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# The Role of Gut Microbiota in Human Immunity and Metabolic Health: A Systematic Review

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| Article History | Abstract |
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| Received: 10th January, 2026 Accepted: 22th February, 2026 | The human gastrointestinal tract hosts trillions of microorganisms collectively known as the gut microbiota. These microbial communities play a fundamental role in regulating immune responses, metabolic pathways, and overall human health. Recent advances in metagenomic sequencing and microbiome research have revealed strong associations between gut microbiota composition and several chronic diseases, including obesity, diabetes, inflammatory bowel disease, and autoimmune disorders. This review synthesizes current literature to examine the relationship between gut microbiota and immune regulation, metabolic health, and disease prevention. It also discusses emerging therapeutic strategies such as probiotics, prebiotics, dietary interventions, and fecal microbiota transplantation. Understanding these complex interactions may provide new avenues for disease prevention and personalized medicine. |
| **Keywords:** Gut microbiota, immune system, metabolism, probiotics, microbiome | |

## 1. Introduction

The human body is colonized by a diverse microbial ecosystem that plays an essential role in physiological processes. Among these microbial communities, the gut microbiota has gained significant attention due to its influence on metabolism, immunity, and disease susceptibility. The human gut contains over 100 trillion microorganisms, primarily bacteria belonging to the phyla Firmicutes, Bacteroidetes, Actinobacteria, and Proteobacteria.

Over the past decade, advances in sequencing technologies have enabled researchers to characterize the complex interactions between host physiology and microbial populations. Studies have demonstrated that gut microbiota contribute to digestion, vitamin synthesis, immune system maturation, and protection against pathogenic organisms.

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Disruptions in gut microbial balance, commonly referred to as dysbiosis, have been linked to numerous diseases including metabolic syndrome, obesity, inflammatory bowel disease, and neurological disorders. Therefore, understanding the mechanisms through which gut microbiota influence human health has become a central focus of biomedical research.

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## 2. Gut Microbiota Composition

The composition of gut microbiota varies significantly among individuals and is influenced by several factors including genetics, diet, environment, antibiotic use, and age.

Firmicutes and Bacteroidetes represent the dominant bacterial phyla in the human gut. These microorganisms participate in the fermentation of dietary fibers and the production of short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate.

Short-chain fatty acids serve as energy sources for intestinal epithelial cells and play a role in maintaining intestinal barrier integrity. Additionally, these metabolites regulate inflammatory pathways and immune responses.

The diversity and stability of gut microbiota are essential for maintaining homeostasis. Reduced microbial diversity has been associated with increased risk of metabolic disorders and inflammatory diseases.

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## 3. Gut Microbiota and Immune System Regulation

The gut microbiota is a key regulator of the host immune system. Microbial signals interact with immune cells through pattern recognition receptors such as Toll-like receptors and nucleotide-binding oligomerization domain-like receptors.

These interactions stimulate the development and differentiation of immune cells including regulatory T cells, dendritic cells, and macrophages. Regulatory T cells help maintain immune tolerance and prevent excessive inflammatory responses.

Furthermore, microbial metabolites such as butyrate promote anti-inflammatory pathways by inhibiting histone deacetylases and regulating gene expression in immune cells.

Disruptions in these mechanisms may contribute to autoimmune diseases and chronic inflammatory conditions.

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## 4. Gut Microbiota and Metabolic Health

Recent research has highlighted the role of gut microbiota in metabolic regulation. Microbial communities influence energy balance by regulating nutrient absorption, lipid metabolism, and glucose homeostasis.

Studies have shown that individuals with obesity often exhibit an altered ratio of Firmicutes to Bacteroidetes. This imbalance may enhance the extraction of energy from dietary carbohydrates, contributing to weight gain.

Additionally, gut microbiota affect insulin sensitivity through the modulation of inflammatory pathways and metabolic signaling molecules.

Experimental studies in germ-free mice have demonstrated that transplantation of microbiota from obese donors can induce increased fat accumulation, suggesting a causal relationship between microbiota composition and metabolic phenotype.

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## 5. Therapeutic Strategies Targeting Gut Microbiota

### 5.1 Probiotics

Probiotics are live microorganisms that confer health benefits when administered in adequate amounts. Common probiotic strains include Lactobacillus and Bifidobacterium species. These bacteria help restore microbial balance and improve intestinal barrier function.

### 5.2 Prebiotics

Prebiotics are non-digestible food components that stimulate the growth of beneficial gut bacteria. Dietary fibers such as inulin and fructooligosaccharides serve as substrates for microbial fermentation and promote the production of short-chain fatty acids.

### 5.3 Dietary Interventions

Diet plays a crucial role in shaping gut microbiota composition. Diets rich in plant-based fibers, whole grains, fruits, and vegetables support microbial diversity and metabolic health.

### 5.4 Fecal Microbiota Transplantation

Fecal microbiota transplantation (FMT) involves transferring microbiota from a healthy donor to a patient with severe dysbiosis. FMT has shown promising results in treating recurrent *Clostridioides difficile* infections and is being investigated for other diseases.

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## 6. Future Perspectives

Although significant progress has been made in microbiome research, many questions remain unanswered. Future studies should focus on identifying specific microbial species responsible for beneficial or harmful effects. Advances in multi-omics technologies including metagenomics, metabolomics, and transcriptomics will help elucidate the complex interactions between host and microbiota.

Personalized microbiome-based therapies may emerge as a new frontier in precision medicine, enabling targeted interventions for metabolic and immune-related diseases.

## 7. Conclusion

The gut microbiota plays a critical role in maintaining human health by regulating immune responses, metabolic functions, and intestinal homeostasis. Dysbiosis has been associated with numerous diseases, highlighting the importance of maintaining microbial balance. Therapeutic approaches such as probiotics, dietary modifications, and fecal microbiota transplantation offer promising strategies for restoring healthy microbial ecosystems. Continued research in this field may lead to innovative treatments and improved understanding of the microbiome's role in human physiology.

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