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Review Article

RECENT ADVANCES OF ZINC IN HUMAN HEALTH: A REVIEW

Payel Mukherjee [1]*, Arindam Chakraborty [2], Manas Chakraborty [2]
[1]Department of Pharmaceutics, Gurunanak Institute of Pharmaceutical Science and Technology, Panihati, Kolkata, India
[2]Department of Pharmaceutical Biotechnology, Calcutta Institute of Pharmaceutical Technology and AHS, Uluberia, Howrah, India
*Corresponding Author Email: pmukherjee832@gmail.com

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ABSTRACT

Zinc is a very essential trace element for human health. Adequate zinc level is very necessary for several body functions. Proper zinc level can reduce the child illness and may increase the physical growth of the children. Daily dietary intake of zinc is 8-11 mg/day for normal human being, excess and lower of this amount can cause illness in the human body. Approximately 2 billion people can be affected by the zinc deficiency. Zinc mostly found in all plants, animals and available in all sorts of vitamin supplements as well. Zinc can control the enzyme activity and DNA formation. Exposure to excess zinc can cause some serious illness like metal fume fever, prostate cancer, nausea, vomiting, fatigue etc. Zinc deficiency may lead to the world's third most important cause of impaired child growth. Apart from reduced child growth, diarrhea, common cold, impaired mental development can be caused by the lack of zinc concentration. In this review we will give insights to the zinc functions biochemistry, source, metabolism, assessment methods and definitely the deficiency and toxicity effect.

Key words: Trace Element, Daily Dietary Intake, Vitamin Supplements, DNA Formation, Child Growth, Zinc.

INTRODUCTION

Zinc is one of the most important elements in the world. It has a significant role for all life forms and in their body nutrition and health. In developing countries, zinc deficiency is one of the most important factors for reducing child growth[1]. Zinc inadequacy can also cause diarrhea, pneumonia and some other abnormalities[2]. Due to its critical activities, zinc supplements can manage some illnesses. Zinc is generally required for enzyme activities cell divisions, DNA and Protein synthesis, and metabolism of protein, fat, carbohydrate[3]. Zinc can be also helpful in normal growth of tissues, wound healing, proper functions of the immune system, adequate sperm production etc[4]. Lower intake of zinc for pregnant women can lead to a fetal brain cell decreases and affect the mental development. Lack of zinc in children may cause improper growth and development, in adult males' zinc deficiency can cause prostatic hyperplasia, reduced reproductive function and can hamper the fertility[5].

SOURCES OF ZINC

Zinc is very essential for the growth purpose. Enzyme which operate and renew the cells in the human bodies can be controlled by zinc[6-7]. Recommended daily allowance (RDA) of zinc in infants (0 to 12 months) is ranging from 2-3 mg/day, for the children (1 to 8 years) zinc requirement is about 3-5 mg/day, pregnant and lactating women need a more amount of zinc in daily basis which is about 11 to 14 mg/day, generally females need about 8 to 9 mg/day, RDA for males is nearly about 8-11 mg. There are a variety of sources for zinc[8].

Following table represents the zinc sources with the amount of zinc in them[16-18].

TABLE 1: FOOD SOURCES, THEIR RESPECTIVE ZINC CONTENTS AND AVAILABLE ZINC CONTENTS FOR ABSORPTION

Food Sources	Zinc Content (mg/100 g)	Absorbable Zinc Content (mg/100 g)
1. Bread (white flour, yeast)	0.9	0.4
2. Refined cereal grains (white flour, white rice, etc.)	0.4-0.8	0.1
3. Fruits	0-0.2	< 0.1–0.2
4. Vegetables	0.1-0.8	< 0.1–0.4
5. Beans, lentils (soy, kidney bean, chickpea, etc.)	1.0-2.0	0.1-0.2
6. Dairy (cow's milk, cheese)	0.4-3.1	0.2-1.6
7. Whole-grain cereal (wheat, maize, brown rice, etc.)	0.5-3.2	0.1-0.3
8. Seeds, nuts (sesame, pumpkin, almond, etc.)	2.9–7.8	0.3-0.8
9. Seafood (fish, etc.)	0.5–5.2	0.2-2.6
10. Poultry (chicken, duck, etc.)	1.8–3.0	0.9-1.5
11. Eggs (chicken, duck)	1.1–1.4	0.6-0.7
12. Meat (beef, pork)	2.9–4.7	1.4-2.4
13. Liver, kidney (beef, poultry)	4.2–6.1	2.1-3.1

ZINC METABOLISM

Zinc is generally absorbed through small intestine into the body. Small intestine can also regulate the zinc homeostasis of the whole body by making changes in both absorption of dietary zinc and excretion of endogenous zinc in pancreatic and other gastrointestinal juices[9-10]. Apart from gastrointestinal excretion, zinc can also be lost through urine, semen, menstrual secretion, dead skin, nails, hair etc. During diarrhea zinc excretion is drastically increased which leads to zinc deficiency[11].

In adult human's total zinc content is about 1.5-2.5 gm, which is mostly found intracellularly. About 90% of the body's zinc is not metabolizable and remaining portion can be available for metabolism[12].

Less than 0.2 % of the total body zinc content can be circulated in plasma, having mean concentration of about 15 µmol/L. Concentration of zinc in tissues is 50 times higher than that of in plasma. There are some factors affecting plasma concentration such as pregnancy, infection, hypoalbuminemia etc.[13-15].

ZINC HOMEOSTASIS

Zinc is required for the function of several enzymes, proteins and transcriptional factors. Zinc can bind with 10% of the total body's protein approximately. Zinc mostly reserved in skeletal muscle and bones[16]. Zinc must be taken on everyday basis through the proper diet for the maintenance of normal cellular processes. Zinc content in an adult human is about 2-3 gm. Zinc is stored in skeletal muscle (60%), bone (30%), liver or skin (5%) and other tissues (2-3%)[17]

Less than 1% of the total zinc can be found in serum. Serum zinc's 80% can be bound to serum albumin, 20% can be bound to α2 micro-globulin strongly. Zinc can be supplemented by daily food intake. About 0.1% cellular zinc can be distributed in the cellular compartments, the cytoplasm, the nucleus, the plasma and the organelles containing 50, 30, 40 and 10% respectively. Concentration of the Zinc for mitochondria (0.14 pM), the mitochondrial matrix (0.2 pM), the ER (0.9 pM–5 nM), and the Golgi (0.2 pM)[18].

BIOCHEMISTRY OF THE ZINC

Zinc is mainly a Redox neutral but it also reactive as a Lewis acid in many biological reactions. Zinc generally acts as a structural, catalytic and signaling component[19]. Crystallization of insulin with zinc has first verified the peptide-zinc association. Zinc is very important for cellular biochemistry which can be indicated clearly by 'zinc-finger' motif; first found in transcriptional factor TF IIIA of Xenopus. Zinc finger are now categorized into more than 20 classes of different structural models and can interact with a variety of protein and nucleic acids[20-21]. Due to the strong Lewis acid property of zinc it can activate enzyme's substrate through the stabilization of the negative charges. Zinc can be coordinated by Nitrogen, Oxygen and Sulphur within protein with different coordination number[22].

ZINC IN HUMAN HEALTH

Zinc is very much necessary for several cellular functions, growth development, functioning different parts of the body and maintaining some important hormone and enzymes level in the body. Following are some of the major functions of zinc in human health.

Zinc in Men's Health

Zinc maintains the normal level of serum testosterone. Luteinizing and follicle stimulating hormone from pituitary gland stimulate the production of testosterone which is maintained by proper zinc level. Zinc usually inhibits the aromatase enzyme which converts the testosterone into estrogen. Higher level of estrogen leads to a higher risk of weight gain, obesity and most precisely heart disease.

Zinc helps the body to produce healthy sperm by increasing the motility and sperm count. Lower amount of zinc intake can cause decreased semen volume and serum testosterone volume as well.

Inadequate amount of zinc can have a serious impact on male prostate gland. Deficiency of zinc can cause prostate infection leading to enlarged prostate gland also called as prostatic hypertrophy[23-24]

Zinc in Pregnancy

RDI for a pregnant woman is 19 mg per day as per official notification. As per reports lower intake of zinc can have an increased risk of lower birth weight and abnormal child growth[24]

It is very necessary to give zinc supplementation to the lactating mother for the proper maintenance of zinc label in babies for proper growth in length and weight. Zinc is necessary for the development of the fetus.

Zinc In Immune System And Brain Functions:

Adequate amount of zinc is necessary for the lymphocyte maturation process. In cell division and DNA replication, zinc plays an important role. Zinc regulates the body's immune system. Zinc also found to play an important role in enhancing thinking skills and memory. It's also very necessary for healing the injury or surgery. Lower zinc concentration may lead to anorexia and other mood disorders.

Apart from the above-mentioned benefits, zinc is also necessary for the proper physical growth, skin protection, ability to taste, smell etc[25-26].

ZINC STATUS ASSESSMENT

There are a few proposals to evaluate the Zinc status in individual. But amongst them, no methods are reliable. Zinc can be only assessed in the individual when its deficiency happened by measuring the changes in tissue[27].

To evaluate proper zinc status, plasma zinc concentration and dietary intake data measurement can be used as alternative techniques.
To assess the zinc status using plasma zinc, the mean plasma zinc concentration should be measured which requires a proper collection and processing of respective blood sample of the population and measurement of the zinc concentration in the serum or plasma. This method could give useful information regarding the zinc status.

Zinc status assessment can also be done via dietary intake data method where the food intake from respective sample of the population should be measured and the zinc content of those food items must be known. After gathering all the desired information, the dietary intake assessment can be done by modified interactive 24-hour dietary recall method[28-29].

ZINC DEFICIENCY

Deficiency of the zinc can cause a severe and widespread problem on human health. Zinc deficiency in human was first reported in 1961, in Iranian males who were suffering from growth retardation, mental lethargy, hypogonadism, skin abnormality etc[29].

Zinc deficiency can be both inherited and acquired. Acrodermatitis enteropathica is the most severe form of inherited zinc deficiency. It is an autosomal recessive metabolic disorder resulting from intestinal Zip-4 transporter mutation. Skin lesions, diarrhea, weight loss, loss of immune function, alopecia are the common symptoms of this disorder[28].

Acquired zinc deficiency can be occurred by severe malabsorption, excessive alcohol consumption, or taking excessive antibiotics[30].

Moderate zinc deficiency can be seen in patients having low dietary intake of zinc, malabsorption, alcohol consumption, chronic renal disease etc. Growth retardation, mental lethargy, hypogonadism, skin problems, taste problems are the common symptoms.

For mild zinc deficiency symptoms like hyperammonemia, weight loss, oligospermia can be observed.

According to reports more than 20% of the total world population and more than 2 billion people in developing countries can be affected by the zinc deficiency[31].

ZINC TOXICITY

The recommended daily allowance (RDA) of zinc is 8 mg/day for women and 11 mg/day for men and lower for infants 2-3 mg/day, for children 5-9 mg/day according to their body weight[32].

So, the increase amount of zinc in the body can cause several disorders in the human body. On inhalation of zinc oxide in a huge amount metal fume fever can be caused. This is a severe industrial disease resulting from inhalation of fresh metal fume having particle size <1 μm. Symptoms are including fever, nausea, fatigue, cough, chest pain and soreness of the muscle, dyspnea[32].

There are general symptoms of zinc toxicities including nausea, vomiting, renal failure, abdominal pain, lethargy, dizziness anemia etc.

Zinc toxicity or excessive consumption of zinc may lead to Copper deficiency. Copper deficiencies have some serious symptoms like anemia, leukopenia, decreased superoxide dismutase (SOD), improper iron mobilization, neutropenia, hypocupremia, sickle cell anemia as well[33].

A very high and long-term supplementation of zinc can cause prostate cancer and can also affect lymphocytes function[34].

Excess consumption of zinc lead to accumulation of zinc in brain resulting Alzheimer's disease and neuronal death[35].

CONCLUSION

Zinc is very essential for life. Compared to other elements, the toxicity and severity is less in case of zinc. Zinc plays an important role in various functions of human body and also control the enzyme level. Zinc is present in many food sources. Intake of zinc is very necessary for humans. Zinc with vitamin C can be taken as immunity booster in this corona situation. Dietary intake of zinc can prevent several diseases of immune systems and other parts of the body. It is very important to take the adequate amount of zinc every day.

On exposure to excess zinc concentration, human body leads to some unusual disorders like neuronal death, enlarged prostate gland, and respiratory disorder. Lower of the same can also cause some diseases including the diarrhea, abnormal child growth, mental illness.

In developing countries approximately 42 % of the people suffer from the zinc deficiency. Adequate zinc intake could be useful for the severity of the disease and help the mankind. In this corona pandemic zinc can be an immune booster with vitamin c, which will be a life saver for humans.

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