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THE IMPACT OF CHRONIC STRESS ON HUMAN HEALTH AND METHODS FOR ITS PREVENTION

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Abstract. This study analyzes the impact of chronic stress on human homeostasis, specifically focusing on hormonal dysregulation, molecular aging, and systemic inflammation. By examining the Hypothalamic-Pituitary-Adrenal (HPA) axis and neuroplasticity, the research highlights the vulnerability of students and the general population to chronic conditions. The study further identifies evidence-based resilience strategies, including vagus nerve stimulation and kognitive appraisal, to mitigate these risks.

Keywords: chronic stress, cortisol, nervous system, cardiovascular system, immunity, student health

INTRODUCTION. In the modern era, stress has transitioned from a survival mechanism to a persistent health crisis. Chronic stress—prolonged exposure to stressors—inflicts severe damage on the cardiovascular, nervous, and immune systems. The concept, pioneered by Hans Selye in 1936 as a "nonspecific response," has evolved through decades of research into the biochemical links between hormones like cortisol and adrenaline and systemic pathology. The Aim of this Study: To analyze the molecular and neurophysiological causes of chronic stress, evaluate its long-term health consequences (including inflammation and cellular aging), and identify effective modern management methods.

MATERIALS AND METHODS.

This study is based on a systematic analysis of scientific literature across psychology, physiology, and medicine. The methodology includes:

Reviewing recent research articles and statistical reports from organizations like the WHO and Nature Medicine.

Analyzing Hans Selye's stages of stress development.

Evaluating biochemical processes and hormonal data.

Synthesizing observational findings from the 2020–2023 period.

Stress and Systemic Chronic Inflammation (SCI). Under normal conditions, the hormone cortisol acts as a powerful anti-inflammatory agent. However, when stress becomes chronic, immune cells lose their sensitivity to cortisol, a phenomenon known as glucocorticoid resistance.

Mechanism: The immune system loses its regulatory balance and begins to release an excessive amount of pro-inflammatory cytokines (such as IL-6 and TNF-alpha) into the bloodstream.

Consequences: These substances circulate throughout the body, triggering low-grade but persistent inflammation. This process is a primary driver of joint pain, damage to the inner lining of blood vessels (endothelium), and chronic fatigue syndrome.

Neuroinflammation and Mental Health. Recent studies indicate that chronic stress activates microglia, which are the primary immune cells of the brain.

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Neuroinflammation: Once activated, microglia produce inflammatory molecules that disrupt the synaptic connections between neurons.

Link to Depression: Currently, this inflammatory process within the brain is viewed as one of the fundamental causes of clinical depression and anxiety. In essence, inflammation serves as the "fuel" for both physical ailments and mental health disorders.

RESULTS.

Biochemical Mechanisms of Stress - The findings confirm that the Hypothalamic-Pituitary-Adrenal (HPA) axis is the primary biochemical pathway for stress. The process occurs as follows:

- Hypothalamus: Synthesizes Corticotropin-Releasing Hormone (CRH).
- Pituitary Gland: Releases Adrenocorticotropic Hormone (ACTH) into the bloodstream.
- Adrenal Glands: Secretes cortisol (a glucocorticoid) and adrenaline.

Stages of Stress and Metabolism - According to Selye, stress develops in three stages: Alarm (surge in adrenaline), Resistance (stably elevated cortisol), and Exhaustion (systemic failure). Key metabolic shifts include:

Carbohydrate Metabolism: Activation of gluconeogenesis in the liver, increasing blood glucose levels.

Oxidative Stress: Increased production of free radicals leading to lipid peroxidation and cell membrane damage.

Systemic Effects and Statistics - Nervous System: Chronic stress can reduce the volume of the hippocampus (memory) and increase the activity of the amygdala (fear/emotions).

- Cardiovascular System: It leads to tachycardia and hypertension. Studies (2022) show that chronic stress increases heart attack risk by 30–40%.

- Student Demographics: Between 2020 and 2022, 60–70% of students experienced chronic stress. During the pandemic, these levels rose by an additional 25–30% (WHO, 2022).

Systemic Chronic Inflammation (SCI) - Prolonged stress leads to glucocorticoid resistance, where immune cells lose sensitivity to cortisol's anti-inflammatory signals. This results in an uncontrolled release of cytokines (IL-6, TNF-alpha), causing low-grade systemic inflammation linked to heart disease (a 30–40% increased risk) and chronic fatigue.

DISCUSSION

The results indicate that while short-term stress can be adaptive, chronic exposure leads to pathological changes. Research by Sapolsky (2004) and modern studies in *Nature* (2021) highlight the neurodegenerative and immunologic risks associated with prolonged cortisol elevation.

The transition from adaptive "short-term" stress to "pathological" chronic stress is mediated by the body's inability to downregulate the HPA axis. However, the data suggests that Resilience can be cultivated through psychophysiological interventions:

- Vagus Nerve Stimulation: Techniques such as diaphragmatic breathing and cold-water immersion (the "diving reflex") activate the parasympathetic nervous system to rapidly lower heart rate and cortisol.

- Cognitive Appraisal: Adopting a "stress-mindset"—viewing stress as a challenge rather than a threat—prevents vascular constriction and protects the heart.

- Shinrin-yoku (Forest Bathing): Exposure to nature increases "Natural Killer" (NK) cell activity, restoring immune function suppressed by stress.

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Effective Management Strategies:

Physical Activity: 150 minutes of exercise per week reduces chronic stress by 25% (Nature Reviews Psychology, 2023).

Sleep Hygiene: Quality sleep is essential for regulating cortisol rhythm.

Psychological Interventions: Mindfulness, breathing exercises, and social support are proven to calm the nervous system and lower hormonal triggers.

CONCLUSION

Chronic stress is a significant threat to human health, acting as a catalyst for cardiovascular disease, immune suppression, and cognitive decline. Effective management through lifestyle modifications—such as regular physical activity, adequate sleep, and social connectivity—is essential to mitigate these harmful effects and improve overall well-being.

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