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Micronutrients Why and How

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Abstract

Nutrition is one of the important factors that affect the immune system. The key nutrients for a healthy immune system are proteins, antioxidants, micronutrients, prebiotics, and probiotics.

The only food that has all the nutrients needed by the body is breastmilk. Breastmilk is not sterile since it has its own microbial composition. It helps in the development of a breastfed infant's gut microbiome.

Keywords: *proteins, antioxidants, micronutrients, prebiotics, and probiotics.*

Introduction

Nutrition is one of the important factors that affect the immune system. The key nutrients for a healthy immune system are proteins, antioxidants, micronutrients, prebiotics, and probiotics [1].

The only food that has all the nutrients needed by the body is breastmilk. Breastmilk is not sterile since it has its own microbial composition. It helps in the development of a breastfed infant's gut microbiome [2]. The constituents of breast milk which are present at every feed and may not be replicated include:

- **Live cells** such as stem cells which may play a role in the treatment of neonatal diseases [3]
- **Proteins** that help the infant to grow and develop. Proteins also activate the immune system and stimulate intestinal growth [4]
- **Nucleotides** that increase at night and scientists think they may induce sleep [5]
- **Enzymes** that help in nutrient digestion and absorption [6]
- **Complex sugars** (oligosaccharides)that act as prebiotics. They help in supporting the growth of beneficial bacteria and preventing infections [7]
- **Growth factors** that support healthy development. They affect intestines, blood vessels, nervous system, and glands [8]
- **Vitamins and minerals** that support healthy growth and organ function and help build infant's teeth and bones [8]
- **Antibodies** (immunoglobulins) that protect the infant against illnesses and infections. There are three basic forms of antibodies that can be found in breast milk [8]
- **Long-chain fatty acids** that play an important role in building infant's nervous system [8]
- **MicroRNAs** that regulate gene expression, help prevent disease development or progression, and support infant's immune system [9]

All these components can fluctuate over time, depending on the infant's age and needs [8].

Nutrition and Immunotherapy

It is possible to modulate the immune system via nutrition given that immune and metabolic pathways are interconnected, and that metabolism regulates function in immune cells. Targeting the immune system with nutrients could help in treating autoimmune and inflammatory diseases [1].

Inflammation is one consequence of an immune reaction. It is protective and assists in removing foreign bodies [1]. However, if the immune reaction is not appropriate, it may lead to undesirable consequences such as increased vulnerability to infections (in the case of decreased immune function), allergies (in the case of hyper-active immune function), as well as autoimmune diseases and chronic inflammation [1].

Orally consumed nutrients are converted by intestinal microbes into bioactive compounds (postbiotics) which affect the intestinal microbiota [10]. Gamma-aminobutyric acid (GABA) and short-chain fatty acids (SCFAs) act on epithelial cells, immunomodulation, and pain perception [11]. The interactions between the gut microbiome, immune system, metabolism, and nutrition are crucial determinants of health outcomes [1]. Proper nutritional supply during the gestation, neonatal maturation, and weaning contributes to the development of balanced immune responses [1].

Microbes are important components of the human ecosystem, including those residing outside as well as inside the human body [12]. The gut microbiome is important in regulating the defense responses and metabolism, contributing to the immune response, and aiding in the maturation of the immune system. The various physiological factors responsible for differences in genetic elements of the microbiome in a host include diet, geographical location, and environmental interaction [12].

Micronutrients and the Immune System

Micronutrients are becoming an important topic because of the recognition that micronutrients in diet can alter disease prevalence and ameliorate progression. Micronutrients are important for energy metabolism, cellular growth and differentiation, growth of the organs, and immune function [13]. Micronutrients influence the host-microbe-metabolic axis. Lack of adequate macronutrients or selected micronutrients can lead to clinically significant immune deficiencies and infection in children. These are reflected in the increase in prevalence of allergy, inflammation, and infection among children such as gastroenteritis, serious respiratory infections, throat infections, and chronic gastro-intestinal tract infection [14].

Sufficient micronutrients are one of several factors that help the immune system to function properly if it is associated with proper hygiene, stress control, adequate sleep, in addition to early and appropriate nutrition. Micronutrients act as antioxidants [14]. Micronutrient deficiencies and chronic undernutrition compromise cytokine response and influence cell trafficking [15]. Micronutrients influence human metabolism organ function either directly after absorbance and transfer to target cell organs or indirectly mediated by microbiota in intestinal tract, with the help of short chain fatty acids [16].

Vitamins, Minerals, & Micronutrients

It is critical to differentiate between essential nonenergy-delivering micronutrients (minerals, vitamins, trace elements) and energy-delivering macronutrients. Micronutrients including iron, copper, zinc, selenium, β-carotene, vitamins A, C, and E, as well as folic acid can influence several components of the innate immunity [14]. Micronutrients have an important role in modifying oxidant-mediated tissue injury and phagocytic cells as part of the defense against infections. Deficiencies in zinc and vitamins A and D could reduce natural killer cell function, while supplemental zinc or vitamin C could improve their activity. There are alterations of micronutrients in disease states [17].

Vitamins were originally thought as essential compounds of amines and because they were important to human health, they became known as “vital amines”. When it was discovered that some were not amines, the name was changed to vitamins [18]. Vitamins are important organic compounds, usually being coenzymes or cofactors for enzyme activity. Vitamins form biochemically through the life processes of plants and animals that we consume [18].

Specific nutrient deficiencies (zinc, vitamin A, and protein) and intestinal pathogens lead to intestinal dysbiosis and inflammation with disruption of intestinal barrier function. Reduced barrier function allows the translocation of bacteria and their products from the intestine to the blood circulation which in turn activates innate immune cells [19].

Characteristics of Trace Minerals

Each has a range of safe and adequate intake. They are required in very small quantities which makes measuring presence in food & body difficult. The body maintains balance mainly by absorption and it does not excrete trace minerals well. They have variable bioavailability [20]. They may also cause toxicity. Toxicity of iron from poisoning or repeated blood transfusions will lead to secondary hemosiderosis. Toxicity of zinc from galvanized iron cooking utensils can cause gastro-intestinal upsets and copper deficiency. Excessive dietary copper is suspected to cause Indian childhood cirrhosis [21]. Excessive dietary fluorine (>4-8 mg/d) causes teeth mottling and/or osteosclerosis (fluorosis) [22]. Other trace element toxicity is rarely seen, mainly during total parenteral nutrition and it is treated with its suitable chelating agent [20].

Immune Defects in Nutrient Deficiency

- Below is a summary of primary nutrient deficiency [15, 17]
- Protein calorie deficiency

- Clinical characteristics
  - Wasting,
  - stunting,
  - low weight for height,
  - growth (z score),
  - nongenetic short stature.
- Associated nutrient deficiency
  - Zinc, magnesium, selenium, copper, iron, vitamin A
- Immune system
  - Altered T-cell subsets,
  - High IgA,
  - IgG is normal or high
- Immune response
  - Decrease skin test reactivity
  - Decrease cytokine response
  - Risk of bacterial, viral, parasitic, opportunistic infections

- Iron
  - Clinical characteristics
    - Anemia, pallor, s
    - poon-shaped nails,
    - recurrent infections.
  - Associated nutrient deficiency
    - Zinc with dermatological manifestation
  - Immune system
    - T-cell defects
    - Decrease in IgG levels
    - Decrease in phagocytic activity
  - Immune response
    - Decrease in cytokine response
    - Risk of parasitic and opportunistic Candida species infections
    - Reduced IL-2 response
- Zinc
  - Clinical characteristics
    - Diarrhea,
    - skin lesions,
    - infections,
    - alopecia,
    - poor wound healing
  - Associated nutrient deficiency
    - Rarely iron, copper
  - Immune system
    - Lymphopenia,
    - Thymic atrophy,
    - Altered T-cell subsets
  - Immune response
    - Decrease skin test reactivity
    - Decrease cytokine response
- Selenium
  - Clinical characteristics
    - Muscle aches and pains,
    - cardiomyopathy,
    - infections
  - Associated nutrient deficiency
    - Not reported
  - Immune system
    - Decrease Antioxidant defense
  - Immune response
    - Increase viral virulence
- Copper
  - Clinical characteristics
    - Neutropenia,
    - anemia
  - Associated nutrient deficiency
    - Increase in Zinc (might be causative)
  - Immune system
    - Lymphopenia
  - Immune response
    - Reduced IL-2 response
- Vitamin E
  - Clinical characteristics
    - Neurologic symptoms,
    - atopic disease with increased IgE
  - Associated nutrient deficiency (Juyal R. Asia2004)
    - Rare
- Vitamin A
  - Clinical characteristics
    - Xerophthalmia,
    - keratomalacia,
    - diarrhea and respiratory infection
  - Associated nutrient deficiency
    - Zinc
  - Immune system
    - Lymphopenia
    - Decrease mucosal barrier function
  - Immune response
    - Decrease T-cell response, especially TH2

- Decrease phagocytic cell and NK cell function
- Vitamin C
  - Clinical characteristics
    - Scurvy,
    - purpura,
    - petechiae,
    - hyperkeratotic lesions,
    - recurrent furunculosis,
    - stress exercise
  - Associated nutrient deficiency
    - Not reported
  - Immune system
    - Decrease plasma glutathione
  - Immune response
    - Decrease phagocyte function
    - Increase the risk of infections
- Vitamin D
  - Clinical characteristics
    - Harrison's Groove or Pigeon Chest,
    - spinal deformity,
    - bowlegs,
    - beading of the rib cage,
    - rachitic rosary,
    - rickets

Conclusion

micronutrients are chemical elements or substances required in trace amounts for the normal growth and development. They can be divided into four groups: water-soluble vitamins, fat-soluble vitamins, macro minerals and trace minerals. Deficiencies in micronutrients can have devastating consequences. They have a major role in metabolism and immune function.

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