Exploring the Importance of Trace Elements in Nutrition: Understanding Their Vital Role in Health and Well-being

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Abstract. Trace elements despite being needed in extremely small amounts, trace elements are essential for many body’s physiological processes. The relevance of trace elements in human nutrition is examined in this abstract, which also conclude their functions in immunological response, hormone production, enzyme activity, and tissue structure maintenance. It is crucial to maintain a balanced intake of these nutrients since deficiencies or excesses of them might have negative effects on one's health. People can get these trace elements—which are necessary for general health—by eating a varied and nourishing diet. The complex functions that trace elements play in human health are still being uncovered by ongoing research, which emphasises how important it is to comprehend and maximise their presence in our diets. To provide accessibility to essential micronutrients and to promote optimal health, trace elements must be included in dietary recommendations.

1 Introduction

Dietary minerals referred to as trace elements can be found in extremely small concentrations less than 0.015 of the total amount of the organism. They are beneficial in optimum development, growth, maintenance and healing of organism’s health. (Marjan Mehri Aliasgharpour; Marjan Rahnamaye Farzami, 2018). Different roles are played by these trace elements in human body. Certain enzymes are necessary for certain processes in which they absorb substrate molecule and help them to evolve into desirable end product. In addition, some of them engage in redox processes, which are crucial for producing and utilising metabolic energy, by giving or receiving electrons while some of them play crucial structural function and are in charge of maintaining the stability of significant biological molecules. Additionally most of trace elements play significant role in certain biological processes,(Nielsen & Hunt, 1989)(Hemilä & Chalker, 2013). The actual amount of necessary trace elements is small but their influence on regular metabolic processes can be significant and frequently increased due to their engagement with or incorporation into proteins specifically enzymes. Essential trace elements can cause detrimental effects on bone metabolism when present in high amounts. however, in rare cases therapeutic dosages of a trace elements might produce apparent benefits. For those with advanced osteoporosis, fluoride treatment, for instance, promotes bone density. The data now available doesnot support a direct impact on bone, either poisonous or necessary for trace metals molybdenum and boron (Underwood & Mertz, 1986).

There are 19 trace elements whose nutritional importance has been determined and categorised into three groups (according to the WHO):
1-Essential elements such as iodine and zinc and etc.
2- Probably essential elements such as manganese and silicon and etc
3- Potentially toxic elements such as fluoride,lead,cadmium, mercury , & Lithium

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2 Essential element

Man needs to ingest 50 ug to 18 mg of vital trace elements daily. They are structural or catalytic components present in larger molecules. Six essential trace elements that were previously unidentified for their functions are chromium, copper, zinc, selenium, molybdenum, and iodine. To ascertain the marginal trace element status in humans, functional testing, improved analytical methods, and a deeper comprehension of the mechanisms of action are all necessary for the proof of cause and effect links. A risk factor for a number of illnesses with significant implications for public health is a marginal or severe necessary trace element imbalance. (Nguta, 2010).

2.1 Chromium

For overweight people, chromium is the most important mineral. Moreover, a crucial mineral for controlling blood sugar and fat levels. The primary component of glucose tolerance factor (GFT), chromium, aids in the reduction of blood glucose levels by muscles and other tissues through increased absorption of glucose. Low blood levels of chromium also result in low amounts of GFT, which reduces the effectiveness of insulin in decreasing blood sugar levels. Thus, greater insulin secretion is induced, but it is still inefficient, and blood sugar levels remain elevated. This cycle continues with the consequences of insulin resistance, the ultimately leads to diabetes.

It is advised that individuals consume 20–35 g/day of chromium. (Intakes et al., 2002). A chromium (Cr) is required for influencing the metabolism of proteins, fats, and carbs. There is now uncertainty on the specifics of the relationship between chromium and insulin function, however (WHO/FAO/IAEA, 1996). Chromium deficiency may occur in patients undergoing total parenteral nutrition. Increased plasma free fatty acid concentrations, abnormal nitrogen metabolism, neuropathy, encephalopathy, hypoglycemia, and impaired glucose tolerance have all been associated with chromium deficient patients. The advantages of chromium supplementation for diabetics, however, are left for discussion till now. (Ryan et al., 2003)

2.2 Copper

The body’s third-most mineral is copper in all of its forms. Not to mention that it's crucial for several enzymes. Although the brain and liver contain the highest concentration of copper, the musculoskeletal system as a whole contains copper. Because copper helps many antioxidants work and is involved in the release of energy within cells, it absorbs free radicals, which harm cells. The generation and regulation of melatonin are two instances of This enzyme is responsible for the production of several neurotransmitters and other neuroactive chemicals, including catecholamines and encephalins, under the guidance of copper due to its involvement in the blood protein ceruloplasmin. Furthermore, the formation of collagen, red blood cells, and the oxidation process depend on the quantity of copper. (Chan et al., 1998) Biological systems may include copper (Cu) in both its +2 and +1 valence states. Because of this, oxidation-reduction reactions are essential to its primary function. It is an essential component of many enzymes, such as zinc-copper superoxide dismutase (antioxidant defence), cytochrome c oxidase (electron transport), dopamine monooxygenase (neurotransmitter synthesis), lysyl oxidase (collagen cross-linking, bone formation), dopamine beta-hydrolase (skin pigmentation), and tyrosinase (melanin production). (Danks, 1988) Copper is an essential component for several enzymes, such as coenzymes, cytochrome oxidase (COX), and superoxide dismutase (SOD). Elimination of free radicals.
synthesis, wound healing, antioxidant defences, immune system function, and collagen synthesis all depend on it. Unless malnourishment and long-term TPN are involved, deficiency is rare since the liver maintains a considerable amount of copper. Copper deficiency causes haematological anormalités such as anaemia, neutropaenia, and thrombocytopenia; it also causes osteopenia with bone and joint deformities, psychomotor delay, and skin depigmentation. Copper should be used less in situations of liver failure and cholestasis since it is largely eliminated in bile and can build up to be poisonous. Wilson's disease with Kayser-Fleisher rings, hemolytic anaemia, gastroenteritis, cirrhosis, hepatitis, anomalies in conduct and personality, and cognitive decline are all of copper poisoning. (Strachan, 2010)

2.3 Zinc

Zn is a chemical element with the atomic number thirty and the symbol Zn. It is the first element in group 12 of the periodic table. German scientist Andreas Sigismund Marggraf made the discovery of this element in Germany in 1746. (Heiserman, 1992) It weighs 65.4 atomic weight. After iron (approximately 4 g) but before copper (about 0.2 g), zinc (about 2.5 g) is the second metal found in the human body. It is present in every bodily system, with the muscle tissue containing half of it. (Zevenhoven & Kilpinen, 2001). Zinc is a necessary trace element that appears in about 300 distinct enzymes and acts as a cofactor for several enzymes related to metabolism and the creation of cells. (Osredkar & Sustar, 2011) (Prasad, 2003) (Plum et al., 2010) It serves as essential for maintaining a healthy immune system as well as for battling sore throat and skin issues like acne. Cell division, the growth of hair, tissue, nails, skin, and muscles all demand it further. Zinc is also necessary for children's healthy growth and sexual development. Zinc additionally helps in the regulation of oil glands and is necessary for the creation of collagen and protein, both of which are necessary for the healing of wounds and the maintenance of healthy skin. (Nguta, 2010) In instances where it is severe, zinc deficiency results in hair loss, delayed sexual development, impotence, hypogonadism in men, and lesions of the skin and eyes. It can also cause weight loss, delayed wound healing, aberrant tastes, and mental lassitude. (Heyneman, 1996) (Maret & Sandstead, 2006) (Prasad, 2004)

2.4 Selenium

It has been estimated that the human body has 13–20 mg of selenium. Nuts, cereals, meat, mushrooms, fish, and eggs are excellent providers of dietary selenium. The richest popular dietary source is Brazil nuts. High quantities are also present in kidney, tuna, crab, and lobster, in decreasing order of concentration. (Fordyce, 2012) (Rayman, 2012) A crucial trace element for human health, selenium is present in the active site of several different types of selenium-containing proteins, including selenocysteine. It is a crucial part of the antioxidant enzymes thioredoxin reductase and glutathione peroxides. (Intakes, 1997). Selenium is extremely harmful if consumed in excess, even though selenium deficiency is uncommon in healthy humans. Dietary selenium has been shown to be crucial for a functioning immune system, since it intensifies T-lymphocyte immunological responses. Low serum levels of selenium (Se) have been linked to a higher death rate from cardiovascular disease. Moreover, reports state that the primary cause of Keshan illness is a deficiency in selenium. However, there is substantial evidence that selenium (Se) protects against some cancers, including breast, prostate, and colon cancer. (Brown & Arthur, 2001) (Chen et al., 1980)

2.5 Molybdenum
The trace element molybdenum (Mo) is necessary for all living things, including plants, animals, and microorganisms. Originally misidentified as lead, molybdenum was called after the Greek term molybdos, which means lead-like. Thus far, only four molybdenum-dependent enzymes in humans have been identified: xanthine oxidoreductase, aldehyde oxidase, sulfite oxidase, and mitochondrial amidoxime-reducing component (mARC). (Novotny & Peterson, 2018) Molybdenum insufficiency is very uncommon in humans and is linked to stunted development and compromised reproductive processes. Decreases in blood and urine uric acid concentrations and an increase in the excretion of xanthine and hypoxanthine are signs of molybdenum loss. (Anke, 2004). The body has reduced molybdenum in vertebrates and more in the liver and kidneys. Human dental enamel contains molybdenum as well, which may slow down the deterioration of the enamel. (Borel & Anderson, 1984)

2.6 Iodine

The thyroid hormones triiodothyronine (T3) and thyroxine (T4), which have plasma half-lives of around two and eight days, respectively, are dependent on iodine (I). (Agarwal et al., 2011) The brain and central nervous system will not grow normally if there is an iodine shortage during this time, which leads to a thyroid hormone shortage. Thyroid hormones also regulate the body’s many metabolic processes, which is their second physiological function. These consist of the metabolism of vitamins, minerals, fats, proteins, and carbohydrates. Thyroid hormone, for instance, stimulates lipolysis, boosts energy generation, and controls glycolysis and neoglucogenesis. (Delange, 1985). The crucial role thyroid hormones play in human growth and development accounts for iodine's important role in nutrition. The current name for the effects of iodine deficiency on growth and development is "iodine-deficiency disorders" (IDD). These effects are seen at all developmental stages, although they are more common in the foetus, neonate, and infant. To assess the nutritional status of iodine, goitre exams, measures of thyroid hormone and pituitary thyroid stimulating hormone (TSH) levels, and estimates of urine iodine excretion can all be utilised. (Hetzel et al., 1990).

3 Probable essential elements

3.1 Manganese

In the human body, manganese makes up just 0.00016% of the total. It serves the dual purpose of being an enzyme's ingredient and activator in the body. Many animal species have developed manganese insufficiency, however there isn't conclusive evidence that human patients have the same problem. (BJ, 1988). Although manganese insufficiency in humans is extremely rare, it has been seen in those with severely limited diets. Manganese deficiency was linked to dyslipidemia and scaly dermatitis in human experiments. (Friedman et al., 1987). Even, excessive manganese may have detrimental effects on cognition, including problems with executive functioning and movement and tremor symptoms like those of advanced Parkinson's disease. (Kornblith et al., 2018), whereas, low Mn levels (deficiency of Mn) have been linked to hypercholesterolemia, poor glucose tolerance, dermatitis, hair colour changes, skeletal abnormalities, infertility, deafness, and low synthesis of vitamin K-dependent clotting factors. (Dutta & Mukta, 2012)(Al-Fartusie & Mohssan, 2017)(Soetan et al., 2010)

3.2 Silicon
Grains, root vegetables, beans, maize, fruits, dried fruits, nuts, and seeds are among the food sources of silicon (Si), a beneficial trace element. Drinking water is also a good idea. Certain alcoholic beverages also contain a sizable amount of silicon. In the presence of hydrochloric acid and other stomach acids, the gastrointestinal tract hydrolyzes silicon compounds in food to create forms of silicic acid that are easily absorbed. (Jugdaohsingh et al., 2002). While it might not seem necessary to humans and not necessary for every stage of plant growth, it is essential for giving most plants their mechanical strength. Mammals' connective tissue contains a large amount of it, which contributes to the ash content of their feathers and may be the cause of their stiffness. Furthermore, studies conducted on two distinct species of laboratory animals have shown how important silicon is for bone formation. Nevertheless, no data are available to evaluate the silicon need of humans. (Carlisle, 1970)

3.3 Nickel

Nickel is a necessary ultratrace nutrient for people, animals, and plants is well acknowledged. According to reports, nickel is necessary for the active urease production in plant cells. It is necessary for efficient urea metabolism and urease production in a number of higher plant species, including rice, tobacco, soybeans, and jack beans (Kasprzak, 1987) (Welch, 1981). Other than its toxicity, nickel is often not of biological interest. Humans absorb between 8% and 50% of the nickel consumed in drinking water following an overnight fast, which causes a noticeable hypernickelaemia in blood. Moreover, the most significant clinical consequence of prolonged exposure to nickel is contact dermatitis. Status signs of reduced intake of nickel have not gotten much attention because there hasn't been any evidence of a nickel deficit. (Smart & Sherlock, 1987). Research has shown that consuming certain foods, smoking cigarettes, and breathing in the air can all expose people to nickel. Nickel exposure can also occur through skin contact with water or soil polluted with nickel. In actuality, the body needs trace amounts of nickel, but excessive absorption can be harmful to human health. Research has indicated that acute exposure to nickel in humans can result in a number of health issues, including damage to the liver, kidney, spleen, brain, and tissue, vesicular eczema, lung, and nasal cancer. (Poonkothai & Vijayavathi, 2012) (Sydor & Zamble, 2013) (Salnikow et al., 2003)

4 Potentially toxic elements

4.1 Flourine

A trace amount of flourine makes up just a small portion of a person's weight, and it enters the body through food and drink. Body flouride status is determined by a number of variables, such as the natural drinking water's flouride concentration, the total quantity consumed each day, the length of time consumed, and the effectiveness of the kidneys' and intestines' waste removal processes. Natural water may have less than 0.1 mg/L of flouride or more than 20 mg/L. (Davis & Mertz, 1987) . The majority of the flouride that we eat is absorbed from the upper intestines and is utilised by bones and teeth, with the remainder being excreted in urine (Fawell et al., 2006). But dental flourosis is a well-known consequence of consuming excessive amounts of flouride through food, and one of the main symptoms is mottling of tooth enamel. (Kaminsky et al., 1990) (Aliaagharpour & Rahnamaye Farzami, 2013)

4.2 Lead
The most significant harmful heavy metal in the environment is lead, often known as plumb (Pb). (Patrick, 2006). Exposure to lead can have detrimental effects on a child's health. Lead damages the brain and central nervous system at high exposure levels, resulting in unconsciousness, convulsions, and even death. Severe lead poisoning survivors may experience mental impairment and behavioural problems as adults. Lead is known to cause a range of damage across several bodily systems at lower exposure levels that don't immediately manifest any symptoms. Lead harms people over the long run, including anaemia. (Aliasgharpour & Abbassi, 2006)

4.3 Cadmium

Cadmium (Cd), a trace element, is not believed to be necessary for human nutrition or higher physiological functions. The primary source of cadmium exposure for nonsmokers is the food supply. Generally speaking, foods high in cadmium include grains, potatoes, legumes, sunflower seeds, peanuts, and green veggies like spinach and lettuce. (Mehri, 2020) Although cadmium is found in most organs, the kidneys have the highest concentration, where it builds up with age in proportion to the body's overall cadmium load. The brain is also a vital organ. Urine excretion of more cadmium is the most significant indicator of excessive exposure. Urinary cadmium excretion is minimal and consistent in populations not exposed to high levels of cadmium; it typically amounts to one or two ug per day. When all of the metallothionein's accessible cadmium binding sites are saturated, a rise in urine cadmium levels may not happen in certain cadmium workers. (Thévenod & Lee, 2013)

4.4 Aluminium

Natural forms of aluminium (Al) in the environment include hydroxides, oxides, and silicates. It also forms compounds with biological materials and joins forces with other elements like salt and fluoride. Around the world, drinking water is frequently supplemented with aluminium sulphate [Al₂(SO₄)₃] as a "clarifying agent." Ingestion of food and drink, skin contact with cosmetic items, inhalation of dust and other airborne particles, and medicine use (antacids) are all ways that aluminium can enter the body. Aluminium is not well absorbed dermally and is weakly absorbed by food, inhalation, and other routes. (Alexandrov et al., 2018). There isn't any solid proof that aluminium is necessary for either humans or animals. Its possible toxicity in the event of excessive exposure is the sole important consideration. It has been demonstrated that the high aluminium content of some of the water used to prepare dialysates contributes to dialysis encephalopathy in a significant proportion of patients with renal failure receiving chronic dialysis. (Hambidge, 1986). When consumed in extra amount, aluminium can stop the absorption of a variety of other elements, such as calcium, fluorine, iron, magnesium, phosphorus, and strontium. (Lotz et al., 1968)

4.5 Tin

Tin's necessity for humans is not supported by any data. For any sort of creature, tin in its single or molecule form is not extremely hazardous. However, in animal models, the toxicity of the organic form, or organotin, has been epidemiologically connected to many indicators of compromised growth and health. (Mahurpawar, 2015). It has been suggested that tin poisoning alters with the metabolism of zinc, copper, and calcium in addition to altering the actions of several other enzymes. Organic tin compounds are very poisonous and target the central nervous system in contrast to inorganic tin. (Piver, 1973)
4.6 Lithium

A common ingredient utilised in clinical settings for mental therapy is lithium, which occurs naturally. While antimania, psychosis, or anti-cancer effects are yet unknown, a number of studies suggested that micro-dose lithium (e.g., lithium in drinking water) may have anti-aging and anti-dementia benefits in addition to an anti-suicidal impact. (Terao, 2015). Reliable doses which one adult can take is 250–500 mg of lithium per day needs to be closely monitored because there is not a large margin of safety and side effects including thyroid issues and significant weight gain are frequent. At both therapeutic and hazardous doses, lithium influences a variety of metabolic processes and organ functions; nonetheless, its fundamental role and manner of action remain unclear. (SCHOU, 1973)

5 Conclusions

Minerals that comprise less than 0.01% of the total body weight or that adults need in doses ranging from 1 to 100 mg per day are commonly referred to as trace elements, or trace minerals. (Lotz et al., 1968). Minerals that are needed in levels smaller than 0/001 mg/day are referred to as ultra-trace minerals. They have a very important role in growth and development of humans body. These components are necessary for a number of physiological functions, such as hormone production, immune system control, enzyme activity, and tissue integrity maintenance. A balanced intake of trace elements through a diverse and nutrient-dense diet is essential to supporting general well-being, even if excesses or deficits of these elements can cause major health issues. There is a great risk of overdosing these trace elements because most elements have harmful effects when their concentrations are higher than specific thresholds. Because if we take them in excess they work in against also. (Marjan Mehri Aliasgharpour; Marjan Rahnamaye Farzami, 2018)

References


