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EXPLORING THE RELATIONSHIP BETWEEN SERUM COPPER, MAGNESIUM, AND GLYCATED HEMOGLOBIN LEVELS IN INDIVIDUALS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by high blood glucose levels. Various factors, including mineral imbalances, have been implicated in the pathogenesis of T2DM. **Objectives:** to investigate the relationship between serum copper, magnesium, and glycated hemoglobin (HbA1c) levels in individuals with T2DM.**Methods:** A cross-sectional study was conducted on 150 patients diagnosed with T2DM. Serum copper and magnesium levels were measured using atomic absorption spectrophotometry, while HbA1c levels were determined using high-performance liquid chromatography. Statistical analysis was performed to assess the association between serum copper, magnesium, and HbA1c levels, considering potential confounding variables.**Results:** The mean serum copper level was found to be significantly higher in individuals with T2DM compared to the control group ($p < 0.001$). In contrast, the mean serum magnesium level was significantly lower in the T2DM group ($p < 0.001$). Furthermore, HbA1c levels were significantly elevated in individuals with T2DM ($p < 0.001$). Pearson's correlation analysis revealed a positive correlation between serum copper and HbA1c levels ($r = 0.387$, $p < 0.001$), while serum magnesium showed a negative correlation with HbA1c levels ($r = -0.298$, $p < 0.001$). Multiple regression analysis confirmed these associations after adjusting for potential confounders.**Conclusion:** Our findings suggest that altered serum copper and magnesium levels are associated with glycemic control in individuals with T2DM. Further

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research is warranted to explore the underlying mechanisms and potential therapeutic implications of these mineral imbalances in T2DM management.

Keywords: Type 2 diabetes mellitus, serum copper, serum magnesium, glycated hemoglobin, mineral imbalances

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and impaired glucose regulation. It is a significant global health concern, with a rising prevalence worldwide (International Diabetes Federation, 2019). The pathogenesis of T2DM involves multifactorial interactions, including genetic predisposition, lifestyle factors, and metabolic abnormalities.

Recent studies have highlighted the potential role of mineral imbalances in the development and progression of T2DM (Kazi TG et al[1]., Arpaci D et al[2].,). Copper and magnesium, in particular, have gained attention due to their involvement in glucose metabolism and insulin signaling pathways (Sun et al., Wintergerst ES et al.,). Copper plays a crucial role as a cofactor for enzymes involved in glucose homeostasis, while magnesium influences insulin secretion and action (Jeukendrup AE et al[4]; Barbagallo et al[3].,).

Glycated hemoglobin (HbA1c) is a widely used clinical marker for assessing long-term glycemic control in individuals with diabetes[7]. Elevated HbA1c levels indicate poor glycemic control and have been associated with an increased risk of diabetes-related complications (Nathan et al[6].,). Understanding the relationship between mineral imbalances, particularly serum copper and magnesium, and HbA1c levels could provide insights into the pathophysiology of T2DM and potentially identify novel therapeutic targets.

MATERIALS AND METHODS

Study Design and Participants :A cross-sectional study was conducted on 150 individuals diagnosed with T2DM attending the Diabetes Clinic at government general hospital,suryapet. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Data Collection: Demographic and clinical data were collected using structured questionnaires and medical records. Anthropometric measurements including height, weight, and body mass index (BMI) were recorded. Fasting blood samples were collected to measure serum copper, serum magnesium, and HbA1c levels.

Laboratory Analysis: Serum copper and magnesium levels were measured using atomic absorption spectrophotometry. HbA1c levels were determined using high-performance liquid chromatography.

Statistical Analysis: Statistical analysis was performed using SPSS software. Descriptive statistics were calculated for demographic and clinical variables. Independent sample t-tests or Mann-Whitney U tests were used to compare continuous variables between groups, depending on the data distribution. Pearson's correlation analysis was conducted to assess the relationship between serum copper, magnesium, and HbA1c levels. Multiple regression

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analysis was performed to examine the independent associations after adjusting for potential confounding factors.

RESULTS :

Table 1 presents the comparison of serum copper, magnesium, and HbA1c levels between individuals with Type 2 Diabetes Mellitus (T2DM) and the control group. In the T2DM group (n=150), the mean serum copper level was 120.3 ± 15.6 μg/dL, significantly higher than the control group (n=150) mean of 98.7 ± 12.4 μg/dL ($p < 0.001$). Conversely, the T2DM group had a lower mean serum magnesium level of 1.8 ± 0.3 mg/dL compared to the control group mean of 2.3 ± 0.4 mg/dL ($p < 0.001$). HbA1c levels, reflecting long-term glycemic control, were significantly elevated in the T2DM group (8.5 ± 1.2%) compared to the control group (5.2 ± 0.7%) ($p < 0.001$).

Table 2 shows the results of Pearson's correlation analysis between serum copper, magnesium, and HbA1c levels in individuals with T2DM. Serum copper exhibited a positive correlation with HbA1c levels ($r = 0.387$, $p < 0.001$), indicating that higher serum copper levels were associated with elevated HbA1c values. In contrast, serum magnesium showed a negative correlation with HbA1c levels ($r = -0.298$, $p < 0.001$), indicating that lower serum magnesium levels were associated with higher HbA1c values. These correlations were statistically significant.

These findings suggest that individuals with T2DM have elevated serum copper levels, decreased serum magnesium levels, and elevated HbA1c levels compared to the control group. The positive correlation between serum copper and HbA1c levels, as well as the negative correlation between serum magnesium and HbA1c levels, further support the associations between these mineral imbalances and glycemic control in T2DM.

DISCUSSION:

The present study aimed to explore the relationship between serum copper, magnesium, and HbA1c levels in individuals with Type 2 Diabetes Mellitus (T2DM). Our findings revealed significant differences in serum copper, serum magnesium, and HbA1c levels between individuals with T2DM and the control group, indicating potential mineral imbalances in T2DM.

The elevated serum copper levels observed in individuals with T2DM are consistent with previous studies (Kazi TG et al[1].,; Arpaci D et al[2].,), suggesting a potential role for copper in glycemic control. Copper serves as a cofactor for enzymes involved in glucose homeostasis and insulin metabolism[8]. Alterations in copper levels may impact insulin secretion and action, potentially contributing to the dysregulation of glucose metabolism observed in T2DM (Jeukendrup AE et al[4]). However, further research is needed to elucidate the underlying mechanisms and the specific implications of elevated copper levels in T2DM pathophysiology[9,10].

In contrast, our study revealed lower serum magnesium levels in individuals with T2DM compared to the control group, which is in line with previous research (Kazi TG et al[1].,; Arpaci D et al[2].,). Magnesium plays a crucial role in insulin signaling, facilitating insulin secretion, glucose uptake, and insulin sensitivity. Insufficient magnesium levels have been

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associated with insulin resistance and impaired glucose metabolism (Barbagallo et al[3].,). The negative correlation between serum magnesium and HbA1c levels further supports the notion that lower magnesium levels are associated with poorer glycemic control in T2DM. This highlights the importance of assessing magnesium status in individuals with T2DM and considering its potential role in diabetes management.[11]

The observed correlations between serum copper, serum magnesium, and HbA1c levels further underscore the potential influence of these mineral imbalances on glycemic control. The positive correlation between serum copper and HbA1c levels suggests that higher copper levels may be associated with elevated HbA1c levels, reflecting poorer long-term glycemic control. On the other hand, the negative correlation between serum magnesium and HbA1c levels indicates that lower magnesium levels may contribute to higher HbA1c values, indicating suboptimal glycemic control. These correlations support the idea that copper and magnesium play distinct roles in glucose metabolism and glycemic regulation in T2DM.[12,13]

Monitoring serum copper and magnesium levels in individuals with T2DM could provide valuable insights for diabetes management. Assessing and optimizing these mineral levels, along with traditional glycemic control measures, may help improve overall glycemic management and reduce the risk of diabetes-related complications. However, further research is needed to establish the causality and underlying mechanisms behind these associations and to explore the potential therapeutic implications of targeting copper and magnesium imbalances in T2DM management.

CONCLUSION: this study provides evidence for altered serum copper and magnesium levels in individuals with T2DM. The positive correlation between serum copper and HbA1c levels, as well as the negative correlation between serum magnesium and HbA1c levels, suggest potential implications for glycemic control in T2DM. Further research is needed to elucidate the underlying mechanisms and evaluate the therapeutic potential of addressing these mineral imbalances in T2DM management.

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Table 1: Comparison of Serum Copper, Magnesium, and HbA1c Levels in Individuals with Type 2 Diabetes Mellitus and Control Group

Parameters	**Type 2 Diabetes Mellitus (n=150)**	**Control Group (n=150)**
Serum Copper (μg/dL)	120.3 ± 15.6	98.7 ± 12.4
Serum Magnesium (mg/dL)	1.8 ± 0.3	2.3 ± 0.4

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Parameters	Type 2 Diabetes Mellitus (n=150)	Control Group (n=150)
HbA1c (%)	8.5 ± 1.2	5.2 ± 0.7

Note: Values are presented as mean ± standard deviation (SD).

Table 2: Pearson's Correlation Analysis between Serum Copper, Magnesium, and HbA1c Levels in Individuals with Type 2 Diabetes Mellitus

Parameters	Serum Copper	Serum Magnesium	HbA1c
Serum Copper	1.000	-0.298*	0.387**
Serum Magnesium	-0.298*	1.000	-0.187
HbA1c	0.387**	-0.187	1.000

Note: *p < 0.001, **p < 0.05 (significant correlations)