical postures), pranayama (breathing practices), and meditation, which together targeted both the physiological and psychological components of stress. Research by Khalsa et al. (2009) [42], supported the claim that yoga reduces cortisol levels, enhances parasympathetic nervous system activity, and restores autonomic balance. In line with these findings, Tyagi et al. (2016) also observed the significant improvements in HRV and vagal tone after yoga practice, which are the indicators of improved autonomic regulation and reduced stress [43].

Moreover, yoga has been shown to modulate neurotransmitter systems. Increased levels of GABA and serotonin have been linked to better emotional regulation and reduced anxiety under academic pressure. These findings are aligned with this present review study, which found that yoga enhances neuroplasticity, improves memory, cognitive flexibility and attentional control, all of which are essential for academic performance. Neuroimaging studies, such as those by Cahn & Polich (2006) [23], demonstrated enhanced activation in regions like the prefrontal cortex and hippocampus, which played crucial roles in memory and decision-making; further supporting the neurological and cognitive benefits of yoga (Figure-1).

Notwithstanding these promising findings, several limitations were found to be happened in the current body of literature. Many studies have small sample sizes and short durations, often with varying yoga protocols, as noted by Gothe et al. (2020) [40]. These methodological differences limited the generalizability of the results. Furthermore, while short-term benefits were well-established, long-term effects, especially in diverse student populations, remained underexplored. Hence, future research should be focused on longitudinal studies with larger, more diverse samples to evaluate the sustained impact of yoga practice on academic stress and performance.

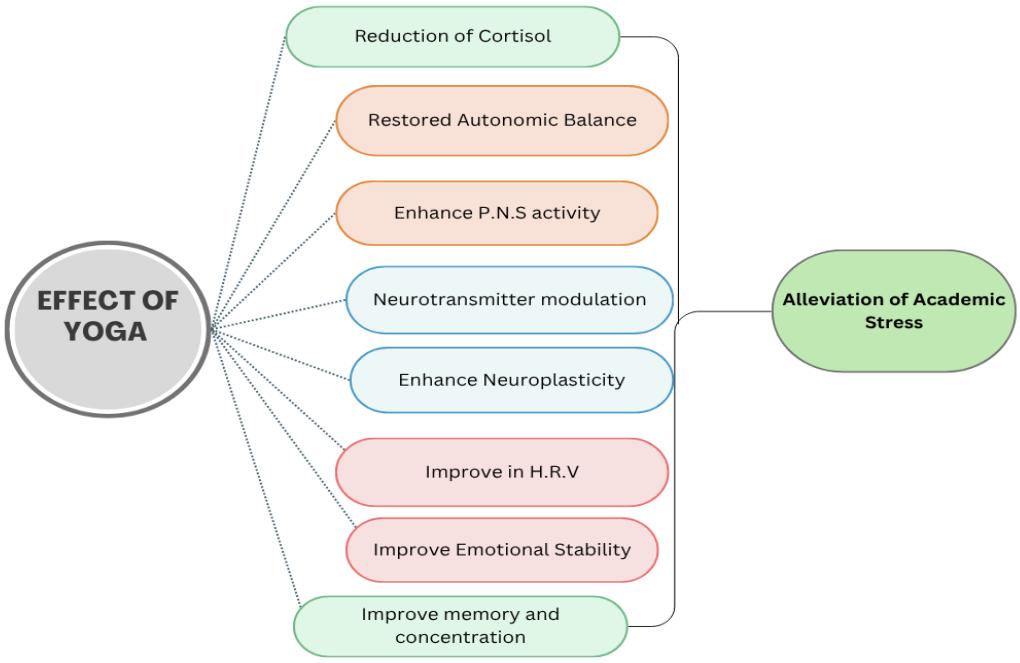

Figure-1. Effect of Yoga Practices in the Alleviation of Academic Stress

CONCLUSION

This review study concluded that yoga practices are highly effective in alleviating academic stress by influencing key psycho-physiological and neurophysiological mechanisms that regulate psychological and physiological responses to stress. Regular yoga interventions consistently lead to lessen the levels of anxiety, depression and stress among students, alongside measurable improvements in heart rate variability, blood pressure and brain functions, underscoring yoga's role in strengthening stress resilience and promoting holistic well-being in educational contexts. The study also concluded that yoga offers a promising approach in reducing academic stress and improving student well-being through its effects on the autonomic nervous system, HPA axis, neurotransmitter regulation and brain functions. Thus, the results of the study suggested that by integrating yoga module into educational settings, a cost-effective and accessible strategy for fostering mental clarity, emotional resilience and academic success can be achieved. However, further research, particularly rigorous, large-scale and longitudinal studies are needed to confirm its long-term efficacy and mechanistic pathways.

Future Direction and Educational Implications

Future research should focus on exploring the neurophysiological mechanisms by which yoga alleviates academic stress, utilizing tools such as EEG, HRV, and fMRI. Longitudinal and comparative studies are necessary to assess the sustained effectiveness of yoga compared to conventional stress-management methods. Researchers should also be examined age- and discipline-specific outcomes, as well as the feasibility of integrating structured yoga programs into educational curricula. The study highlighted that incorporating yoga into education can significantly reduce students' academic stress by stabilizing neurophysiological processes such as brain wave patterns, hormone levels and nervous system activity. Regular yoga practice enhances concentration, memory and emotional balance, which lead to improve the academic performance and mental well-being. It promotes relaxation, self-discipline and a positive attitude, helping students to cope better with academic pressure. Therefore, integrating yoga sessions into academic curricula can create a healthier, more focused and more stress-free learning environment that supports both academic success and holistic development.

Declaration by Authors

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