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REVIEW ARTICLE

Gut Microbiota and Their Role in Mental Health: A Review

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ABSTRACT

Background: Current findings shown the microbiota, which has been found in human gut play various important role in many areas of health, including psychological to mental health. Dietary changes, lifestyle, probiotics, prebiotics, and some other factors directly inflected gut microbiota and its influence on mental health

Objective: Recent research has shown that direct communication between the digestive tract biota and the brain, known as commonly the "gut-brain axis".

Methods: A literature review was conducted to this mystery that how they affect each other. In this article, the search was based on the title and keywords such as mental health "microbiota stress, and depression, used on various websites, such as PubMed, Google Scholar, Research Gate, and Science Direct.

Results: The populations of microorganisms in the intestines affect mental and neurological activities. The gut microbiota, directly affect the mental health issues including schizophrenia, anxiety, depression, and autism spectrum disorder.

Conclusion: So for future prospect neurological experts gut microbiota will be important tools for diagnostic and therapeutic agent.

Keywords: Anxiety, Autism, Depression, Gut microbiota, Gut-brain axis, Mental health, Probiotics, Prebiotics, Schizophrenia.

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INTRODUCTION

In the human gut trillions of microorganisms living in the gastrointestinal tract when we compared to bacteria, viruses, fungi, and protozoa. These tiny organisms participate in many metabolic activities, immune modulation, and digestive processes among other physiological functions. Recent study reveals that a new theory known as gut-brain axis that shown the strong relationship between the gut flora's and their major impact on brain function and behavior. This axis is a dynamic, to way communication system and connecting directly to the central nervous system (CNS) and enteric nervous system (ENS), therefore integrating signals from the endocrine, immune, and neural systems. With new research and studies emphasizing the microbiota as a possible treatment target, knowing this complex communication system is essential for treating a variety of psychiatric and neurological disorders.[1,2]

Emotions are a two-way dialogue between the brain and the body that controls various activities. The brain and the gut bacteria operating various biological, physiological and neurological mechanism via the uses of immunological, endocrine, and neurological systems. This two-way link comprises neuronal control, immunological response, and hormone release. This two-way interaction affects both the blood-brain barrier and intestinal epithelial permeability control. Among the metabolic byproducts that affect the reaction of the gut flora are hormones such as cortisol and modulators such as quinolinic acid. Some gut bacteria can produces neurotransmitters such as serotonin and gamma-aminobutyric acid (GABA) and these microbiome influences both brain function and human behavior.[3,4]

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Gut Microbiota Composition and development

Gut Microbiota Composition and development differs from individual to individual and depends on various factors. Gut microbiota composition is shaped by many elements, including genetics, delivery (vaginal *vs.* cesarean), breastfeeding, diet, antibiotic use, geographic location, and general lifestyle. The human gut contains generally Firmicutes, Bacteroidetes, Actinobacteria, and Proteobacteria phylum types of microbes. The gut microbiota changes quickly and diversifies during infancy with the addition of

solid meals and altered dieting behavior for a prolonged time. The gut microbiota stabilizes by age three and starts to look like the adult-like microbial profile. It's still vulnerable, though, to environmental factors all during life.[1,5] The inflammatory bowel disease, obesity, neuropsychiatric diseases and dysbiosis all disorders are due to an imbalance in the microbial community. Reduced microbial diversity and loss of good bacteria can compromise intestinal barrier function, cause chronic inflammation, and change neurotransmitter production all of which are mental health-related issues.[6,7]

Host metabolism and microbiota

In the human gut a vast and complex biological ecosystem system present with respect to other organism ecosystem. Including Senegal virus, planctomycetes, filamentous fungus, and viruses. The human gastrointestinal system usually contains more genes than the overall human genome. In the intestines of people and rodents, the gut microbiota modulated the expression of genes via various way and directly linked to immunology, nutritional absorption, energy metabolism, and intestinal barrier and blood brain barrier function. The host and the microbiota interact in mutually beneficial symbiotic relationships that guarantee a balanced ecosystem. Maintaining intestinal homeostasis and human health depends on the composition of the microbiota. Many functional bacteria groups working together in the gut microbiota produces vital vitamins and amino acids. Furthermore, the microbiota allows the use of normally indigestible dietary molecules by using several glycoside hydrolases and polysaccharide lyases. Intestinal epithelial cells' main energy source is gut bacteria's fermentation of saccharides. Complex polysaccharides and proteins are broken down by microbial depolymerization into mono- and oligomeric molecules, which are then fermented into short-chain fatty acids (SCFAs), carbon dioxide, and molecular hydrogen.[8-9.]

The Axis of Gut and Brain

There is a complex and bidirectional communication system between the central nervous system to the gastrointestinal system, the gut-brain axis this axis functions via various important channels:

a) **Neural Communication:** The vagus nerve is the main conduit for gut-to-brain information transfer. Signals from the gut microbiota can affect cognitive and emotional processes by means of modulation of neurotransmitter generation.

b) **Endocrine Signaling:** Stress reactions involve the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis activity can be changed by gut microbiota, which affects cortisol levels and stress resilience.

c) **Immune Modulation:** Gut bacteria control body wide immune responses and can affect brain inflammation by means of cytokine generation.[1,10]

d) **Neurotransmitter Production:** There was a confirmed information that Gut microbes can generate or promote the synthesis of very important signals that is known as neurotransmitters one of them is serotonin approximately 90% produced in the gut, second important is dopamine, and gamma-aminobutyric acid (GABA), all of these are important transmitters and connected to mood control and various cognitive performance.[11]

Neuroactive qualities belong to microbial metabolites including short-chain fatty acids (SCFAs), acetate, propionate, and butyrate. These SCFAs can affect gene expression, neuroinflammation, and neuroplasticity by crossing the blood-brain barrier.

Mental Health Disorders and Gut Microbiota

Sadness

Some study found that sadness and major depressive disorder (MDD) due to directly changes in gut flora of people.in that conditions the lesser the amount of beneficial microbes such as Lactobacillus and Bifidobacterium and higher levels of pro-inflammatory bacteria. Germ-free mice in animal models show depressive-like behaviors and increased stress reactions that are lessened when colonized with healthy donor microbiota. Interventional studies have indicated that probiotic use can lower depressive symptoms, probably by means of inflammatory marker modulation, neurotransmitter synthesis increase, and gut barrier integrity restoration. In a therapy, it was found that in depressed people, randomized controlled trials using multi-strain probiotics such as Lactobacillus helveticus and Bifidobacterium longum have shown notable changes in mood, anxiety, less uncomfortable and sleep quality.[12,13]

Anxiety

Anxiety is one of the common psychiatric and neurological disorders. Increasing research points a connection with gut microbiota dysbiosis. Studies on animals indicate that some bacterial strains can affect anxiety-like behaviour via, the vagus nerve and GABAergic pathways. Clinical studies on psychobiotics—probiotics with mental health advantages—have produced encouraging outcomes in people. Lactobacillus rhamnosus, for instance, has been linked to better emotional processing and lower anxiety.

Moreover, gut flora could affect anxiety by changing the HPA axis and affecting whole-body inflammation. Chronic stress can alter the makeup of the microbiota, so fueling a cycle that aggravates anxiety symptoms.[14,15]

Autism Spectrum Disorder (ASD)

Children with ASD often have gastrointestinal problems and show notable variations in gut microbiota composition when compared to neurotypical children. For example, lower levels of Bifidobacterium and Prevotella combined with higher Clostridium species counts have been seen. These changes in microorganisms could influence brain

development and social behavior by means of immune and metabolic pathways.

Early clinical studies indicate that treatments aimed at microbiota may help behavioral problems in ASD. One significant study looked at modified FMT, or microbiota transfer therapy, which produced long-term changes in GI and behavioral symptoms. Dietary changes like gluten-free or casein-free diets might also have an impact by means of gut microbiota alteration.[16,17]

Schizophrenia

A multifactorial etiology including genetic, environmental, and now microbial elements makes schizophrenia a complicated neuropsychiatric disease. Research indicate that those with schizophrenia have changed microbial diversity and composition, with higher Lactobacillus species and lower Bacteroides.

In a study, it was found that a Microbiota isolated from schizophrenia patients transplanted into germ-free and healthy mice has caused behavioral changes, mental disorders and changed neurotransmitter levels. These results highlight the possibility of gut microbiota to affect neurodevelopment and psychotic symptoms. Antipsychotic drugs might change gut flora, therefore complicating causal readings. But new dietary plans and probiotic-based therapies provide promise for adjunctive therapies.[18,19]

Therapeutic Interventions Aimed at Gut Microbiota

Prebiotics and Probiotics, live bacteria called probiotics have shown promise in changing brain function. Specific strains like some micobes such as Lactobacillus plantarum, Lactobacillus casei, and Bifidobacterium breve have been shown to reduce anxiety, tension and sadness in both animal and human studies. Probiotics might work by generating neuroactive chemicals, restoring gut barrier integrity, and lowering body-wide inflammation.[20,21] Non-digestible dietary components that encourage the development of good bacteria, such as inulin and galacto-oligosaccharides (GOS) have also been shown to be promising in improving cognitive function and lowering stress-related symptoms. Probiotic-prebiotic combinations (synbiotics) might work together. One of the most potent gut microbiota modulators is diet. Diets high in fiber, plant-based foods, omega-3 fatty acids, and polyphenols, mediterranean diet help to maintain a varied and balanced microbiome. Diets like these are linked to less anxiety and sadness. By contrast, Western diets rich in fructose and high fat in processed foods, and saturated fats are connected to gut dysbiosis and higher rates of psychiatric disorders. Foods that have been fermented include yogurt, kefir, kimchi, and sauerkraut all of which include live bacteria that could improve gut health and mental well-being. Fecal Microbiota Transplantation (FMT) FMT restores microbial diversity by moving stool from a healthy donor into the patient's gastrointestinal tract. Though mostly used to treat Clostridioides difficile infection, FMT is now being looked at in clinical trials for anxiety, depression, and ASD. Early findings imply that FMT might improve behavior by probably restoring a healthy microbial environment. Major obstacles in FMT research still are standardization, donor screening, and long-term safety. But developments in synthetic microbiota consortia could one day offer a more controlled and safer substitute.[22,23]

Future Directions and Challenges

There are various issues in the research of this field. Small sample sizes, diverse approaches, and confounding variables like diet, drugs, and lifestyle limit many studies. The intricate interaction between host and microbiota makes it challenging to determine causality. Longitudinal studies, individualized medicine strategies, and discovery of particular microbial biomarkers linked to mental health should be the emphasis of future studies. Next-generation probiotics and targeted microbial therapies are being developed with promise. Unraveling microbiota-host interactions at a mechanical level will depend on integrating omics technologies—metagenomics, metabolomics, and transcriptomic. Fully exploiting the clinical and therapeutic potential of the gut microbiome and use like a clinical practice will require more research and study in this field.

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