Integr. J. Soc Sci., 2016, 3(1), 30-33 Article

INTEGRATED JOURNAL OF
SOCIAL SCIENCES

The role of Nutrition in the Immune system functions

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Received: 2-Aug-2016 Accepted on: 30-Sept-2016, Published on: 10-Oct-2016

ABSTRACT

The immune system in our body is a complex network of cells that defends the body against infection and reduces the risk of degenerative diseases. The immune system has two functional divisions: the innate and the acquired. Adequate nutrition is an essential determinant of the immune response. Micronutrients contribute to the body's defense by supporting physical barriers i.e. skin and mucosa, cellular immunity, and antibody production. Vitamins A, C, E, and zinc help to enhance this skin barrier. The vitamins A, B6, B12, C, D, E and iron, zinc contribute to our immune cells' protective activities. Inadequate intake of these vitamins and trace minerals may lead to suppressing immunity, leading to more infection chances. Studies have indicated that adding the deficient nutrient back to the diet can revive immune function and resistance to an ailment.

Keywords: Immunity, Nutrient, Antibody, Micronutrients, Infection

Introduction

Adequate nutrition is required for all cells in the body to function and the same applies to the cells of the immune system. Also, after a spurt of infection, immune system's nutritional demands increase due to an increase in BMR of the body. The immune system fulfils this requirement either from exogenous sources, which usually is diet or from endogenous sources such as body stores if dietary sources are insufficient. Nutritional components have an essential role in the development of an effective immune system throughout our life. Undernutrition causes impairment of immune function and its extent depends on the severity of deficiency. Malnutrition is commonly associated with impaired responses, particularly cell-mediated immunity, phagocyte function, cytokine production, antibody affinity, and the complement system (Chandra, 1996). Chronic undernutrition weakens immune response, leading to altered resistant cell populations and a generalized increase in inflammatory mediators (Beisal, 1996).

Malnutrition is a systemic alteration that is caused in our body by an imbalance between nutrient intake and energy requirements. It also affects immune response resulting in a decrease in the defense mechanisms and thus making the host more susceptible to infections.

It has been surveyed that a huge number of Indians have a lower intake of vitamins and other micronutrients in their diet than what is required. As a result, there is a rise in many lifestyle-related diseases as well as lower immunity levels. Intake of nutrient-rich foods and a well-balanced diet is the best way to obtain these nutrients. This paper intends to study the functioning of the immune system and how a good diet can improve our immune function so that the incidence of infection is decreased.

Immune System

Immunity is the ability of the organisms to resist the invasion of microorganisms and harmful substances. Our immune system is a system, it cannot be considered as a single entity. The healthy immune system which acts as a warrior for our system needs good and regular nourishment. Our immune system's essential functions are to protect the host against infection from pathological microorganisms, to repair the damaged tissues and to arrest the growth of malignant cells that grow in our body.

The cell of the immune system includes white blood cells, macrophages, and lymphocytes. The primary lymphoid tissues of the immune system are the thymus and the bone marrow. The first line of defense against non-self-pathogens is the innate or nonspecific immune response. The mechanism of working of the innate immune system is the same for all types of germs and foreign particles, that is why it is sometimes referred to as "nonspecific" immune system. Also, it acts quickly to defend the body. For example, it detects the bacteria entered through a small wound and destroys it within a few hours. But it has limited ability to stop the spread of infection. The innate immune system consists of two components. The skin and mucus membrane offers the first protection, and the second protection is provided by the immune system cells and

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Cite as: *Integr. J. Soc. Sci., 2016, 3(1), 30-33.*

 IJSS ISSN: 2348-0874

http://pubs.iscience.in/ijss

proteins. Both outer and inner surfaces of the human body constitute innate immune system. They protect the human body from germs. In addition to this chemical substance like acid, enzymes or mucus prevents bacteria and viruses from multiplying. Tears, sweat, and urine also have similar effect. The innate immune system also activates special immune system cells and proteins if germs crosses the skin barrier and mucous membranes and enter the body. The second line of defense against non-self-pathogens is called an adaptive immune response. It is also known as acquired immunity. If the innate immune response cannot destroy the germs, then the adaptive immune system comes to the rescue. First of all, it identifies the germs. It means it deals with the situation more accurately. Also, there is an added advantage as it is capable to "remember" germs. If the known germ is reencountered, the adaptive immune system will respond faster. The second infection is then usually milder and sometimes goes unnoticed. It develops over time as the body is exposed to microorganisms. The adaptive immune response is made up of T lymphocytes and B lymphocytes found in the tissues and antibodies found in the body fluids. Antibodies fight off any invading organisms and thus protect the body.

There is considerable difference among individuals in the relation of their immunological function due to genetics, environment, lifestyle, nutrition, and their interaction. Protein-calorie deficiency, essential lipid deficiency, and vitamin and mineral deficits all result in some aspect of impaired immunity. Nutrients are necessary for synthesis and secretion of signaling molecules, proliferation of cells, generation of free radical , and the active process of immune suppression at the end of the response (Percival, 2011). Lacking any nutrients would impair the response. It has been long recognized that people living in poor conditions and malnourished are more vulnerable to infectious diseases. The role of food nutrients in immunity is well documented.

Modulations of Immune Function by Nutrients and Food Components

VITAMIN A: Vitamin A is a micronutrient that has important role in maintaining vision, promoting growth and development, and protecting epithelium and mucus integrity in the body. Vitamin A is required to keep the cells' structure in the skin, respiratory tract, and gut. This acts as the body's first line of defense. Also, vitamin A is needed to make antibodies that neutralize the pathogens which cause infection. It is often referred to as the "anti-inflammatory vitamin' as it plays a vital role in improving immune function. Vitamin A has promoting and regulatory roles in both the innate immune system and adaptive immunity. It can help to enhance the organism's immune function and thus provide an enhanced defense against multiple infectious diseases. It plays regulatory roles in cellular immune response and humoral immune processes. Evidence shows that vitamin A support decreases the inflammatory response in acute bronchopulmonary dysplasia and some cancer cells (Reifen, 2002; Aiguo et al., 2008; Mullin, 2011). Vitamin A has a role in modulating a broad range of immune processes, such as lymphocyte activation and proliferation, the production of specific antibody isotypes and regulation of the immune response (Mora et al., 2008).

Food Sources: It is present in oily fish, egg yolk, cheese, tofu, nuts, seeds. Also, some vegetables contain beta carotene, which our body can convert into vitamin A. Beta carotene is found in green leafy vegetables, yellow-orange vegetables like pumpkin and carrot.

VITAMIN C: For us vitamin C is an essential micronutrient. Vitamin C contributes to immune system defense by supporting various innate and adaptive immune systems' cellular functions. It also supports the epithelial barrier function against pathogens and restricts the entry of pathogens. It is a potent antioxidant, thus protects our body against environmental oxidative stress. Vitamin C also has a role in protection against infections and inflammations. Vitamin C has been proven to enhance differentiation and proliferation of B and T cells. Vitamin C acts as a free-radical scavenger that can scavenge superoxide and peroxyl radicals, hydrogen peroxide, hypochlorous acid, and oxidant air pollutants (Marmot et al., 2006; Pozzer et al., 2012). The antioxidant properties of vitamin C protect lung cells exposed to oxidants and oxidant-mediated damage caused by various pollutants, heavy metals, pesticides, and xenobiotics (Haryanto et al.,2015; Sram et al.,2012). It has involvement in wound healing as it enhances collagen formation (Kivirikko et al.,1989; Fuge et al., 1994). Vitamin C deficiency results in impaired immunity and higher susceptibility to infections. Strohle and Hahn, (2009) confirmed that Vitamin C deficiency resulted in a reduced resistance against pathogens, on the other hand a higher supply enhances several immune system parameters.

Food Sources: Fruits especially citrus fruits, green leafy vegetables, tomatoes.

VITAMIN D: Among all vitamins, vitamin D is unique as it can be synthesized in our skin from the precursor 7-dehydrocholesterol when we are exposed to sunlight. Vitamin D has other roles in addition to its primary function on calcium and bone homeostasis. Deficiency in vitamin D is shown to be associated with increased autoimmunity and increased susceptibility to infection. The vitamin D receptor is expressed on our immune cells like T cells and antigens. These immune cells can synthesize vitamin D metabolites and act in an autocrine manner in a local immunologic milieu (Aranow, 2011). Vitamin D can influence the innate and adaptive immune responses. It slows B cell proliferation and blocks B cell differentiation and immunoglobulin secretion (Lemire et al., 1984; Chen et al., 2007). Deficiency in vitamin D is linked with increased autoimmunity and increased susceptibility of the body to infection. As our immune cells in autoimmune diseases are responsive to the increased effects of this sunshine vitamin, the advantage of supplementing vitamin D deficient individuals with autoimmune disease may surpass beyond the effects on bone and calcium homeostasis.

The effects of vitamin D on protective immunity are partly due to its impact on the innate immune system (Provvedini, 1983). It plays an essential part in the innate antimicrobial response (Aranow, 2011). Supplementation with vitamin D lowers the probability of developing acute respiratory tract infections to varying degrees (Charan et al, 2012).

Food Sources: Oil fish such as salmon, red meat, liver, egg yolk, fortified foods.

VITAMIN E: Vitamin E is a broader term that includes all tocopherols and tocotrienols that exhibit tocopherol's biological activity. Vitamin E, a fat-soluble antioxidant can protect the polyunsaturated fatty acids (PUFAs) in the membrane from oxidation. Vitamin E acts as a chain-breaking, lipid-soluble antioxidant present in the membranes of all cells, including our immune cells, which protects them from oxidative damage related to high metabolic activity, as well as high PUFA content in these cells (Coquette, 1986). Even a

slight vitamin E deficiency has been shown to weaken the immune response and its role in promoting a healthy immune system is particularly evident in older people (Abdukalykova et al., 2008; Meydani et al, 2005). Vitamin E supplementation in our diet has been shown to enhance humoral responses (Beharka et al., 2000).

Food Sources: Vegetable oils, nuts, soybean, sunflower, corn, walnut, cottonseed, palm, wheat germ oils, green leafy vegetables.

VITAMIN B6: Vitamin B6 is important for the metabolism of nucleic acids, amino acids, and lipids and thus influences cell growth. It has three forms - pyridoxine, pyridoxal, and pyridoxamine. These three forms are converted into pyridoxal phosphate (PLP), which is involved in several enzyme reactions in our body. As it is a cofactor for enzymes of amino acid metabolism, hence effects the immune system. It is also vital for normal blood homocysteine levels. Raised levels of homocysteine could be a risk factor for cardiovascular diseases. Vitamin B6 deficiency is associated with a decrease in both humoral and cell-mediated immune responses in our body. Lymphocyte differentiation and maturation are altered by deficiency, delayed-type hypersensitivity responses are reduced, and antibody production may be indirectly impaired (Rail and Simin, 1993). Vitamin B6 supplementation increases the immune function in critically ill patients (Cheng et al, 2006). Vitamin B6 helps to improve the immune response by increasing the antibodies' production (Kunisawa and Kiyono, 2013).

Food Sources: Chicken, liver, fish, nuts, bananas, potatoes, chickpea, whole grains.

VITAMIN B12: Vitamin B12 is essential for DNA synthesis, cellular energy production, red blood cell formation and nerve system function. Vitamin B12 deficiency is widespread, mainly due to less intake of animal foods in the diet or malabsorption of the vitamin in the body. Vegetarians are seen to be at risk of vitamin B12 deficiency. Other groups are those with low intakes of animal foods or those with restrictive dietary patterns. Malabsorption of vitamin B12 is most commonly seen in the elderly, secondary to gastric achlorhydria (O'Leary et al., 2010). Together with Vitamin B6, it helps to maintain normal levels of homocysteine in the blood. It aids in the metabolism of every cell of the human body, mainly affecting DNA synthesis, fatty acid, and amino acid metabolism. Research indicates a significant role of vitamin B12 as immune modulation for cellular immunity (Tamura et al., 1999). Vitamin B12 plays a significant role in the immune system as it is involved in the synthesis of purines and pyrimidines, including fast-dividing immune cells.

Food Sources: Meat, fish, poultry, dairy products.

IRON: Iron is an essential mineral for almost all living organisms. It takes part in several critical biological processes in the human body. Iron deficiency anemia is a severe problem of public health significance that affects our mental and physical development, overall health, and work performance of the body. Worldwide it is the most common micronutrient deficiency. It is more than 50% in developing countries and is usually attributed to inadequate nutrition (DuBois and David, 2005). The influence of iron on immune function has long been studied, and found that its deficiency and excess can influence the functioning of the immune system's innate and adaptive arms. Iron plays a crucial role in immunosurveillance because of its growth-promoting and differentiation-inducing properties for immune cells and its interference with cell-mediated immune effector pathways and cytokines activities (Weiss, 2002). Iron also has some effects on the growth and virulence of microbial pathogens (Cherayil, 2010). Iron has a role in enzyme reactions essential for immune cells to recognize and target pathogens in the body (Kuvibidila, 2013).

Food Sources: Meat, chicken, fish, legumes, whole grains, iron-fortified breakfast cereals.

ZINC: Zinc is essential for the function of the immune system. Zinc ions are involved in regulation of intracellular signal pathways in innate and adaptive immune cells. Zinc is beneficial in maintaining the integrity of the skin and mucous membrane. It also helps in eliminating some of the damage caused by oxidative stress. Its role in improving immune tolerance is well recognized. Its deficiency negatively impacts immune cells development and functions in both innate and adaptive immunity, as well as impaired immune functions including lymphocyte proliferation and certain functions of neutrophils (Prasad, 2008). Zinc deficiency has been known for an extended period and is associated with skin abnormalities, hypogonadism, cognitive impairment, growth retardation, and imbalanced immune reactions, which favor allergies and autoimmune diseases (Prasad ,2009; Rink, 2011). Conversely, checking zinc deficiency by supplementation can reverse impairment in the immune system (Haase and Lothar, 2009) and reduce mortality from the infectious disease (Christa and Robert, 2004).

Food Sources: Oysters, beans, nuts, whole grains, fortified breakfast cereals, and dairy products.

DIETARY FIBER: Non-digestible parts of fruits, vegetables, and cereals are an essential source of energy for bacteria residing in our intestines. The fiber's fermentation leads to the formation of short-chain fatty acids (SCFA) an essential nutrient for humans. SCFA reduces the risk of colorectal cancer. SCFA after absorption are distributed in the body via blood circulation, thus preventing pathologies outside the gut. Dietary fibers positively support the immune system, which may lead to increased resistance to infections. (Meyer, 2008). There is sufficient evidence that fermentable nutritional fibers and the newly described prebiotics can affect various aspects of the immune system, including those of the gut-associated lymphoid tissues (Schley and Field, 2002)

Food Sources: Whole cereals and pulses, green leafy vegetables, oatmeal, beans, nuts, and fruits such as apples, berries, citrus fruits, and pears

FISH OIL AND N-3 PUFA: Many dietary lipids, especially polyunsaturated fatty acid (PUFA), and their metabolic products can regulate cell functions. The polyunsaturated fatty acids can affect significant changes in the activation of innate and the adaptive immune system, although the mechanisms for such regulation are diverse. Being a part of the cellular membrane, omega-3 fatty acids can regulate cellular membrane properties, such as membrane fluidity (Yan et al., 2013). Omega-3 fatty acids have shown the ability to reduce inflammation (Calder, 2011).

Food Sources: flaxseeds, walnuts, chia seeds, fish oils.

GREEN TEA AND EPIGALLOCATECHIN-3-GALLATE [EGCG] Green tea has a high content of catechins, which is 10-15% of its dry weight, which include epicatechin (EC), epicatechin-3-gallate (ECG), epigallocatechin (EGC), and epigallocatechin-3-gallate (EGCG). EGCG is proven to effectively modulate multiple aspects of innate and adaptive immunity (Pae, 2013).

Conclusion

It is well understood that for the proper functioning of the immune system, nutritional adequacy is required. Also, both macronutrients and micronutrients and phytochemicals and functional foods play an essential role in immune function as they affect inflammation and decrease infection risk. Nutrients may impact directly or indirectly affect immune cells or may exert effects via changes in the gut microbiome. That is why a better understanding of the role of nutrients in immune function will facilitate to improve human health.

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