What is The Role of Gut Bacteria in Human Health?

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It has been long known that microorganisms in the human gut play an important role in digestive health. However, more recent research indicates that gut bacteria may relate to wider aspects of health, including obesity and metabolic health.

Microorganisms in the human body

Microorganisms inhabit various sites of the human body, including the skin, nose, mouth and the gut. In particular the human gut is home to an enormous number of microorganisms, approximately 100 trillion bacteria cells, outnumbering human cells by an estimated 10 fold.[1] The microorganisms present in the gut are mainly bacteria and belong to more than 1,000 species, 90% of which belong to Firmicutes and Bacteroidetes.[2,3] Each person has a distinct and highly variable composition of gut microbes, although a core set of microorganisms are common to all individuals.[2,4] The composition of the gut microorganisms is called the gut 'microbiota', whereas the totality of the genes of the microbiota is called the 'microbiome'. The genes of the gut microbiome outnumber the genes of the human body by approximately 150-fold.[1]

What influences the gut microbiota?

The human microbiota is established in early life – the foetus in the womb is sterile and exposure to microorganisms starts with birth, e.g. during passage through the birth canal and/or exposure to microbes present in the environment. Babies that are born by Caesarean have a different gut microbiota, which has been suggested to be less favourable and has been suggested to be associated with increased risk of disease, and increased risk of overweight and obesity in later life, compared to those delivered vaginally.[5] Although the microbiota is established in early life, it can shift throughout life with changes in age, diet, geographical location, intake of food supplements and drugs, and other environmental influences.[6] Excess body fat and disease are also associated with an altered gut microbiota.

Diet from early life, including whether an infant is breastfed or formula-fed, is known to modulate the composition of the gut microbiota in humans, and it is thought that long-term dietary habits have a considerable effect, explaining some of the geographical differences.[2] This is because components of the diet, for example dietary fibre, are broken down by bacterial fermentation and used as fuel. Eating increased levels of certain food components can boost the number of bacteria that use these specific components as fuel, which means that changes in dietary composition can lead to changes in the composition of the gut microbiota. The macronutrient composition (i.e. the proportion of protein, carbohydrate and fat) of the diet seems to have an influence, and any changes in the diet are likely to lead to a shift in the gut microbiota.[2] Research is still ongoing as to how diet interacts with the microbiota.

The gut microbiota and health

Most research on the human microbiota focuses on the microorganisms in the gut, as they are thought to influence health in various ways. It has been documented that people, who suffer from certain diseases (e.g. inflammatory bowel disease, irritable bowel disease, allergy) have a microbiota that is different to that of healthy people, although in most cases it is impossible to say if the altered microbiota is a cause or a consequence of the disease. The patterns of a gut microbiota that are associated with health are, however, more difficult to define.[6] The composition of the gut microbiota is highly variable even between healthy subjects. Researchers have found that even though the composition varies between individuals, different compositions can have similar functions (e.g. how microorganisms break down certain compounds in the diet or how they affect the body's immune system). It has therefore been suggested that the function of the gut microbiota, rather than the composition, is more important for health.[6]

The microorganisms present in the gut play a crucial role in digestive health, but also influence the immune system. Immune tissues in the gastrointestinal tract constitute the largest and most complex fraction of the human immune system. The intestinal mucosa is a large surface lining the intestine and is exposed to pathogenic (disease-causing) and non-pathogenic environmental antigens (substances that trigger the immune system to produce antibodies). In the gut lumen, the microorganisms play a critical role in the development of a robust and balanced immune system.[3] Alterations in an individual's gut microbiota, which can happen when taking certain antibiotics for example, can increase the risk of infections with opportunistic pathogens such as Clostridium difficile.[6]

In recent years researchers have established a link between the gut microbiota and body weight. Although much of the research is still in its early stages, studies have revealed that people with obesity tend to have a somewhat different composition of gut bacteria compared to lean individuals.[7,8,4] Whether the altered microbiota composition is a cause or consequence of obesity is currently unknown. Studies show that the composition of the gut microbiota shifts with weight loss and/or weight gain; however, the significance of such changes for human health are still debated.[8] Some researchers have suggested that the microbiota of people with obesity may help the body increase the amount of energy that is 'harvested' from food, suggesting that certain structures of gut microbiota may increase the likelihood of having obesity.[2,4] However, this theory is still debated and more studies are needed to investigate if this hypothesis holds true. Much of the evidence on the association between the gut flora and risk of obesity so far comes from animal studies. Findings from animal studies indicate that the microbiota of a person with obesity (i.e. certain compositions of the microbiota found in people with obesity) can lead to excessive weight and unfavourable metabolic changes when it is transferred to sterile lean mice.[2,4] Although animal models provide interesting insights, no direct conclusions can be drawn about such associations in humans. This area of research is fairly new and more studies, in particular in humans, are needed to understand how and to what extent the composition of microorganisms in the gut influences various metabolic functions in the body.

Probiotics and prebiotics

Probiotics are defined as live microorganisms, which, when administered in adequate amounts, may confer a health benefit. Numerous types of probiotics have been studied. There is some evidence that certain probiotics are effective in improving symptoms of irritable bowel syndrome, ulcerative colitis (a form of

inflammatory bowel disease), and infectious disease, as well as reducing the risk of developing eczema and other allergic conditions.[9,10]

Also healthy individuals may benefit from taking probiotics – there is some evidence suggesting that probiotics can reduce the risk of infectious diseases, including upper respiratory tract infections, in healthy populations.[9] Any effect of a probiotic is generally specific to the strain of a probiotic bacteria used. This means that if an effect of one probiotic strain is found, no conclusions about the possible effects of other probiotic strains can be made.[10] Whereas there is a good amount of evidence supporting a positive effect of specific probiotic strains on certain conditions, such as Clostridium difficile infections and ulcerative colitis, for other health issues, evidence is still inconclusive and more studies will be needed to confirm benefits of probiotics, in particular in healthy people. The European Food Safety Authority, which provides scientific advice to the European Commission, has so far rejected any health claims for use on food products that suggest that healthy individuals benefit from taking probiotics. More research is underway, using newer technologies and specific biomarkers that may help understand whether or how individuals may benefit from the use of probiotics.

Although it remains unclear how exactly probiotics act on health, it has been suggested that probiotics may have the potential to affect the function, more than the composition, of the microbiota.[6,9] If this is the case, consuming probiotics could have an effect on health even when there is no change in the composition of the gut microbiota.[6]

Prebiotics

Prebiotics are nondigestible food components that are selectively used by gut bacteria for fermentation. This means that bacteria associated with beneficial health outcomes can be specifically targeted. There is good evidence that prebiotics can induce changes in the gut microbiota, but it is still unclear exactly how the use of prebiotics can alter the composition and function of the gut microbiota, how stable these changes are, and what any changes in the microbiota mean for human health – this will need to be investigated further.[6]

Effects of antibiotics on the gut microbiota

Taking antibiotics can lead to disturbances of the gut microbiota. This is because of their differential effect on different types of bacteria in the gut; specific bacteria are particularly susceptible, or resistant, to the antibiotic in question.[6] This can lead to antibiotic-associated diarrhoea, and in the hospital setting can increase the risk of a more severe form of diarrhoea caused by the pathogen Clostridium difficile. The impact of antibiotics is usually short-term, but disturbances of the gut microbiota for extended periods of times have been documented as well.[6] There is evidence that taking probiotics during antibiotic treatment can reduce the risk of developing antibiotic-associated diarrhoea.[11]

Conclusion

The microorganisms present in the human gut are without doubt crucial for human health. Exactly how, to what extent, and what areas of human health are influenced by our “inhabitants” is yet to be established, as is the evidence on how the composition and/or function of the microbiota could be manipulated to achieve specific health benefits.