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Influence of Diet on the Microbiome

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Target audience: For healthcare professionals interested in learning about the influence of diet on the gut microbiome

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Learning Outcomes

By the end of this activity, participants should be able to:

1. Describe how various dietary components alter microbiota
2. Understand the impact of dietary patterns on the microbiome
3. Understand the role fermented foods play in gut health
4. Understand the links between dietary choices, changes in the microbiome and potential health impact

Introduction

There is a growing body of research investigating the impact of diet on the microbiome and its subsequent impact on health. A healthy microbiome is often measured by microbial diversity (1). Specifically, this refers to the range of different microbiota (bacteria, viruses and fungi) present within the microbiome. A richer and more diverse microbiome is associated with good health (2).

The influence of diet on the microbiome is evident from the beginning of life (3). Early dietary influences such as infant feeding mode (breast fed or formula-fed) helps to establish the gut microbiota (4). Microbial diversity in the infant gut is initially low and increases during development. The microbiome shifts to its adult-like pattern within the first three years after birth (5).

In adults, cross sectional studies have shown that microbiota composition is strongly associated with long-term dietary habits (6). Additionally, a parallel arm study showed that short-term dietary habits, (e.g. switching from a plant-based, high-fibre diet (> 30 grams/day) to a low-fibre, meat-based diet), have been shown to alter microbial composition within 24 to 48 hours (7). This article explores dietary factors which influence the microbiome.

Specific Nutrients and Their Effects on the Microbiome

Studies have demonstrated that different food components, especially macronutrients, alter the diversity and/or composition of the microbiome. Further research is required to determine the effects of micronutrients on the microbiome (1).

Carbohydrates

Carbohydrates such as dietary fibre, resistant starches (RS), non-starch polysaccharides and oligosaccharides pass largely undigested to the large intestine, where they serve as a major source of fuel for microbiota. They are termed "microbiota accessible carbohydrates" (MACs) and food sources include fruits, vegetables, pulses, and wholegrains such as oats and barley.

Fermentation of MACs by gut microbiota leads to the production of short-chain fatty acids (SCFAs) such as butyrate, acetate, and propionate (8). SCFAs have a key role in health and greater production of SCFAs is associated with lower risk of conditions such as type 2 diabetes, chronic kidney disease, and cardiovascular diseases (9, 10).

Both short- and long-term changes in carbohydrate consumption can result in changes to the microbiome (11). Diets low in MACs result in reduced bacterial diversity, increased levels of bacteria associated with negative outcomes (12) and reductions in beneficial SCFA-producing bacterial species.

Fibre and Prebiotics

Fibre is associated with many gut health benefits, including reduced risk of bowel cancer. In the UK, the government recommends that healthy adults consume at least 30g fibre per day (13). A 2018 systematic review (14) showed that dietary fibre interventions, particularly those involving fructans and galacto-oligosaccharides, leads to higher faecal abundance of beneficial *Bifidobacterium* and *Lactobacillus*. Conversely, long-term adherence to a lower-fibre diet (12-15g/day) results in reduced microbial diversity (15, 16).

However, beneficial responses to increasing dietary fibre may be dependent on pre-existing microbiota (17). So, if individuals are used to consuming a diverse and balanced diet which is high in fibre, increasing their fibre intake may have little effect on the microbiota. Further research is required to better understand the role of individual types of fibres on the microbiome and gut health.

Prebiotic fibres are found in plant-based foods such as fruits, vegetables, wholegrains, nuts, and seeds. They are non-digestible substrates which are selectively utilised by host microorganisms to confer health benefits. When included in the diet, these also favour the growth of beneficial bacterial strains (such as SCFA-producing *Bifidobacteria*) (18).

Protein

The effects of proteins on gut microbiota composition vary according to the protein type (19). Diets high in plant-based protein (7, 20) can increase beneficial *Bifidobacterium* and *Lactobacillus*, while decreasing pathogenic strains such as *Bacteroides fragilis* and *Clostridium perfringens*. These shifts are associated with higher levels of SCFAs and potential health benefits. The consumption of animal-based protein, (i.e. red meat and dairy products) may lead to an increase in bacterial species such as *Bacteroides*, *Alistipes*, and *Bilophila*. These cause an increase of trimethylamine N-oxide (TMAO), a pro-atherogenic compound linked to cardiovascular diseases (21).

Fats

Similarly, the quality and type of dietary fat determines its influence on the microbiome (22). A recent study examined the effect of consuming different types of fats in 88 subjects at risk for metabolic syndrome (23). They found that diets high in saturated fats led to reduced numbers of beneficial bacteria, while a diet high in monounsaturated fats did not alter the microbiome. Furthermore, a cross-sectional study of 876 women demonstrated that polyunsaturated fats were associated with an increase in microbial diversity (24). However, further interventional studies are required with a longer intervention phase to fully determine the effects of dietary fats on the microbiome (25).

Fermented Foods

A recent longitudinal study (26) has found an association between consumption of fermented foods and slight changes in the gut microbiome and metabolome when compared with people who don't eat fermented foods. The researchers analysed stool samples from 6,811 individuals from the American Gut Project and recorded their consumption of fermented foods. The main fermented foods consumed included fermented dairy products (i.e. yoghurt, kefir), sauerkraut, kimchi, pickled vegetables, kombucha and beer.

There were subtle but statistically significant differences in the diversity and species of microorganisms between consumers and non-consumers. Additionally, consumers of fermented foods had an abundance of a chemical called conjugated linoleic acid (CLA), which is thought to have health benefits. Although these findings are exciting, it is important to remember that observational studies can, at best, suggest an association between two variables.

Probiotics

Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (27). Probiotics (commonly *Bifidobacterium* and *Lactobacillus* species) can be included in a variety of products, including medications, fermented milk or yoghurt, and water-based food supplements.

Probiotics can colonise the gut, depending on the baseline microbiota, probiotic strain, and gastrointestinal tract region (3). Increases in beneficial gut bacterial load of *Bifidobacterium* and/or *Lactobacilli* have been seen following the administration of several different types of probiotics. Probiotic-containing yoghurt has also been shown to significantly reduce counts of the harmful bacteria such as *Helicobacter pylori* (28).

However, not all studies have demonstrated associations of altered microbiota following treatment with probiotics. Two studies found individual differences in response to probiotic supplements, suggesting that some individuals may be resistant to effects (29, 30). The effects of probiotics can be individual and specific to certain probiotic species and strains, therefore recommendations for their use should be strain-specific and personalised (31).

Dietary Patterns

When considering dietary patterns, diversity appears to be key. The more diverse the diet, the more diverse the microbiome, which may confer health benefits (32). Globally, dietary patterns and their effects on the microbiome differ significantly between countries (6). For example, Western diets (typically high in saturated fats, refined carbohydrates and animal proteins and low in fibre) have been associated with significantly lower microbial diversity and number of bacterial species. A well-known study (33) compared the faecal microbiota of European children with children from a rural African village called Burkina Faso (BF). The European children typically consumed a Western diet whereas the children from BF consumed high-fibre diets which were low in animal proteins.

There were significant differences in the microbiota between the two groups. The microbiome of the children from BF showed a greater richness and variety and produced more of the beneficial SCFA butyrate compared to the European children. Additionally, there were fewer pathogenic bacteria (such as *Escherichia, Salmonella, Shigella,* and *Klebsiella*) found in the intestinal tracts of children in BF compared with the European children.

The Mediterranean diet (MD) is another dietary pattern thought to have beneficial effects on gut health and the microbiome. The MD is high in fruits and vegetables, pulses and legumes, nuts and seeds and olive oil and fish. It contains moderate to low amounts of red meat, dairy products and saturated fats. This dietary pattern has been associated with an increase in beneficial bacterial species such as *Lactobacillus*, *Bifidobacterium*, and *Prevotella*, as well as decreased levels of pathogenic *Clostridium*. A recent study demonstrated that out of 153 participants, those following a MD had increased levels of beneficial SCFAs (34). A further study involving 612 people across five countries demonstrated positive changes in the microbiota following a one-year MD intervention (35).

When comparing plant-based diets with omnivorous diets, observational data suggests that there are differences in microbiota (36). As mentioned above, diets high in plant-based protein have been shown to increase beneficial *Bifidobacterium* and *Lactobacillus*, while decreasing potentially pathogenic species (37).

Summary

- Dietary manipulation of the microbiome is an exciting and evolving area of scientific research. Further studies are required to fully understand the impact of fermented foods and probiotics on the gut microbiome in health and disease.
- Consuming a diverse and varied diet which is predominantly based on plant foods is known to be beneficial for the microbiome and gut health.
- Encouraging a high-fibre diet (aiming for >30g/day) which contains fruits and vegetables, wholegrains, beans and pulses and nuts and seeds is recommended by the UK government.

Questions

1) In the UK, the recommended daily amount of fibre is:

- a. 18g/day
- b. 25g/day
- c. 30g/day

2) Low fibre diets have been associated with:

- a. Higher amounts of *Bifidobacterium* and *Lactobacillus*
- b. Reduced microbial diversity
- c. Higher production of SCFA

3) Prebiotics:

- a. Favour the growth of beneficial bacteria
- b. Are supplements which contain bacteria
- c. Do not survive transit in the gut

4) When recommending probiotics, healthcare professionals should:

- a. State that only tablet form has been found to be effective
- b. Recommend that probiotics are taken indefinitely
- c. Use an individual approach when making recommendations

5) Dietary patterns associated with a more diverse microbiome include:

- a. Paleo Diet
- b. Mediterranean Diet
- c. Low Carbohydrate Diet

6) Protein and Fats do not affect the microbiome?

- a. True
- b. False

Answers the on the last page

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Answers

1. C
2. B
3. A
4. C
5. B
6. B