Current Research in Diabetes & Obesity Journal
ISSN: 2476-1435

Juniper Publishers
key to the Researchers

Research Article
Volume 17 Issue 5 - December 2024
DOI: 10.19080/CRDOJ.2024.17.555971

Curr Res Diabetes Obes J

The Gut Microbiome: A Key Player in Obesity and Type 2 Diabetes - Mechanisms and Therapeutic Potential

Asif Ali[1]* and Farhana Farhad[2]

[1]*School of Pharmacy and Pharmaceutical Science, Ulster University, Coleraine, Northern Ireland, UK*

[2]*Hamdard Institute of Medical Sciences & Research (HIMSR), New Delhi, India*

Submission: September 05, 2024; **Published:** December 18, 2024

***Corresponding author:** Asif Ali, Centre for Diabetes, Ulster University, Cromore Road, Coleraine, Northern Ireland, BT52 1SA, UK

Abstract

Obesity and diabetes have emerged as global health crises, with their prevalence reaching epidemic proportions. With increasing food intake and sedentary lifestyles contributing significantly to the obesity epidemic, recent research has highlighted the critical role of gut microbiota in the development and progression of these metabolic disorders. The gut microbiome is increasingly recognized as a key player in obesity and diabetes through its involvement in food absorption, energy regulation, low-grade inflammation, and insulin resistance. This review paper explores the latest advancements in understanding the gut microbiota's role in the development of obesity and type 2 diabetes (T2D), also focusing on the therapeutic potential of modulating gut microbiota to mitigate the impacts of these metabolic diseases, elucidating the underlying mechanisms and implications for human health.

Keywords: Gut Microbiome; Obesity; T2D

Introduction

Obesity and its related conditions, particularly type 2 diabetes (T2D), have reached alarming levels globally. Poor diet and physical inactivity remain primary contributors to this epidemic [1]. Obesity, characterized by excessive fat accumulation, is not just a public health crisis but also an economic burden. The World Obesity Atlas 2023 projects that by 2035, nearly half of the global population will be overweight or obese, with related costs estimated to reach 3% of the global GDP [2]. This surge in obesity correlates closely with the increasing prevalence of T2D-a metabolic disorder characterized by insulin resistance and impaired glucose metabolism. The number of adults aged 20 to 79 with diabetes has more than doubled as per International Diabetes Federation (IDF), rising from approximately 151 million (4.6% of the world's population) in 2000 to 537 million (10.5%) in 2021. Without intervention, this figure is projected to escalate to 783 million by 2045 (IDF) [3]. While traditional explanations for obesity and diabetes focus on genetics, diet, and physical activity, emerging research highlights the gut microbiome's significant role in energy metabolism, inflammation, and weight regulation (Figure1) [4]. Dysbiosis, or imbalance of gut microbial communities, has been linked to obesity, insulin resistance, and chronic low-grade inflammation [5]. Key metabolites produced by gut microbes, such as short-chain fatty acids (SCFAs), are central to these processes [6]. This review examines recent advances in understanding the gut microbiota's role in obesity and diabetes and explores the potential of microbiome-based therapies to address these metabolic disorders.

The unhealthy gut microbiome plays an essential role in the development of obesity and diabetes

The human gut microbiota is shaped by a combination of genetics, diet, and environmental factors. Its composition is established early in life, influenced by birth method (vaginal delivery vs. Cesarean section) and infant feeding practices (breastfeeding vs. formula feeding) [7]. Throughout life, the gut microbiota continues to evolve, undergoing significant changes during diet transitions, aging, and exposure to environmental factors. This diverse microbial community primarily consists of bacteria, with key phyla including Firmicutes, Bacteroidetes,

Actinobacteria, Proteobacteria, and Verrucomicrobia [8]. Additionally, the gut ecosystem contains viruses (notably bacteriophages), fungi, archaea, and protozoa, albeit in smaller proportions [4,8].

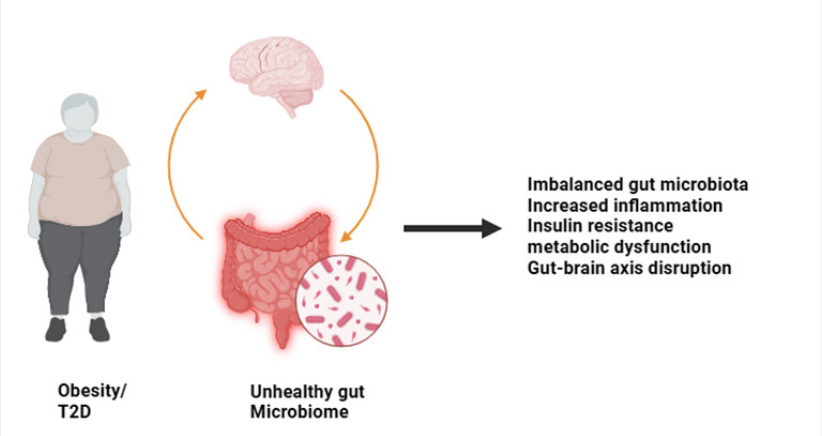

Figure 1: This image illustrates the relationship between obesity, T2D, and the unhealthy gut microbiome. The presence of obesity or T2D contributes to gut microbiome imbalance.

The gut microbiota plays a crucial role in host metabolism through various mechanisms: Gut microbes aid in the digestion and metabolism of dietary components that the human body cannot process alone, such as complex carbohydrates and fiber [4]. This process generates short-chain fatty acids (SCFAs), which serve as an energy source for the host and influence whole-body metabolism [6]. Certain microbial species, such as Roseburia, are capable of degrading complex polysaccharides into butyrate, a fermentation product that impacts human physiology and provides energy to colonocytes [4]. Gut microbiota-derived metabolites can cross the blood-brain barrier and influence neural circuits and neuroendocrine pathways involved in appetite control and energy expenditure [9]. The gut microbiome plays a crucial role in regulating inflammatory responses, with dysbiosis potentially contributing to chronic low-grade inflammation associated with obesity and diabetes [8].

Obesity, diabetes, and gut microbiome dysbiosis

Obesity is one of the 21st century's most pressing health challenges, driven largely by poor diet and physical inactivity [1]. The rise in obesity has led to a corresponding increase in T2D, characterized by insulin resistance and hyperglycaemia [1-3]. Despite extensive research on genetic and environmental factors, gaps remain in our understanding of these conditions. Recent studies have turned attention to the gut microbiome as a key player in obesity and T2D [10]. Gut bacteria influence energy extraction from food, immune response modulation, and fat storage. Dysbiosis, particularly an altered Firmicutes to Bacteroidetes ratio, has been associated with increased susceptibility to metabolic diseases [11]. The gut microbiota impacts host metabolism through fermentation, SCFA production, and interactions with the immune system [6].

Mechanisms linking gut microbiome to obesity and diabetes

The gut microbiome influences obesity and diabetes through several interconnected mechanisms [8,10]. Certain gut microbes can enhance energy extraction from the diet, leading to increased caloric absorption and fat storage [1]. Microbial dysbiosis can trigger chronic low-grade inflammation, which contributes to insulin resistance and the development of type 2 diabetes [12]. Alterations in the gut microbiome can compromise the intestinal barrier, leading to increased gut permeability and the translocation of bacterial endotoxins, further exacerbating inflammation and metabolic dysfunction [12]. The gut microbiome influences the gut-brain axis, affecting appetite regulation, food intake, and energy expenditure [9]. Gut microbes play a role in bile acid metabolism, which can impact glucose and lipid homeostasis.

Therapeutic potential of targeting the gut microbiome

The growing understanding of the gut microbiome's role in obesity and diabetes has opened new avenues for therapeutic interventions. Several approaches show promise in modulating the gut microbiome to improve metabolic health (Figure2).

Dietary Interventions

Non-digestible food ingredients that selectively stimulate the growth and/or activity of beneficial gut bacteria (Prebiotics). Live microorganisms that, when administered in adequate amounts, confer a health benefit to the host (Probiotics) [13]. Combinations

How to cite this article: Asif A, Farhana F. The Gut Microbiome: A Key Player in Obesity and Type 2 Diabetes - Mechanisms and Therapeutic Potential. Curre Res Diabetes & Obes J 2024; 17(5): 555971. DOI: 10.19080/CRDOJ.2024.17.555971

of prebiotics and probiotics that synergistically promote the growth of beneficial bacteria (Synbiotics). Fecal Microbiota Transplantation (FMT) involves the transfer of fecal material from a healthy donor to a recipient with the aim of restoring a healthy gut microbiome. While primarily used for treating recurrent Clostridioides difficile infections, FMT has shown potential in improving metabolic parameters in individuals with obesity and diabetes [13].

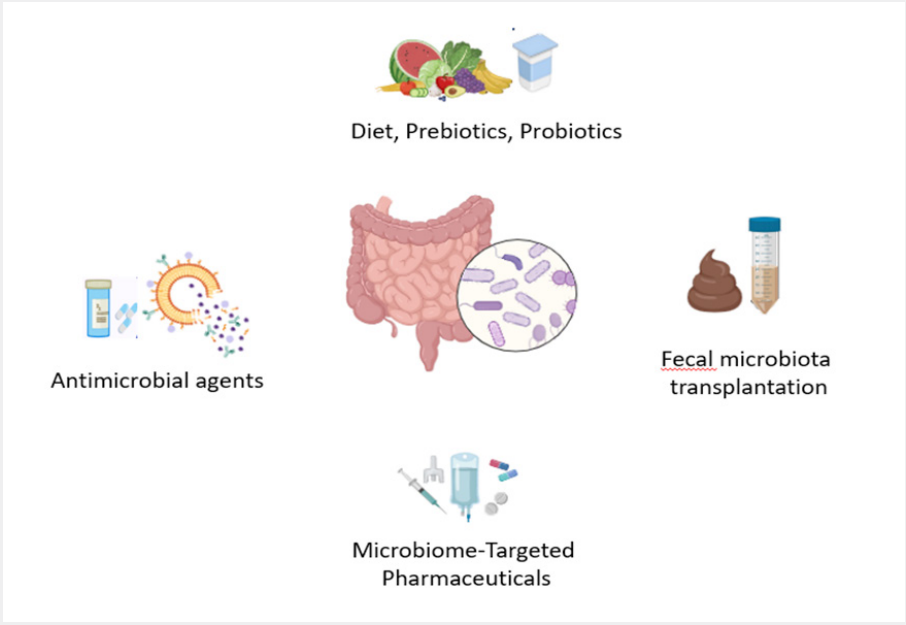

Figure 2: This figure illustrates various therapeutic approaches aimed at modulating the gut microbiome to improve metabolic health and combat obesity and type 2 diabetes.

Microbiome-Targeted Pharmaceuticals

Emerging research is focusing on developing drugs that target specific microbial species or metabolic pathways implicated in obesity and diabetes [4-6]. These may include selective antibiotics or bacteriophages to target harmful bacteria (antimicrobial agents). Beneficial compounds produced by gut microbes, such as SCFAs, which can be administered directly. Genetically modified bacteria designed to produce specific beneficial compounds or perform targeted functions in the gut [6].

Conclusion

The gut microbiome plays an essential role in the development of obesity and diabetes by influencing metabolic pathways, immune function, and inflammatory processes. While the exact mechanisms remain complex and not fully understood, recent advances highlight the importance of gut microbiota in regulating energy homeostasis, insulin sensitivity, and low-grade inflammation. Modulating the gut microbiome through dietary interventions, probiotics, prebiotics, and FMT offers promising therapeutic avenues to combat obesity and T2D. A deeper understanding of gut microbiota's role in metabolic disease will facilitate the development of targeted microbiome-based therapies to address these global health challenges. By leveraging the power of the gut microbiome, we may be able to develop more effective strategies to combat the global obesity and diabetes epidemics, ultimately improving health outcomes and quality of life for millions of individuals worldwide.

References

1. Ruze R, Liu T, Zou X, Song J, Chen Y, et al. (2023) Obesity and type 2 diabetes mellitus: connections in epidemiology, pathogenesis, and treatments. Front Endocrinol (Lausanne)21(14) :1161521.
2. Koliaki C, Dalamaga M, Liatis S (2023) Update on the Obesity Epidemic: After the Sudden Rise, Is the Upward Trajectory Beginning to Flatten? Curr Obes Rep 2023 Dec 12(4): 514-527.
3. Magliano DJ, Boyko EJ (2021) IDF Diabetes Atlas 10th edition scientific committee. IDF DIABETES ATLAS [Internet]. 10th ed. Brussels: International Diabetes Federation.
4. Tadese DA, Mwangi J, Luo L, Zhang H, Huang X, et al. (2024) The microbiome's influence on obesity: mechanisms and therapeutic potential. Sci China Life Sci.
5. Scheithauer TPM, Rampanelli E, Nieuwdorp M, Vallance BA, Verchere CB, et al. (2020) Gut Microbiota as a Trigger for Metabolic Inflammation in Obesity and Type 2 Diabetes. Front Immunol 16(11): 571731.
6. Baothman OA, Zamzami MA, Taher I, Abubaker J, Abu-Farha M (2016) The role of Gut Microbiota in the development of obesity and Diabetes. Lipids Health Dis 18(15): 108.

How to cite this article: Asif A, Farhana F. The Gut Microbiome: A Key Player in Obesity and Type 2 Diabetes - Mechanisms and Therapeutic Potential. Curre Res Diabetes & Obes J 2024; 17(5): 555971. DOI: 10.19080/CRDOJ.2024.17.555971

7. Catassi G, Aloi M, Giorgio V, Gasbarrini A, Cammarota G, et al. (2024) The Role of Diet and Nutritional Interventions for the Infant Gut Microbiome. Nutrients 16(3): 400.

8. Hou K, Wu ZX, Chen XY, Wang JQ, Zhang D, et al. (2022) Microbiota in health and diseases. Signal Transduct Target Ther 7(1): 135.

9. Wachsmuth HR, Weninger SN, Duca FA (2022) Role of the gut-brain axis in energy and glucose metabolism. Exp Mol Med 54(4): 377-392.

10. Crudele L, Gadaleta RM, Cariello M, Moschetta A (2023) Gut microbiota in the pathogenesis and therapeutic approaches of diabetes. EBioMedicine 97: 104821.

11. Magne F, Gotteland M, Gauthier L, Zazueta A, Pesoa S, et al. (2020) The Firmicutes/Bacteroidetes Ratio: A Relevant Marker of Gut Dysbiosis in Obese Patients? Nutrients 12(5): 1474.

12. Krajmalnik-Brown R, Ilhan ZE, Kang DW, DiBaise JK (2012) Effects of gut microbes on nutrient absorption and energy regulation. Nutr Clin Pract 27(2): 201-14.

13. Pandey KR, Naik SR, Vakil BV (2015) Probiotics, prebiotics and synbiotics- a review. J Food Sci Technol 52(12): 7577-7587.

DOI: 10.19080/CRDOJ.2024.17.555971

How to cite this article: Asif A, Farhana F. The Gut Microbiome: A Key Player in Obesity and Type 2 Diabetes - Mechanisms and Therapeutic Potential. Curre Res Diabetes & Obes J 2024; 17(5): 555971. DOI: 10.19080/CRDOJ.2024.17.555971