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Research Article

The Relationship between Serum Zinc and Glycemic Control among Type 2 Diabetic Patients in Khartoum State, Sudan

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Abstract

Background: Previous studies suggest a significant relationship between type 2 diabetes mellitus (T2DM) and a lack of zinc. A lack of zinc can negatively impact insulin synthesis, storage, and secretion, leading to insulin resistance and inadequate glycemic control. Nevertheless, the correlation between serum zinc levels and glycemic control in T2DM has not been well studied in various populations.

Objective: To investigate the relationship between serum zinc levels and glycemic control, assessed by HbA1c, in individuals diagnosed with type 2 diabetes mellitus.

Methods: This case-control study was carried out between April 2018 and July 2019 at Omdurman Teaching Hospital in Khartoum State/ Sudan. The study included 100 participants: 50 were T2DM patients, and the other 50 were healthy individuals who served as controls. Serum zinc levels were determined with atomic absorption spectrophotometry, while HbA1c levels were evaluated with the Ichroma system. A comparative analysis was conducted on the groups, with correlation coefficients being calculated to investigate the correlations between age, serum zinc, and HbA1c levels.

Results: The diabetics showed notably lower zinc levels in their blood compared to the control group, along with notably elevated HbA1c levels. In diabetic individuals, age correlated positively with HbA1c and serum zinc levels. Additionally, diabetic patients showed a significant inverse correlation between their serum zinc levels and HbA1c values (r=-0.82, p=0.000).

Conclusion: This research indicated that individuals with diabetes might exhibit decreased zinc levels in their bloodstream and that a connection could exist between age, zinc levels in the bloodstream, and HbA1c levels in these individuals. The results of this research may impact how diabetes mellitus and zinc deficiency are managed.

Keywords: Glycemic control; HbA1c; Serum Zinc levels; Type 2 Diabetes; Zinc deficiency.

Introduction

Diabetes mellitus (DM) is the most common hormonal disorder and a quickly advancing condition, identified by high levels of blood sugar (1). Type 2 diabetes mellitus (T2DM), which impacts millions of individuals globally every year, is the most prevalent form of diabetes (2). Based on information in the fifth edition of the Diabetes Atlas by the International Diabetes Federation, the projected rise in diabetes cases is from 366 million in 2011 to 552 million by 2030 (3). Zinc is acknowledged to be vital in the process of making, storing, and releasing insulin in response to carbohydrate consumption, as well as crucial for energy generation. It also helps maintain the structural integrity of insulin (4). Lowered blood zinc levels impact the pancreatic islets' capacity to generate and release insulin, potentially resulting in insulin resistance, a major factor in the development of T2DM (5). HbA1c% is a measure that gives an overall indication of glucose regulation in the blood.

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Measuring HbA1C% is a reliable way to detect long-term high blood sugar levels and assess the potential for diabetes-related issues (6). Chronic hyperglycemia in diabetic patients leads to increased oxidative stress by producing oxidants and weakening the antioxidant defense system. This results in oxidative damage to cells, leading to cell dysfunction. Zinc (Zn) is a crucial micronutrient that functions as an antioxidant and decreases oxidative pressure in the human body. Deficiency of zinc is linked to several chronic illnesses like T2DM (7).

There is no definite cause-and-effect connection between Zn deficiency and DM. Diabetes mellitus can lead to lower zinc levels in the body through a combination of increased secretion and decreased absorption from the intestine or excretion from the kidneys (8). Zinc deficiency is present in some T2DM patients but is not linked to diabetes management (9). A slightly decreased risk of T2DM may be linked to a higher intake of zinc (10). Giving diabetic patients zinc orally enhances wound healing and indicates potential diabetic complications.

The goal of the current research was to examine the relationship between serum zinc levels and glycemic control in patients with T2DM in Khartoum State, Sudan.

Cases and Methods

Study Population: This study, conducted at Omdurman Teaching Hospital in Khartoum State between April 2018 and July 2019, investigated the relationship between serum zinc levels and HbA1c levels in patients with T2DM. A total of 100 participants were included: 50 individuals with T2DM comprised the case group, while 50 healthy individuals served as the control group.

Criteria for selection: Participants in the case group must have newly diagnosed T2DM to meet the inclusion criteria, and should not be taking zinc supplements or medications that impact zinc absorption. Having chronic illnesses, being pregnant, having diabetic complications, or using oral hypoglycemic agents or insulin, is meeting the exclusion criteria.

Data collection and blood sampling: A data collection form was utilized to gather the data. Each participant provided three milliliters of venous blood, which was then spun at 4000 revolutions per minute for 5 minutes to separate the serum. The serum samples were frozen at -20°C until serum zinc analysis using the atomic absorption spectrophotometer method. An additional three milliliters of venous blood were obtained in EDTA tubes and utilized for HbA1c measurement using the Ichroma technique.

Statistical analysis:

The data were analyzed using SPSS software version 25. The mean values of serum zinc and HbA1c were compared between the two groups using Student's t-test. A regression analysis was conducted in the case group to evaluate the relationship between serum zinc and HbA1c levels.

Results

The study participants were 41 - 60 years old. The mean age for the case group was 60.5 ± 8.50 years, compared to 50.7 ± 8.80 years for the control group. The mean values of HbA1c and serum zinc among the cases were 13.3 ± 1.30% and 0.2 ± 0.12 mg/L, respectively. As for the controls these means were 4.5 ± 0.35% and 0.6 ± 0.08 mg/L, respectively. Diabetic patients had a significantly higher HbA1c level compared to the control group (p-value = 0.000). Serum zinc levels were significantly lower among diabetic patients than the control group (p-value = 0.000), Table 1. There were 16% males and 34% females among the cases compared to 28% males and 22% females among the controls (Figure 1). The diabetic individuals had an illness duration ranging from 6 - 12 years, with a mean of 8.86 ± 1.565 years In diabetic patients, the mean values of HbA1c and serum zinc levels were 13.5 ± 1.31% and 0.2 ± 0.09 mg/L respectively in males, and 13.2 ± 1.40% and 0.2 ± 0.13 mg/L respectively in females (P value > 0.05). The mean HbA1c and serum zinc in the control group was 4.2 ± 0.36% and 0.6 ± 0.07 mg/L respectively in males, and 4.4 ± 0.32% and 0.6 ± 0.09 mg/L respectively in females ($p > 0.05$), Table 2.

A strong correlation between age and HbA1c levels and a significant correlation between age and serum zinc levels among diabetic patients was found. No correlation was found between the duration of the illness and HbA1c (r = 0.19, p = 0.17) (Figure 4) or serum zinc levels (r = 0.06, p = 0.64)

Table 1: Mean±SD of age, HbA1c% and serum zinc among the study groups

Variables	Cases (n=50)	Controls (n=50)	P value
Age (years)	60.5 ± 8.5	50.7 ± 8.8	0.000
HbA1c%	13.3 ± 1.3	4.5 ± 0.35	0.000
Zinc (mg/L)	0.2 ± 0.12	0.6 ±0.08	0.000

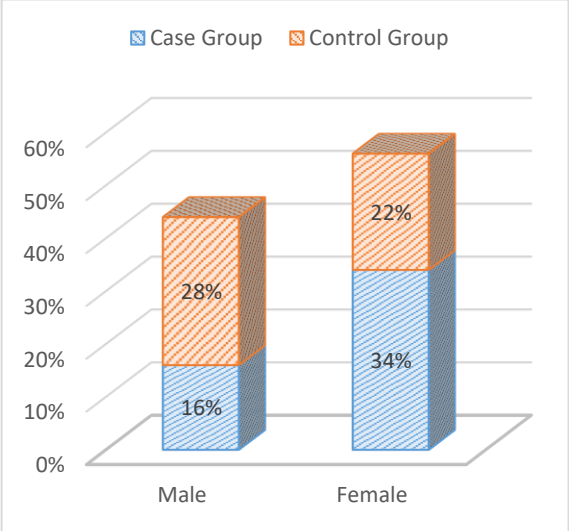

Figure 1: Distribution of the study groups by gender

Table 2: Mean ± SD of HbA1c and serum zinc according to gender

Variables	Case Group		*P* value	Control Group		*P value*
	Male (n=16)	Female (n=34)		Male (n=28)	Female (n=22)	
HbA1c %	13.5 ± 1.31	13.2 ± 1.4	0.57	4.2 ± 0.36	4.4 ± 0.32	0.26
Zinc (mg/L)	0.2 ± 0.09	0.2 ± 0.13	0.30	0.6 ±0.07	0.6 ± 0.09	0.87

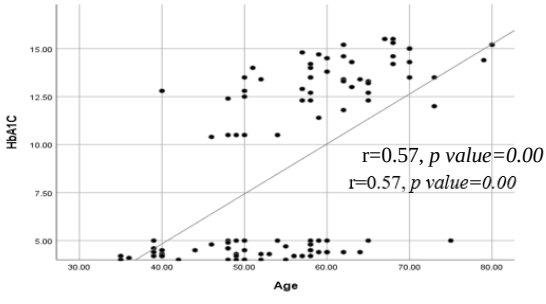

Figure 2: Correlation between age and HbA1c among diabetic patients

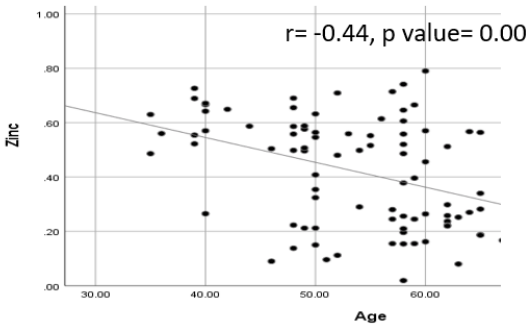

Figure 3: Correlation between age and serum zinc among the diabetic patients

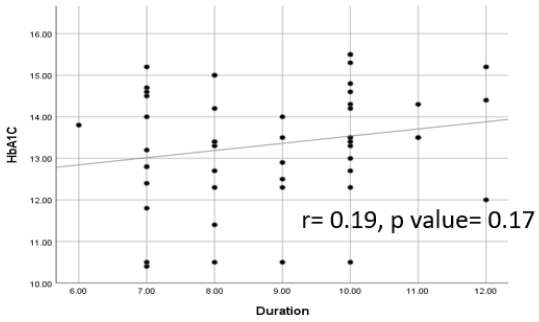

Figure 4: Correlation between duration of disease and HbA1c% among the diabetics

Discussion

An analytical case-control hospital-based study was undertaken among outpatients at Omdurman Teaching Hospital in Khartoum state. The finding of the current study of low serum zinc levels in the diabetic group when compared to the healthy group is comparable to the findings of Abbas *et al*., who found reduced zinc levels (12). Our findings further support those of Farooq *et al*., study that low zinc levels were related to T2DM, and that serum zinc levels were inversely associated with poor glycemic control (5). These results were consistent with those of the current study. These findings were comparable to those reported by Saharia and Goswami (13), and also consistent with those of Omidian *et al*. (14) and Masood *et al*. (15), in which serum zinc levels were considerably lower in the diabetes group. Al-Maroof *et al*. also found that diabetics had considerably lower serum zinc levels than controls (16). Singh *et al*. indicated that low zinc levels in diabetics were caused by poor gastrointestinal absorption and increased urine excretion (17). According to research conducted by Zargar *et al*., diabetic and control subjects showed comparable zinc levels (18). On the other hand, research conducted by Mumza *et al*. found elevated zinc levels in individuals with diabetes (19). Osman *et al*. also found that a high level of zinc was linked to T2DM (9). Zinc is essential for the production, retention, and release of insulin. Nonetheless, the impact on insulin release is characterized by a two-phase trend, where inadequate or excessive zinc concentrations can hinder insulin effectiveness. Zinc plays a role in the creation of insulin crystals within pancreatic beta cells and assists in insulin stabilization and release. Excessive zinc levels can cause oxidative stress and harm beta cells, but inadequate levels can lead to insufficient insulin storage and secretion. Thus, it is essential to keep zinc levels balanced for proper glucose regulation in the body. According to our research backed by Farooq, *et al*., diabetics exhibit lower zinc levels compared to non-diabetics, and inadequate glycemic control is linked to reduced zinc levels (6).

Farooq, *et al*., found no significant difference in zinc levels based on the patient's age, in contrast to the study by Naila *et al*., which found no gender-based difference in zinc levels, in line with previous research by Saharia and Goswami.

The current research showed a significant inverse correlation between serum zinc levels and HbA1c in diabetic individuals. Saharia and Goswami also found a negative correlation between HbA1c and zinc levels (r = - 0.804) (13). The study showed comparable findings to Tripathy *et al*., indicating a noteworthy inverse correlation between serum zinc and HbA1C% (r = -0.408). Farooq *et al*. (5) also provided backing for these findings. The results of this study align with Al-Maroof *et al*.'s findings, demonstrating a notable inverse correlation between serum zinc levels and HbA1c% in diabetic patients (16).

The reason for lower zinc levels in diabetic patients might be caused by higher excretion through the urine due to decreased kidney function linked to the disease, poor absorption in the gastrointestinal tract, genetic influences, or the body using zinc as a defense mechanism in response to infection. Concurrent low zinc levels and reduced zinc stores in the tissue are present. Nevertheless, a disrupted zinc metabolism has been proposed to be involved in the development of diabetes and its related issues (6). Based on the information provided, it can be inferred that there is a notable decrease in serum zinc levels in individuals with T2DM. It remains uncertain whether the impact of diabetes and high blood sugar on zinc metabolism precedes the alterations in zinc balance affecting carbohydrates. It has been demonstrated that high blood sugar levels can hinder the movement of zinc back into kidney cells, leading to higher levels of zinc being excreted in the urine. Furthermore, zinc has been found to improve insulin sensitivity by enhancing insulin's ability to bind to its receptors (14).

The limited sample size in the current study may affect the generalizability of the results. The study only measured serum zinc levels and did not consider urinary zinc levels, which may have provided additional insights into zinc metabolism and excretion in T2DM patients. Relying only on serum levels to determine zinc deficiency can be deceptive, as it overlooks the influence of glycemic control (HbA1c) on zinc metabolism.

Conclusion

This research indicates that individuals with diabetes might exhibit decreased zinc levels in their bloodstream and that a connection could exist between age, zinc levels in the bloodstream, and HbA1c levels in these individuals. The results of this

research may impact how diabetes mellitus and zinc deficiency are managed.

Authors' declaration:
We confirm that all the Figures and Tables in the manuscript belong to the current study. Besides, the Figures and images, which do not belong to the current study, have been given permission for re-publication attached to the manuscript. Authors sign on ethical considerations' Approval-Ethical Clearance: The project was approved by the local ethical committee in (Al Neelain University's Faculty of Medical Laboratory Science) according to the code number (n1115) on (Jan. 2018).

Conflict of Interest: None

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Authors contribution
Study conception & design: (GadAllah O. Modawe, Rimaz A. Gurashi, and Shereen F. Hamad). Literature search: (Suzan A. Rahmtalla). Data acquisition: (Suzan A. Rahmtalla). Data analysis & interpretation: (Abdelmula M. Abdalla). Manuscript preparation: (Abdelmula M. Abdalla). Manuscript editing & review: (Abdelmula M. Abdalla).

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العلاقة بين الزنك في المصل والسيطرة على نسبة السكر في الدم بين مرضى السكري من النوع الثاني في ولاية الخرطوم، السودان

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الخلاصة

الخلفية: تشير الدراسات السابقة إلى وجود علاقة كبيرة بين داء السكري من النوع الثاني ونقص الزنك. يمكن أن يؤثر نقص الزنك سلبًا على تخليق الأنسولين وتخزينه وإفرازه، مما يؤدي إلى مقاومة الأنسولين وعدم كفاية التحكم في سكر الدم. ومع ذلك، لم تتم دراسة العلاقة بين مستويات الزنك في المصل والتحكم في سكر الدم في داء السكري من النوع الثاني بشكل جيد في السكان المختلفين.

الهدف: التحقيق في العلاقة بين مستويات الزنك في المصل والتحكم في سكر الدم، الذي يتم تقييمه بواسطة تراكيز الهيموجلوبين السكري (HbA1c)، لدى الأفراد الذين تم تشخيصهم بداء السكري من النوع الثاني.

المنهجية: تم تنفيذ هذه الدراسة المقارنة بين أبريل 2018 ويوليو 2019 في مستشفى أم درمان التعليمي في ولاية الخرطوم/ السودان. شملت الدراسة 100 مشاركا: 50 منهم مرضى سكر من النوع الثاني والـ 50 الآخرين كانوا أفرادًا أصحاء كمجموعة ضابطة. تم تحديد مستويات الزنك في المصل باستخدام التحليل الطيفي لامتصاص الذرات، بينما تم تقييم مستويات الهيموجلوبين السكري (HbA1c)، باستخدام نظام آي-كروما للتحليل المناعي. تم إجراء تحليل البيانات باستخدام الحزمة الإحصائية للعلوم الاجتماعية - النسخة 25. أجري تحليل مقارن بين المجموعات، وتم حساب معاملات الارتباط للتحقق من العلاقات بين العمر، ومستويات الزنك في المصل، والهيموجلوبين السكري (HbA1c).

النتائج : ظهرت مجموعة المرضى المصابين بالسكري من النوع الثاني مستويات زنك أقل بشكل ملحوظ في دمائهم مقارنة بمجموعة الضبط كما أن مستويات الهيموجلوبين السكري (HbA1c)، مرتفعة بشكل ملحوظ. في الأفراد المصابين بالسكري، ارتبط العمر إيجابيًا مع الهيموجلوبين السكري (HbA1c)، (r=0.57, p=0.000), ومستويات الزنك في المصل (r=0.44, p=0.000)، بالإضافة إلى ذلك، أظهرت مجموعة مرضى السكري ارتباطًا عكسيًا كبيرًا بين مستويات الزنك في المصل وقيم الهيموجلوبين السكري (HbA1c)، (r=-0.82, p=0.000).

الإستنتاج: تشير هذه الدراسة إلى أن الأفراد المصابين بالسكري قد يظهرون انخفاضًا في مستويات الزنك في مجرى الدم وأنه يمكن أن يكون هناك ارتباط بين العمر، ومستويات الزنك في مجرى الدم، ومستويات الهيموجلوبين السكري (HbA1c)، لدى هؤلاء الأفراد. قد تؤثر نتائج هذه الدراسة على كيفية إدارة داء السكري من النوع الثاني ونقص الزنك.

الكلمات المفتاحية: التحكم في السكر بالدم، الهيموجلوبين السكري (HbA1c)، مستويات الزنك في المصل، مرض السكري من النوع الثاني، نقص الزنك