

Prebiotic Beyond Immunity: Benefits on Children's Physical and Cognitive Growth

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ABSTRACT: Prebiotics have long been known to play an important role in supporting the immune system, especially in children. However, recent research shows that the benefits of prebiotics are not limited to increasing immunity. Prebiotics also have a positive impact on children's physical and cognitive growth. This study aims to identify and analyze the benefits of prebiotics on children's physical growth and cognitive development. This study uses a qualitative research method. The data collection technique in this study was through literature studies. The data that has been collected was then analyzed in three stages, namely data reduction, data presentation and drawing conclusions. Research shows that prebiotics play a role in supporting children's physical growth by improving nutrient absorption and supporting healthy bone development. In addition, prebiotics also have an important role in improving cognitive function. The relationship between gut health and the brain is increasingly recognized, with recent research stating that the condition of the gut microbiota can affect cognitive health. Beneficial bacteria that receive prebiotic intake can produce compounds that can cross the blood-brain barrier, affecting cognitive functions such as memory, learning, and concentration.

Keywords- Prebiotics, Physical Growth, Cognitive Growth, Children

INTRODUCTION

Prebiotics, which are now redefined as substrates selectively utilized by host microorganisms that confer health benefits, are currently dominated by low molecular weight carbohydrates, such as fructooligosaccharides and galactooligosaccharides (Darma et al., 2024). Health benefits are obtained through their ability to change the composition or activity of the gut microbiota through the fermentation process. The main requirement for a prebiotic component is that it cannot be digested by digestive enzymes, but can be fermented by the beneficial bacteria in the colon, such as Bifidobacterium and

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Lactobacillus. Examples of prebiotics include inulin, fructo-oligosaccharides (FOS), and (trans)-galacto-oligosaccharides (GOS) (Roberfroid et al., 2010).

Prebiotics also have the ability to change the intestinal environment. As previously mentioned, prebiotic fermentation products are mostly acidic, which causes a decrease in pH in the intestine. Research shows that changing the intestinal pH from 6.5 to 5.5 can play a role in modifying the composition and population of the intestinal microbiota. These pH changes can affect acid-sensitive species, such as Bacteroides, and promote the formation of butyrate by Firmicutes bacteria. This process is known as the butyrogenic effect (Davani-Davari et al., 2019)

A well-functioning immune system is essential to protect children from a variety of pathogens. Along with other body systems, the immune system must develop optimally from an early age to be able to carry out this role. The proper development and function of the immune system is greatly influenced by the interaction between the immune system and the microbiota in the digestive tract (Dewi et al., 2024). Prebiotics are widely known for their ability to strengthen the immune system.

Pediatricians in Indonesia believe that the balance of gut microbiota plays an important role in supporting the immunity, growth, and development of premature babies. Breast milk is considered the most ideal nutrition for premature babies because it can help optimize the balance of gut microbiota. However, formula milk containing prebiotic supplements can be considered as an alternative to support infant health if breastfeeding is not possible (Sitorus et al., 2021).

Prebiotics can improve the immune system through several mechanisms. First, prebiotics support mucosal immunity by strengthening the protective layer of the intestinal wall, preventing the entry of pathogens. In addition, prebiotics help regulate immune cell function, especially by increasing the activity of cells that play a role in the body's defense. They also promote a balanced immune response, ensuring that the immune system does not overreact to threats. Prebiotics play a role in controlling inflammation, keeping inflammation from becoming chronic, and helping to reduce susceptibility to infections and reduce their severity when they do occur (Hardy et al., 2013). However, in addition to these benefits, prebiotics also have a variety of additional functions that are important for health, including children's physical and cognitive development.

The immune system and the nervous system are two major regulators of homeostasis in the body that communicate and depend on each other to ensure normal organism function. Components of the immune system, especially microglia, play a critical role in the development and activity of the nervous

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system. Microglia are known to continuously monitor synapses in the central nervous system parenchyma and influence its development from an early age. Thus, a well-functioning immune system in children is essential to support the development of cognitive function and neurogenesis (Kartjito et al., 2023).

This study adds to the literature on the role of prebiotics not only in supporting the immune system, but also in aspects of physical growth and cognitive development in children. In addition, the results of this study encourage other researchers to further explore the mechanisms of action of prebiotics and how they can be optimized to support children's growth and development. This study aims to identify and analyze the benefits of prebiotics on children's physical growth and cognitive development.

RESEARCH METHODS

This study uses a qualitative research method. Qualitative research methods are approaches used to understand social phenomena and human behavior in a more in-depth and holistic way. This method focuses on collecting non-numerical data, such as words, images, and narratives, to explore the meaning and experiences of individuals or groups (Kusumastuti & Khorion, 2019). The data collection technique in this study was through literature studies by exploring journals, books and other information relevant to the research obtained from Google Scholar. The data that has been collected is then analyzed in three stages, namely data reduction, data presentation and drawing conclusions.

DISCUSSION

Children play an important role in society as they define the next generation, so their physical and cognitive growth is the main focus. Childhood, which lasts between the ages of 2 to 6 years, is a significant phase of development. In this stage, a child's physical development includes growth in weight, height, and strength, which supports physical activity and exploration of the environment without adult assistance (Murni, 2017). In physical growth, children are more active in playing and learning, developing fine and gross motor skills. In addition, this physical development also contributes to children's self-confidence, as they begin to feel new abilities and independence when interacting with the world around them.

Then in addition to physical growth, at the age of children, children's cognitive development also begins to progress. The child's brain begins to develop the ability to think, learn and remember. Cognition includes the ability to acquire, compile, and use knowledge, and involves various mental behaviors, such

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as understanding information, solving problems, and strengthening beliefs (Hasugian et al., 2024). Development during this period is often marked by a child's entry into the first grade of elementary school, signaling the end of the preschool period and the opening of a new chapter in a child's education.

To support children's physical and cognitive growth, the role of food intake is very important (A. Bassuoni et al., 2020). Food consumed by humans provides essential nutrients to the body. Adequate nutrition is crucial for children, as their growing years are a crucial time for physical and brain development. If children do not receive adequate nutrition, they risk delays in growth and learning. The nutrients that children need are diverse, with prebiotics being one of the important components in a child's diet.

Prebiotics are dietary fibers that cannot be digested by the human body directly. However, prebiotics have great benefits for the Beneficial bacteria, or probiotics, that live in the gut (Dahiya & Nigam, 2022). When these Beneficial bacteria consume prebiotics, they produce various beneficial substances, such as vitamins, short-chain fatty acids, and anti-inflammatory compounds. Prebiotics serve as a food source for the gut microbiota, and the result of this process is short-chain fatty acids that are then absorbed into the bloodstream.

This absorption not only impacts the digestive tract, but also affects other organs throughout the body. Consumption of prebiotics is therefore essential to support digestive health and positively impact well-being (Davani-Davari et al., 2019). On the other hand, gut microbiota plays an important role in gut function, including metabolism and maintaining gut integrity. Moreover, this microbiota can suppress the growth of pathogens in healthy individuals by producing various immunomodulatory molecules that have antagonistic effects against pathogens. This process is triggered by lactic acid produced by bacteria of the genera *Bifidobacterium* and *Lactobacillus* (Shokri et al., 2018).

There are several key reasons explaining why prebiotics are so important for growing children. First, prebiotics play a role in strengthening the immune system. The gut microbiota, which consists of various microorganisms in the gastrointestinal tract, influences the immune system through various mechanisms. One of the main mechanisms is the production of metabolites, such as short-chain fatty acids (SCFAs), produced by certain bacterial species. These SCFAs have been shown to modulate immune cell function and create an anti-inflammatory environment, which is important for maintaining immune system balance and preventing excessive inflammation (Zhou et al., 2024).

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The gut microbiota is not only involved in food digestion and absorption, but also plays a major role in general health. The symbiotic relationship between the gut microbiota and the immune system is crucial for health (Wernroth et al., 202). Prebiotics, which are indigestible fibers, selectively support the growth of beneficial microorganisms in the gut, thereby increasing microbial diversity and activity. They can improve gut health, strengthen immune responses, and control inflammation through their immunomodulatory properties (Zhou et al., 2024).

Due to the presence of healthy gut bacteria, an exaggerated immune response to harmless substances, such as food antigens, can be prevented. This helps educate immune cells and promotes the formation of immune tolerance, which is crucial for preventing allergies and autoimmune diseases. The gut microbiota interacts with various immune cells, including T cells, B cells and dendritic cells, through diverse signaling pathways. These interactions enhance the immune system's ability to respond to infection, while maintaining tolerance to commensal bacteria and food antigens (Childs et al., 2019). Thus, with a strong immune system thanks to prebiotics, children get sick less often and are better able to fight off diseases. This reflects the vital role prebiotics play in supporting optimal immune health and development in children.

Furthermore, the importance of prebiotics for children is also related to improving their physical growth. Prebiotics play a role in the absorption of nutrients that children need. Evidence increasingly shows that probiotics and prebiotics can improve the absorption of micronutrients, such as calcium and iron, from food. Micronutrients are organic or inorganic compounds present in foods in small amounts, such as vitamins and minerals, which although not used for energy, are essential for good health (Sheridan et al., 2014).

Beneficial bacteria fed prebiotics can help improve the absorption of essential nutrients, including calcium and iron, which are necessary for bone and muscle growth. Research has looked at the ability of prebiotics to improve micronutrient absorption, and although the effects vary between studies in both humans and animals, there are positive indications regarding non-digestible oligosaccharides on mineral metabolism and bone composition and structure (Sheridan et al., 2014). In addition, some studies show that prebiotics can affect growth hormone production, although the effect is not significant, there are changes that indicate a potential reduction in stunting (Waliyo et al., 2020). Then the reduction in potential stunting caused by prebiotics is due to their anti-inflammatory properties, so they can help reduce inflammation in the digestive tract.

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In pediatric environmental enteropathy (PEE), which is a condition with chronic inflammation in the small intestine, the process of digestion and absorption of nutrients can be disrupted. This inflammation causes shortening of the intestinal villi, important structures for nutrient absorption. Damage or shortening of the villi results in limited absorption of necessary nutrients, which impacts the allocation of nutrients for growth and development. These impairments contribute to stunting, where a child's height is less than their age, reflecting long-term malnutrition (Philips & Mulyanti, 2023). By improving gut health and villi function, prebiotics can improve nutrient absorption, support healthy growth, and potentially prevent stunting, especially in regions facing nutrition problems.

Other findings report that prebiotics may support children's growth, making them taller and stronger. Overall, five studies have found positive effects of prebiotics on child growth, although evidence is still limited. Prebiotics have the potential to improve the growth of children in developing countries, especially for malnourished children. Prebiotics play a role in promoting child growth by preventing infections and micronutrient deficiencies, as they have been shown to increase the absorption of certain nutrients such as calcium, zinc, and vitamin B12, and reduce the risk of anemia (Onubi et al., 2015). The study by (Heuven et al., 2021) showed that prebiotics such as *Lactobacillus rhamnosus* GG, *Lactobacillus casei* strain Shirota, and *Lactobacillus acidophilus* increased the height and weight of malnourished children compared to a control group that received no treatment or only isocaloric biscuits. Based on these findings, it is suggested that prebiotics support children's physical growth by improving nutrient absorption and contributing to healthy physical development and potentially reducing the incidence of stunting in children.

Meanwhile, another important role of prebiotics is in improving cognitive function. There is a strong link between gut health and brain function, with recent research suggesting that the condition of the gut microbiota can influence cognitive health. A balanced gut microbiota plays a role in reducing inflammation, which is often associated with neurodegenerative conditions (Eastwood et al., 2021).

Studies show that adding prebiotics to a healthy diet can improve cognitive function and mood. Maintaining a healthy gut microbiota is essential to support optimal cognition, especially in a fast-paced society influenced by western culture (Fekete et al., 2021). Beneficial bacteria fed prebiotics can produce compounds that are able to cross the blood-brain barrier and affect cognitive functions, including memory, learning and concentration.

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Based on these crucial reasons for prebiotics, it is important to provide prebiotics to children to support their physical growth and cognitive development. Prebiotics are naturally found in a variety of foods. For example, asparagus, sugar beet, garlic, chicory, onion, Jerusalem artichoke, wheat, honey, banana, barley, tomato, rye, soy, as well as human and cow's milk, and peas. Recently, seaweed and microalgae have also started to be recognized as sources of prebiotics. However, since the concentration of prebiotics in foods tends to be low, many of them are produced industrially to meet a greater need. This production process often involves the use of lactose, sucrose, and starch as raw materials (Davani-Davari et al., 2019).

However, before giving prebiotics to children, it is important to introduce them gradually. Starting with prebiotic-rich foods little by little can help avoid digestive problems, such as bloating or gas, that may occur if prebiotics are given too quickly (Collins, 2022). Also, keep in mind that prebiotics are only one component of a child's nutritional needs. Therefore, it is important to ensure the child gets a balanced and nutritionally complete diet. This helps fulfill all the nutritional requirements necessary for optimal growth and development.

Before giving prebiotic supplements, it is highly recommended to consult a pediatrician. This consultation will ensure that the dosage is appropriate for the child's health condition, thus supporting health safely and effectively. This careful approach is essential to support the well-being of the child.

CONCLUSION

Research has shown that prebiotics play a vital role in supporting children’s physical growth. One way prebiotics contribute is by improving nutrient absorption, which in turn supports healthy bone development. In addition to these physical benefits, prebiotics are also recognized as playing a role in improving children’s cognitive function. There is an increasingly strong link between gut health and the brain, with recent research showing that the condition of the gut microbiota can influence cognitive health. Beneficial bacteria that are fed prebiotics can produce bioactive compounds that are able to cross the blood-brain barrier. These compounds contribute to cognitive function, including memory, learning, and concentration, demonstrating the importance of prebiotics in a child’s holistic development.

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