Zinc as an Essential Micronutrient and Its Positive Impact in Improving Body Immunity to Infection Through Nutritional Approach

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Abstract:

Background: Zinc is an essential mineral involved in various biological functions, including the regulation of the immune system. Zinc deficiency can lead to impaired immune function, increased susceptibility to infections, and delayed healing of diseases.

Methods: We searched the Pubmed and Google Scholar databases using relevant keywords such as "zinc", "zinc supplementation", "essential micronutrients", "immune system", and "infectious diseases."

Discussion: The results of the study indicate that zinc supplementation significantly impacts individuals with zinc deficiency, particularly in enhancing the number and function of immune cells like T and B cells. However, in a healthy population with normal zinc levels, supplementation did not yield significant improvements in immune function.

Conclusion: Zinc is an essential micronutrient that plays a crucial role in enhancing the immune system, especially in individuals with deficiency. Further research is needed to better understand the mechanisms by which zinc supports immunity in a broader population.

Keywords: zinc, immune system, infectious diseases.

Introduction

Zinc is an essential mineral that plays a crucial role in numerous physiological processes within the body, particularly in the immune system.[1,2] Its functions include regulating the activity of over 300 enzymes involved in various biochemical reactions, such as DNA synthesis, cell division, and tissue regeneration.[3,4] It plays a role in many enzymes or acts as a cofactor of many enzymes, and a deficiency of zinc reduces cellular immunity.[5] In the immune system, zinc is vital for the development and function of immune cells, including T lymphocytes, B lymphocytes, neutrophils, and natural killer cells (NK cells). Additionally, zinc serves as an important cofactor in the production of cytokines, molecules that modulate the immune response to infection and inflammation.[6]

Zinc deficiency has emerged as a global health issue, particularly in developing countries, impacting more than two billion individuals. A lack of zinc in the body can lead to impaired immune function, increasing susceptibility to infections, delaying wound healing, and causing other health issues such as chronic diarrhea and respiratory tract infections.[1,7] In children, zinc deficiency is linked to high morbidity from infectious diseases, including diarrhea and pneumonia.[8]

The significance of zinc in enhancing immunity is receiving increasing attention, especially regarding the prevention of infectious diseases.[8] Zinc supplementation is frequently employed to address zinc deficiency and bolster immune function in vulnerable populations, including infants, children, the elderly, and individuals with medical conditions that may lead to zinc deficiency.[3,6] It has also been associated with a reduced risk of infection and inflammation, as well as improved immune responses to vaccination.[2,9]

Methods

This study employed a randomized controlled trial (RCT) approach alongside a literature review. The RCT was utilized to assess the impact of zinc supplementation on immune function, while the literature review aimed to compare findings from various published studies regarding the role of zinc in enhancing immunity. We searched the PubMed and Google Scholar databases using relevant keywords, including "zinc," "zinc supplementation," "essential micronutrients," "immune system," "T and B cells," and "infectious diseases."

Case Report

Here are some cases related to zinc supplementation in supporting the immune system,

namely:

1. Cases of Zinc in Healthy Children in Iran (RCT). The study was conducted on healthy children aged 6-7 years who received 20 mg zinc supplements daily for 6 months. The purpose of this study was to determine the effect of zinc on lymphocyte proliferation as an indicator of immune function. The results indicated that zinc supplementation did not significantly alter lymphocyte proliferation in healthy children who had not previously experienced zinc deficiency. In healthy children with normal zinc levels, supplementation does not demonstrate significant benefits in enhancing the immune response.[4]
2. Cases in children experiencing zinc deficiency in various studies, such as those with malnutrition, show an increase in immune capacity after receiving zinc supplementation. In malnutrition cases, zinc supplementation significantly boosts the number of T cells and B cells and enhances the production of antibodies that play a crucial role in combating infection.[3]
3. Zinc in infectious diseases, including tuberculosis and HIV infection. In studies involving HIV patients, zinc supplementation improved the immune response to infection and prevented further decline in the number of immune cells.[3]
4. Zinc and pregnancy, zinc plays a crucial role during pregnancy. Zinc deficiency in pregnant women can lead to various problems, including preterm birth and low birth weight. A study by Caulfield et al. indicated that zinc supplementation during pregnancy may slightly reduce the risk of preterm birth but does not address other issues such as low birth weight.[3]
5. Cases of respiratory infections and diarrhoea. WHO and UNICEF recommend zinc supplementation as part of the clinical management of acute diarrhoea in children, based on evidence that zinc effectively reduces the severity and duration of the disease. Additionally, zinc has been shown to lower the incidence of respiratory tract infections. Zinc supports the body's defence against infection by enhancing innate and adaptive immune mechanisms, particularly in cases of respiratory infections and diarrhoea that commonly occur in children in developing countries.[3,7]

Discussion

Zinc homeostasis refers to the regulatory processes that maintain zinc levels in the body to ensure its availability for vital biological functions while preventing toxic accumulation.[9] Zinc is an essential trace element required for numerous cellular activities,

including growth, cell division, DNA synthesis, and immune responses.[8,9] This homeostasis is controlled primarily by two groups of zinc transporter proteins: the ZnT family (solute-linked carrier 30 or SLC30A) and the ZIP family (Zrt- and Irt-like proteins or SLC39A). ZnT proteins are responsible for exporting zinc out of cells or into cellular organelles, while ZIP proteins transport zinc into the cytoplasm from extracellular sources or organelles. The majority of zinc in the body is bound to zinc-binding proteins, such as albumin or metallothioneins, which act as reservoirs to store and release zinc as needed. Metallothioneins, in particular, play a critical role in zinc storage, heavy metal detoxification, and modulating oxidative stress and immune responses. These proteins are highly responsive to changes in zinc levels, and an increase in zinc triggers metallothionein expression to regulate intracellular zinc. When zinc deficiency occurs, the balance of zinc homeostasis is disrupted, leading to impaired cellular functions, including those of the immune system. Conversely, excess zinc can lead to toxicity, affecting the functionality of enzymes and cellular pathways.[9]

Several studies have indicated that zinc is crucial for activating T and B cells, enhancing lymphocyte proliferation, and supporting the production of pro-inflammatory cytokines essential for the immune response. However, the effectiveness of zinc supplementation is highly contingent on an individual's zinc status.[5,7]

A study involving healthy children in Iran revealed that zinc supplementation did not significantly boost lymphocyte proliferation if zinc levels were already within normal ranges. Conversely, in children suffering from zinc deficiency or malnutrition, zinc supplementation was found to enhance immune function and lower the risk of infection. Research has also demonstrated that zinc plays a vital role in improving the immune response in patients with chronic diseases, such as HIV and tuberculosis, by increasing the number of CD4+ T cells and enhancing adaptive immune function. Additionally, zinc is effective in reducing the duration and severity of respiratory tract infections and diarrhea, particularly in vulnerable populations in developing countries.[3,4]

Overall, zinc is beneficial for improving immune function in individuals with deficiency. Zinc supplementation in healthy populations does not consistently yield significant benefits and may lead to excessive doses, which can ultimately disrupt the homeostasis of other minerals like copper. This underscores the importance of a needs-based approach to zinc supplementation.[3,4]

Conclusion

This literature review has thoroughly examined how zinc is a vital element in maintaining and enhancing the immune system, particularly in individuals with zinc deficiency. Overall, zinc serves as an important tool in the body's defence system, but like any tool, its effectiveness relies on proper usage. With a targeted approach, zinc can be key to strengthening the immune system and alleviating the burden of infectious diseases, especially in regions with high rates of zinc deficiency. Further research is necessary to better understand the role of zinc in the broader population, as well as its potential as a preventive therapy.

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