THE INTERCONNECTION BETWEEN MICROBIOTA AND STRESS HORMONES IN THE HUMAN BODY: A NEW SCIENTIFIC APPROACH

Author: ***Qahramonov Davron Dilshod o‘g‘li***
Affiliation: Alfraganus University
Phone Number: +998906762656
Email: qahramonovd035@gmail.com

ABSTRACT

This article analyzes the mechanisms of interaction between the microbiota and stress hormones, particularly cortisol, in the human body. The microbiota plays a vital role in ensuring internal environmental stability and mental health. The study explores the mechanisms of the microbiota’s involvement in physiological responses to stress, as well as the neuroendocrine communication within the microbiota-gut-brain axis. Analyses have shown that increased stress levels can disrupt various components of the microbiota, thereby negatively impacting health. New scientific approaches and metagenomic tools are expanding opportunities to study the role of the microbiota in health more deeply.

Keywords: microbiota, stress hormones, cortisol, gut-brain axis, neuroendocrine system, metagenomics, mental health.

INTRODUCTION

In recent years, the microbiota has been recognized as an important factor in human health and psychological stability. The human gut microbiota consists of hundreds of millions of microorganisms that are intricately linked to digestion, the immune system, metabolic processes, and even brain function [1]. At the same time, hormones released during stress, especially cortisol and adrenaline, have a dramatic impact on the internal environment. The interaction between the microbiota and stress hormones is a relevant and complex area being studied in modern medicine [2].

The microbiota and the central nervous system communicate through a biological system known as the "gut-brain axis." This interaction involves the immune system, the vagus nerve, the endocrine system, and bacterial metabolites (e.g., SCFA - short-chain fatty acids) [3]. This article explores the physiological and molecular mechanisms between stress and the microbiota.

METHODOLOGY

The study is mainly based on secondary data analysis, relying on scientific articles, meta-analyses, and clinical trials published in the last 10 years (2014–2024). Articles were selected from PubMed, ScienceDirect, Nature, and Scopus databases using key phrases such as "microbiota and stress hormones", "gut-brain axis", "cortisol and microbiome". 30 out of 45 articles were selected based on thematic proximity and scientific approach. Among them, 12 were clinical studies, 10 were experiments on animals, and 8 included theoretical analyses.

The methodological approach consists of the following steps:

This study takes a four-step methodological approach to deeply analyze the relationship between the microbiota and stress hormones, especially cortisol, in the human body. Each stage was developed based on existing scientific literature, clinical and experimental research, as well as advanced concepts.

1. Analysis of Cases Showing Variability in Microbiota and Cortisol Levels

This stage focused on studying how stress affects cortisol levels and the structural diversity of the gut microbiota. The analyzes were based on:

Clinical observations: The microbiota composition in stool samples from patients with chronic stress was determined by 16S rRNA gene sequencing and compared with cortisol levels.

Dynamics of cortisol levels: It was observed that the increase in cortisol levels due to the activation of the HPA axis in stressful situations reduces the diversity of the microbiota.

Microbiota diversification: High levels of cortisol mainly led to a decrease in beneficial bacteria such as Lactobacillus and Bifidobacterium, and a change in the ratio of Proteobacteria and Firmicutes.

2. Dynamics of Microbiome Change in Stress Conditions

This stage examined the structural and func

• Experiments on animal models: Mice were subjected to chronic stress (immobilization, sound stimulation), and the microbiota composition was dynamically measured.

• Germ-free (sterile) models: Animals without microbiota were transplanted with microbiota from healthy or stressed donors, and the effects on behavior and cortisol levels were evaluated.

• Permeability analyses: Stress was observed to increase the permeability of the intestinal epithelium ("leaky gut"), and it was confirmed that microbial endotoxins (e.g., LPS) had entered the bloodstream.

3. Analysis of Models Explaining the Stress-Microbiota Connection via the Gut-Brain Axis

Scientific models explaining the connection between the microbiota and the central nervous system through the gut-brain axis were reviewed in this stage:

• Microbiota metabolites: The production of neuroactive substances such as short-chain fatty acids (SCFA), serotonin, GABA, dopamine, and their effects on brain activity were studied.

• Effect through inflammation: It was shown that in dysbiosis, the immune system is activated and enhances stress reactions through cytokines.

• Bidirectional model: It was scientifically elucidated that the gut-brain axis functions bidirectionally, i.e., stress alters the microbiota, and the microbiota shapes reactivity to stress.

4. Practical Aspects of Stress Reduction with Probiotics and Prebiotics

This stage examined practical approaches aimed at reducing stress by regulating the microbiota:

• Clinical studies: Clinical studies on humans with psychobiotics such as Lactobacillus rhamnosus, Bifidobacterium longum were analyzed. It was found that they help lower cortisol levels and improve mood.

• Psychobiotic concept: An approach to managing mental health through psychobiotics — substances that specifically regulate the microbiota — has been developed and used as a stress-reducing strategy. Parallel psychological analysis: In some studies, participants' sleep quality, anxiety levels, and depression scores (e.g., DASS-21, STAI tests) were also assessed.

RESULTS

According to the analyzed data, the following main changes were observed in stress conditions:

• When cortisol levels increased, the diversity of the gut microbiota decreased, especially the number of beneficial bacteria such as Lactobacillus and Bifidobacterium [4].

• Experiments in animals (on cats and mice) showed that stress increased the permeability of the intestinal epithelium, leading to endotoxins entering the bloodstream [5].

• In groups treated with probiotics, cortisol levels decreased, and psychological stability increased. For example, a mixture of Lactobacillus helveticus and Bifidobacterium longum reduced cortisol levels by up to 30% [6].

• Mechanisms affecting the nervous system through the microbiota-gut-brain axis were implemented through the following components: SCFA, bacterial enzymes affecting serotonin, and immune mediators (interleukins, TNF-α) [7].

DISCUSSION

These results confirm a complex, bidirectional relationship between the microbiota and stress hormones. This connection is mediated by the neuroendocrine and immune systems. The microbiota composition can affect stress, and stress, conversely, can disrupt the microbiota balance. Such a two-way relationship is called "bidirectional signaling" [8].

At the same time, increased intestinal permeability (the "leaky gut" phenomenon) activates the immune system, which enhances cortisol production through the hypothalamic-pituitary-adrenal axis [9]. High levels of cortisol lead to the death of beneficial microorganisms, which in turn causes additional stress — i.e., a stress-microbiota loop is formed.

In modern therapeutic approaches, particularly for mental health disorders, microbiota-restoring psychobiotics (a new generation of probiotics) are being increasingly used. However, research in this area is still in its early stages and requires further in-depth investigation [10].

CONCLUSION

Understanding the connection between the microbiota and stress hormones is an important direction in modern medicine, providing a basis for new approaches to improving mental and physiological health. Research indicates that maintaining a healthy microbiome is one of the key factors in reducing stress. In the future, it is expected that individual therapy approaches will be developed using genetic analyses, real-time monitoring of the microbiome, and artificial intelligence.

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