Prebiotics, Probiotics and personalized nutrition in modification of gut microbiota

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Abstract

The human gastrointestinal tract is colonized by trillions of microorganisms including bacteria, fungi, viruses and protozoa. The complexity and diversity of the gut microbiota have been recognized and even considered as a 'new organ'. The diversity of the gut microbes is strongly influenced by diet and dietary patterns. Recent studies highlight the impact of gut microbiota on the host's metabolism. Since, the gut microbial profile is unique to each individual, the interplay among the diet, gut microbiota and the host may play a role in health and disease. Dysbiosis of the gut microbiota is associated with disease. Many studies have shown the effects of prebiotics and probiotics on health. Probiotics have been considered as preventive and therapeutic measures and assist in restoring the healthy composition and function of the gut microbiota. Personalized nutrition approaches have been developed to provide healthy eating advice tailored to the nutritional needs of the individual. This review discusses the role of prebiotics, probiotics and personalized nutrition on human health.

Background

The gut microbiota consists of the trillions of microorganisms that inhabit our gastrointestinal tracts. These microbes are not simply commensal organisms, but instead serve as an important 'organ' that regulates the metabolic processes which include the digestion and absorption of nutrients, synthesis of vitamins and modulation of mucosal immunity. In addition to these processes, microbes produce toxins and carcinogens [1, 2]. The gut microbial profile is unique to each individual, evolving over the lifetime. It can be altered by internal and external factors, especially the food and dietary patterns. Prebiotics are substrates that are selectively used by host microorganisms conferring a health benefit. Probiotics are live microorganisms (bacteria and yeasts) that are administered in a viable form in adequate amounts. Probiotics are beneficial to human health. Synbiotics contain a mixture of prebiotics and probiotics [3,4].

It is essential to recognize the interplay among the diet, gut microbiota and the host. Developing dietary interventions based on one's profile to optimize gut microbial composition is an important practice for personalized nutrition. So, that personalized nutrition is an approach that "assists individuals in achieving a lasting dietary behavior change that is beneficial for health" [5].

Specifically, understanding which nutrients can increase the beneficial bacteria and which can suppress the harmful bacteria, is mandatory in order to formulate dietary regimens and food products. These products can be used to normalize gut microbial composition. Host - gut microbiota interconnection

through personalized nutrition is a new therapeutic area for both disease control and prevention. In this review, the role of prebiotics, probiotics on human health and strengths and weaknesses of personal nutrition will be discussed.

The gut microbiota in health

The gut microbiota is a complex and diverse collection of microorganisms which when compared to the other body sites, has a very high density of microorganisms. More than 90% of the microbes belong to the phyla Firmicutes, Bacteroidetes, while other groups Actinobacteria, Fusobacteria, Proteobacteria, Verrucomicrobia and Cyanobacteria are also reported [6]. The microbial diversity varies depending on the metabolic function and microenvironment of the various parts of the GIT tract. Seven main bacterial phyla are considered as the main residents of the gut and contribute to a diversity of functions. Rajilic-Stojanovic M and de Vos WM 2014 suggested the presence of more than 160 species of bacteria in the large intestine alone [7]. The microbiota plays a major role in food digestion, for example in the colon the microbiota helps the host to conserve energy by assisting the carbohydrate digestion. Production of short chain fatty acids (SCFA) by the microbiota specially in the colon as a result in carbohydrate digestion, has many benefits for the host as well as providing the required carbon and energy source for some resident microbial species. The microbial action contributes to digestion of food components that would otherwise not be digestible by the human digestive system. The contribution of gut microbes to maintain health is also important because of their role in prevention of colonization by pathogens and modulating and stimulating the immune system. When moving deeper towards the large and small intestine, the focus of digestion will be on proteins and fermentation of amino acids which also can release SCFAs but also other compounds that may lead to illnesses such as gut inflammation, IBD and cancer [8]. The ratio of Firmicutes and Bacteroidetes are important in maintaining health.

Recent studies have suggested a wider role in the gut microbiota in human health. For example, the gut brain axes can be regulated by neurotransmitters produced by gut microbes. Thus, gut microbiota can produce serotonin and dopamine which is responsible for controlling the mood of the host [9].

Prebiotics and dietary fibers

A prebiotic is defined as "a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon" by Gibson and Roberfroid in 1995 [3]. Later in 2016, the definition of prebiotic was modified as "a substrate that is selectively utilized by host microorganisms conferring health benefit" [10]. Prebiotics include human milk oligosaccharides, inulin, fructo-oligosaccharides, and galacto-oligosaccharides and also noncarbohydrates may act as prebiotics [11]. Venkataraman et al in 2016, had shown that consuming resistant starches has been linked to enrich specific bacterial groups (Bifidobacterium adolescentis, Ruminococcus bromii, and Eubacterium rectale) in some people [12]. It has been found that low fiber intake reduces production of small chain fatty acids and shifts the gastrointestinal microbiota metabolism to use less favorable nutrients. It has been observed that this has led to the production of potentially detrimental metabolites [13].

According to two studies conducted in 2015 and 2017, low fiber western diet

degrades the colonic mucus barrier, causing microbiota encroachment, which results in pathogen susceptibility and inflammation [14,15]. This finding suggests a potential mechanism for the links of western diet with chronic diseases. In a recent study it has been shown that the detrimental effects of high fat diets on penetrability of the mucus layer and metabolic functions could be prevented through dietary administration of inulin [16]. Available findings alone with the role of butyrate prevent oxygen induced gut microbiota dysbiosis. Therefore, this provides a strong rationale to enrich dietary fiber consumption to maintain intact mucosal barrier function in the gut [17]. Clinical trials using prebiotics like arabinoxylan and inulin-type fructans have shown positive results in diabetic, overweight and obese populations [18].

Probiotics

Probiotic is "a preparation of, or a product containing viable, defined microorganisms in sufficient numbers, which alter the microflora (by implantation or colonization) in a compartment of the host and by that exert beneficial health effects on the host" [4]. Mostly Bifidobacterium and

Lactobacillus species are included in a variety of products, including foods, dietary supplements or drugs. Probiotics can affect health independently of the gut microbiota through direct effects on the host. It is led through immune modulation or the production of bioactive compounds. The effects of probiotic supplementation have been studied in a broad range of diseases. Substantial evidence is available for beneficial effects of probiotic supplementation in different disease conditions such as diarrhoea, necrotising enterocolitis, acute upper respiratory tract infections, pulmonary exacerbations in children with cystic fibrosis and eczema in children [19,20, 21 & 22]. Further, Probiotics can improve cardiometabolic parameters and reduce serum concentration of C reactive protein in patients with type 2 diabetes [23].

Through a cascade of immunological reactions, probiotics mimics the tolerance induced by commensal organisms and contrasts with the inflammatory response to pathogens. Use of newer microbes and combinations, combining probiotics and prebiotics (synbiotic refers to the combination of a prebiotic with a probiotic) have been identified as emerging areas of probiotic treatment.

Personalized nutrition

Gut microbiota between people shows vast diversity. Personalized nutrition approaches aim to identify key microbiome features that predict the response to particular food components, which can then inform the design of a diet leading to favourable outcomes. Many studies have been shown that variations in dietary macronutrients, including fat, protein and carbohydrates, lead to significant alterations in the human gut microbiota [24 & 25]. Extreme changes during the short time period of a diet are necessary to alter the gut microbiome. Animal based food or plant products consumed, or the fat content or fiber content of the diet may be entirely changed within a few days [25]. However, in addition diet, personalized gut microbiota composition is affected by many other factors, such as gastric diseases, age, sex, medications and ethnicity. Composition of the gut microbiota is strongly influenced by dietary fat intake, and also has an impact on the host's metabolism as well. A study done on mice models found that high saturated fat and low fiber diet results in reduction in Bacteroidetes and an increase in Firmicutes

and Proteobacteria [26]. In humans, a high consumption of dietary fat including saturated fatty acids is associated with reduced gut microbial diversity. Similarly, protein content of the diet affects the gut microbial diversity, species composition and abundance, in a significant way. In humans, Bacteroides enterotype found to be associated with a long-term animal protein-rich diet [27].

In 2014 Korpela K et al showed that some obese individuals gain health benefits from a very simple and easily managed dietary change, while others show no or even adverse responses [28]. However, No personalized nutrition study has been carried out at a large scale, in an appropriate population group and over a sufficiently long time to show result in better health and wellbeing. Whether the personalized nutrition is feasible, sustainable and has a positive effect on clinical outcomes than conventional approaches is to be investigated.

Conclusion

Probiotics, prebiotics and combinations have been found to be clinically effective for disorders like IBD, digestion, travelers' diarrhea, and for improving/helping to maintain general health. Personalized nutrition is a new therapeutic approach for both disease control and prevention.

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