Role of Diet on Gut Microbiota

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Gut microbiota plays a significant role in the maintenance of physiological homeostasis, contributing to human health. Nevertheless, some factors (sex, age, lifestyle, physical activity, drug-based therapies, diet, etc.) affect its composition and functionality, linked to pathologies and immunological diseases. Concerning diet, it interacts with microorganisms, leading to beneficial or detrimental outcomes for the health of host and leads to a signature on gut microbiota.

Keywords: gut microbiota ; Mediterranean diet ; ketogenic diet

1. Introduction

Nowadays, in developed countries, men reach the age of 79 and women up to 84 years old. Thus, adults over the age of 65 are projected to represent 20–25% of the total population in Europe and the United States by 2030. Therefore, the population is aging, and modern societies must face this problem, worsened by the fact that elderly subjects often have pathologies associated with a series of comorbidities [1].

Having a healthy lifestyle is a goal that everyone should aim for; having a good sleep, a balanced and healthy diet, physical activity, free time to devote to hobbies, and living in healthy environments are some of the key factors to achieving a healthy lifestyle. An active lifestyle, including daily physical exercise, is considered an optimal method to preserve health in all stages of life. The reduction of body weight, counteraction of blood hypertension and dyslipidemia, or attenuation of insulin resistance are only some of the benefits to prevent undesirable events, such as cardiovascular problems and metabolic disorders [1]. On the other hand, a balanced diet providing the energy and nutrition researchers need is also crucial in promoting the well-being state. Both factors can influence the health of the human organism as they can influence the intestinal microbiota, defined as the “assemblage of living microorganisms presents in a defined environment” [2]. For example, Mika et al. [3] conducted a study on young rats who experienced physical activity voluntarily every day. The researchers observed that, thanks to physical exercise, rats developed a more advantageous microbial structure, with the expansion of some intestinal probiotic bacterial species. Furthermore, compared to the groups of sedentary rats, adults, and regularly active adults, young rats had: (i) changes in the qualitative composition of gut-microbiota, with a modulating effect on the taxa able to affect fat composition in the body; (ii) abundance of beneficial microbial species; (iii) increase in butyrate, which is linked to some epigenetic processes.

Diet, together with other environmental factors (work activity, socio-economic status, etc.), acts during a lifetime, affecting the type of the individual’s intestinal microbiota, which changes in relation to the different age and in relation to the characteristics of the individual [4]. Considering the growing interest towards “microbiota” topic, this article focuses on diet as a factor able to drive changes in the quali-quantitative composition of gut microbiota.

2. How Diet Affect Microbiota Composition

Several factors, such as genotype, sex, age, immune status, and various environmental factors, cause an inter-individual variability of human gut microbiota. Amongst these factors, dietary habits play a fundamental role in shaping the gut microbiota composition [5]. A famous sentence of Hippocrates is: “Let food be the medicine and medicine be the food” since he considered foods one of the main tools that doctors can use. Effectively, the main function of foods is to satisfy the hunger needs of each person; on the other hand, foods are also essential for sustaining human growth, reproduction, and health. Therefore, nutrient intake is important for the survival and well-being, but it is also crucial for modulating the symbiotic microbial communities living in the intestine, that is gut microbiota. Microbiota is composed of Bacteroidetes, Firmicutes, Proteobacteria, Actinobacteria, Verrucomicrobia, Cyanobacteria, and Fusobacteria, but Bacteroidetes and Firmicutes are the most abundant and their activity has been particularly studied [6].

The source, quality, and type of food shape gut microbiota, influencing its composition and function and impacting on host-microbes' interactions. In fact, gut microbiota composition is different between individuals, and, as reported by Leeming et al. [7], diet is responsible of at least 50% variability in mice and 20% in humans, thus stressing the importance of some dietary strategies to counteract diseases through positive quali-quantitative changes in gut microbiota. Therefore, it is essential to study how diet can impact on gut microbiota and which nutritional components can better shape it, promoting a healthy microbial community.

In the past, some researchers studied oral microbiota from skeleton teeth of people over the various epochs. The results showed that the most notable changes in human gut microbiota happened both during the transit from the hunter-gatherer paleolithic era to the farming neolithic era, characterized by diet rich in carbohydrates, and at the beginning of the industrialised period, whose main sign was a diet rich in processed flour and sugar [8]. Other studies focused on the changes resulting from the agricultural era. In fact, before the development of agriculture and animal farming, humans ate wild plants, animal meats, and minimally processed foods. Then, the initial domestication of plants and animals led to changes in the nutrient composition of these foods. In the pre-agricultural diet, foods as cereals, sugars and refined vegetable oils, dairy foods, alcohol, salt, and fatty domesticated meats did not exist. Nowadays, they represent the primary constituents of the post-agricultural, and typical Western diet [9]. The importance of some dietary constituents has been clearly reported by Yatsunenko et al. [10], who documented variations in gut microbiota between Americans and Africans. The United States population has mainly a low-fiber diet while African and South American people consume large quantities of plant-based polysaccharides. Comparing the gut microbiome of these populations, the authors observed that microbiota of United States population was far less diverse than African and South American people.

According to the foods researchers supply to the organism, different types of microorganisms are fed. This led to the identification of three intestinal microbiota models (or enterotypes), different for the most abundant microbial species present. Enterotype 1, which has *Bacteroides* as the most abundant genus, is typical of the industrialised countries where diet is based on high-fat diet and low fiber intake, and where refined and/or industrialised foods, red meats, and dairy products are consumed in large quantities. Enterotype 2, with *Prevotella* as one of the most abundant components, is typical of less industrialized countries where diet is generally based on the consumption of fibers rather than of meat and dairy products [11]. Finally, enterotype 3, with *Ruminococcus,* a mucin-degrading bacterium as the most important constituent, is the least common enterotype.

The prevalence of a specific enterotype depends also on long-term dietary habits, because high-fat and protein diet favours enterotypes 1 and 3, while a diet rich in carbohydrates supports the rise of enterotype 2, but short-term habits could also exert an effect.

David et al. [12] reported that gut microbiota can be modified by short-term dietary changes, but that these changes persist only for a few days. In fact, gut microbiota resists some external inputs, including extensive dietary changes, thus maintaining its own composition [7].

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