Review Article

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Chromium in controlling diabetes and metabolic aspects

Abstract

Chromium can be found chemically in different forms among which trivalent form is beneficial and hexavalent is toxic. Chromium has various benefits in acting as antioxidant agent. It has been widely studied in metabolic diseases. Chromium was found to help in improving the function of insulin and accordingly it can be used in controlling type 2 diabetes. As a conclusion, chromium supplementation should be considered in controlling diabetes and other metabolic diseases.

Keywords: chromium, trivalent chrome, hexavalent chrome, diabetes, metabolic diseases

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Introduction

Since the discovery of the carcinogenic effects of hexavalent Cr at the end of the nineteenth century, chromium (Cr) has been investigated.[1] The essentiality of trivalent Cr was established in 1959; Cr3+ has been investigated in humans and laboratory animals since the 1970s, but Cr has only been investigated as an essential element in pastoral animals with the same intensity since the 1990s.[2] Normal glucose, lipid, and protein metabolism all require trivalent chromium.[3] Chromium is biologically active as part of an oligopeptide called chromodulin, which helps insulin attach to receptors on the cell surface, potentiating its impact. Because chromium is an insulin cofactor, Cr activity in the body is linked to insulin activities.[4] Inorganic Cr absorption is modest, ranging between 0.4 and 2.0 percent, whereas organic Cr availability is more than 10 times higher. Cr that has been absorbed circulates in the circulation as part of the -globulin plasma fraction and is delivered to tissues that have been bound to transferrin.[5] The demand for Cr has been rising as a result of stresses, particularly during various forms of dietary, metabolic, and physical strain.[6]

Diabetes mellitus (DM) is a metabolic condition in which diabetic patients have excessively high blood glucose levels due to inadequate insulin production or insulin resistance.[7] In diabetic individuals, chronic hyperglycemia can harm different cells and organs, including the retina, heart, kidneys, and blood vessels.[8] According to recent studies, the global prevalence of diabetes mellitus has risen from 451 million individuals in 2017 to 693 million people by 2045.[9] Most individuals with increased blood glucose levels (more than 90%) are diagnosed with type 2 diabetes (T2DM), which is insulin-independent pathologically.[10]

Increased blood glucose, fatty acid synthesis, and reactive oxygen and nitrogen species can all lead to mitochondrial and metabolic dysfunction, resulting in reduced insulin secretion by –cells.[11] Furthermore, because free radicals play such an important part in the initiation and evolution of life, they are now referred to as "obligatory harmful chemicals." When free radicals cooperate with the superoxide dismutase enzyme, they can activate some signaling cascades, such as the extracellular signal regulated kinase (ERK) and/or mitogen-activated protein kinase (MAPK) pathways, which participate in the alteration of gene expression as well as the initiation of cell death.[12]

Free radical molecules are formed when oxygen reacts with non-enzymatic organic compounds, or they can be created by ionizing radiation.[13] As a result, oxidative stress can be induced by a variety of factors, including cigarette smoking, reactive nitrogen species, reactive oxygen species (ROS), and irradiation.[12] The decrease in the production of endogenous antioxidants such as superoxide dismutase (SOD), catalase (CAT, non-enzymatic/enzymatic), and glutathione peroxidase is primarily responsible for the elevated levels of ROS (GSH-Px).[14] As a result, even if antioxidant enzyme levels are somewhat reduced, tissues and organs of the human body, such as the pancreas, are susceptible to oxidative stress.[15] The mitochondrion is the principal source of oxidative stress in diabetes. Certain amounts of molecules are transformed into oxygen free radicals (O•) during oxidative phosphorylation in mitochondria, which account for the majority of ROS.[12] Other prooxidant agents, such as OH, H2O2, and ONOO, could be made from these molecules.[15]

Insulin signaling is precisely regulated by ROS/RNS via two routes, according to several lines of evidence. In addition, ROS/RNS are generated in response to insulin signaling to complete their physiological activities.[16,17] ROS and RNS have a negative feedback effect on the insulin signaling cascade, resulting in the development of insulin resistance, which is a risk factor for type 2 diabetes.[18] Oxidative stress has also been linked to diabetes' micro- and macrovascular consequences, such as nephropathy and retinopathy.[19] Inflammation and oxidative stress are hypothesized to have a causative relationship in renal and cardiovascular problems of diabetes.[20] Medication, lifestyle changes, and complementary therapies such as vitamins, minerals, and herbal extracts are generally used to treat diabetes.[21,22] Trivalent chromium is thought to be an insulin sensitizer that prevents the development of type 2 diabetes, according to prior research. The three stable forms of chromium found in nature are 0, 3+, and 6+. 22 Chromium 3+ appears to be beneficial for metabolic responses in the human body,[23] but hexavalent chromium is harmful to people and animals.[24]

Chromium is abundant in whole grains, egg yolks, green beans, nuts, high-bran cereals, brewer's yeast, beef, beer, broccoli, and wine, but it is also present in small amounts in most fruits and vegetables, as well as dairy products.[25] Chromium can enhance the number of insulin binding receptors and their phosphorylation rates, making glucose transfer into the liver, muscle, and adipose tissue easier.[26]

Additionally, chromium can increase the production of antioxidant enzymes and prevent lipid peroxidation via a variety of cellular mechanisms, including increased expression of the nuclear factor erythroid 2–related factor 2 (Nrf-2),[27] 5'-adenosine monophosphate-activated protein kinase (AMPK) pathways,[28] and the inhibition and reduction of the MAPK pathway, all of which reduce oxidative stress.[29] Furthermore, the antioxidant capabilities of chromium may help to reduce oxidative stress and inflammation produced by T2DM hyperglycemia.[28]

Another study found that dietary supplementation with chromium picolinate reduced the damage caused by oxidative stress in rats with induced diabetes, implying a potential positive effect on diabetic patients.[30] Capsules with 200 g chromium picolinate are more prevalent in the United States, but the amount can be as high as 1000 g, according to information gathered by MicromedexTM.[31]

Low Cr levels can influence blood glucose, insulin, total cholesterol, triglycerides, and high-density lipoprotein cholesterol, as Cr is essential for appropriate glucose and lipid.[32,33] Although the minimum estimated safe and appropriate daily dietary intake for Cr for people aged 7 and up is 50–200 g/day, typical Western diets do not meet these needs.[34] According to Anderson and Kozlovsky[35] 90% of the US population do not consume the recommended safe and appropriate daily dietary intake. According to a more recent study, adults in the United States consume less than the recommended daily intake of 25–35 g of Cr.[36] Brewer's yeast, beer, whole grains, cheese, liver, and pork are all good sources of Cr in the diet; however, the amount of Cr in different foods varies a lot.[37] Furthermore, most of the absorbable Cr is removed during the refining of grains and sugars, as well as food preparation.[38] Much of the Cr found in foods comes from contamination of food-processing equipment and is therefore not bioavailable.[37]

Reduced Cr status[39] and excessive ingestion of refined carbohydrates[40] have both been linked to a higher prevalence of T2DM. Urinary Cr losses have been reported to increase 10–300% after eating a high-sugar diet.[38] Age, illness, pregnancy, burns, and stress can worsen relative Cr shortage.[41] Hair analysis revealed low Cr status in more than half of 2,000 Canadian individuals in one epidemiological research.[42]

Conclusions

Chromium supplementation should be considered for potential use in controlling diabetes and metabolic disorders.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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