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Original Research Article

SERUM MAGNESIUM LEVELS IN TYPE 2 DIABETES MELLITUS AND ITS CORRELATION WITH HbA1c LEVEL: AN INSTITUTIONAL STUDY

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ABSTRACT

Background: In recent years, there has been increasing interest in the role of micronutrients, particularly magnesium, in the pathophysiology and management of Type 2 Diabetes Mellitus (T2DM). This study examines the relationship between serum magnesium levels and HbA1c in individuals with Type 2 Diabetes Mellitus.

Material and Methods: The study was a hospital-based observational study conducted in the Department of General Medicine at Mallige Medical Center, Bangalore, involving 100 patients with Type 2 Diabetes Mellitus who met the inclusion and exclusion criteria. The study period spanned from December 2019 to June 2021. Anthropometric measurements were recorded, and blood samples were collected for biochemical analysis. Serum magnesium levels were considered normal if they fell within the range of 1.6 to 2.4 mg/dL.

Results: The study enrolled a total of 100 participants, with a mean age of 60.52 ± 15.54 years (range: 36–95 years). Of the 100 subjects, 52 (52%) were male. Low serum magnesium levels were observed in 10 patients (10%). The mean serum magnesium level in the study population was 1.889 ± 0.260 pg/mL, which falls within the normal range. Serum magnesium levels demonstrated a strong negative correlation with HbA1c levels ($p = 0.003$, $r = -0.295$) and age ($p = 0.037$, $r = -0.209$).

Conclusion: The study found a negative correlation between serum magnesium levels and HbA1c in patients with Type 2 Diabetes Mellitus, with hypomagnesaemia observed in 10% of the study population.

Keywords: Type 2 Diabetes Mellitus, Hypomagnesaemia, glycated haemoglobin, Age.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and β-cell dysfunction, leading to hyperglycemia. It is associated with various complications, including cardiovascular diseases, neuropathy, and kidney dysfunction, which contribute to increased morbidity and mortality. The management of T2DM primarily focuses on controlling blood glucose levels, with long-term monitoring of HbA1c (glycated haemoglobin) serving as the key indicator of glycemic control.[1-2]

In recent years, there has been growing interest in micronutrients, particularly magnesium, in the pathophysiology and management of T2DM. Magnesium is essential in over 300 enzymatic reactions for glucose metabolism and insulin function. Low serum magnesium levels have been reported in individuals with T2DM, and it has been suggested that magnesium deficiency may exacerbate insulin resistance and contribute to poor glycemic control.[3-6]

This study explores the relationship between serum magnesium levels and HbA1c in individuals with Type 2 Diabetes Mellitus. By examining the correlation between these two factors, we hope to provide insights into the potential role of magnesium supplementation as an adjunctive

therapy to improve glycemic control in T2DM patients.

MATERIALS AND METHODS

This hospital-based observational study was conducted in the Department of General Medicine at Mallige Medical Centre, Bangalore, Karnataka. A total of 100 eligible patients with Type 2 Diabetes Mellitus (T2DM) who met the inclusion and exclusion criteria were included in the study. A convenience sampling technique was used for participant selection. The study period extended from December 2019 to June 2021.

Participants included in the study met the following inclusion criteria: those who provided informed consent and had fasting blood glucose levels greater than 126 mg/dL, postprandial glucose levels exceeding 200 mg/dL, HbA1c levels above 6.5%, or a previously diagnosed case of diabetes mellitus. Exclusion criteria comprised individuals with Type 1 Diabetes Mellitus, renal failure as determined by eGFR values, albuminuria, and serum creatinine based on KDIGO criteria, and those with electrolyte imbalances other than magnesium. Patients with comorbidities such as cardiovascular disorders or infections, those who had experienced an acute myocardial infarction in the past six months, and individuals on diuretics were also excluded. Additionally, individuals with a history of alcohol abuse, those taking magnesium supplements or magnesium-containing antacids, and patients with malabsorption syndromes, chronic diarrhoea, or a documented history of renal failure were not included. Lastly, individuals with suspected or known neoplastic illnesses were excluded from the study.

A detailed medical, family, and treatment history was obtained. A comprehensive examination encompassed vitals, anthropometry, and general physical assessment. Biochemical parameters were measured, including fasting and postprandial blood glucose, HbA1c, complete hemogram, and serum magnesium levels. Diabetes Mellitus was defined as fasting plasma glucose levels ≥126 mg/dL on multiple measurements, postprandial glucose ≥200 mg/dL, a previous diagnosis of diabetes mellitus, or the use of anti-diabetic medications (oral anti-diabetic agents or insulin).[7] Hypomagnesemia was defined as serum magnesium levels <1.46 mg/dL, with the reference range for serum magnesium in this study being 1.6 to 2.4 mg/dL.[8] Body Mass Index (BMI) was calculated as weight (kg) divided by height (m^2), with overweight classified as BMI ≥25 kg/m^2 but <29.9 kg/m^2 and generalized obesity as BMI ≥30 kg/m^2.[9] Chronic Kidney Disease (CKD) was defined by a glomerular filtration rate (GFR) <60 mL/min/1.73 m^2, albuminuria ≥30 mg/24 hours, or markers of kidney damage persisting for more than three months.[10]All participants and/or their attendants were informed about the study, and written consent was obtained.

Age, weight, height, and BMI were recorded. Age was obtained from patient history, weight was measured in kilograms using a calibrated weighing machine, and BMI was calculated using the standard formula. A fasting venous blood sample was collected after an overnight fast of at least eight hours for biochemical investigations, including serum magnesium, fasting blood glucose (FBS), postprandial blood glucose (PPBS), and HbA1c. FBS and PPBS were measured using the hexokinase method, HbA1c was analyzed using the turbidimetric inhibition immunoassay, and serum magnesium levels were determined using the Xylidyl Blue Method on a Roche Cobas C311 Fully Automated Biochemistry Analyzer.

Data analysis was performed using SPSS version 21. Descriptive statistics were used to express frequencies as percentages, while mean values were presented with standard deviations. The correlation between HbA1c and serum magnesium levels was assessed using Pearson's correlation coefficient, with a p-value <0.05 considered statistically significant. The Chi-square test was used to determine the association between serum magnesium levels and Metformin versus non-metformin (Insulin) therapy.

RESULTS

The total number of participants enrolled in the study was 100. The mean age of the patients was 60.52 ± 15.54 years (range: 36–95 years). Among the 100 subjects, 52 (52%) were male. Regarding body weight distribution, 2 (2%) participants were underweight, 44 (44%) were overweight, and 16 (16%) were obese. Among the study population, 16 (16%) had fasting blood sugar (FBS) levels below 126 mg/dL, while 84 (84%) had FBS levels above 126 mg/dL. Postprandial blood sugar (PPBS) levels exceeded 200 mg/dL in 66 (66%) participants. Glycated Hemoglobin (HbA1c) levels were above 6.4% in 96 (96%) subjects. The total number of patients with low serum magnesium levels was 10 (10%). Baseline characteristics of the study population are shown in Table 1.

Regarding diabetes treatment, 62 (62%) participants were on Metformin, while 38 (38%) were on insulin therapy. The mean height of the study population was 164.83 ± 9.59 cm, and the mean weight was 69.83 ± 11.24 kg. The mean body mass index (BMI) was 25.81 ± 4.11. The mean duration of diabetes mellitus among the participants was 9.95 ± 7.14 years. The mean duration of metformin use was 3.50 ± 4.78 years. The mean FBS level was 160.33 ± 35.89 mg/dL, while the mean PPBS level was 236.37 ± 59.85 mg/dL. The mean HbA1c level among the subjects was 8.79 ± 1.46%. The mean serum magnesium level in the study population was

1.889 ± 0.260 pg/mL, within the normal range (Table 2).

A strong positive correlation was observed between FBS and PPBS levels, with a statistically significant p-value of <0.05 ($p < 0.001$, $r = 0.799$). Serum magnesium levels showed a strong negative correlation with HbA1c levels ($p = 0.003$, $r = -0.295$) and age ($p = 0.037$, $r = -0.209$) [Table 3].

Other variables, including BMI, FBS, PPBS, diabetes duration, and metformin use duration, showed no significant correlation with serum magnesium levels ($p > 0.05$). Additionally, no significant difference in serum magnesium levels was found between metformin users and non-users. A comparison of serum magnesium levels between male and female participants also yielded no significant results. [Table 4]

Table 1: Baseline Characteristics of the Study Population

Variable	N(100)
sex	
Males	52
Females	48
BMI	
<18.5	2
18.5-24.9	38
25-29.9	44
>30	16
Fasting Blood Glucose	
≤126	16
>126	84
Post Prandial Blood Glucose	
≤200	34
>200	66
HbA1C	
<6.4	4
>6.4	96
Serum Magnesium levels	
Normal	90
Low	10
Metformin use	
Yes	62
No	38

Table 2: Distribution of Mean Values and Standard Deviations for Different Variables

Variables	Mean +Standard Deviation
Age	60.52 + 15.541
Height	164.83 + 9.593
Weight	69.83 ± 11.240
Body Mass Index	25.806 ± 4.107
Diabetes Mellitus duration (years)	9.95 ± 7.138
Metformin Usage (years)	3.50 ± 4.779
Fasting Blood Sugar	160.33 ± 35.889
Postprandial Blood Sugar	236.37 ± 59.855
Glycated Hemoglobin (HbA1C)	8.785 ± 1.456
Serum Magnesium	1.886 0.260

Table 3: Correlation Between Serum Magnesium and Fasting Blood Sugar (FBS), Postprandial Blood Sugar (PPBS), HbA1c, Duration of Diabetes, Age, Body Mass Index (BMI), and Metformin Usage

Variable	r value	P value
FBS	-0.017	0.869
PPBS	0.098	0.331
HbA1c	-0.295	0.003
Diabetes duration	-0.141	0.162
Age	-0.209	0.05
Body Mass Index	-0.065	0.522
Metformin use	0.031	0.774

Table 4: Association Between Serum Magnesium Levels, Metformin Usage, and Sex

Variable		Normal N (%)	Low magnesium levels N (%)	Odds ratio (95 % CI)	P value
Metformin usage	No	35(92.1%)	3(7.9%)	1.485(0.360-6.127)	0.583
	Yes	55(88.7%)	7(11.3%)		
Gender	Female	46(95.8%)	2(4.2%)	4.182(0.841-20.789)	0.062
	Male	44(84.6%)	8(15.4%)		

DISCUSSION

In this study, the prevalence of hypomagnesemia in the Type 2 diabetes mellitus population was 10%. The results indicated a significant association between serum magnesium levels and HbA1c levels. However, no significant association was found between serum magnesium levels and BMI, fasting blood sugar (FBS), postprandial blood sugar (PPBS), or diabetes duration, consistent with previous studies.[11-14] Additionally, no significant correlation was observed between serum magnesium levels and metformin usage or gender.

Mario Barbagallo et al. found significantly lower Magnesium ion levels in elderly Type 2 Diabetes Mellitus (T2DM) patients compared to age-matched controls.[14] Similarly, the present study on 100 T2DM patients analyzed total Serum Magnesium and demonstrated a significant negative correlation with HbA1c levels ($r = -0.295$, $p < 0.003$). Unlike Barbagallo et al., a wider age range was included and found a significant negative correlation between Serum Magnesium and age ($r = -0.209$, $p < 0.05$). Chen Chu et al. reported no significant link between dietary magnesium and diabetes but found a strong negative association between Serum Magnesium and diabetes.[15] Our findings align with their Serum Magnesium and HbA1c results but also highlight the influence of age, which they did not study.

Jesse Bertinato et al. studied serum magnesium levels in the Canadian population (ages 20–79) and their correlation with BMI, HbA1c, and diabetes-related parameters. They found no significant variation in magnesium levels based on age or sex, but Type 2 Diabetes was associated with lower magnesium concentrations. BMI, HbA1c, and serum glucose were negatively correlated with magnesium levels.[16] In contrast, our study found a negative correlation between age and serum magnesium levels.

Studies on serum magnesium levels in Type 2 diabetes have shown varying results. Happy Chutia and Kyrshanlang G. Lynrah found lower serum magnesium levels in diabetic patients, with a strong negative correlation between serum magnesium and FBS levels.[17]Our study, however, found a significant negative correlation with HbA1c but no significant correlation with FBS. Mohammad Munir Noor et al. found hypomagnesemia significantly associated with diabetes duration, while our study did not find such a correlation.[18] Femke Waanders et al,[19] observed associations between magnesium deficiency and age, diabetes duration, HbA1c, BMI, and metformin use, which aligned with our findings for age and HbA1c, but we found no correlation with diabetes duration, BMI, or metformin use

CONCLUSION

Given the crucial role of magnesium in insulin action and glucose metabolism, routine monitoring of serum magnesium in diabetic patients may help to manage better and prevent complications. Further research with larger sample sizes is needed to establish magnesium supplementation as a potential therapeutic approach for improving glycemic control in T2DM.

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