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Review Article

Role of the Essential and Non Essential Trace Elements in Human Health and Disease

Hamadullah Soomro*, Shaista Khan, Zunair Ahmed and Tarique Aziz

Department of Biochemistry, Shah Abdul Latif University, Khairpur, Pakistan

***Corresponding Author:** Hamadullah Soomro, Department of Biochemistry, Shah Abdul Latif University, Khairpur, Pakistan.

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Abstract

The role of essential and non essential trace elements in human health is subject of the growing interest in the field of nutritional and medical sciences. This review aimed to evaluate the impact of essential and non essential trace elements in human body and health. Through a comprehensive literature review. We analyzed the role of trace elements such as iodine promotes appropriate learning and growth throughout the body the essential roles of various trace minerals, including iodine, zinc, selenium, iron, and copper, in human physiology. It emphasizes their significance in promoting growth, immune function, wound healing, and metabolic processes.

The text also underscores the importance of maintaining proper balance in these minerals to prevent health issues and infections. Additionally, it briefly mentions the significance of chromium in body growth and development. Overall, it emphasizes the crucial roles these trace minerals play in various biological functions and the need for understanding and managing them for health and well-being. Nonessential components are those that the body can produce on its own and that diet can also offer in tiny amounts of This paragraph discusses the health risks associated with toxic heavy metals, namely cadmium, arsenic, and lead. Cadmium can lead to cancer and liver disorders, accumulating in the body and causing physiological damage. Arsenic poses risks to humans through contaminated water sources but also has medical uses. Lead contamination affects multiple systems, causing long-term health issues.

Keywords: Iron; Copper; Zinc

Abbreviations

The word “trace elements” are used for elements existing in natural and perturbed environments in small amounts, with excess bioavailability having a toxic effect on the living organism. The ten main trace elements include iron, copper, zinc, manganese, fluorine, bromine, rubidium, silicon, strontium and lead. Among these, iron is the most abundant in human serum, followed by zinc and copper. On the other hand, cobalt, iodine, selenium, boron, molybdenum and chromium, among others, are ultra-trace elements and are present in least amounts [1]. Trace elements (TEs) exert a variety of cellular key functions, although they account for a very small fraction of the total body weight. TEs mediate vital biochemical reactions by acting as cofactors or catalyst for many enzymes and act as centers for stabilizing structures of enzymes and proteins. Consequently, imbalance in TE metabolism and homeostasis (defciency or excess) may play an important role in a variety of diseases [2]. All living things include trace elements, also known as trace metals, in minute quantities, yet despite this, their growth, development, and overall health depend on these tiny levels of these substances. It is essential to numerous biological processes, mostly as vitamins and enzymes’ constituents [3,4]. Trace element imbalances have been connected to numerous deadly diseases and may have a deleterious impact on biological systems [5]. Over a century ago, it was discovered that certain compounds found in live beings contained metals that had not previously been thought to be of biological importance. This finding sparked interest in trace elements in human physiology [6]. Every biological process uses trace elements, including those that produce energy and hormones, transmit nerve signals, control blood sugar and cholesterol levels, and contract muscles, as well as those that regulate pH, digestion, and metabolism [7]. Chemical elements that are present in minute quantities in natural materials are referred to as “trace

elements". The body requires relatively little levels of certain dietary elements for normal growth, development, and function. The definition of a trace element is an element that makes up between 0.01% and 1% of the body's total mass [8]. A variety of dangerous outcomes result from imbalances in the amount of trace elements [9].

Essential trace elements

A chemical element with a very low concentration is referred to as a trace element or a minor element. They are separated into classes that are necessary and optional. Essential trace elements are needed for a variety of physiological and metabolic activities in both plants and animals. The excess or deficiency of these vital trace elements can cause serious physiological dysfunction or, in the worst cases, death since they are so closely linked to the metabolic and physiologic functions of the organism. The body needs elements to perform its many activities, and they can be found in nature in a variety of ways. For biological, chemical, and molecular cell activity, trace elements are essential. Nutritional deficiencies can result in lowered immunity, an increased risk of oral and systemic infections, a delay in physical and mental development, and decreased productivity [10]. Essential trace elements, often known as micronutrients, are vital active ingredients in many metabolic processes that are essential to an organism's regular functioning. They also play a significant part in the organism's ability to adapt to both healthy and unhealthy environments. One of the key conditions for organism health is the stability of the body's physiologically normal chemical composition, particularly its micronutrient status [11,12]. Essential trace elements are including iodine (I), zinc (Zn), selenium (Se), iron (Fe), copper (Cu), chromium (Cr), and molybdenum (Mo) according to World Health Organization [13,14].

Iodine (I)

Iodine is a necessary ingredient for life at every stage of evolution, with fetal life and early childhood being the most important. Thyroxine (T4 tetraiodothyronine), thyroid-stimulating hormone (T3 triiodothyronine), and triiodothyronine (T3 triiodothyronine) all have iodine as a component [15]. The appropriate functioning of the endocrine glands is also essential. Iodine promotes appropriate learning and growth throughout the body and also aids in combustion. Due to its role in biosynthesis, a lack of iodine can cause a wide range of ailments. Despite its significance in the human body, iodine deficiency is common. maintaining the mammalian body in good health those with hypothyroidism who have a goiter or hyperthyroidism people who suffer from thyroid disorders are more likely to have significant Iodine deficiency dysfunction. Extreme fatigue impeded physical and mental processes. extra weight, bloating on the forehead Drowsiness, diarrhea, and a lack of iodine are all symptoms of this condition. Insufficient iodine intake in newborns could be slow and difficult to feed [16]. Iodine (I) is a trace element that is crucial for human health and must be consumed in sufficient amounts. Although there is less knowledge on the variability of urinary excretion, this element in foods is easily absorbed from the digestive tract and eliminated primarily into the urine, reflecting its nutritional status [17]. Iodine is an essential nutrient for human life and the reality that there is a great disparity in its consumption around the world. This causes that approximately 36.5% of the people suffer of IDD and paradoxically 10 countries have high iodine intake [18].

Zinc (Zn)

Zinc is the second most abundant essential trace mineral in the human body [19]. A regular dose of zinc is needed to maintain good health because it is a crucial trace mineral in the human body. Due to its ability to heal wounds and possess antibacterial qualities, zinc has been employed for decades in the formulation of topical and systemic medicines for a variety of skin problems. By regulating zinc homeostasis within dermal layers, zinc transporters significantly contribute to maintaining the integrity of the integumentary system [20]. In the human body, zinc serves numerous vital physiological and biological roles. More than 300 human body enzymes are thought to require Zn for direct or indirect physiologic and biological activity. The body needs a sufficient amount of zinc to perform its crucial biological processes, including the catalytic, structural, and regulatory roles. Zn also plays a crucial role in the regulation of numerous transcription factors in the human body and more than 300 molecular proteins, including Zn finger proteins, by stabilizing their tertiary structures. By binding to proteins, RNA, and DNA, these finger proteins regulate the gene production of several growth factors, immune response mediators, and steroid receptors [21].

Selenium (Se)

Selenium (Se), an essential trace element, is employed in the manufacture of selenoproteins, proteins with one or more selenocysteine residues, and has a significant impact on how the human body functions. Human selenoproteins have a wide range of *in vivo* uses. Numerous selenoproteins have antioxidant activity, which explains their involvement in a variety of biological processes, in-

cluding signal transduction, proliferation, cell transformation and aging, ferroptosis, immune system function, etc. They also play a critical role in cellular antioxidant defense and redox homeostasis maintenance. Selenoenzymes play a crucial role in the manufacture of thyroid hormones, which control the basal metabolism in all body tissues [22].

Iron (Fe)

Humans' immune systems, oxygen transport, and metabolic processes all depend on iron, therefore it's critical for a healthy body to maintain homeostasis—the balance of iron availability. Poor long- term illness prognoses and increased vulnerability to infection are caused by iron deficiency [23]. For bacterial growth, replication, and metabolism, iron is a crucial nutrient. For example, hemoglobin, haptoglobin, transferrin, ferritin, and lactoferrin are just a few of the proteins that humans store iron bonded to. This limits the amount of free iron that pathogenic germs may access. To sequester or scavenge iron from the host environment, bacteria have created a number of ways. Active transport systems for iron uptake include bacterial small molecule siderophores, siderophore receptors on the outer membrane, the TonB-ExbBD energy-transducing proteins that link the outer and inner membranes, and inner membrane transporters [24].

Copper (Cu)

Human bodies require copper, a micronutrient whose distribution in many organs and tissues, metabolism, and physiological effects are still poorly understood. The precise composition and structure of its combinations with other elements, the specific nature of its interactions with other elements, and the effects of copper and copper-enzymes on the body's physiology in illness and health. Identification biomarkers status of copper are currently being established. They are required to determine the preventative measures and treatment of illnesses and ailments associated to variations in human copper concentrations bodies. The development of analytical techniques for determining the presence of copper in used in clinical laboratory diagnostics are serum and urine [25]. Most organisms require copper as a cofactor for critical copper-dependent enzymes that are encoded by both prokaryotes and eukaryotes. Copper is an essential micronutrient. The mammalian immune system depends heavily on copper, as evidence gathered over many years has demonstrated. Infection areas such as the gastrointestinal and respiratory tracts, as well as blood and urine, collect copper, and phagocytic cells use this antibacterial toxicity to directly kill germs [26].

Chromium (Cr)

The chemical element Cr has the atomic number 24 and the symbol Cr. It is a glossy, brittle, hard, and steely-gray metal [27]. It weighs 52.0 atomic pounds. InThe French made the discovery of chromium oxide in 1797.

Louis Nicolas Vauquelin is a pharmacist and chemist. In the year 1798 that followed, Vauquelin learned that he could heat the oxide to isolate metallic chromium. a charcoal oven, making him the discovery's author. of the component [28]. Animals require the mineral chromium, which is crucial for body growth and development [29].

Molybdenum (Mo)

Molybdenum-containing crystals have been seen since antiquity, but the element wasn't discovered until 1778 by Carl Wilhelm Scheele and 1781 by Peter Jacob Hjelm [30]. Molybdenum aids in constructing an enzyme binding site as a component of molybdoprotein. The three most significant molybdenum-containing enzymes are thiosulfate superoxide dismutase, carbonyl dehydrogenase, and xanthine hydroxylase. An alloying elements enzyme must be active for nucleoside breakdown. Fast growth rate and biosynthesis are also impacted [31].

Non essential trace elements

Cadmium (Cd)

Cd is a poisonous non-essential metal that can cause numerous cancers, osteoporosis, liver and kidney disorders, as well as osteoporosis [32]. Man can be exposed to the hazardous metal cadmium while working or in the environment. The most notable toxicological characteristic of cadmium is how long it stays in the body after exposure. Cd is taken into the body and begins to build up, especially in the liver. Although the chemical mechanisms behind Cd's effects on cells have been well studied, they remain unresolved. By using several different mechanisms of action, the liver controls the cadmium to eliminate it. Even so, the work triggers a variety of cellular and physiological reactions that worsen liver damage, including steatosis, steatohepatitis, and ultimately hepatocellular cancer [33].

Arsenic (As)

Being dangerous, arsenic is a well-known element. Exposure to it harms both plants and animals as well as people. One of the main arsenic-related risks for living things is that some nations have high amounts of arsenic in their tap water and soils. Arsenic exposure in

humans typically occurs through tainted drinking water, which can lead to a variety of health issues, from cancer to skin conditions. Contrarily, the FDA-approved medication arsenic trioxide offers remedies for a range of ailments, including numerous malignancies. This problem highlights the significance of species diversity in considering the effects on health of metalloid substances. Arsenic damages the cells in exposed animals, changing their involvement [34].

Lead (pb)

Lead is a common heavy metal that pollutes the environment and builds up in people's bodies through absorption, bioavailability, bioconcentration, and biomagnification, causing disruptions to the cardiovascular, neurological, skeletal, reproductive, and hematological systems. The unique physical and chemical properties of lead make it suitable for a wide range of applications. It is hazardous to health and has long been connected to human activity. Presented here the article looks at how lead exposure affects people's long-term health. Chronic and acute symptoms harm to the kidney, brain, reproductive system, and CNS/PNS are all effects of lead poisoning. The history of toxic metals half-life in the brain and bone matrix is two to three years, which results in neurological issues and bone loss [35].

Trace elements in disease

If the deficiency persists, it will be fatal. Hepatic damage happens along with nausea, vomiting, and diarrhea when iron levels in the body rise suddenly. Hepatic failure, diabetes, and testicular atrophy can all result from chronic or persistent buildup of iron in the body. arthritis, cardiomyopathy, atrophy, and peripheral both hyperpigmentation and neuropathy [36]. Silver diabetes is a trifecta of cirrhosis, diabetes, and hemochromatosis. Hepcidin, a hepatic peptide, is a crucial systemic hormone that controls iron. It manages gastrointestinal plasma iron concentrations, iron absorption, and via promoting breakdown, tissue iron distribution of both the cellular iron exporter and its receptorferroportin. Iron is exported into plasma by ferroportin. from macrophages, from absorbing enterocytes that recycle erythrocytes' senescent iron, and from the iron-storing hepatocytes. inadequacy of hemochromatosis is caused by hepcidin [37].

The trace element selenium (Se), which is necessary for human nutrition, has also been linked to higher health risks. Preventable endemic diseases are known from locations containing Se, which is a requirement for an appropriate immune response [38]. Both animals and people require selenium (Se), which is a crucial trace element. Keshan illness in people could result from se deficiency [39].

According to a 2013 WHO report, 1.4% of fatalities globally (0.8 million) were related to zinc insufficiency: 1.4% in men and 1.5% in women. It is estimated that roughly 33% of the world's population suffers from zinc deficiency, with estimates ranging from 4% to 73% across subregions. Additionally, it accounts for 16% of lower RTIs [40]. In settings of zinc shortage, a broad spectrum of immunological response, both for innate and adaptive immunity derangements, occurs. Zinc deficiency can lead to decreased chemotaxis, phagocytosis, and control of polymorphonuclear cell (PMN) Pathogens are destroyed by NADPH oxidase activity after phagocytosis. Additionally, a lack of zinc results in increased production of pro-inflammatory cytokines such TNF-a, IL-1B, and IL-6 compromised NK cell activity modulation [41]. In settings of zinc shortage, a broad spectrum of immunological response, both for innate and adaptive immunity derangements, occurs. Zinc deficiency can lead to decreased chemotaxis, phagocytosis, and control of polymorphonuclear cell (PMN) Pathogens are destroyed by NADPH oxidase activity after phagocytosis. Additionally, a lack of zinc results in increased production of pro- inflammatory cytokines such TNF-a, IL-1B, and IL-6 compromised NK cell activity modulation [42].

Conclusion

In the fields of nutrition and medical sciences, interest in the function of essential and non- essential trace elements in human health is expanding. The important role that vital trace elements like iodine, zinc, selenium, iron, and copper play in encouraging a variety of physiological processes, such as growth, immunological response, and wound healing, is highlighted in this review. To avoid illnesses and infections, it is crucial to keep these minerals in the right proportion. It also briefly discusses chromium's function in the growth and development of the human body. The body can generate non-essential trace elements on its own and obtain them in trace amounts from food, but they are still significant. Although the majority of the focus of this review is on vital trace elements, it's crucial to acknowledge the whole range of trace elements and their benefits to human health.

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