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A study of chromium levels in type 2 diabetes mellitus

Dr. Mohammad Rafi[1], Dr. S Laxmi Narayana[2*]
[1] Professor & Head, Department of Biochemistry, Mahavir Institute of Medical Sciences (MIMS), Shivareddypet, Vikarabad, Telangana, India
[2] Professor & Head, Department of Biochemistry, Government Medical College, Mahbubnagar, Telangana, India

Abstract
Chromium is one of the most abundant elements in the earth's crust. It is an essential trace element for proper insulin functioning and blood glucose regulation. The present study was undertaken in the Dept. of Biochemistry, Gandhi Medical College, Musheerabad, Secunderabad, Telangana, India, to assess the concentrations of chromium in the serum samples of the patients of Type 2 Diabetes mellitus attending the outpatient Department of Gandhi Hospital, Secunderabad. The study is also intended to assess chromium handling in Type 2 Diabetes mellitus patients compared to healthy controls. The study comprised of total n=40 subjects consisting of n=20 subjects of Type 2 Diabetes mellitus and n=20 cases normal healthy controls, between 40-70yrs which were further categorized into Group I n=10 subjects between 40-54 yrs and Group II n=10 subjects between 55-70 yrs. In both the study and control group subject's serum chromium level was measured with flame atomic absorption spectrophotometer. The data of mean levels of serum chromium concentrations in the normal individuals (controls) and Type 2 Diabetes mellitus subjects showed highly significant differences between the two groups ($p<0.001$). The mean level of serum chromium concentration in the normal control individuals was 0.478 µg/L and SD±0.10 and in the subjects with Type 2 Diabetes mellitus, the concentration was 0.278±0.10.
The mean chromium concentration in the normal individuals between 40-54 yrs age group was 0.523±0.08 while 0.443±0.06 between 55-70yrs age group showing significant differences between the two age groups ($p<0.05$).
The results of this study showed significantly low chromium concentrations in the serum of Type 2 DM subjects compared to that of normal healthy controls ($p<0.001$). Results also indicate lower concentrations of chromium in elderly groups (55-70yrs) of normal individuals when compared to the relatively younger group (40-55 yrs) ($p<0.05$). No significant difference was observed between different age groups of diabetic patients, probably because of already compromised chromium status in them. The above observations are in support of giving supplemental chromium to the patients of Type 2 Diabetes mellitus.

Keywords: chromium, glucose, insulin, Type 2 diabetes mellitus

1. Introduction
Diabetes mellitus is the third leading cause of mortality after heart disease and cancer in many countries. Recent estimates suggest that the prevalence of diabetes is rising globally, particularly in developing countries [1]. It affects 2-3% of the general population.
Diabetes mellitus is a clinical syndrome characterized by hyperglycemia due to absolute or relative deficiency of insulin. The clinical significance of chromium rests primarily with its relation to glucose metabolism. Lack of insulin whether absolute or relative, affects the metabolism of carbohydrates, proteins, lipids, water and electrolytes.
Chromium is an essential micronutrient which is required for the normal functioning of insulin and regulation of blood sugar levels. It acts as a vital antioxidant for maintaining insulin homeostasis. Previous studies suggest that low serum levels of chromium are associated with poorer glycemic control.
Chromium acts primarily by regulating insulin action; in the presence of chromium in a physiological form, much lower amounts of insulin are required, since chromium acts by increasing insulin efficiency [2].
Chromium deficiency affects the maintenance of normal glucose tolerance and healthy lipid profiles [3]. Chromium deficient Type 2 diabetics were noted to have decreased insulin binding and reduced number of insulin receptors, thereby leading to glucose intolerance [4]. Chromium supplementation in diabetics has been shown to improve glucose tolerance, decrease blood cholesterol and triglycerides and increase high density lipoprotein cholesterol.
Based on the above observations the present study was undertaken to assess the concentrations of chromium in the serum samples of the patients of Type 2 Diabetes mellitus or adult-onset diabetes. The study is also intended to assess chromium handling in patients of Type 2 Diabetes mellitus compared to that of healthy volunteers expecting possible differences in chromium homeostasis between the two groups.

2. Materials and Methods
The present study was conducted in the Department of Biochemistry, Gandhi Medical College, Secunderabad, Telangana, India. Ethical Committee approval was taken from the Institutional Ethical Committee Board. The study group comprised of total n = 40 subjects consisting of n = 20 subjects of Type 2 Diabetes mellitus and n = 20 cases normal healthy volunteers taken as controls. This study group cases were of age group between 40 – 70 years which were further categorized into two groups. Group I consisted

n = 10 subjects between age group 40 – 54 years and Group II n = 10 subjects between age group 55 – 70 years.

The present study included n = 20 subjects with established Type 2 Diabetes mellitus based on ADA (American Diabetes Association) guidelines attending the outpatient Department of Gandhi Hospital, Secunderabad. After selection of the subjects for the present study, the nature, purpose and benefit of the study was explained to each subject in detail and written consent was taken.

Inclusion criteria included both males and females in the age group 40 – 70 years, known cases of Type 2 Diabetes mellitus diagnosed based on Fasting Blood Glucose (FBS) and are on oral hypoglycemic drugs. Exclusion criteria included individuals with history of peptic ulcer, Pancreatitis, Gall stones, Liver diseases and Renal diseases, patients taking Insulin.

In both the study and control group subjects Fasting Venous Blood Samples were collected and the parameters were measured on a fully automated analyser (Erba). Fasting Blood Glucose was estimated by Hexokinase method.

Following aseptic precautions 5ml of venous blood samples were drawn from anti-cubital vein and transferred into 2 collection bottles separately meant for chromium and glucose estimations. Sodium fluoride was used as anticoagulant in the collection bottles meant for estimation of glucose. The blood sample in the other bottle was centrifuged at 1500 x g for 5 minutes. The plasma was removed with a clean plastic Pasteur pipette. The clot was removed with a plastic covered applicator and the serum was stored at 4ºC for no longer than 7 days until assayed. This procedure was used to prevent the introduction of chromium derived from erythrocytes into the serum if hemolysis occurred during normal clotting process.

Determination of glucose levels in both the normal and Type 2 Diabetes mellitus samples was done by Trinder's (GoD/PoD) glucose oxidase enzymatic method described by Barham and Trinder [5], using commercially available kits from Bio systems (Spain), while the chromium levels in both the serum samples was determined using flame atomic absorption spectrophotometer method previously described by Kaneko [6].

3. Statistical Analysis

Statistical analyses were performed by using a computer based statistical program SPSS Version 20. All the estimates were presented as Mean ± SD and statistical analysis of the data was performed using student's 't' test and *p* values <0.05 and <0.001 were considered as statistically significant.

4. Results

In the present study, the results of mean levels of serum chromium concentrations of subjects with Type 2 Diabetes mellitus and normal individuals taken as control group of two age groups are presented in Table 1 and 2.

The serum chromium concentrations along with the fasting and post prandial blood glucose levels in the normal healthy individuals of age group between 40 – 54 years is given in Table 1 while, that in the subjects between age group 55 – 70 years is presented in Table 2.

The data of mean levels of serum chromium concentrations in the normal individuals (controls) and Type 2 Diabetes mellitus subjects showed highly significant differences between the two groups ($p<0.001$). The mean level of serum chromium concentrations in the normal control individuals was 0.478 µg/L and SD ±0.10 and in the subjects with Type 2 Diabetes mellitus, the mean and SD of chromium concentration was 0.278 ± 0.10.

The mean chromium concentration in the normal individuals between 40 - 54 years age group was 0.523 µg/L (SD±0.08) while between 55 – 70 years age group was 0.443 µg/L (SD±0.06). Statistical analysis data showed significant difference between these two groups ($p<0.05$) of two age group subjects.

Table 1: The concentrations of chromium in the serum samples along with their corresponding blood glucose levels in normal healthy individuals and Type 2 diabetic patients of age group between 40 – 54 years

Case No	Control (µg/L)			Type 2 diabetic subjects (µg/L)		
	Conc chromium	FBS	PPBS	Conc chromium	FBS	PPBS
1	0.52	80	120	0.23	148	212
2	0.44	84	122	0.28	156	260
3	0.56	78	118	0.19	184	322
4	0.48	90	126	0.33	150	216
5	0.61	76	124	0.24	148	228
6	0.49	92	130	0.36	186	326
7	0.67	85	128	0.38	160	262
8	0.58	82	124	0.33	154	218
9	0.46	88	125	0.29	146	206
10	0.42	90	130	0.37	160	261
Mean	0.523			0.300		
SD	± 0.08			± 0.06		
P	< 0.001					

The statistical analysed data clearly indicates significant differences in the serum chromium concentrations between the two age groups however no significant differences were observed between the two age groups of diabetic subjects.

Table 2: The concentrations of chromium in the serum samples along with their corresponding blood glucose levels in normal healthy individuals and Type 2 diabetic patients of age group between 55 - 70 years

Case No	Control (µg/L)			Type 2 diabetic subjects (µg/L)		
	Conc chromium	FBS	PPBS	Conc chromium	FBS	PPBS
11	0.44	82	124	0.18	156	224
12	0.38	90	130	0.24	164	246
13	0.34	96	128	0.22	172	267
14	0.43	92	126	0.28	180	296
15	0.39	86	124	0.19	152	216
16	0.38	88	130	0.26	174	286
17	0.47	85	130	0.34	208	368
18	0.49	95	132	0.27	192	302
19	0.56	90	128	0.26	176	272
20	0.45	98	132	0.32	200	309
Mean	0.433			0.256		
SD	± 0.06			± 0.05		
P	< 0.001			Highly significant		

5. Discussion

Diabetes mellitus (DM) is a group of metabolic diseases characterized by inability of the body to metabolize glucose due to abnormal amount or activity of insulin hormone, which was reported in many studies to be the function of number of trace elements deficiency [7]. A number of studies have reported that chromium supplements enhance the action of insulin and reduce the risk of DM complications development [8]. The trace element deficiency is believed to lead to glucose intolerance, and thus to diabetes related complications [9].

The results of the present study showed that level of serum chromium in Type 2 DM was recorded lower compared to their healthy control individuals in agreement with the general belief and with the findings of several earlier studied reports [10-13].

The present study findings are also similar to the observations reported from earlier studies of Ghosh *et al.* [14], Diwan *et al.* [15], Ding *et al.* [16] and Volpe *et al.* [17].

The results of the present study indicated that persons affected by Type 2 diabetes have relatively lesser concentrations of chromium in their bodies over normal healthy individual controls.

Ageing is associated with elevated blood glucose and circulating insulin, decreased insulin efficiency, elevated cholesterol and triglycerides, decreased high-density lipoprotein cholesterol, decreased nerve conduction, and decreased lean body mass; all these changes also occur in chromium deficiency. Patients with Type 2 Diabetes mellitus have lower serum chromium levels than non-diabetics and chromium supplementation in diabetics has been shown to improve glucose tolerance, decrease blood cholesterol and triglycerides and increase high density lipoprotein cholesterol.

The results of the present study indicate that the chromium concentrations in Type 2 diabetic subjects which are in the range 0.18 - 0.38 µg/L are significantly lower than that of chromium concentrations (ranging between 0.34 – 0.67 µg/L) in the normal control individuals ($p<0.001$) which implies that the Type 2 diabetic subjects probably lack chromium. Further, it was found that serum chromium concentrations of elderly cases are lower than that of younger group in the normal individuals. Serum chromium concentrations of normal group in the age group between 55 – 70 years ranged between 0.34 – 0.56 µg/L (Table 2) which is slightly lower than the serum chromium concentrations in the age group between 40 – 54 years which ranged from 0.42 – 0.67 µg/L ($p<0.05$). There is no significant difference observed between the two age group diabetic subjects, probably indicates irrespective of age diabetics have lower chromium levels.

The data of the present study indicate that the chromium levels in the human body decreases with increase in age. The chromium levels are further decreased in Type 2 Diabetic mellitus. Thus, it can be justified to recommend the supplementation of a certain amount of chromium to the patients of Type 2 diabetes according to their nutritional level.

The decrease in chromium concentration in diabetic patients has profound health consequences in terms of diabetic and cardiovascular disease morbidity and mortality. The role of improved chromium nutrition requires further investigation, including monitoring the response of cardiovascular risk factors such as glucose tolerance, lipid parameters and insulin function, all of which have been shown to improve with chromium supplementation.

As it has been established beyond doubt that chromium is an essential nutrient involved in the metabolism of glucose, insulin and blood lipids, sub-optimal dietary intake of chromium is associated with increased risk factors associated with diabetes and cardiovascular diseases. Within the past five years, chromium has been shown to improve glucose and related variables in the subjects with glucose intolerance and type 1, type 2, gestational and steroid induced diabetes [16]. Severe neuropathy and glucose intolerance of a patient on total parenteral nutrition, who was receiving currently recommended levels of chromium, was reversed by additional supplementation of chromium. Chromium increases insulin binding to cells, insulin receptor number and activates insulin sensitivity. Additional studies are urgently needed to elucidate the mechanism of action of chromium and its role in the prevention and control of diabetes [16].

Our modern diets have an excess of refined carbohydrates that has been stripped of chromium content and refined carbohydrates also cause increased urinary chromium losses. This increase in chromium-depleted refined carbohydrate consumption, along with the absence of an efficient long-term chromium conservation mechanism, would account for the statistically significant age-related decreases in chromium levels observed in this study ($p<0.05$).

Patients with Type 2 diabetes mellitus require more than 200 µg daily of supplemental chromium. Diabetes usually has higher requirement for chromium and have impaired mechanisms to convert chromium to a usable form. Response time to chromium varies from less than 10 days to sometimes more than 3 months. Response to chromium is also related to stress and beneficial effects are greater under physical or dietary stresses. Also, response to supplemental chromium is related not only to dietary chromium intake but also the types of diets consumed, since some dietary components such as simple sugars increase chromium losses. Glucose intolerance and diabetes are also due to a number of causes unrelated to dietary chromium intake.

Large losses of chromium over many years may exacerbate an already compromised chromium status in Type 2 diabetes mellitus patients and might contribute to the developing insulin resistance seen in these patients.

Chromium picolinate may be a useful addition to standard combination drug treatment of Type 2 diabetes mellitus (a new clinical study presented at the 59th Annual Scientific sessions of the American Diabetes Association at San Diego in 1999).

Australian researchers studied the effects of supplementation with chromium picolinate (500 µg, twice a day) for 4 months in 16 obese patients with mean age 56 years. All the patients were pre-treated with and continued to receive stable doses of a sulphonyl urea and metformin, standard treatment for Type 2 diabetes, throughout the study. Chromium picolinate appeared to enhance the effects of metaformin and oral sulfonylureas. The addition of chromium was associated with significant reduction in fasting insulin levels, without detrimental effect on glucose control. The ability of chromium picolinate to lower fasting insulin levels in patients already receiving diabetic medication is clinically important because an elevated insulin levels in the blood is an established risk factor for cardiovascular disease. These findings provide justification for the use of chromium picolinate as a nutritional adjunct in the dietary management of diabetes [19].

Chromium picolinate reduced or eliminated the symptoms in 41 out of 44 patients with steroid-induced diabetes after standard drug therapy failed. 41 patients who had developed diabetes as a result of undergoing steroid treatment and who benefitted from chromium picolinate were able to reduce or eliminate their diabetic medication, such as insulin [20].

As the chromium functions in maintaining normal glucose tolerance primarily by regulating insulin action, in the presence of optimal amounts of biologically active chromium, much lower amounts of insulin are required. Glucose intolerance related to insufficient dietary chromium, appears to be widespread. Improved chromium nutrition leads to improved sugar metabolism in hypoglycemic, hyperglycemic and diabetic individuals.

Perhaps more important is the public health aspect, since most chromium is discarded in the cereal refinement process. We now have added evidence for a return to the diets in which complex carbohydrates predominated. In those who refuse or are unable to do so, possibly the addition of chromium to their drinking water may be of value.

An enormous magnitude of research work is currently underway worldwide on chromium in relation to diabetes mellitus and the medical world will witness some significant positive results in the near future. The above observations are in support of giving supplemental chromium to the patients of Type 2 diabetes mellitus.

6. Conclusion

It has been established that chromium acts as a potentiator of insulin action. Insulin resistance may be a consequence of chromium deficiency and insulin, apparently is ineffective as a glucose regulator without chromium. In a number of well controlled studies conducted worldwide supplemented chromium has been shown to have beneficial effects without any documented side effects on people with varying degrees of glucose intolerance ranging from mild glucose intolerance to overt Type 2 diabetes mellitus.

7. References

1. Jayawardena R, Ranasinghe P, Byrne NM, Soares MJ, Katulanda P, Hill AP. Prevalence and trends of the diabetes epidemic in South Asia: A systematic review and meta-analysis. BMC Public Health. 2012; 12:380.
2. Anderson RA, Cheng N, Bryden NA, Polansky MM, Cheng N, Chi J, Feng J. Elevated intakes of supplemental chromium improve glucose insulin variables in individuals with type 2 diabetic patients. Diabetes. 1997; 46(11):1786-1791.
3. Lewicki S, Zdanowski R, Krzyzowska M, Lewicka A, Debski B, Niemcewicz M. The role of Chromium III in the organism and its possible use in diabetes and obesity treatment. Ann Agri Env Med. 2014; 2:331-335.
4. Cefalu WT, Hu FB. Role of Chromium in Human Health and in Diabetes. Diabetes Care. 2004; 27(11):2741-2751.
5. Barham D, Trinder. An improved colour reagent for the determination of blood glucose by the oxidase system, Analyst. 1972; 97(151):142-145.
6. Kaneko JJ. Clin Biochem of Domestic Animals. 4th Edn. San Diego: Academic Press Inc. New York, 1989, pp. 932.
7. Peter JH. The role of chromium in insulin resistance: A scientific review. Nutrition, 2004, 21.
8. Anderson RA, Cheng N, Bryden NA, Polansky MM, Cheng N, Chi J, Feng J. Elevated intakes of supplemental chromium improve glucose insulin variables in individuals with type 2 diabetic patients. Diabetes. 1997; 46(11):1786-1791.
9. Kazi TG, Afridi HI, Kazi N, Jamali MK, Arain MB, Jalbani N, Kandhro GA. Copper, Chromium, Manganses, Iron, Nickel, and Zinc Levels in Biological Samples of Diabetes Mellitus Patients. Biol trace Elem Res. 2008; 122:1-18.
10. Cefalu WT, Wang ZQ, Zhang XH, Baldor LC, Russell JC. Oral chromium picolinate improves carbohydrate and lipid metabolism and enhances skeletal muscle Glut-4 translocation in obeses, hyperinsulinemic (JCR-LAcorpulent) rats. J Nutr. 2002; 132:1107-1114.
11. Huma Y, Yahya KM, Saqib A. Minerals and type 2 diabetes mellitus-level of Zinc, Magnesium and Chromium in diabetic and nondiabetic population. JUMDC. 2011; 2(1):34-38.
12. Ajibola RS, Ogundahunsi OA, Soyika OO, Ogunyemi EO, Odewabi AO. Serum Chromium, Molybdenum, Zinc and Magnesium levels in diabetes mellitus patients in Sagamu, South West Nigeria. Asian J Med Sci. 2014; 6(2):15-19.

13. Jeejeebhoy KN, Chu RC, Marliss EB, Greenberg GR, Bruce-Robertson A. Chromium deficiency, glucose intolerance and neuropathy reversed by chromium supplementation in a patient receiving long-term total parenteral nutrition. Am J Clin Nutr. 1977; 30:531-538.
14. Ghosh D, Bhattacharya B, Mukherjee B, Manna B, Sinha M, Chowdhury J. Role of chromium supplementation in Indians with type 2 diabetes mellitus. J Nutr Biochem. 2011; 13(11): 690-697.
15. Diwan AG, Pradham AB, Lingojwar D, Krishna KK, Singh P, Almelkar SL. Serum zinc, chromium and magnesium levels in Type 2 diabetes. Int J Diab Dev Ctries. 2006; 26(3):122-123.
16. Ding W, Chai Z, Duan P, Feng W, Qian Q. Serum and urine chromium concentrations in elderly diabetics. Biol Trace Elem Res. 1998; 63(3):231-237.
17. Volpe SL, Huang HW, Larpadisorn K, Lesser II. Effect of chromium supplementation and exercise on body composition, resting metabolic rate and selected biochemical parameters in moderately obese women following an exercise program. J Am Coll Nutr. 2001; 20(4):293-306.
18. Anderson RA. Chromium in the prevention and control of diabetes. Diabetes and Metabolism. 2000; 26(1):22-27.
19. Bahadori B, Wallner S, Hacker C, Boes U, Komorowski JR, Wascher TC. Effects of chromium picolinate on insulin levels and glucose control in obese patients with type-II diabetes mellitus. Diabetes. 1999; 48(suppl):A349 (abstr).
20. Alexander R, Ladislav S, Nitsa M, Anderson RA. Control of steroid-induced diabetes with supplemental chromium. The J Trace Elements in Experimental Medicine. 1999; 12(4):375-378.