



Hypomagnesaemia In Type 2 Diabetes Mellitus

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Abstract:

INTRODUCTION: Magnesium is the second most abundant cation in the body and plays an important physiological role in a wide assay of enzymatic reactions. Its fundamental role is a co-factor in various enzymatic reactions involving energy metabolism. Magnesium acts as a cofactor for several enzymes involved in carbohydrate oxidation and is crucial for the transport of glucose across the cell membrane. It also plays a significant role in the secretion, binding, and function of insulin. A range of factors, such as insufficient magnesium intake and losses through the gastrointestinal tract and kidneys, can lead to magnesium deficiency and hypomagnesemia. Long-term magnesium deficiency has been linked to the onset of insulin resistance. The present review discusses the implications of magnesium deficiency in type 2 diabetes.

METHODS: A retrospective study was conducted in 30 Type II Diabetic subjects from September 2024 to December 2024. Values of FBS more than 136 mg/dl & serum magnesium less than 1.8mg/dl were recorded. Both serum FBS & Serum Magnesium were measured using Photometry.

RESULTS: The serum magnesium levels were recorded at 1.21 ± 0.21 for diabetic individuals and 1.94 ± 0.21 for the control group. Diabetic patients displayed significantly lower average magnesium levels compared to controls, with 90% of inpatients having magnesium levels below 1.5 mg/dl, while none of the controls had levels below this threshold ($p < 0.001$).

CONCLUSION: Compared to controls, type 2 diabetic patients exhibited reduced serum magnesium levels. Commonly unrecognized, magnesium metabolism disorders occur frequently. Magnesium is vital for the onset of type 2 diabetes mellitus (DM). Although the reasons for the high incidence of magnesium deficiency in diabetes remain unclear, potential explanations could include greater urinary loss, lower dietary consumption, or hindered absorption of magnesium when contrasted with healthy individuals. Research indicates that oral magnesium supplementation can enhance both insulin sensitivity and secretion in those with type 2 diabetes mellitus, highlighting the impact of magnesium supplementation on glucose management

Index Terms - Type 2 diabetes, magnesium, hypomagnesemia, glycemic.

1. INTRODUCTION

Magnesium (Mg), recognized as the second most prevalent intracellular cation after potassium, plays an indispensable role in human health. It functions as a pivotal cofactor in over 300 enzymatic reactions, thereby affecting an extensive range of biochemical processes within the organism. The significance of Mg is particularly pronounced in glucose metabolism and the regulation of smooth muscle activity, establishing it as an essential micronutrient. The inadequacy of Mg, notably concerning conditions such as Type 2 diabetes mellitus (T2DM), has been associated with various clinical complications. ⁽¹⁾

Diabetes mellitus is categorized based on the primary mechanisms that lead to high blood sugar levels, with the two main types being type 1 and type 2 diabetes. The causes of hyperglycemia vary and can include reduced insulin production, increased glucose output, and impaired glucose usage, as the metabolic issues

associated with diabetes result in pathophysiological changes in multiple organ systems.^(2,3) Research has confirmed a link between low magnesium levels and poor glycemic control, as well as various chronic complications tied to diabetes mellitus; this study was conducted to investigate the relationship between low magnesium levels and glycemic management.

It is estimated that approximately 65% of individuals with diabetes mellitus experience low magnesium levels; prolonged low magnesium levels contribute to increased blood sugar and insulin resistance, with the severity of magnesium deficiency positively correlating with serum glucose levels and the extent of glucose in urine. Additionally, low magnesium levels may heighten the risk of heart disease due to the crucial role of intracellular magnesium in regulating insulin function; decreased magnesium adversely affects tyrosine kinase activity at the insulin receptor, thus diminishing insulin effectiveness and exacerbating insulin resistance in type 2 diabetes.⁽⁴⁾

The specific mechanisms through which low magnesium levels can either initiate or worsen existing diabetes remain poorly understood. However, since insulin is critical for enhancing renal magnesium retention, it appears that both insulin secretion and its action could be influenced. Therefore, insulin resistance or deficiency may lead to increased urinary magnesium loss. As a result, low magnesium levels are considered a possible risk factor for developing type 2 diabetes; conversely, within the diabetic population, the prevalence of type 2 diabetes may also relate to lower magnesium levels.⁽⁵⁾

Individuals with type 2 diabetes have been observed to have a higher incidence of low magnesium levels, which often goes unaddressed. Magnesium is an essential cofactor for enzymes and is crucial in various physiological functions, including neuromuscular transmission, cellular membrane permeability, cellular growth, and programmed cell death. There are numerous other important roles of magnesium in different cellular processes that are still not completely understood and require further detailed investigation.

Studies have shown that magnesium levels in people with diabetes are significantly lower than those in non-diabetic individuals. Low magnesium levels have been linked to impaired glycemic control and several chronic complications associated with diabetes mellitus.^(6,7) This study aimed to examine the connection between glycemic regulation and low magnesium levels.

2. MATERIALS AND METHODS

A. STUDY DESIGN AND METHODS

DESIGN OF THE STUDY: Retrospective experimental study of 12 months duration, conducted by the division of clinical Biochemistry of St. John's Medical College Hospital, Bangalore.

The size of the population: 30 type 2 diabetes mellitus patients & 30 control.

Subjects: 30 healthy subjects, 15 Males and 15 Females, aged over 35 years participated in the study

B. SOURCE OF DATA

Blood samples were collected from the patient with type 2 diabetes mellitus and control at the inpatient & outpatient department of St John's Medical College Hospital and received by clinical biochemistry.

INCLUSION CRITERIA:

- All individuals above the age of 35 years
- In individuals who are overweight and other risk factors:
- Patients with blood pressure $\geq$ 140/90 mm/hg
- Having a first-degree relative with diabetes
- Fasting Blood Sugar $\geq$ 126 mg/dL

EXCLUSION CRITERIA:

- Normal healthy subjects.
- Patients with deranged lipid profiles and hemolysed blood samples are excluded.
- Patient with intestinal disorders, impaired renal function, and other endocrinal disorders.
- Uncontrolled diabetes persistent FBS $\geq$ 126 mg/ dl with treatment.

3. STATISTICAL EVALUATION OF DATA

Statistical Methods: Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean $\pm$ SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at a 5 % level of significance.

The following assumption on data is made.

1. Dependent variables should be normally distributed,
2. Samples drawn from the population should be random, Cases of the samples should be independent. Student tests (two-tailed, independent) has been used to find the significance of study parameters on a continuous scale between two groups (Intergroup analysis) on metric parameters. The Chi-square/ Fisher Exact test has been used to find the significance of study parameters on a categorical scale between two or more groups. Pearson Correlation between mg and FBS is done to find the correlation

4. RESULTS

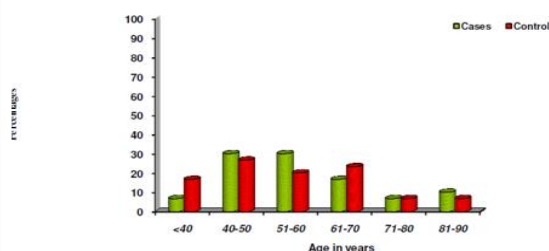
STUDY DESIGN: A comparative study consisting of 50 diabetic Mellitus patients and 50 control was undertaken to investigate the changing pattern of serum magnesium in DM Cases when compared to the control

Study design: A Comparative case-control study

Table 1: Age distribution of patients studied

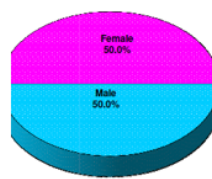
Age in years	Cases	Controls	Total
<40	2(6.7%)	6(20%)	8(13.3%)
40-50	9(30%)	12(40%)	21(35%)
51-60	9(30%)	6(20%)	15(25%)
61-70	5(16.7%)	6(20%)	11(18.3%)
71-80	2(6.7%)	0(0%)	2(3.3%)
81-90	3(10%)	0(0%)	3(5%)
Total	30(100%)	30(100%)	60(100%)
Mean $\pm$ SD	56.00 $\pm$ 13.92	49.17 $\pm$ 10.13	52.58 $\pm$ 12.55

P=0.034*

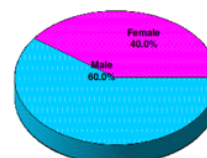


Gender	Cases	Controls	Total
Female	15(50%)	9(30%)	24(40%)
Male	15(50%)	21(70%)	36(60%)
Total	30(100%)	30(100%)	60(100%)

P=0.114



Cases



Controls

DIAGRAMMATIC REPRESENTATION OF AGE DISTRIBUTION

Table 2: Gender distribution of patients' studies

The mean of the diabetic is 56. 56.00 $\pm$ 13.92 years whereas it was 55.07 $\pm$ 14.09 respectively. Both among the cases and controls the sex distribution was i.e. 40 % and 60% males and females respectively. The maximum number of patients was in the age group of 41-50 ie (35%).

Table 3: FBS levels in case and controls

FBS	Cases	Controls	Total
<100	0(0%)	28(93.3%)	28(46.7%)
101-136	0(0%)	2(6.7%)	2(3.3%)
136-200	12(40%)	0(0%)	12(20%)
>200	18(60%)	0(0%)	18(30%)
Total	30(100%)	30(100%)	60(100%)
Mean $\pm$ SD	244.80 $\pm$ 90.44	90.90 $\pm$ 6.53	167.85 $\pm$ 100.32

Mean FBS is significantly more in cases with $P < 0.001^{**}$

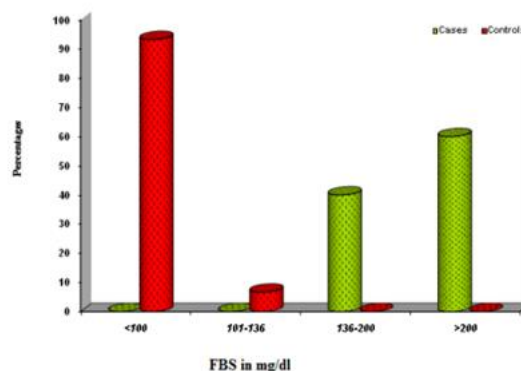


Table 4: Mg levels in two groups studied

Mg	Cases	Controls	Total
<1	2(6.7%)	0(0%)	2(3.3%)
1.1-1.5	27(90%)	0(0%)	27(45%)
1.51-2	1(3.3%)	22(73.3%)	23(38.3%)
>2	0(0%)	8(26.7%)	8(13.3%)
Total	30(100%)	30(100%)	60(100%)
Mean $\pm$ SD	1.21 $\pm$ 0.21	1.94 $\pm$ 0.14	1.58 $\pm$ 0.41

Mean mg levels are significantly less in cases compared to controls with $P < 0.001^{**}$

5. DISCUSSION

Magnesium deficiency adversely affects glucose regulation and insulin sensitivity in individuals with diabetes, as well as the progression of complications like retinopathy, thrombosis, and hypertension. The reasons for the high incidence of magnesium deficiency in diabetic patients remain unclear, but may involve increased urinary excretion, reduced dietary intake, or impaired absorption of magnesium compared to those without diabetes. This study included 30 patients with type 2 diabetes mellitus and 30 control participants. Among the 30 diabetic patients, there were 15 males and 15 females, aged between 38 and 85 years. The mean age of those in the diabetic group was 56.00 ± 13.92 years, while the control group had a mean age of 55.07 ± 14.09 years. In both the diabetic and control groups, the sex distribution was 40% female and 60% male. The largest proportion of patients fell within the 41-60 age range, constituting 60% of the sample. The findings from this study (table no: 7) indicate that the mean serum magnesium levels in the diabetic group were 1.21 ± 0.21 , compared to 1.94 ± 0.21 in the controls. Notably, magnesium levels were significantly lower in diabetic patients compared to controls, with 90% of patients showing levels below 1.5 mg/dl and none of the controls below this threshold ($p < 0.001$). The results imply serum magnesium deficiency in patients with type 2 diabetes.

6. CONCLUSION

Serum magnesium levels were observed to be lower in individuals with type 2 diabetes mellitus when compared to control participants. Disruptions in magnesium metabolism are common and often go unnoticed. Magnesium plays a crucial role in the pathophysiology of type 2 diabetes mellitus. The cause of magnesium deficiency in this diabetic population does not appear to stem from reduced intestinal absorption or insufficient dietary magnesium intake. The lack of insulin or insulin resistance leads to impaired reabsorption of magnesium in the distal convoluted tubules, resulting in increased renal magnesium excretion. Moreover, reduced cellular uptake of magnesium might also contribute to this deficiency. Research on diabetes mellitus often emphasizes hypomagnesaemia. The diabetic state disrupts the management of normal magnesium levels

within the body, thus promoting the development of hypomagnesaemia, particularly in cases of poor metabolic control, which can lead to chronic complications of diabetes. Additionally, hypomagnesemia has been shown to increase the likelihood of developing type 2 diabetes mellitus. The reasons for the higher prevalence of magnesium deficiency among diabetic patients are still unclear, but may include heightened urinary excretion, lower dietary intake, or difficulties in magnesium absorption when compared to healthy individuals. Oral magnesium supplementation may improve insulin sensitivity and secretion in individuals diagnosed with type 2 diabetes mellitus, as supported by various studies illustrating the effects of magnesium supplementation on blood sugar control.

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