Mind body connection: Stress, inflammation, and health

Anuradha Verma*, Aditya Raj, Anchal Goel, Manvi Jha, Devashish Pal, Ayush Kumar, Anshika Garg, Babita Kumar

Sanskar College of Pharmacy and Research, Ghaziabad, UP, India 201302

Email: anuradha.singh@sanskar.org

Abstract

The mind and body are profoundly connected, and this association strongly affects our health. This chapter explains how psychological stress can lead to inflammation in the body and how that impacts physical health. Stress activates systems in the body that release hormones like cortisol and inflammatory chemicals. When stress last long-term, it can lead to chronic inflammation, which is linked to diseases such as heart problems, autoimmune disorders, and depression. Research from psychoneuroimmunology shows that managing stress through techniques like mindfulness and healthy behavior can reduce inflammation and improve overall health. By understanding how stress causes inflammation in the body, we can develop better and more complete healthcare strategies to treat and prevent long-term illnesses.

Keywords: Inflammation, stress, mind, psychological, mental health, mindfulness

1. Introduction

A stress response is triggered by any psychological or physical events that upset equilibrium. The stress response is the term used to describe the physiological and behavioral alterations brought on by stressors. A stress reaction might be psychological or environmental, such as an impending deadline at work. Anxiety, hormones, and the immune system all contribute to a stress response by triggering the hypothalamic-pituitary-adrenal (HPA) axis, the sympathetic-adrenomedullary (SAM) axis, and the immunological system. Chronic stress has lasting impact on both the body and the mind. Prolonged stress causes high blood pressure, and encourages the development of arterial plaque, anxiety, depression, and addiction (1).

The brain initiates the stress reaction starts. When our sense organs, such as our eyes and earssee danger, they communicate with the brain's Amygdala, which controls how emotions are processed. The Amygdala processes it, controls involuntary action, and sends it throughout the body through the ANS. It activates the sympathetic nervous system and the "fight and flight" response. The signal travels to adrenal gland which release epinephrine into the bloodstream. Epinephrine causes physiological changes like increase heart rate,increase blood supply to muscles, heart and another organ. O_2 supply increases which increase

alertness in the brain. The body enters a second phase of the stress response after the immediate effects of epinephrine (adrenaline) wear off, and this is regulated by the Hypothalamic-Pituitary-Adrenal axis (HPA axis), a complex network that includes the pituitary gland, the adrenal glands above the kidneys, and the brain's hypothalamus.When the brain continues to interpret a situation as threatening, the hypothalamus responds by releasing a chemical signal called corticotropin-releasing hormone (CRH). This hormone reaches to the pituitary gland, which then releases adrenocorticotropic hormone (ACTH) into the bloodstream. In turn, ACTH signals the adrenal glands to produce and release cortisol, the body's main stress hormone. The hormone cortisol keeps the body alert. It elevates blood sugar (glucose) levels to provide quick energy, enhances brain function, and suppresses non-essential functions like digestion and reproduction so the body can focus entirely on dealing with the threat. This is part of the "fight-or-flight" survival mechanism.

However, prolonged higher cortisol levels caused by chronic stress can have negative consequences like reduced immunity, elevated blood pressure, disturbed sleep, and even mental health conditions like depression or anxiety. This emphasizes how crucial it is to properly manage stress in order to avoid long-term harm to the body and mind (2).

2. Chronic stress influence inflammation

Although stress is a normal component of life, persistent stress can have very negative effects on our bodies. Regularly experiencing stress triggers the neuro-endocrine pathway that results in stress reactions. The stress hormone cortisol is to blame for this, as it acts on glucocorticoid receptors all over the body. When stressor is strong in intensity or duration it over activate the immune system and causes the imbalance between inflammatory and anti-inflammatory responses. Normally cortisol reduces the inflammation but when chronic stress increases it leads to increase inflammation and supress the immune system. Over long time these chronic stress makes glucocorticoid receptor resistance to inflammatory hormones like cortisol. Chronic stress activates the HPA axis and sympathetic nervous system which causes release of stress hormone in the blood and causes systemic inflammation. Stressful events also triggers the person to adopt unhealthy lifestyles like alcohol consumption,unhealthy food and lack of physical activity which causes chronic inflammation. When cortisol and epinephrine are increased it triggers the chronic stress which damages blood vessels and arteries and causes increase blood pressure and sometimes heart attack. Chronic stress also affects the brain and causes neuroinflammation, neuronal plasticity and affect neurotransmitter release which have a harmful effect on cognitive function and mental health (3).

2.1. Role of cortisol in stress induced inflammation

Cortisol is a natural hormone made by the body that is commonly used (or mimicked by drugs) to reduce inflammation. However, this study takes a fresh look at how cortisol works and shows that it can both increase and decrease inflammation depending on the situation.

2.1.1. Daily cortisol levels don’t always reduce inflammation: Normal levels of cortisol in the body throughout the day don’t seem to reduce inflammation much. This suggests that the relationship between cortisol and inflammation isn’t simple or straightforward.

2.1.2. In surgery patients, cortisol can reduce inflammation: When the body is under stress, like during surgery, cortisol can help reduce inflammation but only within a certain range. Too little or too much might not help (4).

2.1.3. Short-Term cortisol treatment has a two-phase effect: Giving healthy people cortisol before exposing them to inflammation later on showed an interesting pattern: Moderate levels of cortisol made inflammation worse. High levels of cortisol had no clear effect neither helping nor hurting (5).

3. Inflammation link between stress and disease

Inflammation is the body's natural defense against various threats, including infections, cancer, organ

rejection, and even psychological stress. In response, the immune system releases chemicals called pro-inflammatory cytokines to combat these threats. Stress triggers inflammatory responses throughout the body, both in the brain and peripherally. In other words, stress not only activates inflammation in the brain but also in other parts of the body. This inflammation can occur through various mechanisms, including the release of inflammatory mediators and the activation of immune cells (6).

Stressors of varying types and intensities activate both pro-inflammatory and anti-inflammatory pathways in the immune system. Acute stressors tend to enhance immune function, while chronic stressors can suppress it. Intense stressors can lead to an imbalance in these pathways, with pro-inflammatory effects becoming more prominent. This pro-inflammatory response, confirmed by numerous studies, involves markers like C-reactive protein (CRP), IL-6, TNFα, IL-1β, and the transcription factor NF-κB. Stress can significantly contribute to a range of diseases, including cardiovascular problems like hypertension and atherosclerosis, metabolic issues like diabetes and NAFLD, mental health conditions such as depression, and neurodegenerative disorders like Alzheimer's and Parkinson's disease.

3.1. Rheumatoid arthritis (RA)

It is an autoimmune disease where inflammation damages joints and tissues, causing pain and stiffness. This inflammation, partly triggered by stress-induced cytokines, can lead to long-term joint and bone damage.

3.2. Atherosclerosis

An overly active sympathetic nervous system, the body's "fight or flight" response, constricts blood vessels, increasing blood pressure and heart workload. This, along with inflammation, contributes to atherosclerosis, a major risk factor for heart disease.

3.3. Depression

Depressive symptoms like low mood, fatigue, and a lack of enjoyment. In individuals with existing depression, inflammation can exacerbate these symptoms. Essentially, stress-induced inflammation can mimic or worsen depressive symptom (7).

4. Physiological effect of inflammation: The mind response to stress

Under psychological or physical stress, sensory nerve fibers release neuropeptides, notably Substance P, triggering inflammation. This inflammation is further enhanced by the activation of mast cells, which release inflammatory mediators. Stress leads to the release of neuropeptides, such as substance P, and other inflammatory mediators from sensory nerves, which in turn activate mast cells, leading to an inflammatory response. Inflammatory stimuli activate the HPA axis and sympathetic nervous system, triggering the release of stress hormones like cortisol and adrenaline, which can exacerbate inflammation. Psychological stress can also initiate an inflammatory response through the release of neuropeptides from peripheral neurons and the activation of mast cells. A key inflammatory stimulus is lipopolysaccharide (LPS). The brain actively regulates inflammation, and stress responses and inflammatory responses share overlapping mechanisms. Both are mediated by similar neuropeptides like CRF and possibly SP, and cytokines released during stress or inflammation can signal the brain via similar sensory pathways. Inflammation evolved within the context of the broader stress response. (8).

5. The gut brain axis: Stress inflammation and digestive health

The gut brain axis is the pathways that provide signalling between nervous system and gastrointestinal tract (GIT) bidirectionally. This pathway is also linked with vagus nerve, immune system, hormones, neurotransmitters and microbial metabolites. That means the signal transmits from gut to brain and from brain to gut via vagusnerve, hormones , neurotransmitters, and other chemical mediators etc (9)

Whenever the Physical and psychological stress produced in our body, it causes the release of inflammatory mediators like cytokinins and release of catecholamine and glucocorticoid respectively. This affect the permeability of blood brain barrier (BBB) and intestinal barrier resulting in movement of

gut microbiota from gut lumen into blood. This causes change in composition of gut microbiota (Microbiota are the microorganisms like fungi, bacteria, virus etc that are present in human GIT) leading to dysbiosis. Microbiota is responsible for controlling the gut brain axis and inflammatory responses. When microbiota from blood enter into brain through blood brain barrier in response to physical and psychological stress, they causes neuroinflammation. This gut inflammatory response can be reduced by taking high fibre rich food, probiotics, prebiotics. All these food products are beneficial against this gut dysbiosis associated brain disorder (10).

6. Mindfulness and stress reduction: Breaking the cycle of inflammation

Mindfulness means paying full attention to what's happening right now where you are,what you are doing, without getting too caught up in thoughts or emotions - Although in simple terms "training your attention" to achieve a mental calm and positive emotions. Various health related problems like anxiety and depression caused due to stress could be cured doing meditation (11).

MBSR (mindfulness based stress reduction) is a meditation therapy it is being used to treat many different illnesses such as depression, anxiety, cancer, diabetes mellitus, hypertension, immune disease. MBSR also teaches people how to increase mindfulness through yoga and meditation. It can improve physical health, for example - reduce pain, fatigue, stress in people and boost the immune system and help to recover more quickly from cold and flu (12).

Mindfulness based cognitive therapy (MBST) is a kind of therapy that uses both MBSR (mindfulness based stress reduction) and CBT (cognitive-behavioral therapy) which is used to cure the people suffering from depression. It is generally used to reducing stress, anxiety and depression etc (13).

6.1. Yoga for stress

Yoga helps improve how our brain works, and it does this in a different way than activities like running or other aerobic exercises. Studies support the idea that our body and mind are closely connected, how we move and use our body can affect how we think and feel. For example, the way we move our muscles and hold our posture can change how much we think and even what kind of thoughts we have (14).

Table 1. Studies conducted on various populations and effect on inflammation markers

Population/ Condition	Intervention type	Stress/ Inflammation markers measured	Key findings	Ref
IBS & IBD patients	Relaxation Response MBI	ESR, CRP, gene expression	Improved quality of life, reduced symptoms and anxiety, gene expression changes linked to inflammation	(15)
Mixed (chronic stress)	Mindfulness, CBT, Yoga	IL-6, TNF-α, cortisol, immune cell activity	Chronic stress increases pro-inflammatory markers; mind-body interventions reduce stress and normalize immune function	(16)
Mixed (inflammatory conditions)	Mind–Body Interventions	WHO-5 Well-being Index, inflammatory biomarkers	MBI improves well-being and may reduce inflammation	(17)

6.2. Body posture and emotion

How we move and hold our body can change depending on how we feel. For example, when someone feels ashamed, sad, or bored, their upper body might slump or "collapse." This could be one reason why sitting is often linked to feeling more negative emotions. Also, our muscles react during emotional experiences even if we're not actively responding to something we see or hear. All of this supports the idea that our emotions and body posture are closely connected (18).

7. Conclusion

Prolonged stress contributes to inflammation by causing a prolonged release of cortisol, which over time can interfere with immunological control and lead to the onset of disease. A major connection between mental discomfort and physical sickness, stress-induced inflammation impacts all bodily systems, including the gut and brain. Further demonstrating how psychological stress can impact digestive health, the gut-brain axis highlights the intricate relationship between mental and physical health. The significance of stress management for immunological balance and general health is highlighted by an understanding of these pathways.

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