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Original Research Article

Status of serum magnesium and calcium in type 2 diabetes mellitus patients

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by persistently elevated blood sugar levels, resulting from inadequate insulin secretion, ineffective insulin action or both. Several studies have revealed association of hypomagnesaemia with poor glycemic control and various long-term complications of diabetes mellitus. Cohort studies have been found to be associated with higher serum Calcium levels with an increased risk of T2DM. Therefore, we aim to assess serum Mg and Ca status in Type 2 diabetes mellitus patients.
Methods: We conducted a case-control study with normal healthy population and T2DM patients visiting the OPD of Medicine. Normal healthy population and T2DM patients aged between 40 to 70 years of either sex were recruited and biochemical analysis was done.
Results: Total 80 participants (40 control and 40 T2DM patients) were recruited for the study. The mean age of the normal healthy population and T2DM patients was 53.07±10.79 and 55.72±9.86 years respectively. Non-significant change in BMI was observed in T2DM patients (26.49±4.35) as compared to normal healthy control (25.77±3.72). Significant increase ($p<0.001$) in fasting blood glucose and HbA1c was recorded in T2DM patients (222.55±75.63, 8.28±2.43 resp.) as compared to normal healthy control (92.33±8.53, 5.19±0.72 resp.). We observed non-significant decrease in serum Mg level and serum Ca level in T2DM patients (2.05±0.45, 8.68±0.76 resp.) as compared to normal healthy control (2.11±0.23, 8.99±0.77 resp), while Mg/Ca ratio was found unchanged in T2DM patients as compared to normal healthy control.
Conclusions: The study reveals a non-significant decrease in serum Mg and Ca in T2DM patients as compared to normal healthy population.

Keywords: Calcium, Magnesium, Mg/Ca ratio, Type 2 diabetes mellitus

INTRODUCTION

T2DM is a metabolic disorder characterized by persistently elevated blood sugar levels, resulting from inadequate insulin secretion, ineffective insulin action or both.[1] This chronic non-communicable disease (NCD) has become a global epidemic. In 2015, more than 415 million adults were living with diabetes and estimates indicate this number could grow to 642 million by 2040. T2DM) causes significant health problems through damage to small and large blood vessels, affecting the eyes, kidneys, nerves,

heart and major arteries. Several recent reports suggest that magnesium deficiency may contribute to pathological disorders characterized by chronic inflammatory stress, such as cardiovascular disease, metabolic syndrome and diabetes.[2] Despite being the second most abundant intracellular cation after potassium, magnesium (Mg) is a mineral whose scientific significance has been underestimated. This vital mineral plays a key role in many metabolic reactions and, because the body cannot synthesize it, requires constant dietary intake. Notably, Mg acts as a cofactor for enzymes involved in glucose metabolism.[3,4] Magnesium has an essential role in glucose homeostasis. It also facilitates the glucose transportation across the cell membrane and for various enzymes in carbohydrate oxidation.[5]

Hypomagnesaemia has been documented to be frequently associated with diabetes mellitus with prevalence 25-39%. Strong association of hypomagnesaemia with poor glycemic control and complications of diabetes mellitus have been reported. Studies have shown significant decrease in serum magnesium levels in T2DM patients.[6,7] Hypomagnesemia has been found to be associated with increased incidence of retinopathy, nephropathy and foot ulcers.[8] Another study demonstrated that low magnesium levels may exacerbate metabolic abnormalities and depression.[9] Routine monitoring and correcting serum Mg levels in type 2 diabetes patients may help in better control of HbA1c and delaying progression to retinopathy and nephropathy.[10] Calcium, the most abundant mineral in the human body, regulates the voltage-dependent channels required for insulin release in pancreatic cells.[11] Calcium is an essential mineral with multiple functions such as muscle contraction, myocardial contractility, cardiac activity, neurotransmitter release, platelet adhesion, blood clotting and bone and tooth structure.[12]

A study conducted in US adults revealed that consuming the calcium below the recommended dietary allowance (RDA) experienced a higher risk of T2DM in general population.[13] Calcium supplementation (1500 mg/day) for eight-weeks was capable of improving the insulin sensitivity in T2DM patients.[14] Ca and Mg have opposing effects i.e., Mg acts as a Ca antagonist and can compete with Ca for protein and Ca transporter binding sites. An imbalance of Ca and Mg in the blood may result in several clinical complications, including MetS, diabetes, hypertension and CAD. Furthermore, it is essential to maintain serum Ca and Mg levels within appropriate ranges, although these ranges for serum Ca/Mg ratios remain clinically uncertain. Serum Mg/Ca ratios may be more characteristic of homoeostasis than measurements of serum Mg.[15] In present study, we aim to assess serum Mg and Ca levels in T2DM patients.

METHODS

Study design and place

Present study is a case-control study.

Study place

Study was conducted in the department of Biochemistry in collaboration with department of Medicine, at Era's Lucknow Medical College and Hospital, Lucknow.

Prior approval from Institutional ethics committee was taken for the study (ELMC&H/R Cell/2025/522).

Study period

Study was conducted during October 2024 to May 2025.

Subject recruitment

40 type 2 diabetes mellitus patients, attending the OPD of Medicine, Era's Lucknow Medical College, Lucknow, fulfilling the criteria were recruited. Informed consent was obtained from all study participants.

Inclusion criteria

Patients of type 2 diabetes mellitus aged between 40 to 70 years of either sex. T2DM Patients for more than six months duration. Patients willing to give informed written consent.

Exclusion criteria

Patients on steroid therapy. Patients on Mg and/or Ca supplementation. Pregnant women, patients having another additional disease diagnosis (metabolic or liver diseases. T1DM patients. Patients on multi vitamin and multi mineral supplementation were included in exclusion criteria.

Control

40 Normal healthy persons (both sex) aged between 40 to 70 years were recruited.

Biochemical analysis

3 ml blood was drawn from all the study participants for biochemical analysis. Whole blood was used to estimate HbA1c and fasting blood glucose, serum Mg and Ca was estimated using fully automated analyser VITROS 5600 in the hospital lab service of institute.

Statistical analysis

Comparisons were made between normal healthy control and T2DM patients. Data has been represented as numbers and percentages for categorical and as mean±standard deviation for continuous data.

Univariate analysis was done using chi-square test for categorical evaluations. Independent samples 't'-test and ANOVA was performed for continuous evaluations.

RESULTS

Authors have recruited normal healthy controls(n=40) and T2DM patients (n=40), fulfilling the inclusion criteria and willing to participate in the study. Among normal healthy controls, 19 (47.5%) were males and 21 (52.5%) were females, while among T2DM cases, 14 (35%) were males and 26 (65%) were females. Among T2DM cases, females were more than men, this increase was statistically significant ($p<0.001$) (Table 1).

Mean age (mean±S.D) of normal healthy control and T2DM patients was recorded as 53.07±10.79 years and 55.72±9.86 years, respectively. The increased age in T2DM patients was found significantly ($t=4.120$, $p<0.001$) higher as compared to normal healthy controls. Anthropometric analysis demonstrates non-significant change in BMI (mean±S.D) among T2DM patients (26.49±4.35) as compared to normal healthy control (25.77±3.72). Statistically, there was no significant difference between the two groups for BMI ($p>0.05$) (Table 1).

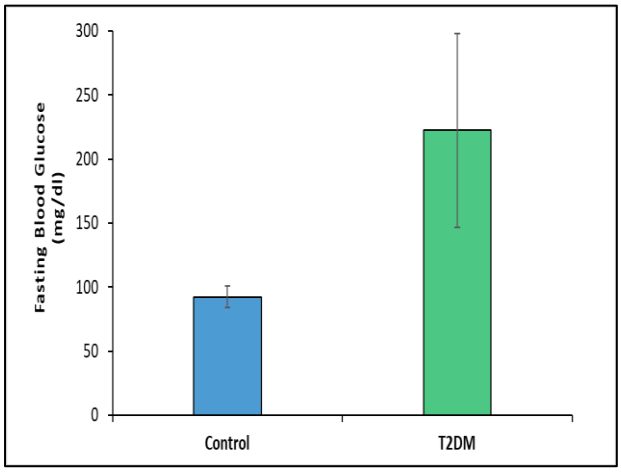

Figure 1: Comparison of fasting blood glucose level between control and T2DM patients.

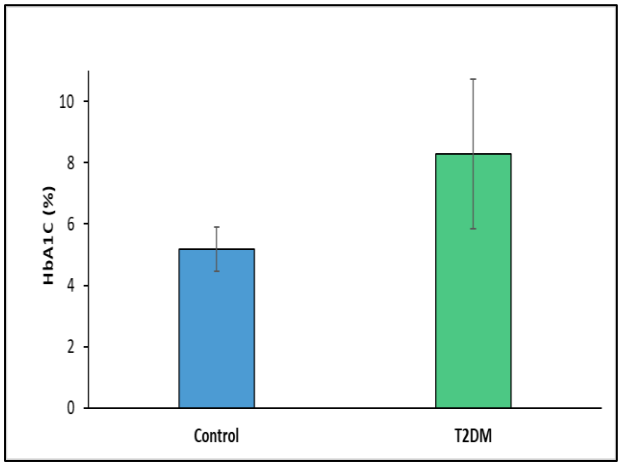

Figure 2: Comparison of HbA1c between control and T2DM patients.

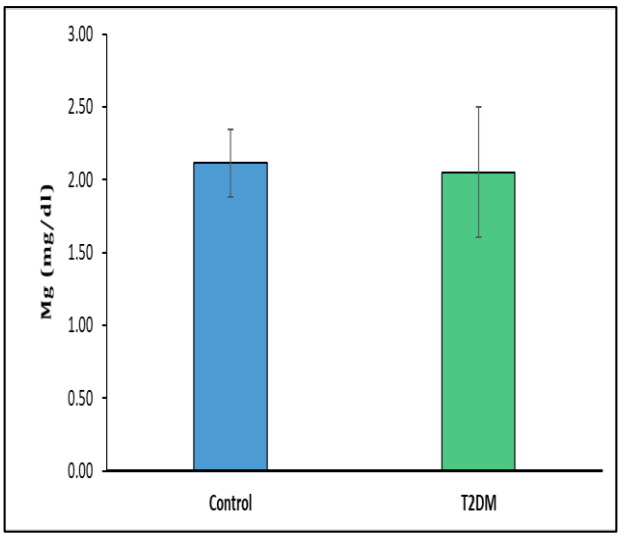

Figure 3: Comparison of serum Mg level in control and T2DM patients.

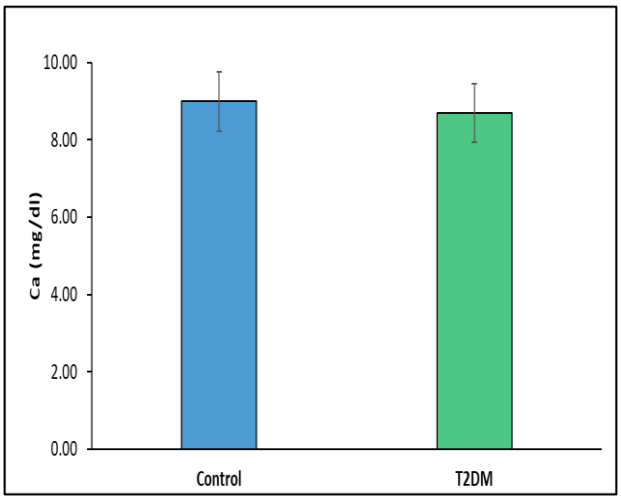

Figure 4: Comparison of serum Ca in control and T2DM patients.

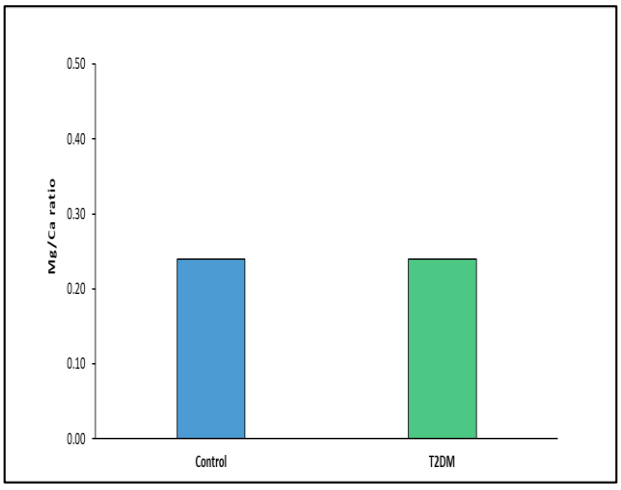

Figure 5: Comparison of serum Mg/Ca ratio in control and T2DM patients.

Authors investigated all the blood samples from control and T2DM subjects for biochemical parameters such as fasting blood glucose, HbA1c, Ca and Mg. All the values are expressed as (mean±S.D). Fasting blood glucose levels were found increased and highly significantly ($p<0.001$) in T2DM patients (222.55±75.63) as compared to normal healthy control (92.33±8.53), similarly HbA1c values were also found increased and highly significantly ($p<0.001$) in T2DM patients (8.28±2.43) as compared to normal healthy control (5.19±0.72) (Table 2, Figure 1 and 2). Serum Mg levels (mean±S.D) were recorded as 2.11±0.23 and 2.05±0.45 in normal healthy control and T2DM patients respectively. This decrease in serum Mg levels was found in T2DM patients but non-significant as compared to normal healthy control. Serum Ca levels (mean±SD) were recorded as 8.99±0.77 and 8.68±0.76 in normal healthy control and T2DM patients respectively. Similarly, non-significant decrease in serum Ca levels was found in T2DM patients as compared to normal healthy control. Serum Mg/Ca ratio was calculated. Serum Mg/Ca ratio was noted same (0.23) in both study groups i.e., remained unchanged (Table 3, Figure 3, 4 and 5).

Table 1: Demographic data of study participants.

Study group	Control	T2DM	P value
Male	20	14	<0.001
Female	20	26	<0.001
Age (in years) (Mean±SD)	53.07±10.79	55.72±9.86	<0.001
BMI (kg/m²) (Mean±SD)	25.77±3.72	26.49±4.35	>0.05

Table 2: Comparison of fasting blood glucose level and HbA1C value between control and T2DM patients.

Study group	Control	T2DM	P value
Fasting blood glucose (mg/dl) (Mean±SD)	92.33±8.53	222.55±75.63	<0.001
HbA_1C (%) (Mean±SD)	5.19±0.72	8.28±2.43	<0.001

Table 3: Comparison of serum Mg level, serum Ca level and Mg/Ca ratio between control and T2DM patients.

Study group	Control	T2DM	P value
Mg (mg/dl) (Mean±SD)	2.11±0.23	2.05±0.45	0.021*
Ca (mg/dl) (Mean±SD)	8.99±0.77	8.68±0.76	0.132*
Mg/Ca ratio	0.2347	0.2361	0.111*

*Nonsignificant change.

DISCUSSION

Type 2 Diabetes mellitus progressively impacts human organs and systems, leading to various systemic complications. Due to its pandemic status and severe threat to human health, T2DM is currently a high-priority health concern globally.[16] Moreover, type 2 diabetes is often linked to low magnesium (Mg) levels both outside and inside cells. A long-term, unnoticed Mg deficiency or clear hypomagnesemia is common in individuals with type 2 diabetes, particularly those with poor blood sugar control.

There appears to be a relationship between insufficient calcium status and T2DM. However, the available human data are limited because most observational studies are cross-sectional and there is a paucity of randomized controlled trials with calcium supplementation specifically designed for outcomes related to T2DM. Present study was conducted to assess serum Mg and Ca levels in T2DM patients. Results of our study indicates that statistically significant increase in T2DM patients was observed with the increasing age and females were the most sufferers as compared to males. BMI data showed non-significant change in T2DM patients as compared to normal healthy control.

Biochemical investigations revealed a highly significant increase in fasting blood glucose levels and HbA1C value among T2DM patients as compared to normal healthy control. Further, we also observed non-significant decrease in serum Mg and Ca levels among T2DM patients as compared to normal healthy control, while no change was observed in Mg/Ca ratio among the study groups. The data observed in the study shows immense similarity with

previously conducted studies with T2DM patients. Study by Kostov et al, showed that serum magnesium levels were significantly lower in type 2 diabetic patients as compared to the control group. Serum magnesium levels were strongly negatively correlated with fasting glucose and HbA1c.[17] Similarly, in studies of Dong et al, positive correlation was found between the serum HbA1c levels and fasting glucose ($r=0.996$, $p<0.01$). There was a positive and moderate correlation between age and HbA1c ($r=0.406$, $p<0.01$) and fasting glucose levels ($r=0.403$, $p<0.01$). There was a positive and low correlation between the Ca/Mg ratio and HbA1c ($r=0.240$, $p<0.01$) and fasting glucose levels ($r=0.235$, $p<0.01$). There was also a significant, very low and negative correlation between the Mg and HbA1c ($r=-0.150$, $p<0.01$), fasting glucose ($r=-0.148$, $p<0.01$).[18] On contrary, Moradiya et al reported the higher prevalence of hypomagnesemia in uncontrolled T2DM patient as compared to controlled glycemic patients. This difference of serum Mg level in relation to HbA1c was statistically significant ($p\leq0.001$).[10] Kieboom et al and team's findings on serum magnesium and prediabetes show that low levels correlate with increased risk, implying a potential causal link between magnesium and diabetes, likely due to magnesium's role in insulin resistance.[19]

Studies conducted by Li et al shows that there was no significant relationship between blood glucose and magnesium levels, blood glucose and calcium levels and between magnesium and calcium levels with a significance of $p=0.058$, $p=0.179$ and $p=0.114$, respectively.[20] Piuri et al expressed that magnesium deficiency is common in individuals with type 2 diabetes and metabolic syndrome. Maintaining adequate magnesium levels could not only reduce diabetes risk but also improve blood pressure and prevent high blood sugar and high triglycerides.[21]

Study of Zamani et al demonstrated that magnesium supplementation may have an indirect role in improved clinical symptoms in T2DM patients. This study showed that magnesium supplementation did not improve serum magnesium levels. The clinical trial also showed a significant reduction in serum calcium levels and the Ca/Mg ratio and a significant increase in serum magnesium levels after magnesium supplementation.[22] The study findings also provide insight into the relationship between the fasting blood glucose, HbA1c level and serum Mg and Ca levels in T2DM patients. The results also provide evidence that in T2DM patients, high HbA1c may be an essential clue to find the adverse effect on the human health.

Limitations

Study was conducted with small sample size, therefore a large group study can provide deeper insight and prospective analysis to find mechanism of changes in serum Mg and Ca in diabetic population.

CONCLUSION

The study findings conclude that high HbA1c or poor glycemic control may be responsible for impairing serum Mg and Ca levels in T2DM patients. Because of unhealthy eating habits, many individuals may have low levels of magnesium and calcium, which fosters inflammation and further disrupts their metabolic processes. Magnesium and calcium supplementation may assist in breaking this negative feedback mechanism. Further, a study with a large group of T2DM patients may help understand the underlying mechanism in more scientific manner.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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