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The Importance of Prebiotics and Quality Nutrition Such as Iron and Vitamin C to Ensure the Psychomotor and Cognitive Behaviors in Toddlerhood

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Abstract: Prebiotics are a class of substances that the gut flora breaks down. Interest in their link to general human health has grown in recent years. Their breakdown products include short-chain fatty acids that are released into the bloodstream and can feed the intestinal microbiota, which has an impact on not only the gastrointestinal tracts but also other distant organs. Scientists are seeking to industrially create prebiotics since meals naturally contain small amounts of fructo and galacto-oligosaccharides. Prebiotics appear to be intriguing possibilities for boosting human health as a substitute or in conjunction with probiotics, given their safety, health benefits, and advantages in manufacture and storage over probiotics. For the brain and neurocognitive system to grow normally, proper nourishment is essential. Early neurodevelopmental optimization can have significant long-term effects on both mental health and quality of life. The central and peripheral nervous systems continue to adapt and grow throughout life, even though the first 1000 days of life are the most crucial for neurodevelopment. Development and functioning have always been reliant on a variety of elements, including proper nourishment. In this review, we discuss the growing roles of polar lipids and high quality protein in the cognitive, emotional, and neurological development of newborns and young children.

Keywords: Prebiotics, Nutrition, Immune System, Psychomotor Development, Cognitive Behavior

1. Introduction

A meal, food component, nutrient, or non-food substance that is purposely eaten in addition to the regularly consumed diet with the goal of gaining a specific health and/or performance advantage is referred to as a dietary supplement [1]. More specifically, dietary supplements include protein, amino acids, purported prohormones, herbal (plant derived) substances, joint health products, combination products, multivitamins/minerals, and individual vitamins/minerals [2,

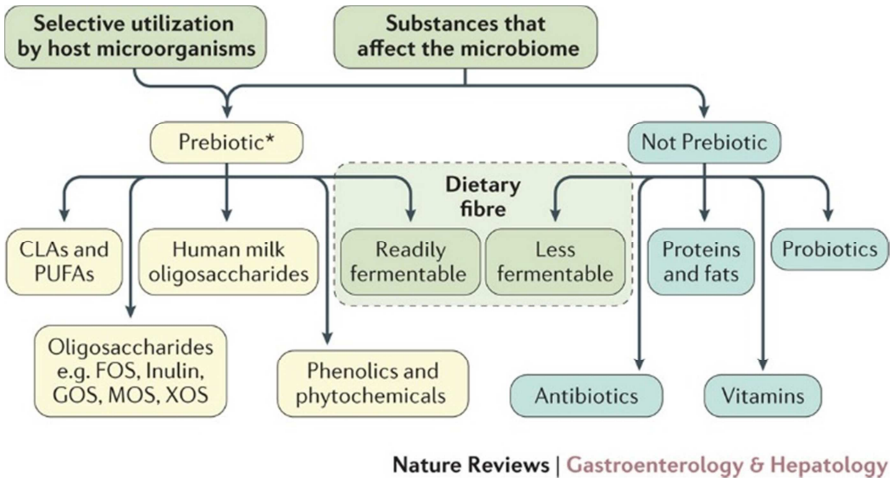
3]. They also include non-categorical dietary supplements (substances derived from plants, animals, and synthetic sources). These can be taken orally as pills, liquids, capsules, or powders. According to estimates, the market for dietary supplements was worth 132.8 billion USD in 2016 and is expected to reach 220.3 billion USD by 2022 [4]. Consumption of nutritional supplements is on the rise, especially among healthy young adults, and is typically self-prescribed and widely available. An Australian university population was found to consume dietary supplements at a rate of over 70% [5], while military populations showed similar but lower percentages [6, 7]. It's interesting to note that a recent study of Australian military members found a rise in the use of dietary supplements, with 76% of men and 87% of women reporting doing so for health reasons [8]. This suggests that the Australian Army has a high level of supplement use.

Despite the lack of scientific support for their efficacy and the detection of negative effects, the reported general increase in dietary supplement usage across the population is concerning [9-21]. These negative effects include death (caffeine and energy supplements, respectively) [22, 23], liver damage (unspecified supplements) [24], an increased risk of bleeding (gingko biloba, fish oil), insomnia (ginseng) [25], interactions with ibuprofen (gingko biloba) [26], and liver damage (unspecified supplements) [24]. A study [27] claiming that a growing proportion of nutritional supplements contain undisclosed, possibly fatal chemicals is especially concerning. However, some research does point to the possibility that certain elements of cognitive function in healthy young people may be modulated by dietary supplements. Caffeine [28], multivitamins and minerals [29, 30], and omega-3 fatty acids are supplements that have demonstrated some cognitive advantages. Defense organizations are also aware of the need to improve or prepare troops' cognitive performance in challenging or unpredictable operating circumstances. These frequently involve greater exposure to a range of stressors, such as lack of sleep, harsh weather, poor diet, physical weariness, and cognitive demands. It can be expensive for the person and the unit if their cognitive ability declines as a result of these pressures. In a firefight, for instance, a 20 millisecond improvement in response time after extensive field training [31] can be crucial. Similarly, sleep loss can impair moral judgment [32] and emotional responses [33], as well as speed up reaction time and mistake rates [28]. Finding evidence-based ways to maintain or improve military personnel's cognitive function is essential since errors may be expensive. Other approaches, such computer-based cognitive training and mindfulness training, are still being studied for their efficacy, viability, and acceptance. These additional techniques take a lot of time and call for repetition to maintain expertise. Scientifically validated dietary supplements could serve as an alternative to other approaches. Given that healthy young persons, including military personnel, frequently use these supplements, proper intake of them is probably more acceptable than using alternative methods to improve cognitive function.

Further research into the relationship between legal dietary supplements and cognitive performance in healthy young adults is necessary given the high consumption of dietary supplements by the military, the ambiguous empirical evidence for a positive effect on cognitive performance, and the desire to maintain or enhance cognitive performance during deployment.

1.1. Prebiotics

Prebiotics, also known as non-digestible oligosaccharides, can lower the risk of allergic diseases in young infants by increasing the development and metabolism of protective commensal microbes in the baby gut [11]. When administered in appropriate amounts, live bacteria known as probiotics interact with the gut microbiota to have beneficial effects. They boost the stomach's barrier defenses and regulate the immune system. Probiotics also affect immune system cells, in particular dendritic cells, and improve regulatory T cell activity. A source must be shown to benefit the host in order to be classified as a prebiotic [3]. One well-known kind of prebiotic is fermentable carbohydrates generated from xylans and fructans [3]. Resistant starch from starchy foods is also a well-documented prebiotic and has historically been the main source of prebiotics in the diet since it has been shown that 4-10% of the starch in mixed meals enters the large intestine [4]. One research found that persons in Africa who had a traditional diet daily consumed 38 grams of resistant starch [2]. When the concept of prebiotics was first put forward in 1995, Bifidobacteria and Lactobacillus received the majority of the attention [18]. As a result of improved mechanistic approaches in recent years, the prebiotic targets have expanded to encompass a wider range of bacteria, including Roseburia spp., Eubacterium spp. Akkermansia spp., Christensenella spp., Propionibacterium spp., and Faecalibacterium spp. [19]. These bacteria have been recognized as crucial probiotics and advantageous gut bacteria because they may have a variety of favorable effects on the host in terms of digestion (including but not limited to boosting mineral absorption) [20] and the effectiveness and innate strength of the immune system [21]. Prebiotic specificity in bifid bacteria and Lactobacillus has been shown to differ, and both may selectively digest prebiotic fiber depending on the bacterial enzymes present community. In this fashion, lactobacilli prefer inulin and fructooligosaccharides while bifid bacteria exhibit selectivity for inulin, fructooligosaccharides, xylooligosaccharides, and galactooligosaccharides [25]. Prebiotics can promote the growth of good gut bacteria while simultaneously inhibiting the growth of potentially pathogenic and toxic microorganisms in the gut, such as clostridia, according to studies [4].



Source: Nature reviews Gastroenterology & Hepatology

Figure 1. *Distinguishing what is considered a prebiotic with the proposed definition.*

1.2. Immune System

Examples of nonspecific defenses include the mucous membranes of the skin and other mucous tissues, phagocytic cells, mucus, cilia, lysozyme, interferon, and other humoral components. These innate systems exist regardless of previous contact with the infectious pathogen [13]. They act as the first line of defense and halt the emergence of overt infection. Antigen-specific systems include the T cell system for cell-mediated immunity and the B cell system for antibody production. Because they are specific reactions induced by prior encounter with the bacteria and its antigenic determinants, these mechanisms are flexible and necessary [15]. They are effective at eliminating the invader and halting the spread of the illness. The basis for prophylactic immunization against common infectious diseases like measles, respiratory illnesses caused by Hemophilus influenza, and systemic illnesses caused by Salmonella is the specific immune responses. In the body, nonspecific and antigen-specific defenses collaborate. Lymphoid atrophy is a prominent sign of a protein-energy deficit (PEM). Thymus weight and size decrease. Histologically, the Hassall bodies are enlarged, degenerating, and very rarely calcifying. There is also a lack of corticomedullary differentiation and a decrease in lymphoid cells. These changes are clearly distinguishable from those seen in primary immunological deficits such the DiGeorge syndrome [14, 15]. The Para cortical areas of the spleen, which rely on the thymus for the generation of lymphocytes, also experience loss in PEM. In PEM, the majority of host defense mechanisms are vulnerable. Delay-induced delayed-hypersensitivity cutaneous responses elicited by fresh antigen as well as memory are both markedly reduced. It is common to have complete energy to a battery of different antigens. Mild impairments also manifest these changes. The skin reactions are restored after obtaining the right nutritional treatment for a few weeks or months. Additionally, there is a reduction in fully developed, mature T cells, which is associated with a reduction in serum thymic factor activity. Deoxy-nucleotidyl transferase activity is also increased in leukocytes.

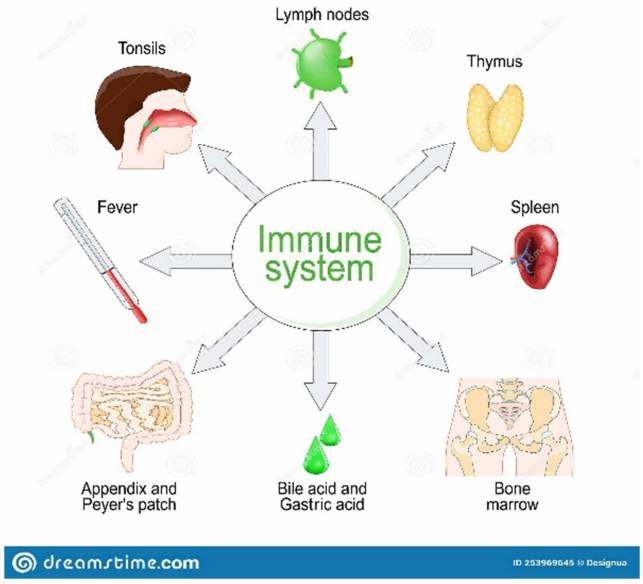


Figure 2. *Adaptive immune system.*

Source: https://www.dreamstime.com/immune-system-organs-function-vector-diagram-immune-system-organs-function-image253969645

1.3. Children's Learning Styles

Different ways humans learn, process, and remember knowledge are referred to as learning styles. All early children acquire knowledge through engaging hands-on activities, such as touching, doing, and moving. Children also learn by seeing and hearing things [17].

1.4. Types of Learning Styles

These are the four main types of learning styles:

1) *Visual* (learn through seeing);
2) *Auditory* (learn through hearing);
3) *Tactile* (learn through touch);
4) *Kinesthetic* (learn through doing and moving).

Visual learners acquire knowledge through seeing. Children who receive information visually often examine a parent or teacher's body language and facial expressions to determine the subject matter and learn through examples and explanations. They frequently visualize things and have strong imaginations. They could become distracted in a classroom if there is too much activity. Written instructions may aid in the clarification of vocal instructions for older children who can read.

Auditory occurs through listening for auditory learners. Auditory learners gain knowledge through engaging in dialogues and discussing things out. Clarifying spoken instructions or written material may be beneficial. Children with this strength may study best in a calm atmosphere because excessive noise might be distracting.

Tactile learning is a tactile learning process. Those kids who are more tactile choose games or crafts that let them use their hands. To help with remembering, your youngster may choose doodling or drawing.

Kinesthetic learners pick up knowledge by doing and moving. Children who learn better via bodily sensations may struggle to sit quietly for extended periods of time. Your kid will learn best with a hands-on approach that enables her to actively explore her physical environment.

Source: https://abilitypath.org/ap-resources/childrens-learning-styles/

Figure 3. *Children learning style.*

1.5. Cognitive Development

The terms cognition and cognitive development both relate to the processes involved in thinking and remembering. The cognitive stage theory of Swiss psychologist Jean Piaget is among the most well-known viewpoints on cognitive development. Piaget developed and researched an explanation of how children and young people eventually acquire the capacity for logical and scientific thought.

Basically, this is a “staircase” model of development. Piaget proposed four major stages of cognitive development, and called them (1) sensorimotor intelligence, (2) preoperational thinking, (3) concrete operational thinking, and (4) formal operational thinking. Each stage is correlated with an age period of childhood, but only approximately.

1.6. The Sensorimotor Stage: Birth to Age 2

The first stage is known as the sensorimotor stage, during which time newborns "think" using their senses and muscular movements. Infants constantly touch, manipulate, stare, listen, and even chew on items, as any new parent will confirm [28]. These activities, in accordance with Piaget, enable youngsters to learn about the outside world and are essential to their early cognitive development. Infants can represent (i.e., create basic notions of) things and events thanks to their behaviors. A kid may first see a toy animal as merely a perplexing collection of feelings, but as she looks at, feels, and plays with it repeatedly, she progressively organizes her sensations and actions into a consistent concept: toy animal. The depiction gains a stability that is missing from the varied, ever-changing sensations of the item itself. Even if the actual toy animal is momentarily hidden from view, the youngster "knows," or at least believes, that it exists since the representation is steady. This sense of stability, which Piaget dubbed object permanence, is the conviction that things exist whether or not they are truly there [30]. A significant milestone in sensorimotor development, object permanence represents a qualitative shift in how older children (>24 months) conceptualize experience compared to younger infants (6 months).

1.7. The Preoperational Stage: Age 2 to 7

Children employ their newly acquired capacity to represent things in a range of tasks throughout the preoperational stage, but they do not yet do so in ways that are structured or wholly logical. Dramatic play, or the spontaneous pretending of young children, is one of the most visible instances of this type of cognition. You have probably seen this kind of play if you have ever been in charge of young children. When children are engaged in creative play, they are simultaneously thinking on both an imaginative and a realistic level. Dramatic play is a prime example of metacognition, which is the process of reflecting on and supervising one's own thought processes. Teachers of young children (preschool, kindergarten, even first or second grade) frequently create time and space in their classrooms for dramatic play, and occasionally even participate in it themselves to help the play develop. This is because metacognition is a highly desirable skill for success in school.

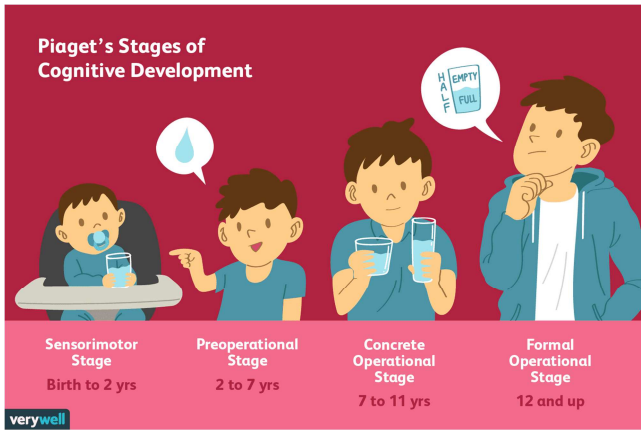
1.8. The Concrete Operational Stage: Age 7 to 11

As children progress through primary school, kids gain the ability to express concepts and events in more flexible and logical ways [20]. Children are able to solve issues more methodically than before, which helps them succeed with many scholastic activities, even if their norms of thought still appear extremely simple to adults and typically function unconsciously. Each of the two ways that concrete operational thinking differs from preoperational thinking

makes kids better students. One distinction is reversibility, or the capacity to consider a process's phases in any sequence. Consider conducting a straightforward science experiment where a youngster places a variety of things in a water basin to see why certain objects sink or float. Only the concrete operational kid is able to recall the stages of this experiment in any particular order, however both the preoperational and concrete operational children may recall them and describe them (e.g., chronological, reverse chronological, etc) [26]. This ability is highly beneficial for any work requiring numerous phases, which is a characteristic of assignments in the classroom. Another illustration of what a teacher may do is use a tale to teach kids new words. The child's capacity to decenter, or concentrate on more than one aspect of an issue at once, is another new cognitive function that emerges during the concrete operational stage [28]. In preschoolers' dramatic play, which necessitates being aware of two things at once knowing that a banana may be both a banana and a "telephone"-there are clues of decent ration. However, the decrement of the concrete operational stage is more intentional and purposeful than the pretend play of young children. The child's capacity to decenter, or concentrate on more than one aspect of an issue at once, is another new cognitive function that emerges during the concrete operational stage [32].

1.9. The Formal Operational Stage: Age 11 and Beyond

The child develops the ability to reason not just about actual things and occurrences, but also about speculative or hypothetical ones. As a result, it is known as the formal operational stage, which is the time when the person may "operate" on forms or representations. The young person must use their minds to reason their way to the answer rather than attempting to solve the problem by trial and error using the resources themselves. He or she must see changing each variable independently, while also visualizing keeping the other variables constant, in order to do it methodically. The ability to manipulate mental images of the pertinent objects and events is necessary for this type of thinking-exactly the ability that defines formal operations.



Source: https://www.simplypsychology.org/formal-operational.html

Figure 4. *Formal stage of Cognitive Development: Age 11 Beyond.*

1.10. Stages of Child Development

The first five years of a child's life lay a foundation for a child's learning, behavior, and health. Early childhood experiences shape a child's brain and capacity to learn, develop social skills, and navigate daily challenges and stressors. The emotional, social, and physical development of young children has a direct effect on their behavior, social skills, school readiness, and overall child development, influencing habits that extend into adulthood. Each stage of development surrounds progressions across four different domains. These various developmental domains are interdependent, and a child is unable to advance in one sphere without progressing in the other.

2. Communication Domain

Children must acquire the skills necessary for good communication with their family, friends, teachers, and other people. The first phase of the five stages of child development is communication, which later evolves into conversational abilities and relationship management as the kid becomes older.

2.1. Physical Domain

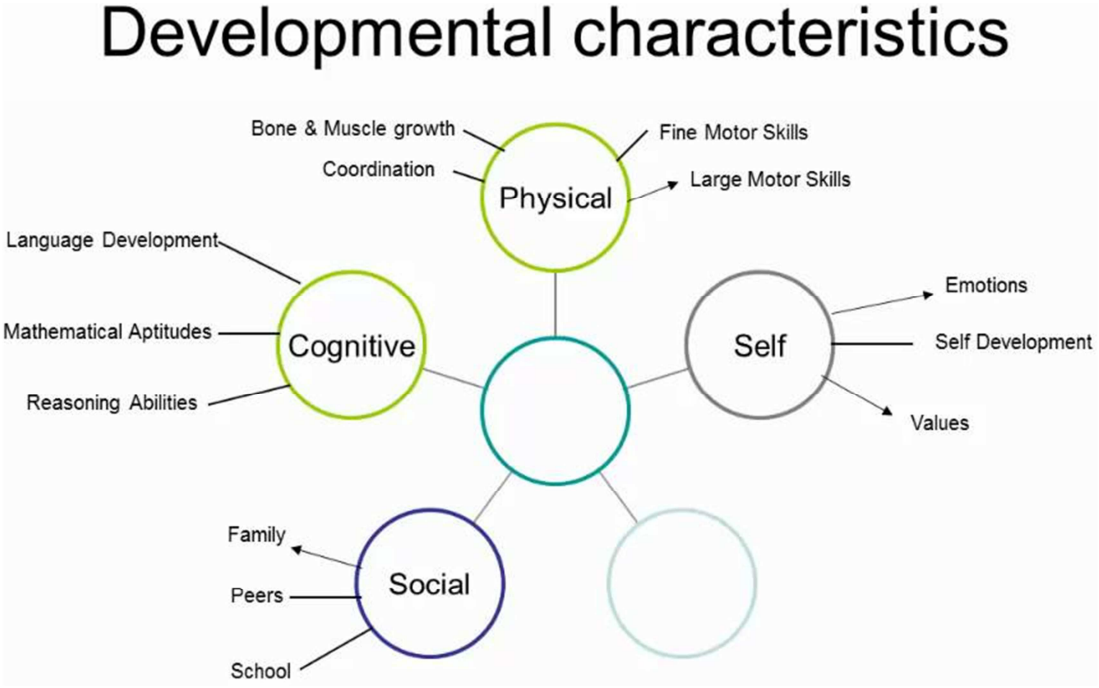
The body grows in both gross and fine motor development during the course of a child's first five developmental stages. Your child's ability to move with balance, coordination, comfort, and confidence in the outside world is a result of their gross motor development. At KCC, we support children's gross motor development from an infant's initial attempts to reach for a caregiver, through a toddler's clumsy walking and running, through preschoolers' active play, and beyond - leaping, kicking, climbing, and dancing.

2.2. Social-Emotional Domain

The social and emotional growth of a kid aids in their understanding of who they are, what they are feeling, and how to relate to others. Preschoolers who are socially and emotionally healthy are better able to build lasting connections and control and express their emotions in a variety of situations.

2.3. Cognitive Domain

All of a child's cognitive development includes their ability to reason, comprehend, and navigate their environment. Quantity, categorization, and cause and effect are examples of mathematical and scientific notions that represent developmental milestones in the cognitive realm. How children approach learning is shaped in the first five years of life. Curiosity, taking the initiative to look for information, and changing behavior in response to new information are all aspects of this cognitive development.



Source: https://www.amle.org/developmental-characteristics-of-young-adolescents/

Figure 5. *Developments Characteristics.*

2.4. Negative Impact of Delayed Cognitive Behavior in Children

Cognitive delays may interfere with a kid's ability to think critically, impair awareness, and result in learning challenges that frequently surface once a child starts school. Children with cognitive disabilities may struggle to play and communicate with others. Children who have had a brain damage as a result of an illness, such as meningitis, which can result in brain swelling known as encephalitis, may have this kind of delay. A cognitive delay may also be more likely in those with shaken infant syndrome, epilepsy disorders, and genetic conditions that influence intellectual development, such Down syndrome. However, it is frequently impossible to pinpoint a specific cause for this kind of delay.

Parental results, particularly in terms of psychosocial outcomes, are significantly impacted by caring for a kid with a cognitive delay. Research has repeatedly shown that moms of kids with cognitive and intellectual impairments have poorer levels of happiness, self-esteem, and self-efficacy, as well as inferior physical health, sleep problems, and increased rates of melancholy, anxiety, and mental health issues. compared to moms of children with usual development, [7, 8] and stress [3]. Such results are probably related to the heavy financial and caregiving responsibilities these families bear [10-12]. Children's behavioral issues are another possible impacting element. Compared to their peers who are regularly developing, children with cognitive delays are more likely to experience behavioral and mental health issues [13-16], with rates of comorbidity in children and adolescents ranging between 30 and 50% [13]. Parental mental health issues are more closely linked to the children's behavioral issues than to their actual disability in children with cognitive delay and related developmental disabilities [17]. Parents of kids who have both intellectual disability and coexisting behavioral issues report finding it challenging to cope as well as to raise and manage their kids. Compared to parents of intellectually disabled children without such behavioral issues, they are more prone to view their children as a heavy burden. [10] Additionally, it has been demonstrated that families with children who have cognitive delays experience the effects of behavioral issues in children more severely than families with children who do not have cognitive delays. [4] Although not among a representative or national sample of children with cognitive delay, the relationship has been thoroughly researched using convenience samples of families of children and young people with cognitive delay [18-21, 25]. Additionally, much of the previous study on this subject has depended on mother accounts. [3] It's probable that moms' mental health will color their perceptions of their kids' conduct. The coordination of big muscle groups, like the arms and legs, and smaller muscle groups, like the hands, is hampered in children with motor skill delays. Infants with gross motor delays could have problems turning over or crawling, and older kids with this kind of delay might appear awkward or struggle to climb stairs. Fine motor delays can make it difficult for some people to grip onto small things like toys or do chores like tying shoes or cleaning their teeth [33]. Achondroplasia, which shortens the limbs, and diseases that affect the muscles, including cerebral palsy or muscular dystrophy, can cause certain motor delays in children. In addition,

anatomical issues such an imbalance in limb length may be to blame. Social, emotional, or behavioral impairments are frequently present in children with developmental delays, including those who also have concomitant neurobehavioral disorders including attention deficit hyperactivity disorder and autism spectrum disorder [35]. They may receive information or respond to their surroundings differently than kids their age due to variances in brain development. These delays may affect a child's capacity for learning, communication, and social interaction. Social and emotional skills are frequently challenging for kids with developmental impairments. For instance, individuals could struggle to pick up on social signs, start a discussion, or maintain a two-way dialogue [36]. They could also have trouble handling anger or adjusting to change. Children with developmental delays may have lengthier tantrums and require more time to calm down than other children when the environment becomes too emotionally or socially demanding. This conduct may indicate that the kid requires further help, such as changing his or her surroundings or developing coping mechanisms for dealing with social and emotional difficulties.

2.5. Role of Prebiotics in Children

A newborn has a sterile gastrointestinal system at birth, similar to the fetus, but bacterial colonization happens quickly [20-21, 25]. The gestational age, birth method, and food of the newborn child all appear to have a substantial impact on this process. Neonatals who underwent a Caesarean section, were born preterm, or were given perinatal or postnatal antibiotics experienced a delay in the colonization of their intestines by commensal probiotic bacteria. Babies who are breastfed and those who are given formula share a similar pattern of bacterial colonization at 48 hours of age when they are born vaginally. However, at the age of 7, only 22% of children breastfed have a prevalence of Bacteroides fragilis, compared to about two-thirds of infants given formula [20]. In developing nations, it has been discovered that towards the end of the first month of life, breastfed children have a Bifidobacteria-predominant colonization whereas formula-fed newborns have an equal colonization with Bacteroides and Bifidobacteria species. However, there are less obvious differences between breastfed and formula-fed newborns in nations with abundant resources [15]. After infancy, the gut microflora's makeup hardly changes at all. As a result, older children and adults have less variable and diet-dependent fecal flora compositions. In actuality, anaerobic bacteria outweigh aerobic coliforms by a factor of more than 1012 colony-forming units per mL of intestinal contents beyond infancy (10-fold the total number of human cells in the human body). [24]. The colonic microflora of an adult typically contains 500 distinct bacterial species, however just 30 to 40 species account for 99% of the microflora [24]. In an effort to more accurately identify one's microbial habitat, experts in the area are replacing older words like "microflora" with more descriptive ones like "microbiota" and "microbiome" [26]. The term "microbiome" refers to the particular full population of microorganisms and their complete genetic material that occupy one's body, whereas the term "microbiota" refers to a population of microscopic organisms that inhabit a biological organ or area of a person's body. A complex immunoregulatory network that also contains the gut microbiota comprises the intestinal mucosal defense system [22, 24, 27, 29, 37 38]. Early in life, maybe even in utero, the recognition of self- and non-self-antigens begins and is greatly impacted by processes that take place in the digestive system shortly after birth. The young infant's food, level of bacterial colonization, early exposure to possible infectious pathogens and drugs, as well as the infant's genotype, have a substantial impact on the digestive system's immunoresponsiveness. It is believed that dysregulation or interference with the early development of the intestinal mucosal defense system can be linked to the onset of numerous illnesses, both intestinal and nonintestinal [37, 38]. Those considered to be atopic (such as asthma, eczema, and allergic rhinitis) or autoimmune are examples of these conditions (multiple sclerosis, type 1 diabetes mellitus, and chronic inflammatory bowel disease (IBD) [37]. Without a doubt, a person's genetic makeup plays a major role in how their immune system develops [22]. The identification and reaction of mature T lymphocytes to trigger molecules, such as those obtained from food and bacterial-breakdown products inside the digestive tract, are assumed to provide the biochemical foundation for both innate and acquired immunity [38]. Dietary oligosaccharides and nucleotides are also trigger chemicals. T cells' surface membranes have toll-like receptors that make it easier for these trigger molecules to be recognized. This recognition eventually results in specialized T-lymphocyte recognition and response to future exposure to the same or very similar molecules. In order to avoid gastrointestinal disease, T-lymphocyte identification of certain oligosaccharides linked to intestinal bacteria is crucial. The infant's early food and gut microbial environment are expected to have a key role in general health given these significant implications on intestinal microflora colonization and immune function. It is thought that probiotic bacteria, postbiotic bacterial metabolites, and dietary prebiotics have a favorable impact on how the mucosal immune system develops. Additionally, it is thought that in susceptible people, exposure to "unbeneficial" microbes and antimicrobial drugs during the neonatal period may result in immunological dysregulation and may cause various chronic disease states. There is proof that human milk contains mononuclear cells that transport germs from the mother's intestine to the baby. It is believed that the swallowed human milk, which contains bacterial components originating from the mother, affects the newborn infant's growing immune system.

2.6. Role of Iron and in Psychomotor and Cognitive Behavior

Haemoglobin (Hb), myoglobin, and the metabolism of certain neurotransmitters, such as dopamine, all depend on iron for their creation. Additionally, it has been

hypothesized that iron is necessary for the development of myelin in the brain [18]. Studies on animals, mostly rats, have revealed that severe iron insufficiency can result in a deficit of brain iron, that this deficit may persist, and that iron deficiency may be linked to changes in motor activity and behavior [18] Children with severe iron deficiency are frequently described as irritable, apathetic, and having low appetites in the clinical literature. Most, but not all, of the numerous observational studies that looked at the connection between iron deficiency anemia (IDA) and psychomotor development discovered that young children with IDA scored worse on measures of psychomotor development [19]. If lack of iron is associated with adverse effects on children's psychomotor development and these effects could be reversed by administration of iron, there would be a strong argument for either population supplementation with iron or screening of young children for IDA. It is widely acknowledged that the age period from birth to three years old is critical for psychomotor development and cognitive development, thus children under the age of three years would be the most sensitive population. Safety outcomes are important to a Cochrane review. However, the purpose of this review is to assess the effect of iron therapy specifically on psychomotor development and cognitive development.

2.7. Role of Vitamin C in Psychomotor and Cognitive Behavior

Vitamin concentrations in the brain are much higher than those in the rest of the body, and the brain retains its levels of the vitamin for a very long time [37]. This is partially due to the fact that the metabolic engines in your neurons burn glucose to power all of your thoughts, feelings, and movements, and that the vitamin's role as an antioxidant is to give up electrons to neutralize errant oxygen molecules released in the process-free radicals that damage DNA and generally accelerate the aging of your cells. But vitamin C also has additional functions, some of which are only now being known 80 years after the vitamin's discovery. Vitamin C is essential for cognitive function because it helps neurons develop and mature as well as produce the myelin coating that speeds up impulse transmission and protects them. In addition to being a cofactor in the production of various neurotransmitters and being necessary for the conversion of dopamine to serotonin, it also controls the release of neurotransmitters by nerve cells [29]. Scurvy is known to be caused by a severe vitamin C deficiency. However, scientists are aware that the human body requires far more than what is necessary to stop the disease from becoming as widespread as it previously was. It is unclear exactly how much is required to sustain all physiological processes. The fact that the amount taken does not always convert into acceptable blood levels complicates problems [28]. Additionally, as they put the body under oxidative stress, things like smoking, exposure to toxins from air pollution, and alcohol use increase the need for the mineral. Studies have found that low vitamin C levels can lead to symptoms including weariness, depression, and slow wound healing.

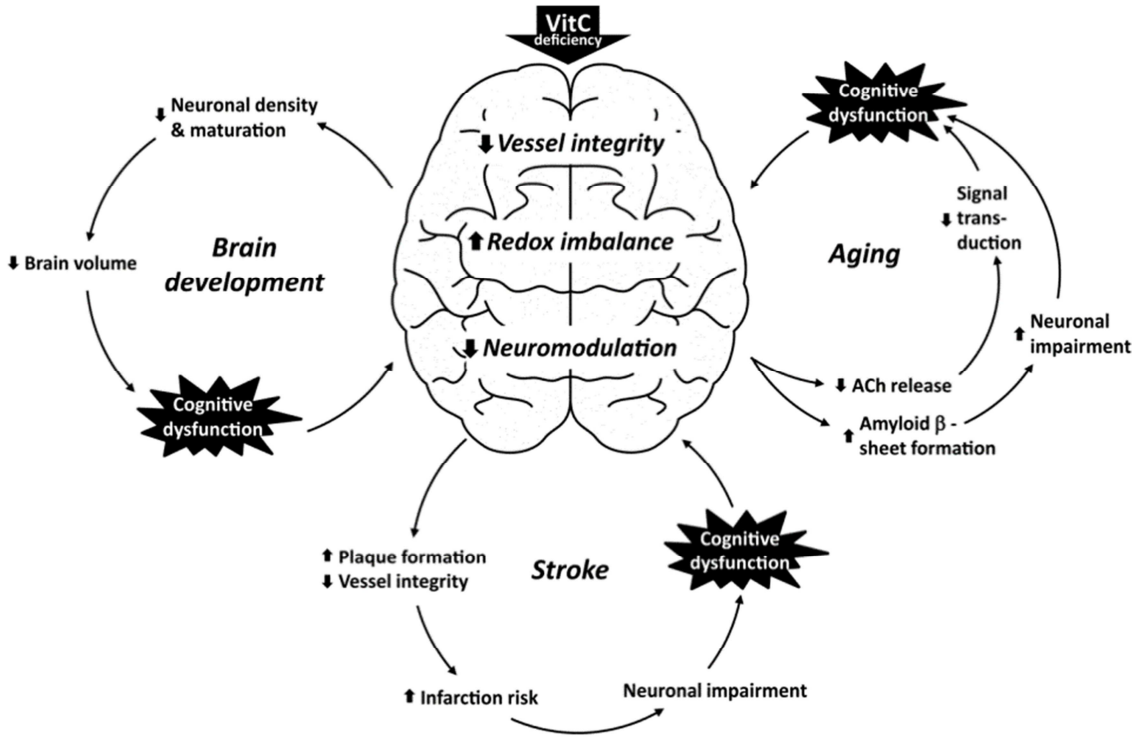


Figure 6. *Role of vitamin C in Psychomotor and Cognitive behavior.*

Source: Hansen SN, Tveden-Nyborg P, Lykkesfeldt J. Does vitamin C deficiency affect cognitive development and function Nutrients? 2014 Sep 19; 6 (9): 3818-46. doi: 10.3390/nu6093818. PMID: 25244370; PMCID: PMC4179190.

2.8. Nutrition and Immunity: Recent Advances and the Future

The immune system is one of the many things that nutrition impacts. It is an organ system that is both physically complex and functionally diverse. An immune response's quantitative and qualitative elements both have an impact on a person's immunity [25]. The developing fetal and neonatal immune system can be influenced by a variety of factors, including genetic predisposition, maternal stress, nutritional status, exposure to contaminants in the environment, infant's nutritional adequacy (quantitative levels of macro & micronutrients), etc. There is no one test that can reliably predict an infant's immunological condition, despite the fact that the newborn immune system is vulnerable to insults during the vital window of development and has a large range of biomarkers and proteomic indications. Children who get illnesses repeatedly, severely, or often may have immune system weaknesses due to undernutrition, shortages in certain micronutrients, or other factors [18]. Early treatment of hidden hunger is crucial for helping a newborn realize their maximum potential for growth and development. It may be useful to evaluate the levels of critical immune-supporting substances including iron, zinc, vitamin B12, and vitamin D in order to detect a deficient state. Iron, long regarded as a micronutrient, is now regarded as a macronutrient because of the critical role it plays in the immune system, hematological system, growth, and cognitive development of infants and toddlers. Iron deficiency anemia may be diagnosed using hemoglobin levels, and the need for iron supplementation can be determined by measuring serum ferritin levels [26].

Clinical prediction of immune system dysfunction is challenging since there is no set of recurring symptoms that can be used to quantify it. Close observation of a child's development chart may be one of the clinically useful indicators of macronutrient deficit. A growth chart may not be helpful for detecting micronutrient deficits unless there is severe malnutrition. In general, if a child is progressing along a growth chart in the right percentile, it may be a good indication that their diet contains enough macronutrients [15]. As soon as supplementary feeding is initiated, newborns should be provided a balanced diet that contains the required levels of macro- and micronutrients to guarantee their overall health and welfare. According to the expert panel's findings, parents and other caregivers need to be well-informed on the value of nutrition throughout an infant's first 1000 days of life. In addition to affecting an infant's growth and development, nutrition also plays a role in immune system programming. Any nutritional damage or shortage today might have long-term implications on the immune system, cognition, susceptibility to infections, and even a loss of 5 to 10 IQ points when an individual is an adult [17]. The expert group advises parents, guardians, and caregivers to learn more about nutrition in general. The medical fraternity's approach should be to provide age-specific, real-world problem-solving education and nutritional guidance on child feeding approaches [19]. In order to improve dietary adequacy, growth, and health of an infant and help them to reach their full potential for growth and development, the medical profession can help in achieving this goal by focusing on different touch points, such as vaccination visits, routine check-up visits, or other visits [21].

To integrate nutrition services into the healthcare system, it is vital to take into account the NNP's lessons learned and current expertise, as well as make any required adjustments to the plan. Better complementary feeding, more effective behavior change communication, improved micronutrient status through food consumption and micronutrient supplementation, etc. should all be highlighted by the adjustment [30]. Food supplementation should only be used as a safety net for vulnerable people living in regions of the country where there is a high prevalence of malnutrition and food insecurity, not as a regular practice. In order to make the supplement nutritionally appropriate, it should also be evaluated for quality and quantity. Micronutrients and any meals made with animal products, such milk, should be included because they are crucial for the growth of undernourished children [35]. For the purpose of providing fundamental nutrition treatments at the community level, the government aims to construct community clinics across the country, one for every 6,000 citizens. At this approach, the nutrition manager may be a physician who works in the sub-district health complex. This physician would be in charge of managing the program at the sub-district level with the aid of field supervisors and community health workers. However, it is imperative that the community clinic employ at least one individual who is completely in charge of nutritional therapies [34]. There is a potential that other competing health issues will take precedence over diet. It will be clear that additional, qualified personnel must be enlisted. Coordinated interministerial efforts are essential to combating the large problem of undernutrition. Coordination between various ministries with substantial responsibilities for health, nutrition, and food security as well as with NGOs, the commercial sector, and international efforts on nutrition issues can only be ensured by a strong body in the Prime Minister's Office (Scaling up Nutrition, REACH, and Feed the Future) [39].

3. Conclusion

Prebiotics have an extraordinary impact on human health, making them tempting and desirable treatments for cancer, vascular disease, obesity, and mental problems. There are several research on the beneficial benefits of prebiotics on human health; nevertheless, to substantiate the health claims, carefully planned long-term clinical trials and genomics studies are required. In order to improve human health, scientists will be able to create better dietary supplements by figuring out the basic workings of prebiotics. Prebiotic food components have the potential to normalize the makeup of the gut microbiota, which is an appealing method in the

management and recovery of several serious illnesses. In other words, the gut microbiota may be properly fed with prebiotics to become stronger and healthier, which can then have an influence on general health. The gut is a significant organ of the body. Considering the diversity of the gut microbiota between communities, nations, and even within people depending on a range of dietary practices, it does not appear to be particularly practical to generate effective and varied probiotics for the modulation of microbiota hemostasis. Prebiotics, on the other hand, appear to be a more practical choice in this respect, particularly because of a much simpler manufacture and formulation process and the lack of a requirement for a cold chain during transit and storage. Prebiotics' low negative effects are another significant benefit. As a result, developing specialized, population-specific prebiotics with consideration for the local gut bacteria unique to each group may eventually help to reduce certain illnesses in each civilization as a standardized method. Future prebiotics recommendations from the FAO and/or the WHO may endorse this idea as a way to end the major prebiotic debates.

References

[1] Mudd A. T., Alexander L. S., Berding K., Waworuntu R. V., Berg B. M., Donovan S. M., Dilger R. N. Dietary prebiotics, milk fat globule membrane, and lactoferrin affects structural neurodevelopment in the young piglet. Front. Pediatr. 2016; 4: 4. doi: 10.3389/fped.2016.00004. [PubMed] [CrossRef] [Google Scholar].

[2] Grenham S., Clarke G., Cryan J. F., Dinan T. G. Brain–gut–microbe communication in health and disease. Front. Physiol. 2011; 2: 94. doi: 10.3389/fphys.2011.00094. [PubMed] [CrossRef] [Google Scholar].

[3] Liu X., Cao S., Zhang X. Modulation of gut microbiota–brain axis by probiotics, prebiotics, and diet. J. Agric. Food Chem. 2015; 63: 7885-7895. doi: 10.1021/acs.jafc.5b02404. [PubMed] [CrossRef] [Google Scholar].

[4] Forsythe P., Bienenstock J., Kunze W. A. Microbial Endocrinology: The Microbiota-Gut-Brain Axis in Health and Disease. Springer; New York, NY, USA: 2014. Vagal pathways for microbiome-brain-gut axis communication; pp. 115-133. [Google Scholar].

[5] Savignac H. M., Corona G., Mills H., Chen L., Spencer J. P., Tzortzis G., Burnet P. W. Prebiotic feeding elevates central brain derived neurotrophic factor, n-methyl-d-aspartate receptor subunits and d-serine. Neurochem. Int. 2013; 63: 756-764. doi: 10.1016/j.neuint.2013.10.006. [PubMed] [CrossRef] [Google Scholar].

[6] Williams S., Chen L., Savignac H. M., Tzortzis G., Anthony D. C., Burnet P. W. Neonatal prebiotic (bgos) supplementation increases the levels of synaptophysin, glun2a-subunits and bdnf proteins in the adult rat hippocampus. Synapse. 2016; 70: 121-124. doi: 10.1002/syn.21880. [PubMed] [CrossRef] [Google Scholar].

[7] Sudo N., Chida Y., Aiba Y., Sonoda J., Oyama N., Yu X. N., Kubo C., Koga Y. Postnatal microbial colonization programs the hypothalamic–pituitary–adrenal system for stress response in mice. J. Physiol. 2004; 558: 263-275. doi: 10.1113/jphysiol.2004.063388. [PubMed] [CrossRef] [Google Scholar].

[8] Heijtz R. D., Wang S., Anuar F., Qian Y., Björkholm B., Samuelsson A., Hibberd M. L., Forssberg H., Pettersson S. Normal gut microbiota modulates brain development and behavior. Proc. Natl. Acad. Sci. USA. 2011; 108: 3047-3052. doi: 10.1073/pnas.1010529108. [PubMed] [CrossRef] [Google Scholar].

[9] Neufeld K., Kang N., Bienenstock J., Foster J. Reduced anxiety-like behavior and central neurochemical change in germ-free mice. Neurogastroenterol. Motil. 2011; 23: 255-e119. doi: 10.1111/j.1365-2982.2010.01620.x. [PubMed] [CrossRef] [Google Scholar].

[10] Nelson E. D., Ramberg J. E., Best T., Sinnott R. A. Neurologic effects of exogenous saccharides: A review of controlled human, animal, and in vitro studies. Nutr. Neurosci. 2012; 15: 149-162. doi: 10.1179/1476830512Y.0000000004. [PubMed] [CrossRef] [Google Scholar].

[11] Best T., Howe P., Bryan J., Buckley J., Scholey A. Acute effects of a dietary non-starch polysaccharide supplement on cognitive performance in healthy middle-aged adults. Nutr. Neurosci. 2015; 18: 76-86. doi: 10.1179/1476830513Y.0000000101. [PubMed] [CrossRef] [Google Scholar].

[12] Best T., Kemps E., Bryan J. Saccharide effects on cognition and well-being in middle-aged adults: A randomized controlled trial. Dev. Neuropsychol. 2009; 35: 66-80. doi: 10.1080/87565640903325709. [PubMed] [CrossRef] [Google Scholar].

[13] Han H. S., Jang J.-H., Jang J. H., Choi J. S., Kim Y. J., Lee C., Lim S. H., Lee H.-K., Lee J. Water extract of triticum aestivum l. And its components demonstrate protective effect in a model of vascular dementia. J. Med. Food. 2010; 13: 572-578. doi: 10.1089/jmf.2009.1242. [PubMed] [CrossRef] [Google Scholar].

[14] Schmidt K., Cowen P. J., Harmer C. J., Tzortzis G., Errington S., Burnet P. W. Prebiotic intake reduces the waking cortisol response and alters emotional bias in healthy volunteers. Psychopharmacology. 2015; 232: 1793-1801. doi: 10.1007/s00213-014-3810-0. [PubMed] [CrossRef] [Google Scholar].

[15] Van den Berg J. P., Westerbeek E., Bröring-Starre T., Garssen J., van Elburg R. M. Neurodevelopment of preterm infants at 24 months after neonatal supplementation of a prebiotic mix: A randomized trial. J. Pediatr. Gastroenterol. Nutr. 2016; 63: 270-276. doi: 10.1097/MPG.0000000000001148. [PubMed] [CrossRef] [Google Scholar].

[16] Smith A. P., Sutherland D., Hewlett P. An investigation of the acute effects of oligofructose-enriched inulin on subjective wellbeing, mood and cognitive performance. Nutrients. 2015; 7: 8887-8896. doi: 10.3390/nu7115441. [PubMed] [CrossRef] [Google Scholar].

[17] Smith A. P. The concept of well-being: Relevance to nutrition research. Br. J. Nutr. 2005; 93: S1-S5. doi: 10.1079/BJN20041351. [PubMed] [CrossRef] [Google Scholar].

[18] Waworuntu R., Hain H., Chang Q., Thiede L., Hanania T., Berg B. Dietary prebiotics improve memory and social interactions while reducing anxiety when provided early in life to normally developing rodents (637.5) FASEB J. 2014; 28: 637.5. [Google Scholar].

[19] Messaoudi M., Rozan P., Nejdi A., Hidalgo S., Desor D. Behavioural and cognitive effects of oligofructose-enriched inulin in rats. Br. J. Nutr. 2005; 93: S27-S30. doi: 10.1079/BJN20041348. [PubMed] [CrossRef] [Google Scholar].

[20] Buie T., Campbell D. B., Fuchs G. J., Furuta G. T., Levy J., VandeWater J., Whitaker A. H., Atkins D., Bauman M. L., Beaudet A. L., et al. Evaluation, diagnosis, and treatment of gastrointestinal disorders in individuals with asds: A consensus report. Pediatrics. 2010; 125: S1-S8. doi: 10.1542/peds.2009-1878C. [PubMed] [CrossRef] [Google Scholar].

[21] Adams J. B., Johansen L. J., Powell L. D., Quig D., Rubin R. A. Gastrointestinal flora and gastrointestinal status in children with autism comparisons to typical children and correlation with autism severity. BMC Gastroenterol. 2011; 11: 22. doi: 10.1186/1471-230X-11-22. [PubMed] [CrossRef] [Google Scholar].

[22] Nankova B. B., Agarwal R., MacFabe D. F., La Gamma E. F. Enteric bacterial metabolites propionic and butyric acid modulate gene expression, including creb-dependent catecholaminergic neurotransmission, in pc12 cells-possible relevance to autism spectrum disorders. PLoS ONE. 2014; 9: e103740. doi: 10.1371/journal.pone.0103740. [PubMed] [CrossRef] [Google Scholar].

[23] Müller J. B., Guggenheim P., Haemmerli U. Treatment of chronic portal-systemic encephalopathy with lactulose. Lancet. 1966; 287: 890-893. doi: 10.1016/S0140-6736(66)91573-X. [PubMed] [CrossRef] [Google Scholar].

[24] De Angelis M., Piccolo M., Vannini L., Siragusa S., De Giacomo A., Serrazzanetti D. I., Cristofori F., Guerzoni M. E., Gobbetti M., Francavilla R. Fecal microbiota and metabolome of children with autism and pervasive developmental disorder not otherwise specified. PLoS ONE. 2013; 8: e76993. doi: 10.1371/journal.pone.0076993. [PubMed] [CrossRef] [Google Scholar].

[25] Navarro F., Liu Y., Rhoads J. M. Can probiotics benefit children with autism spectrum disorders? World J. Gastroenterol. 2016; 22: 10093. doi: 10.3748/wjg.v22.i46.10093. [PubMed] [CrossRef] [Google Scholar].

[26] Lefranc-Millot C., Guérin-Deremaux L., Wils D., Neut C., Miller L., Saniez-Degrave M. Impact of a resistant dextrin on intestinal ecology: How altering the digestive ecosystem with nutriose®, a soluble fibre with prebiotic properties, may be beneficial for health. J. Int. Med. Res. 2012; 40: 211-224. doi: 10.1177/147323001204000122. [PubMed] [CrossRef] [Google Scholar].

[27] Prasad S., Dhiman R. K., Duseja A., Chawla Y. K., Sharma A., Agarwal R. Lactulose improves cognitive functions and health-related quality of life in patients with cirrhosis who have minimal hepatic encephalopathy. Hepatology. 2007; 45: 549-559. doi: 10.1002/hep.21533. [PubMed].

[28] Hamer H. M., Jonkers D., Venema K., Vanhoutvin S., Troost F., Brummer R. J. Review article: The role of butyrate on colonic function. Aliment. Pharmacol. Ther. 2008; 27: 104-119. doi: 10.1111/j.1365-2036.2007.03562.x. [PubMed] [CrossRef] [Google Scholar].

[29] Zhou Z., Zhang Y., Zheng P., Chen X., Yang Y. Starch structure modulates metabolic activity and gut microbiota profile. Anaerobe. 2013; 24: 71-78. doi: 10.1016/j.anaerobe.2013.09.012. [PubMed] [CrossRef] [Google Scholar].

[30] Clarke T. B., Davis K. M., Lysenko E. S., Zhou A. Y., Yu Y., Weiser J. N. Recognition of peptidoglycan from the microbiota by nod1 enhances systemic innate immunity. Nat. Med. 2010; 16: 228-231. doi: 10.1038/nm.2087. [PubMed] [CrossRef] [Google Scholar].

[31] Den Besten G., van Eunen K., Groen A. K., Venema K., Reijngoud D.-J., Bakker B. M. The role of short-chain fatty acids in the interplay between diet, gut microbiota, and host energy metabolism. J. Lipid Res. 2013; 54: 2325-2340. doi: 10.1194/jlr. R036012. [PubMed] [CrossRef] [Google Scholar].

[32] Gibson G. R., Scott K. P., Rastall R. A., Tuohy K. M., Hotchkiss A., Dubert-Ferrandon A., Gareau M., Murphy E. F., Saulnier D., Loh G., et al. Dietary prebiotics: Current status and new definition. Food Sci. Technol. Bull. Funct. Foods. 2010; 7: 1-19. doi: 10.1616/1476-2137.15880. [CrossRef] [Google Scholar].

[33] Howlett J. F., Betteridge V. A., Champ M., Craig S. A., Meheust A., Jones J. M. The definition of dietary fiber-discussions at the ninth vahouny fiber symposium: Building scientific agreement. Food Nutr. Res. 2010; 54: 5750. doi: 10.3402/fnr. v54i0.5750. [PubMed] [CrossRef] [Google Scholar].

[34] Roberfroid M. B. Handbook of Prebiotics. CRC Press; Boca Raton, FL, USA: 2008. Prebiotics: Concept, definition, criteria, methodologies, and products; pp. 49-78. [Google Scholar].

[35] Slavin J. Fiber and prebiotics: Mechanisms and health benefits. Nutrients. 2013; 5: 1417-1435. doi: 10.3390/nu5041417. [PubMed] [CrossRef] [Google Scholar].

[36] Bindels L. B., Delzenne N. M., Cani P. D., Walter J. Towards a more comprehensive concept for prebiotics. Nat. Rev. Gastroenterol. Hepatol. 2015; 12: 303-310. doi: 10.1038/nrgastro.2015.47. [PubMed] [CrossRef] [Google Scholar].

[37] Trompette A., Gollwitzer E. S., Yadava K., Sichelstiel A. K., Sprenger N., Ngom-Bru C., Blanchard C., Junt T., Nicod L. P., Harris N. L., et al. Gut microbiota metabolism of dietary fiber influences allergic airway disease and hematopoiesis. Nat. Med. 2014; 20: 159-166. doi: 10.1038/nm.3444. [PubMed] [CrossRef] [Google Scholar].

[38] Hernot D. C., Boileau T. W., Bauer L. L., Middelbos I. S., Murphy M. R., Swanson K. S., Fahey Jr G. C. In vitro fermentation profiles, gas production rates, and microbiota modulation as affected by certain fructans, galactooligosaccharides, and polydextrose. J. Agric. Food Chem. 2009; 57: 1354-1361. doi: 10.1021/jf802484j. [PubMed] [CrossRef] [Google Scholar].

[39] Hutkins R. W., Krumbeck J. A., Bindels L. B., Cani P. D., Fahey G., Goh Y. J., Hamaker B., Martens E. C., Mills D. A., Rastal R. A., et al. Prebiotics: Why definitions matter. Curr. Opin. Biotechnol. 2016; 37: 1-7. doi: 10.1016/j.copbio.2015.09.001. [PubMed] [CrossRef] [Google Scholar].