

Correlation of Serum levels of Chromium, Copper, and Manganese with the Glucose levels in Type 2 Diabetes Mellitus in Iraq

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Abstract:

Background: The metabolism of many trace elements such as chromium, copper, and manganese were reported to be altered in type 2 diabetes mellitus. This element may have specific roles in the pathogenesis and progress of this disease.

Objectives: To evaluate the serum levels of copper, chromium and manganese in type 2 diabetic patients in Iraq.

Patients and Methods: This case-control study included 100 type 2 diabetic patients, 35-60 years old, with high BMI as the cases and 100 non-diabetic subjects as controls who were healthy volunteers not suffering from type 2 diabetes (staff and student). The data was collected from October 2022 until January 2023. The cases were seen in the Diabetes Consultation Unit / Baghdad Teaching Hospital / Medical City. Serum chromium, copper, and manganese were measured using atomic absorption. ELISA was used to test for insulin. spectrophotometry to measure glucose and HPLC was used to measure whole-blood HbA1c. Insulin resistance was calculated using the semi-empirical formula: $HOMA-IR = \text{glucose} * \text{insulin} / 405$ (glucose in mg/dl). To test for the difference between means of numerical data across several parameters, ANOVA test were utilized. Pearson's correlation was used to test correlation between variables.

Results: Diabetics had higher HbA1c, serum copper (P value<0.01) and blood glucose than healthy controls. Compared to controls, diabetics had lower serum chromium (P value<0.01) and manganese (P value < 0.01). In diabetics, chromium and manganese are highly negatively correlated with insulin resistance. Copper levels increase with increasing insulin resistance. Insulin levels were greater in type 2 diabetics ($18.6 \pm 4.1 \text{mIU/L}$) than the control (6.2 ± 1.3) (p <0.01).

Conclusions: Serum copper was high while serum chromium and manganese were low in type 2 diabetics, which indicates that these elements may have a role in the occurrence and development of type 2 diabetes.

Keywords: chromium, copper, manganese, type 2 diabetes, insulin resistance, BMI, insulin.

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Introduction

Diabetes is a chronic metabolic disorder that affects the metabolism of carbohydrate, fat and protein, due to the deficiency in insulin secretion or a defect in insulin action, or both. Several trace elements have been implicated in the pathogenesis and development of type 2 diabetes. Alteration of specific trace elements may disturb normal glucose metabolism and insulin action, or could cause increased oxidative stress that may contribute to insulin resistance and the development of type 2 diabetes mellitus (1). Essential micronutrients known as trace elements are found in the body in extremely small amounts (2). Chromium was discovered in 1957 and has an effect on insulin and its control, so chromium supplements have an effect on controlling diabetes (3).

It is an essential component that facilitates the elimination of excess glucose from the body. Nicotinic acid, glycine, glutamic acid, cysteine, glutathione, and chromium as an active component) make up the glucose tolerance factor also known as GTF. It affects insulin receptors, increases their sensitivity, and strengthens intracellular signaling, which improves the peripheral action of insulin (4). All living things contain copper. It contributes to the creation of suitable protein conformations and serves as an enzyme cofactor. Because it can result in the generation of free radicals or the disruption of protein structures Too much copper inside the cells is detrimental. Lipid peroxidation, which is intimately connected with diabetes, may be induced by Copper-Superoxide Dismutase (SOD) and hydrogen peroxide (H₂O₂) system (5). Diabetes causes a rise in urine excretion and a fall in serum manganese level. Lack of manganese increases oxidative stress in diabetic individuals, which promotes the emergence of diabetes complications (6). Numerous trace elements function as activators

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or inhibitors in a variety of biological processes, and as a result, they are crucial to many biological processes including the permeability of cell membranes, by interfering with enzymatic activities, by vying with other substances and proteins for binding sites, or by other means (7).

The objective of this study is to explore the role of serum levels of chromium, copper, and manganese in the pathology and development of type 2 diabetes.

Patients and Methods

A case control study on 200 individuals with an age range of 35 to 60 years and a BMI classification of overweight to obese. They were seen in Baghdad Teaching Hospital / Medical City Department, from October 2022 until January 2023. They were 100 diabetic patients and 100 controls. The diabetics were those with Type 2 diabetes mellitus for a period of no longer than ten years. The exclusion criteria were the following: Type 1 diabetes mellitus, those who take dietary supplements, and patients who have type 2 diabetes complications such as nephropathy, retinopathy, or neuropathy. The assessments of the following biochemical parameters was done using serum samples: HPLC technology to measure whole blood HbA1c, the atomic absorption approach to measure trace elements (chromium, copper and manganese), ELISA to quantify insulin hormone, spectrophotometry to measure glucose, and the semi-empirical formula for calculating insulin resistance HOMA-IR (homeostatic model assessment for insulin resistance) = $\text{Glucose} * \text{insulin} / 405$ (glucose in mg/dl). The t-test was used to test the difference between the means of numerical data across many variables.

Results

The means \pm SD of the trace elements, insulin and insulin resistance in the diabetics and their controls. The differences between these mean values appear to be statistically significant ($P < 0.01$), with lower serum chromium and manganese in the cases than the controls. The other three parameters were higher in the cases than the controls, as show in the table 1. In the table 2 shows that the correlation between HOMA-IR and the trace elements in the type 2 diabetic patients. The correlation was negative for chromium and manganese and positive for copper. All correlations were statistically significant. In the figure 1 the correlation of serum chromium and HbA1C show negative correlation, in figure 2 the correlation of serum copper and HbA1C show positive correlation and figure 3 The correlation of serum manganese and HbA1C show negative correlation.

Table 1: The means for trace elements and insulin variables for the two study groups

Parameter	Type 2 D.M Mean \pm SD	Control Mean \pm SD	p-value
Serum Cr ³⁺	0.1 \pm 0.01	0.3 \pm 0.04	<0.01
Serum Mn ²⁺	6.8 \pm 1.9	11.3 \pm 3.2	<0.01
Serum Cu ²⁺	160.6 \pm 6.4	100.5 \pm 5.05	<0.01
Insulin	18.6 \pm 4.1	6.2 \pm 1.3	<0.01
HOMA-IR	6.5 \pm 1.5	1.4 \pm 0.35	<0.01
HbA1c	7.8 \pm 1.1	5.03 \pm 0.74	<0.001

Table 2: the correlation between the levels of trace elements and insulin resistance within two groups

Parameter	Mean \pm SD	p-value		
Serum Cr ³⁺	0.12 \pm 0.01	<0.01	Significant	Negative correlation
HOMA-IR	6.25 \pm 1.5			
Serum Mn ²⁺	6.8 \pm 1.9	<0.01	Significant	Negative correlation
HOMA-IR	6.25 \pm 1.5			
Serum Cu ²⁺	146.3 \pm 14.9	<0.01	Significant	Positive correlation
HOMA-IR	6.25 \pm 1.5			

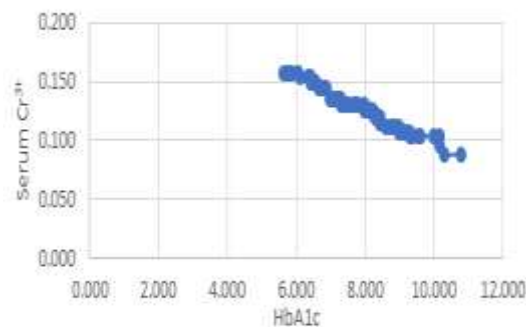


Figure 1: The correlation of serum chromium and HbA1C

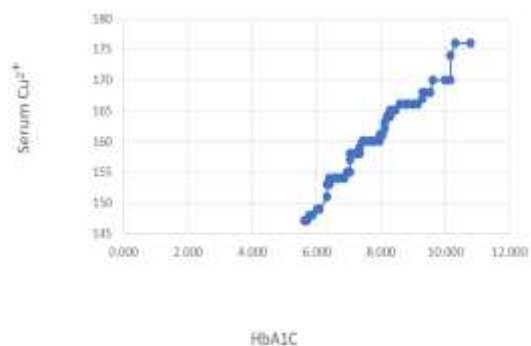


Figure 2: The correlation of serum copper and HbA1C

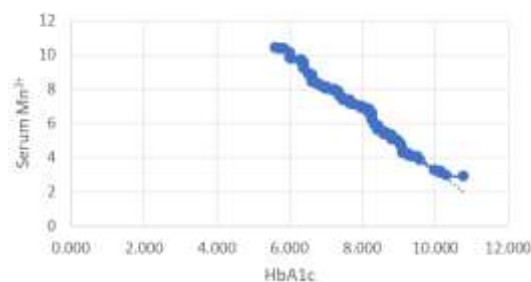


Figure 3: The correlation of serum manganese and HbA1C

Discussion

Diabetes mellitus is intricate and multifaceted. Diabetes-related metabolic dysregulations lead to secondary pathophysiologic alterations in a number of organ systems, which place a significant load on morbidity and death from macrovascular and microvascular consequences (8). The significant decrease in the level of chromium in diabetics in comparison to that of normal subjects were observed in other researches (9). One possible explanation for these findings of the trivalent chromium properties are by overcoming insulin resistance, delaying the onset of diabetes mellitus, inhibiting the production of free radicals, because of low chromium appeared insulin resistance and hyper glycemetic state (10). The important functions of Cr^{3+} are to bind to the insulin receptor beta subunit, which has already been activated by the hormone. This causes the receptor tyrosine kinase to become active and amplifies the insulin signal. As a result, the glucose transporter protein GLUT4 (glucose transporter 4) is co-localized to the cell membrane upon activation of the intracellular insulin signal transduction pathway. The primary glucose transporter, GLUT4, mediates glucose transfer across the cell membrane (11). The rise in serum Cu^{2+} that was seen is consistent with type 2 DM results made earlier (12). Important trace element, Cu^{2+} , is needed for many biological processes. It was an essential component of many metalloenzymes and is necessary to the redox process. (13). Epidemiology studies also shown an association between blood copper levels and the prevalence of type 2 diabetes. This might be the case because copper could regularly create an active site and increase oxidative stress, which supports in the development of diabetes (14). A significant and high negative correlation in serum manganese for patient with type 2 diabetes. Low manganese can lead to impaired glucose metabolism (15). Furthermore, manganese is necessary for producing and secreting insulin normally; a change in its metabolism has been linked to the development of diabetes (16). This study agrees with study and compared to their control subject; type 2 diabetic individuals had lower levels of manganese (15).

Conclusion

The current study shows lower serum levels of chromium and manganese and a higher serum level of copper in type 2 diabetics than controls. Serum chromium and manganese levels were negatively correlated with HOMA-IR, while serum copper level was positively related with HOMA-IR.

Authors' Contributions:

Ahmed Zaid Khamees: MSc student
Dr. Hedef Dh. Al-Yassin: Supervisor

Authors' Declarations:

The authors have signed an ethical considerations approval. The project was approved by the local ethical committee of the Iraqi Ministry of Health, the Medical City Consultative Unit / Baghdad Teaching Hospital, Code number (ISU.47237.9.11.22).

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دراسة المتغيرات من العناصر النادرة المختارة في عينة من المرضى العراقيين المصابين بداء السكري من النوع الثاني

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الخلاصة:

الخلفية: التغيير في التمثيل الغذائي للعديد من العناصر النزرة مثل الكروم والنحاس والمنغنيز في مرض السكري من النوع 2. قد يكون لهذا العنصر أدوار محددة في التسبب في هذا المرض وتطوره.

الهدف: لتقييم مستويات النحاس والكروم والمنغنيز في الدم لدى مرضى السكري من النوع الثاني في العراق.

المنهجية: تضمنت دراسة الحالة والشواهد 100 مريض بالسكري من النوع 2، تتراوح أعمارهم بين 35-60 عامًا، مع مؤشر كتلة جسم مرتفع و 100 شخص غير مصاب بمرض السكري كعناصر تحكم، تم اختيارهم عشوائيًا من أكتوبر 2022 حتى يناير 2023 في وحدة استشارة خبراء مرض السكري في مستشفى بغداد التعليمي / مدينة الطب. تم قياس مصل الكروم والنحاس والمنغنيز باستخدام الامتصاص الذري. تم استخدام إليسا إليسا لتحليل اختبار الأنسولين. مقياس الطيف الضوئي لقياس الجلوكوز. و HPLC تم استخدامه لقياس نسبة HbA1c في الدم الكامل. تم حساب مقاومة الأنسولين باستخدام الصيغة شبة التجريبية = HOMA-IR: الجلوكوز * الأنسولين / 405 (الجلوكوز في مجم / ديسيلتر). لتحليل اختبار الفرق بين وسائل البيانات الرقمية عبر العديد من المعلمات ، تم استخدام دراسة الحالة والشواهد واختبار ANOVA. تم استخدام ارتباط بيرسون المترابط لاختبار الارتباط بين المتغيرات.

النتائج: كان لدى مرضى السكر نسبة سكر تراكمي ومصل النحاس عالي (الأحتمالية أقل من 0.01) مقارنة بالضوابط الصحية وكان لدى مرضى السكر انخفاض في قيمة الكروم والمنغنيز (الأحتمالية أقل من 0.01). ترتبط الكروم والمنغنيز بشكل سلبي للغاية بمقاومة الأنسولين. تزداد مستويات النحاس مع زيادة مقاومة الأنسولين. كانت مستويات الأنسولين أكبر في مرضى السكري (18.6 ± 4.1 ملل / لتر) من مجموعة التحكم (6.2 ± 1.3). الاحتمالية أقل من 0.01).

الاستنتاجات: كان لمستويات الكروم والمنغنيز في المصل في الدراسة الحالية علاقة سلبية مع الجلوكوز في مرضى السكر. في مرضى السكر، كانت هناك علاقة إيجابية بين النحاس والجلوكوز في الدم. قد تكون هذه الأشياء التي تقلل من حساسية الأنسولين. ومع ذلك، هناك حاجة إلى مزيد من البحث للتأكد من الوظيفة الجزئية للكروم والمنغنيز والنحاس في ظهور مشاكل السكري.

الكلمات المفتاحية: داء السكر النوع الثاني، الأنسولين، مقاومة الأنسولين، النحاس، الكروم، المنغنيز، مؤشر كتلة الجسم