



## **Role of Trace Elements in Heart Failure**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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**Review Article**

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## **ABSTRACT**

This study more on the role of trace elements such as iron(Fe), zinc(Zn), chromium(Cr), manganese(Mn), copper(Cu), cobalt(Co), selenium(sn) on the medicinal conditions like heart failure, myocardial infarction, cardiomyopathy, congestive heart failure, pericardial effusion, keshan's disease and various other cardiovascular diseases. This study highlights the levels of individual trace elements or the elements which are present in minute quantities either it is a deficiency or in excess which can lead to various different cardiac diseases such mainly focusing on heart failure. it also stresses on the side of heart failure as it may be right-sided or left sided based on the location of deficiency. In an averagely built human adult, 0.02percent constitute of eleven essential trace elements. It also discusses that inadequate consumption of these minor elements via diet may lead to pathological conditions of heart. This study also throws light on the classification of trace elements given by Frieden in 1981,broadly classified as micro elements, trace elements, and ultra-trace elements on the basis of amount detected in tissues of averagely built human adult , further trace elements are classified as essential trace elements, probable essential trace elements, physically beneficial trace elements, .the basic pathophysiology and etiology is also given which can lead to heart failure and various other cardiovascular diseases or conditions.

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Diagnosis of various diseases can be made by monitoring the levels of various trace elements and it can also help to reduce the risk of having heart related medicinal conditions by including these minor elements in diet so as to improve the operating condition of heart this study also focuses on the dietary sources of trace elements. Cardiovascular emergency can also be avoided by continuous monitoring of subjects who are at high risk.

*Keywords: Trace elements; heart failure; operating condition; dietary sources.*

## 1. INTRODUCTION

Heart failure (HF) is a health condition that affects people characterized by anomalies in the myocardium that restrict ventricular filling or blood ejection morphological and functional abnormalities in the myocardium that limit ventricular refilling or blood expulsion. The most prevalent cause of heart failure is inadequate functioning of left ventricle; however, malfunction of the three major muscular layers of heart including great valves, or great vessels, whether it may be alone or in conjunction, is also connected to failure of heart. Steadily increasing Hemodynamic stress, ischemia-related damage, and ventricular humoral stimulation, altered myocyte calcium cycling, and overwhelming or insufficient Proliferation is one of the most important factors, pathophysiological processes contributing to HF.

Depending upon the place of the heart's musculature where there is a deficiency, cardiac failure can be categorized as mainly left-sided ventricular, predominantly right ventricular, or predominantly involving both ventricles. HF is characterized as short standing, i.e. (acute), or prolonged standing i.e. (chronic) based on the time of onset. Diagnostically, It is normally classified into two types based on the patient's heart's operating state.

The role of the several trace elements in heart failure is addressed in this review article [1].

The major four key electrolytes, particularly sodium, magnesium, potassium, and calcium, constitute for approximately 1.89 percentage, while the residual 0.02 percent or 8.6 g of an averagely built human adult is constitute up of eleven basic trace elements [2]. This little amount, however, has a huge impact on all biological systems. The majority of them influence critical biological events by serving as cofactors or catalysts for several enzymes.

They also serve as hubs for the construction of structurally stable components including such

enzymes and proteins. Metal buildup or a lack of certain components might promote an other course that could also result in sickness Interactions between trace elements may potentially operate as a foundation for the etiopathogenesis of various diseases. There are metabolic problems.

Secondary metabolites are rapidly becoming recognized as critical facilitators of the genesis and evolution of cardiovascular disorders. Selenium, Zinc, and Copper concentrations in blood are widely recognized to impact specific cardiac illnesses such like Keshan disease, cardiac failure, cardiomyopathy, and atherosclerosis [3-5]. As a consequence, elements which are present in trace quantities may play a critical part in illness etiology and pathological processes involving development of disease. Selenium is a component of glutathione peroxidase, which safeguards biological membranes against degradation in the cytosol and mitochondria. Selenium additionally functions as a major enzyme in the elimination of nascent oxygen as well as peroxidase. Copper, zinc, and manganese are found in enzymes such as superoxide dismutase and glutathione peroxidase. As a consequence, trace elements which including Se, Zn, and Cu have an antioxidant function in various critical enzymatic reactions. In the absence of superoxide dismutase, superoxide anions combine with hydrogen peroxide to actually create radicals of hydroxide, which induce lipid peroxidase along with cell membrane damage. Trace elements may be defensive towards oxygen free radicals in the formation in the development of cardiac and also cardiovascular disease, according to theory. Inadequate consumption of vitamins, minerals, and trace elements, for example, may have an contribution to the create pathological conditions in heart. The association among trace elements and cardiac disease is becoming more studied. In China, for example, a cardiomyopathy known as Keshan disease is caused by a lack of selenium inside the nutrition [6,3].

Keshan disease is distinguished by widespread necrosis and fibrous substitution of myocardial

tissue. The condition can cause heart failure and is strongly impacted by nutritional selenium consumption. Furthermore, numerous latest evidence [3] reveal a link amongst particular trace element status and heart related illnesses such as heart failure, cardiomyopathy, and atherosclerosis (Selenium, Zinc, and Copper). Furthermore, the etiopathogenic function of all these alterations is never completely apparent as of yet. Ions are well established to have an important role in cardiovascular function. Trace elements such as selenium, zinc, and copper may be useful in the prevention of cardiovascular disease. Trace element shortage, on the other hand, induces cardiomyopathy due to the loss of critical enzymes that safeguard cellular membranes from free radical damage. Because trace elements play an important role in vital enzymes like glutathione peroxidase (GPx) and superoxide dismutase (SOD). It is hardly inexplicable, then, that one of the trace elements' major biological activities is antioxidation).

The importance of trace elements in protein synthesis and integrity of collagen is well documented, and deficits in certain trace elements is being linked to cardiac friability and necrosis of cardiac musculature [7]. As a result, trace element shortage in average adult may have a role in cardiovascular disease.) The importance of trace elements in protein synthesis and collagen integrity is well documented, and deficits in certain trace elements have been linked to cardiac friability and necrosis.

As a result, trace element shortage may be to blame for cardiac disease.) The importance of trace elements in formation of proteins and connective tissue strength is well documented, and deficits of certain minor elements required in minute quantities have been linked to friability in musculature of heart and necrosis in heart muscles. As a result, trace element shortage might have been to blame for heart disease.

Trace elements: The four majorly present electrolytes, namely sodium, magnesium, potassium, and calcium, account for around 1.89 percent of a typical healthy adult's body weight, while the residual 0.02 percent or 8.6 g is made up of 11 common trace elements [2]. The large percentage of them facilitate critical biological events by serving as cofactors or catalysts for several enzymes. They also serve as focal points for creating stabilizing complexes.

Enzymes and proteins, for example. Trace elements are "elements that exist in minute

levels in nature and disturbed environments and are harmful to living organisms when administered in adequate amounts of bioavailable concentrations [3]". Iron, zinc, and selenium are crucial aspects of biological modulators that draw or remove molecules and promote their transition to certain final required molecule. Some trace elements regulate crucial processes in biological organisms by promoting the attachments of molecules to their specific receptors on cell membranes, switching the infrastructures or ion sensitive nature of membranes to suppress or enable particular molecules to enter or exit a cell, resulting in gene expression which results in the upregulation of molecules involved in various processes involved in living organisms.

## 2. COMPOUNDS REQUIRED BY THE HUMAN BODY

- H, C, N, and O are the four organic vital factors.
- Quantitative elements include Na, Mg, K, Ca, P, S, and Cl.
- Mn, Fe, Co, Ni, Cu, and Zn are important trace elements.

Zn, Mo, Se, & I.

## 3. CATEGORIZATION IN BIOLOGICAL TRACE ELEMENTS

Frieden (1981) made available a classification. He categorised the components as micro, trace, and ultra-trace.

The amount of an element detected in tissues is used to classify it.

- Boron, cobalt, copper, and zinc are very essential trace elements. Iodine, iron, manganese, molybdenum, and zinc are all elements.
- Probable essential trace elements: chromium, selenium, selenium, selenium, selenium, seleni fluorine, nickel, selenium, and vanadium are all elements.
- Trace elements that are physically beneficial: Bromine,

Lithium, silicon, tin, and titanium are all elements.

#### 4. TRACE OR MICRO ELEMENTS

**Trace elements:-** Iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), Iodine (I), Cobalt (Co), Nickel (Ni)

**Micro elements:-** Fluorine (F), Vanadium (V), Chromium (Cr), Molybdenum (Mo), Selenium (Se), Tin (Su), Silicon (Si)

##### 4.1 Iron (Fe)

Iron is abundant throughout the crust of the earth and may also be obtained in large quantities from the plant kingdom. The entire body iron content is roughly 3grams-5grams, with 75 percent of it present in body fluids and the majority of it present in the liver, marrow present in bones, and majority of bodily musculature.

Cytochrome A, B, C, F 450, cytochrome C reductase, catalases, peroxidases, xanthine oxidases, tryptophan pyrrolase, succinate dehydrogenase, glucose 6 phosphate dehydrogenase, and choline dehydrogenase are the enzymes connected with iron [5].

An current average daily need of iron is 1-2 mg, which must be provided in the form of 20 milligram of iron in meals. The absorption of iron in gastrointestinal tract is inhibited by oxalates and phytates.

A lack of such a crucial trace metal would result in severe illnesses, the most serious of which being iron deficiency anemia.

**Dietary sources:-** Iron is divided into two types: haem-iron and non-haem iron. Non-haem iron is not as well absorbed as haem iron. Liver, beef, chicken, and fish are all good sources of haem-iron. They are not only essential sources of quickly available iron, but they also aid in the absorption of non-haem iron from plant meals when eaten together. Milk has a low iron concentration in all mammalian species. Breast milk has an iron level of less than 0.2 mg/dl, and it is adequately utilized.

Cereals, green leafy vegetables, legumes, nuts, oilseeds, jaggery, and dried fruits are examples of foods that contain non-haem iron. In the diets of the vast majority of Indians, they are key sources of iron. Non-haem iron has a low bioavailability due to the presence of phytates, oxalates, carbonates, phosphates, and dietary fiber, which all interfere with iron absorption. Milk,

eggs, and tea are other items that limit iron absorption. The Indian cuisine, which is mostly vegetarian, contains a lot of these inhibitors, such as phytates in bran and phosphates in egg yolk, for example.

Oxalates in veggies and tannin in tea Significant amounts of iron can be obtained in some regions by cooking in iron containers. Anemia caused by iron deficiency might result in heart failure [6].

##### 4.2 Zinc (Zn)

Zinc is an omnipotent metal with an amphoteric character. Due to which, it is ionized either as acidic or alkaline states. The typical average adult zinc content is 2-3 nanogram, whereas the average body zinc level is 2-3 grams.

The majority is present in the cell, with the minority in extracellular fluid. The typical everyday need is 15-20 mg. In myocardial infarction, plasma zinc levels are reduced [8].

**Dietary sources:-** Zinc is found in a wide variety of meals, both animal and vegetable, however its bioavailability in vegetable diets is poor.

Animal foods, such as meat, milk, and fish, are reliable sources of protein. Adults should take 12 mg per day, women should take 10 mg per day, children should take 10 mg per day, and infants should take five mg per day.

##### 4.3 Chromium (Cr)

In an normal human adult, the total chromium content is roughly 0.006 g. The daily requirement is around 0.005 mg. Chromium is advantageous to the cardiovascular system since it lowers the risk of excessive cholesterol and arterial clogging. A deficit of chromium has been related to high cholesterol levels, and high cholesterol levels can be harmful to your heart. Elevated blood cholesterol levels in the blood promote the production of plaques, which block the arteries and cause the artery walls to harden. Atherosclerosis is a disorder that drastically lowers blood flow. The total amount of chromium in the body is low, less than 6 mg.

The discovery of atypical glucose tolerance curves that are responsive to chromium [9] has piqued the public's interest in chromium. There is some evidence that chromium plays a role in carbohydrate and insulin activity.

Hypercholesterolemia and atherosclerosis have both been related to an increased risk of cardiovascular diseases.

#### 4.4 Manganese (Mn)

The average human adult's entire body composition contains roughly 15 mg of manganese, which is commonly found in nuclear material present in nucleus.

The daily requirement is around 2-5 milligram/day. In rats, it is found that magnesium deficiency can result in heart failure [10].

#### 4.5 Copper (Cu)

Copper is essential to our metabolism because this permits several crucial enzymes to work correctly.

The average mature person weighing 70 kg carries around 100 milligrams. The everyday need is around 2-5 mg, of which 50% is consumed through the Absorption of gastrointestinal system (GIT) A lack of Cu in the diet for an extended length of time, particularly throughout period of active growth spurt, causes low Hb (anemia), growth restriction, poor keratin deposition in hair and nails and depigmentation of hair, heat loss, mental retardation, abnormalities in the skeletal structure, and ageing process changes in a elastin in aorta [11].

Extra Copper, whether obtained by dietary or any another means, causes nausea, vomiting, diarrhea, intense sweating, and renal failure. Copper levels in the blood rise in myocardial infarction patients [12].

**Dietary sources:-** Copper levels in an adult's body are believed to be between 100 and 150 mg. Even the poorest diets include enough copper to meet human needs. It is extremely rare to have a deficiency or excess of this element. Wilson's illness, protein-energy deficiency, and newborns who have been exclusively fed cow's milk for lengthy periods of time can all cause hypocupremia.

Hypercupremia can be caused by overeating food cooked in copper cooking pots, or it can be linked to a variety of acute and chronic infections (severe anemia, myocardial infarction, and hyperthyroidism). Adults' copper needs are estimated to be around 2.0 milligrams per day.

#### 4.6 Cobalt

The typical human average adult contains around 1.1 g, with a daily need of 0.0001 mg. It is a vitamin B12 component. Cardiomyopathy, congestive heart failure, pericardial effusion, polycythemia, and goiter are all symptoms of shortage.

In the United States, the recommended daily consumption of Vitamin B12 for an adult is 3 g, which corresponds to 0.012 g of cobalt. The only known function of cobalt in humans is as a component of the vitamin B 12 molecule, which must be consumed before use. There is currently no evidence of cobalt deficiency in humans [11]. Cobalt deficiency and a high cobalt iodine ratio in the soil have recently been linked to goiter in humans [13].

It has been suggested that cobalt is required for the first stage of hormone production, i.e., the gland's uptake of iodine [14]. Cobalt may interact with iodine, affecting its absorption.

- Iodine is a crucial nutrient that is required in micro quantities at all stages of life, with fetal life and early life being the most critical stages where of requirement is of utmost importance

#### 4.7 Selenium

There is some data that suggests a link between selenium and Keshan syndrome.

Keshan syndrome may be caused by an increase in selenium consumption [15].

Keshan sickness was first identified in North China in 1935. Keshan disease manifested clinically as acute and chronic bouts of cardiogenic shock, enlarged heart, congestive heart failure, and cardiac arrhythmias. Selenium insufficiency is an uncommon cause of cardiomyopathy that forensic pathologists may find. A lack of selenium has been linked to cardiomyopathy, myopathy, and osteoarthropathy. Nutritional selenium insufficiency is linked to Keshan disease, a cardiomyopathy, and osteoarthritis in Asia and Africa. :- There is some data that suggests a link among both selenium and Keshan syndrome.

Keshan syndrome may be accompanied by a rise in selenium consumption [15-19].

Nutritional selenium inadequacy is linked to Keshan disease, a cardiomyopathy, and Kashin-Beck disease, an osteoarthropathy [20,21]. Studies on role of different trace elements were reviewed [22-25].

## 5. CONCLUSION

Trace element's play a major role in cardiac diseases continuous monitoring and adequate dietary intake can reduce the risk of cardiovascular diseases significantly.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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