Insight

Chromium in Health and Disease

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Chromium is a mineral found in all living creatures; man, animal, and plant. It is naturally found in two valencies; trivalent - in living matter, and hexavalent – toxic and used in industry. Human and animal need for chromium is very minute - measured in microgram or picogram, hence the mineral is termed a trace element.

Chromium and Diabetes Mellitus

Chromium was shown more than four decades ago to potentiate the action of insulin and the essentiality of chromium to human beings was repeatedly confirmed during the late 1970s. These findings have led the American Medical Association to recommend adding sufficient amounts of chromium to intravenous solutions[1].

Encouraged by the observation that substitution of barley bread for wheat bread was beneficial to diabetics in some parts of the Middle East, Mesopotamia in particular, a series of investigations were conducted by the author during the 1980s. These conclusively showed that replacing the Mesopotamian barley flour for wheat flour in the diet of diabetic animals significantly improved the cardinal signs of diabetes of those animals, including the hyperglycaemia[2]. They also confirmed that trivalent organic chromium in Mesopotamian barley was responsible for the significant improvement of the cardinal signs of diabetes[3].

Quite a number of investigation have revealed the beneficial effects of chromium supplementation in type II diabetics[1,4], with further improvement of the blood glucose by increasing the dosage of the supplemental chromium[5]. The rise in serum cholesterol which commonly occurs in diabetic patients has been shown to be significantly reduced by chromium supplementation with improvement in total cholesterol, LDL cholesterol and HDL cholesterol[6]. Beneficial effects of chromium supplementation were also reported in the glucose tolerance of elderly people[7]. Moreover, chromium supplementation was frequently shown to improve the glucose tolerance of patients who had no evidence of chromium deficiency[1].

Thickening of the capillary basement membrane of the arterial system is a characteristic lesion of long-term diabetes and is considered to be the ultimate cause of diabetic microangiopathy. It would be relevant and interesting to point that the pathology of the main basement membrane antigens of the arterial system, 7S collagen and laminin P2 glycoprotein, have been shown by the author and co-workers to improve significantly in the serum, kidney, and liver of streptozotocin-diabetic rats fed a high chromium diet compared with matched control animals fed on a low chromium diet. Accordingly, the authors suggested that this effect might well have been due to the enhancement of the action of insulin by the dietary chromium[8]. Although extrapolation to humans would not be advisable, it would seem, however, that ensuring sufficient chromium status can retard long-term diabetic complications.

Chromium and Cardiovascular Diseases

Trivalent chromium is an essential nutrient required for normal glucose and lipid metabolism and insufficient dietary chromium has been associated with type 2 diabetes and/or cardiovascular diseases[9]. Severe and/or accelerated atherosclerosis in man has been associated with abnormalities of glucose metabolism; a low tolerance to glucose being often found. For many years the association of diabetes mellitus and atherosclerosis has been known. In atherosclerosis, disorders of both glucose and lipid metabolism coexist; the common factor appears to be a high level of circulating insulin[10]. Accordingly, the author postulated that "chromium deficiency might contribute to insulin resistance, type 2 diabetes mellitus, dyslipidaemia, and atherosclerosis"[11].

The beneficial effects of chromium on cardiovascular diseases were first hypothesized by Schroeder and coworkers after their observation of reduced chromium concentration in the aortas of people dying from heart disease compared with those killed by accidents. This is

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consistent with their observation of increased occurrence of aortic plaques and elevated blood lipids of rats kept in a strictly controlled, low chromium environment[1].

Of particular interest is the observation of a reversal of established atherosclerosis in the aortas of cholesterol-fed rabbits by the daily injection of chromium. Similar results were obtained from another experiment with hypercholesteraemic patients. The relation of serum chromium concentration to coronary artery disease was further supported by two independent studies using a total of 122 patients, of whom 82 were diagnosed by cine-arteriography as having coronary artery disease. The reported serum chromium level differed significantly (by 41% in the first study and 12% in the second study) in the subjects with and without coronary artery disease[1].

Chromium and Gestational Diabetes

Experimental evidence indicates that chromium salts, administered orally or intravenously, do not cross the placenta unless they are of glucose tolerance factor (GTF) composition[12]. Transfer of chromium from mother to foetus is thought to occur during pregnancy. This leads to a reduction in maternal body chromium pool and an alteration in maternal hair chromium concentration; a decrease in hair chromium being most marked in multiparae. A distinct difference was observed when hair chromium concentration in women with history of multiple births was compared with that in women with no children. The results of the longitudinal study on hair chromium levels during pregnancy also revealed that the mean hair chromium concentration for every consecutive trimester shows a step-wise decrease with advancing pregnancy[13]. Moreover, a randomized controlled trial, albeit being small (n = 20), of chromium supplementation to women with gestational diabetes reported significant reduction in glucose and insulin concentrations in the chromium-supplemented group[14].

Chromium in Pediatric Nutrition

Although multiple deficiencies are more likely to occur in malnourished individuals than in those consuming typical Western diets, malnourished children responded promptly to chromium supplementation as found in several studies. If one study on malnourished children in Egypt[15] is excluded from the evaluation, because of the generally high chromium intake locally and because chromium was supplemented for surprisingly short period (3 days only), all other trials on children in the recovery periods of Kwashiorkor and marasmic types of protein-calorie malnutrition in adjacent areas (Jordan and Turkey) reported profound improvement in glucose tolerance with chromium supplementation[1].

In spite of the therapeutic roles of trivalent chromium and its preventive aspects in delaying the initiation of glucose intolerance by overweight and/or physical inactivity[16] or impeding the deterioration of glucose intolerance with advancing age[10], the undeniable currently observed lack of interest in chromium nutrition among the medical profession is really surprising. Why are we neglecting the well founded prospect of halting, or at least impeding, the deterioration of glucose tolerance by chromium supplementation before a mild insulin resistance turns into frank diabetes mellitus with all the inherent risk factors for cardiovascular diseases, human sufferings, and the rocketing financial burden on health authorities from the ever increasing demand to manage the diabetes syndrome and deal with the long term diabetic complications?[10]

It would be interesting to highlight in this context that impaired insulin sensitivity, necessarily accompanied by impaired glucose tolerance is common among Western adults - present in about 25 % of non-diabetics and tends to correlate with hypertension, hypertriglyceridaemia, obesity, and cardiac risks. Marginal chromium deficiency may increase the risk of insulin resistance, diabetes mellitus and coronary heart disease[10]. It would be equally interesting to highlight that well-controlled studies sponsored by the US Department of Agriculture[17] indicate that the typical high fat, over-refined American diet is a poor source of chromium. In those studies over 90% of the large sample of subjects received less than the minimum recommended daily intake of 50 μg chromium and 25% of them received less than 20 μg. Consequently, it is reasonable to believe that sub-optimal chromium nutrition may contribute to the current American epidemic of insulin resistance[1] and mild chromium deficiency is a risk factor for a spectrum of disturbances that are almost identical to those of Syndrome X[10].

Reasons for the observed lack of interest in chromium nutrition among medical professionals are many. The generally low awareness of the preventive and therapeutic roles of nutrition is widespread and regrettable. Clearly this is due to the hitherto widespread low emphasis on topics of nutrition in the undergraduate and postgraduate medical teaching curricula. However, since the mid-1980s teaching nutrition to medical students has been recommended in most developed countries in order to create awareness among the medical profession, and through them the public at large, about the importance of sound, sensible diet and nutrition to health. It is worth mentioning that efforts to rectify the situation are advancing in many countries like the United Kingdom and United States–culminated in the former by the recommendations of the workshop of the Nutrition Society to teach nutrition to medical students[18] and in the latter by The National Nutrition Monitoring and Related Research Act[19].

Other causes for this lack of interest in chromium nutrition among the medical profession include some discouraging negative results of chromium supplementation trials which, however, were explained by the author[20] and the unavailability of a reliable biochemical index reflecting chromium status of human beings yet[1,4]. In addition, the fact that chromium is a nutrient not a therapeutic agent necessarily implies that chromium supplementation will only benefit those people whose signs and symptoms are due to a marginal or an overt chromium deficiency [1,9] and that chromium supplementation would exercise a contributory, subtle role in the management of diabetes together with the other dietetic and mode of life measures.

There is evidence that human tissue chromium decline with advancing age[1,9]. Well controlled studies carried out in many parts of the developed world including Britain[21] and the United States[9] indicate that dietary chromium intake, even by affluent, apparently healthy people is suboptimal-around the minimum suggested safe amount of 50μg, sometimes half of it[9]. This led leading researchers in the field to conclude that "suboptimal dietary chromium intakes are almost universal"[9] and that "chromium deficiency does occur in populations in the United States and elsewhere"[1]. Moreover, modern methods of food processing lead to loss of chromium from staple foods[22]. In addition, increased chromium losses ensue from any stress including strenous exercise, high sugar diet, surgical operations, any physical trauma[9] and from pregnancy and lactation[9,13].

On the other hand dietary sources rich in chromium are scanty. The literature indicates that the highest known concentration of chromium was thought to be particularly in brewer's yeast[20] until the author showed in the late 1980s that certain types of barley grown in parts of the Middle East (Mesopotamia) contain ten times more chromium (5.5 ppm) than brewer's yeast[3]. Different types of beer were found to contain variable amounts of chromium–with no sound explanation being reported then[22]. However, a reasonable explanation for this variability of the chromium content of different types of beer was put forward by the author[20]. Fenugreek (Helba) and lentil contain high level of chromium[15]. Vegetable oils and unrefined sugars have relatively high chromium concentration while spices (like black pepper, thyme, and cloves), fruit and vegetables, fish and meat (except liver and kidney) are low in chromium, and human milk generally contains more chromium than cow's milk[23].

In addition to the insulin potentiation action due to its high chromium content[24], barley is a food known for its high fibre content, ranging from 15.3% to 31.6% compared to 9.6% in wholemeal wheat flour[25]. Even dehusked (pearl) barley contains more fiber (5.9%) than white wheat flour (3.7%)[26]. Added to this, barley is notably rich in amylose compared to other foods; reports of the amylose content of barley range from a relatively high 27% in normal barley to an exceptionally high 35% in glacier barley[27]-an additional factor ameliorating postprandial hyperglycaemia of glucose intolerant and diabetic people[28]. Moreover, purification of the oily non-polar fraction of high protein barley (Hordeum vulgare L) yielded ten major components, two of which (D-α-tocotrienols) are potent inhibitors of cholesterogenesis[29].

The aforementioned clearly shows that the advantages of barley consumption by human beings, specifically by glucose intolerant, diabetic, hyperlipidaemic and/or overweight individuals need no more emphasis. Since barley would be a more acceptable human food in the Middle East and Gulf countries than the West where it is used mainly for brewing of beer, and since firmness makes traditional barley bread hardly palatable few hours after baking (personal observation), the author hereby invites knowledgeable and interested food scientists, nutritionists, and dietitians to take up the challenge of coining recipes of more palatable barley bread, barley snacks and dishes-especially those made from barley varieties rich in chromium[30] in order to increase the consumption of this functional food, barley, thereby increasing the intake of organic trivalent chromium, fibre, and amylose as a cheap an affordable nutritional public health preventive and therapeutic measure against today's common degenerative diseases; diabetes mellitus, hyperlipidaemia, cardiovascular diseases, and obesity.

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