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Role of Zinc as a Micronutrient in Life and Human Health

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Abstract:

There are so many micronutrients which are important to human health and nutrition but among them, Zinc is an essential element which is most significant and its importance for the health is increasing day by day and due to its deficiency, many diseases may appear. Zinc plays three major biological roles such as catalytic, structural and regulatory ion, hence it is an important trace element for the organisms. Zinc is critically affected in many aspects of human health such as in homeostasis, immune function, oxidative stress, apoptosis, aging and many disorders related to the health of human are also associated with the zinc deficiency. Zinc deficiency may complicate the clinical features of several chronic diseases or disorders such as atherosclerosis, malignancies, neurological disorders, autoimmune diseases, aging, age-related degenerative diseases and Wilson's disease increases oxidative stress and reaches to the generation of inflammatory cytokines and affects immunological status adversely. In this paper, the multipurpose of zinc is discussed and also discussed its biological role in immunity and chronic diseases including cancer, diabetes, HIV, Wilson's disease and other age and skin related diseases.

Keywords: *Zinc, Human Health, Health Benefits, Immune Responses, Zinc Deficiency*

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Introduction

Zinc (Zn) is one of the most important trace element in the body and is ubiquitous. It is very essential for the growth and development of microorganism, plants, and animals. In adults, the average amount of the zinc is about 1.4-2.3g. It is secreted in all tissues of the body, and it secretes with a high proportion in the muscles and bones with 85% of the whole body, in skin and liver, it is approximately 11% and higher concentration from other remaining secretes in the prostate and parts of the eye. The minimum need for zinc in humans for their satisfactory growth, health, and well-being differs according to the diet consumed, climatic conditions stress existence caused by the trauma, infections and parasitic infestations.

Zinc and Immunity

Zinc plays a crucial role in the maintenance of immune functions such as cellular and humoral immunity and zinc deficiency. Zinc may affect the aspects of immune systems and crucial for phagocytosis, cell-mediated immune systems also for the function of neutrophils, natural killer cells, and macrophages. The growth of T and B cells may be adversely affected by the deficiency of zinc and it may potentiate the apoptosis. It has been observed that the thymic atrophy, decrease in an absolute number of splenocytes, and decreased responses to both T-cell dependent (TD) and T cell independent (T1) antigens in young adult zinc-deficient mice. Animals developed a severe weakening in their ability to generate a cytotoxic T killer response to the tumor challenge and maintained on a zinc-deficient diet for as slight as 2 weeks.

Zinc and Its Health Benefits

Zinc deficiency causes reduce in the circulating luteinizing hormone and testosterone concentrations, modifies sex steroid hormone receptor levels along with the alterations in the hepatic steroid metabolism hence causing male reproductive dysfunction. For maintaining normal serum testosterone, Zn is very essential and the pituitary gland is prevented from releasing luteinizing and follicle stimulating hormone by the inadequate level of Zn. It also inhibits the aromatase enzyme converts testosterone into excess estrogen. Increased risk of heart disease, weight gain, and obesity are caused by the higher estrogen activity. Zinc also helps to produce healthier sperm with increase sperm count and motility along with the other impacts on hormone levels. Zn deficiency leads to the enlargement of the prostate gland due to the infection.

1. Zinc as an antioxidant

Cytosolic Zinc/Cu superoxide dismutase stabilizes by the Zn which starts catalysis of superoxide removal by virtue of zinc –histidyl-Cu triad, which acts as a proton donor during the oxidation cycle. The NADPH oxidases which catalyze the production of superoxide O_2^- from O_2 and Cytotoxic cytokines TNF- α, IL-1β and IL-8 which generate free radicals are also inhibited by the zinc element. Whereas, the production of cysteine-rich metallothionein which is the excellent scavenger of hydroxyl (OH-) radical induces by the zinc element.

2. Zinc and Central Nervous System

Abnormal excessive interaction of beta-amyloid 42 (Aβ42) with copper, zinc, and iron induce peptide aggregation and oxidation in Alzheimer's disease which results in a neocortical Aβ precipitation. Since zinc has the property of antagonist of the glutamate N-methyl-D-aspartate (NMDA) receptor, therefore it shows antidepressant-like activity in rodent models and also induces the neurotrophic factors gene expression derived from the brain. In psychopathy and therapy of depression, zinc homeostasis is relevant.

3. Zinc and diabetes

In patients with type II diabetes mellitus, just because of the impaired zinc absorption and hyperzincuria, zinc deficiency occurs. Hyperzincuria correlates with the mean serum glucose concentration and is proportional to the proteinuria.

4. Zinc in wound healing

During the repair of the wound, auto debridement and keratinocyte migration are increased by the Zinc-dependent matrix metalloproteinase. With cytoprotection against reactive oxygen species and bacterial toxins, zinc discusses resistance to epithelial apoptosis through the antioxidant activity of the cysteine-rich metallothioneins. Zinc deficiency decreases the nuclear factor-kB activation due to which wound healing delays. During the early stages of wound healing, its deficiency may cause decreased neutrophil infiltration. The expression of proinflammatory cytokines such as interleukin (IL)-1β and tumor necrosis factor (TNF-α) are reduced by the deficiency of zinc element. In the treatment of zinc-deficient leg ulcer patients, oral zinc supplementation is beneficial but the therapeutic role of zinc in surgical patients remains to be seen.

5. Zinc and aging

Zinc prevents the neoplastic cell growth, therefore, the role of zinc is very crucial in healthy aging and also involved in mitotic cell division, DNA and RNA

repair. Even marginal zinc deprivation may contribute to immunosenescence, although most of these studies which confirmed declination of zinc levels with age do not classify the majority of elderly as zinc deficient. The potential to improve immunity and efficiently downregulates chronic inflammatory responses in the elderly is demonstrated by the physiological oral zinc supplementation.

6. Zinc and Cancer

In the metabolism and interaction of malignant cells particularly in apoptosis, zinc has been qualified roles. The structural stabilization and activation of an important component of the apoptotic process i.e., cytochrome P53 are done by the zinc element and also inactivation of certain members of the caspase family of proteases. It provides an effective dietary chemopreventive tactic to disease in a susceptible section of the population having a family history of carcinoma and also exerts a positive beneficial effect against chemically induced preneoplastic progression in rats.

7. Zinc and liver disorders

There is so many acute and chronic liver disease which are associated with the zinc deficiency. Zinc supplementation is used as a therapy for hepatic encephalopathy in patient's refractory to standard treatment and prevents against toxin-induced liver damage. It also decreases hepatic encephalopathy and blood ammonia levels and reduces gastrointestinal disturbances, weight loss, hair loss and mild anemia in chronic Hepatitis-C-Virus infected patients.

8. Zinc and HIV

The immunological failure and diarrhea in HIV-infected patients have been reported to decrease by the long-term zinc supplementations of 12-15 mg/days with poor viral control. More advanced disease and increased mortality in HIV patients is associated with the decreased serum zinc level.

9. Zinc in Skin diseases

Mild to moderate facial acne vulgaris can be cured by giving Oral APC (methionine-based zinc complex with antioxidants) thrice daily for 12 weeks to the patient and it is found to be effective and well tolerated. Scalp seborrheic dermatitis can be treated by using shampoos containing zinc pyrithione as it provides clinical benefits. The patient suffering from alopecia areata can be treated by using oral zinc sulfate supplementation as it is useful adjuvant therapy with encouraging results. Treatment of plane warts can be done by using the topical 10% zinc sulfate solution 3 times daily for 4 weeks.

10. Zinc and Wilson's disease

Induction of intestinal and hepatic MTs synthesis is the main function of the zinc compounds in Wilson's disease. Decreased protein degradation accumulates the hepatic MTs in a mouse model of Wilson's disease and this appears to offer some protection from the high hepatic Cu levels. In Wilson's disease, the clinical signs and laboratory findings of the patient do not aggravate by the zinc treatment but improve some clinical symptoms of the patients.

Therapeutic Effects of Zinc Supplementation in Humans

There are so many health benefits of the zinc supplementations in humans shown by several studies. Some of which are discussed as follows:

Parasitic Infections:

The plasma zinc levels remain lower in patients with cutaneous, mucosal and visceral leishmaniasis. The decrease in erythema and size of induration is associated with the zinc supplementation and causes an increase in cure rate.

Bacterial Infections:

In developing countries, the duration, severity, and incidence of diarrhea can be reduced by zinc. Fulfilling of the zinc deficiency requirement improves the absorption of water and electrolytes by the intestine which promotes the growth of levels of electrolyte brush border enzyme and leads to a faster regeneration of the gut epithelium. Zinc deficiency may cause the immune dysfunction which can be treated or cured by the zinc supplementations. Zinc is very beneficial in the treatment of shigellosis and leprosy patients according to several previous types of research. An increase in plasma retinol concentration, earlier sputum conversion, and resolution of x-ray lesions occurs by giving zinc supplementation to the patient with Mycobacterium tuberculosis. Zinc deficiency is characterized by a reduction of IL-2 and IFN-γ in humans and zinc induces the generation of both IL-2 and IFN-γ. Polaprezinc (zinc-L-carnosine) with antimicrobial triple therapy promotes the improved cure rate in the treatment of ulcer.

Viral Infections:

Since 1984, so many studies have been observed that the effect of zinc lozenges on the duration or severity of common cold symptoms. Zinc acetate and gluconate as zinc ions are released at physiological pH as it is suitable salts. Zinc lozenges must be started within 24 h of the onset of common cold and the daily total dose of elemental zinc should be at least 75 mg

are these two important factors. Zinc supplementation is used as a supporting therapeutic intervention in Infection with the human immunodeficiency virus (HIV) results in the acquired immune deficiency syndrome (AIDS) disease. The results of zinc supplementation in AIDS varies greatly i.e., and its explanation is that the patients with deficiency of zinc only respond to zinc supplementation and exhibit beneficial effects but zinc sufficient patients do not respond.

Effect of Zinc on Vaccination:

An investigation of a study is that whether the vibriocidal antibody in children is affected by the micronutrients supplementation to a killed oral cholera vaccine or not. Only zinc supplementations can improve seroconversion to vibriocidal antibody and therefore has the potential to improve the efficacy of oral cholera vaccine in children.

Review of Literature

Brown, Wuehler, and Peerson, (2001) summarized the research on the importance of zinc for human health and also reviewed the available literature for the evaluation of zinc status in individuals and populations. Their analysis results as the indication of nearly half of the world's population are at risk for insufficient zinc intake and suggested the public health program is needed for controlling the zinc deficiency.

Frassinetti, (2006) summarized the role and manifestation of zinc in the environment and its importance for human health and metabolism. Zinc plays an important role in biological processes. Zinc is required for DNA synthesis, cell division, and protein synthesis. It is evidentially found that zinc finger proteins are involved in the expression of various growth factors and steroid receptors. They found that the zinc is required for the normal development and maintenance of immune functions. They also found that zinc salts were neither toxic nor mutagen.

Imtiyaz *et al*., (2010) worked on the role of micronutrients in crop production and human health. To overcome the micronutrients disorders in soil and for the improvement in human health, the development of micronutrient efficient genotypes can be a successive tool. They said for ensuring the role of preventable deficiency on crop productivity and quality not give adverse effect is checked by the available micronutrients status of arable soils. The farmers and agronomist need to always think about Zn as the deficiency of zinc are widespread in our country. They mentioned that the repeated spraying of ferrous sulfate or chelated iron can cure the chlorosis and also improves the quality of foodstuff.

Chasapis *et al*., (2011) reviewed the zinc as multipurpose trace elements, its role in homeostasis, proliferation and apoptosis and its role in immunity and chronic diseases. Zinc has three major biological roles which are as a catalyst, structural and regulatory ion hence it is an important element. There are so many micronutrients which are important to human health and nutrition but among them, Zinc is an essential element which is most significant and its importance for the health is increasing day by day and due to its deficiency, many diseases may appear. Therefore zinc is very necessary to cure many diseases as it has many therapeutic effects on the health.

Akhtar, (2013) highlighted the prevalence of zinc deficiency and its health and economic consequences in South Asian developing countries and also enlightened the possible approaches to combating zinc deficiency. This study screened on the basis of population groups, age, and sex, pregnancy, and location. Pregnant and lactating women, preschool and school children are included in this study and it revealed by the analysis that zinc deficiency is high among children, pregnant and lactating woman in India, Pakistan, Bangladesh, Sri Lanka and Nepal. Clearly, development of awareness among the susceptible populations has shown promise to diminish the distressing effect of this nutritional deficiency.

Devi *et al*., (2014) discussed on the zinc with relation to the human health. Zinc deficiency is becoming the world problem which is affecting increasingly to the women and children in India and all over the world. It is impossible the formation of DNA which is the basis of life on the earth, without zinc. Deficiency of zinc is the fifth leading risk factor for disease in the developing world. This element is very important in human especially in infants and young children's health. They suggested that the status of zinc should be assessed in relevant clinical situations. There are still opportunities for further research mostly controlled clinical trials for establishing the potential use of zinc as a precautionary and therapeutic agent for a wide range of diseases in human.

Rajeshwari and Swaminathan, (2015) studied the role of zinc and copper in infertility. This study is the outcome of the extensive literature search and compiling of key finding during the last 15 years. They suggested this review as an eye opener for the more research in this field. This study covers a simple disease to the advanced cancer depicting the role of zinc and copper in human health and disease. They found the zinc as predominated that of copper as it discussed many important roles of zinc and copper in a variety of human disorders especially in reproductive health of both the genders.

Wieringa *et al*., (2015) showed the estimates of the prevalence of zinc deficiency using these different indicators can vary widely by using data from a recent national micronutrient survey in Vietnam leading to inconsistencies. They found that zinc deficiency among children is four times more prevalent than iron deficiency and 2.3 times more than stunting prevalence for example. They suggested that the efforts should be made for the identification of most suitable indicator to evaluate the impact of programs aimed at improving zinc status and health of populations.

Conclusion

As zinc has three major biological role, such as catalytic, structural and regulatory, it is very important micronutrient for the organisms. It involves in the proper functioning of the immune system to its role in cellulat growth, cell proliferation, and cell apoptosis and in the activity of numerous zinc binding protiens hence plays an important role in human physiology and essential for the structure and functioning of various proteins and cellular components. It is also very crucial for various chronic diseases such as cancer, aging, diabetes, Wilson's disease, HIV, liver disorders and central nervous system disorders. Therefore it is very important to overcome the problem of zinc deficiency. There are so many opportunies to further research in this field.

References:

Akhtar, Saeed. "Zinc Status in South Asian Populations—An Update." *Journal of Health, Population and Nutrition*, vol. 31, no. 2, Sept. 2013.

Brown, Kenneth H., *et al*. "The Importance of Zinc in Human Nutrition and Estimation of the Global Prevalence of Zinc Deficiency." *Food and Nutrition Bulletin*, vol. 22, no. 2, 2001, pp. 113–125.

Chasapis, Christos T., *et al*. "Zinc and Human Health: an Update." *Archives of Toxicology*, vol. 86, no. 4, Oct. 2011, pp. 521–534.

Devi, Ch. Bimola, *et al*. "Zinc in Human Health." *IOSR Journal of Dental and Medical Sciences*, vol. 13, no. 7, July 2014, pp. 18–23.

Frassinetti, Stefania, *et al*. "The Role of Zinc in Life: A Review." *Journal of Environmental Pathology, Toxicology and Oncology*, vol. 25, no. 3, 2006, pp. 597–610.

Imtiaz, Muhammad, *et al*. "The Role of Micronutrients in Crop Production and Human Health." *Pak. J. Bot*, vol. 42, no. 4, 2010, pp. 2565–2578.

Patil, Yogesh P., *et al*. "Biochemistry of Metal Absorption in Human Body: Reference to Check Impact of Nano Particles on Human Being." *International Journal of Scientific and Research Publications*, vol. 3, no. 4, Apr. 2013, pp. 1–5.

S., Rajeswari, and SwaminathanSwaminathan S. "Role of Zinc and Copper in Infertility: An Update." *International Journal of Multidisciplinary and Current Research*, vol. 3, June 2015, pp. 607–612.

Wieringa, Frank, *et al*. "Determination of Zinc Status in Humans: Which Indicator Should We Use?" *Nutrients*, vol. 7, no. 5, June 2015, pp. 3252–3263.