DOI: https://doi.org/10.47648/jswmc2024v14-01-94

Original Article

Study of Serum Magnesium Level in Type 2 Diabetes Mellitus

*Chowdhury MR[1], Begum RA[2], Khatun S[3], Ahmed J[4], Islam MB[5].

Abstract:

Background: Type 2 Diabetes Mellitus (DM) is the most prevalent metabolic disease associated with magnesium deficiency. Renal magnesium wasting can be made worse by insulin resistance and hyperglycemia increases the osmotic urinary excretion of magnesium. High incidence of hypomagnesaemia in Type 2 DM has been reported in different studies.

Aims and Objectives: To assess status of serum magnesium level in patients with Type 2 diabetes mellitus.

Materials and Methods: This cross-sectional analytical study was conducted in the Department of Biochemistry, Sylhet MAG Osmani Medical College, Sylhet between January 2021 and December 2021. Fifty-five type-2 diabetics and age and sex matched 55 healthy volunteers were included by applying non probability convenient sampling technique. Diabetics with acute complications, diarrhoea or other malabsorptive states, those taking alcohol or drugs such as amino glycosides, thiazide diuretics and pregnant women were excluded. All underwent fasting plasma glucose, serum magnesium and HbA1c levels.

Results: The mean serum magnesium level was 1.67 ± 0.41 mg/dl and 2.02 ± 0.40 mg/dl in diabetics and non-diabetics respectively; difference was statistically significant (p=0.001). Hypomagnesaemia was more frequent in diabetic group [22 (40.0%) versus 2 (3.6%), p<0.001] compared to non-diabetics.

Conclusion: Serum magnesium level is lower and hypomagnesaemia is more frequent in diabetics compared to the healthy subjects.

Key words: Magnesium, hypomagnesemia, Type 2 Diabetes Mellitus

JSWMC 2024 [14(01)] P: 58-63

Introduction:

Diabetes mellitus is defined as an elevated blood glucose associated with absent or inadequate pancreatic insulin secretion, with or without concurrent impairment of insulin action.[1] Type 2 diabetes mellitus accounts for about 90-95% of all diagnosed cases of diabetes globally.[2]

1. Dr. Marzia Rahman Chy, Lecturer, Department of Biochemistry, Sylhet Women's Medical College, Sylhet .
2. Dr. Roushon Ara Begum, Associate Professor and Head, Department of Biochemistry, Sylhet MAG Osmani Medical College, Sylhet.
3. Dr. Sakhina Khatun, Professor and Head, Department of Biochemistry, Sylhet Women's Medical College, Sylhet.
4. Dr. Jasim Ahmed, MD Resident – Internal Medicine, Sylhet MAG Osmani Medical College Hospital, Sylhet.
5. Dr. Mohammed Badrul Islam, General Practitioner and Director, Barlekha Diabetes and Diagnostic Centre, Barlekha, Moulvibazar .

Corresponding author: Dr. Marzia Rahman Chy, Lecturer, Department of Biochemistry, Sylhet Women's Medical College, Sylhet .
Email: drmarzia1989@gmail.com

Currently, 465 million (9.3%) people of 20-79 years worldwide, are estimated to have diabetes and is expected to rise to 700 million (10.9%) in 2045.[3] In developing countries, the prevalence of diabetes is rising. The overall prevalence of diabetes in Bangladesh is 7.8%.[4]

Magnesium is the second most prevalent intracellular divalent cation and the fourth most abundant mineral in the human body. Approximately 300 enzymatic processes involving energy metabolism, protein and nucleic acid production have been found to require magnesium as a cofactor. Insulin is the most significant of several variables that tightly regulate magnesium levels. After ingesting a glucose load, insulin induces magnesium to move from extracellular to intracellular space, resulting in a marked decrease in plasma magnesium levels and an increase in the magnesium content of erythrocytes. [5] Hypomagnesemia in people with Type 2 diabetes may result from or contribute to increased insulin resistance. Low dietary magnesium intake, inadequate or defective

gastrointestinal absorption, and increased urine loss from osmotic diuresis may all contribute to magnesium insufficiency in diabetes mellitus.[6]

Insulin binding activity and secretion are all impacted by magnesium. Cellular magnesium deficiency can alter the membrane-bound sodium-potassium-adenosine triphosphatase, which is essential for preserving the gradient.

The development of post-receptoral insulin resistance and decreased cellular glucose utilisation can also be caused by magnesium deficiency. Specifically, disorders of tyrosine kinase activity on the insulin receptor may arise from magnesium deficiency. This means that the lower the basal magnesium level, the greater the amount of insulin required to metabolise the same glucose load, indicating decreased insulin sensitivity.[7].When magnesium tubular reabsorption is reduced, hyperglycemia and hyperinsulinemia increase the excretion of magnesium in the urine. [8]. The amount of urine magnesium wasting is decreased by adequate glycemic control.[9]

In patients with Type 2 diabetes, magnesium deficiency seems to have a detrimental effect on insulin sensitivity and glucose homeostasis. It has been discovered that diabetes-related microvascular damage is linked to magnesium deficiency.[10]

Numerous studies have shown lower serum magnesium concentrations in Type 2 diabetic patients compared to healthy controls.[7,9,11,12] On the contrary, a study in Bangladesh, Ruhul-Kabir et al.[13] observed a higher frequency of hypomagnesaemia in the T2DM group than the control group though the difference failed to reach the level of statistical significance (p=0.074). They also found no significant difference in serum Mg levels between the two groups (p=0.582). Tiwary et al.[14] also found no significant difference in serum magnesium level between Type 2 diabetic patients and healthy controls (p=0.14).

This study was undertaken to assess the status of serum magnesium level in patients with Type 2 diabetes mellitus.

Materials and Methods

This cross-sectional analytical study was conducted in the Department of Biochemistry, Sylhet MAG Osmani Medical College, Sylhet between January 2021 and December 2021. Fifty-five diagnosed cases of Type 2 diabetes mellitus attending the inpatient and outpatient Department of Medicine, Sylhet MAG Osmani Medical College Hospital, Sylhet were enrolled. Another 55 controls were age sex matched apparently healthy individuals taken from healthy relatives or attendants of patient and also from hospital stuff. Non-probability convenient sampling technique was applied. Exclusion criteria were diabetic patients with acute complications, diarrhea or other malabsorptive states, pregnant women and those taking alcohol or drugs such as aminoglycosides, thiazide diuretics.

Detailed history was taken and clinical examination was performed accordingly. They were asked to come back on next morning between 8.00 to 10.00 am with fasting of 12 hours for FPG, HbA1c and serum magnesium.

Weight was recorded in kilograms and height was recorded in meter. Body Mass Index (BMI) was calculated using the following formula, BMI=Weight in Kilogram's/Height in meters^2.

After a fasting status of 8-10 hours 6ml venous blood was drawn from antecubital vein by using disposable syringe under aseptic precaution. Then blood was transferred into separate clean, dry, glass tubes. For HbA1c blood was collected in separate specialized tube containing EDTA.

Blood samples were kept in room temperature for one hour. After clot retraction centrifugation of blood was done at 3000 rpm for 30 mins. Afterward, serum was removed by disposable pasture pipettes and transferred into airtight tube.

Fasting plasma glucose and serum magnesium were measured by automated biochemistry analyzer, vitros 350 machine with calibration. Whole blood for HbA1c was measured by GH900 Lifotronic Auto Machine by ion

exchange chromatography, to separate HbA1c directly.

All biochemical analysis of blood was performed in the pathology laboratory of Sylhet MAG Osmani Medical College.

Diabetes mellitus was diagnosed when individuals were found to have fasting plasma glucose level of ≥126mg/dl, or HbA_1c of ≥ 6.5%.[2] Hypomagnesemia was defined as serum magnesium level less than 1.7 mg/dL (1.4 mEq/L or 0.7 mmol/L).[15]

Analysis and Interpretation: Data were processed and analyzed with the help of SPSS (Statistical Package for Social Sciences) Version 25.0. Quantitative data were expressed as mean and standard deviation and comparison was done using unpaired t test. Qualitative data were expressed as frequency and percentage and comparison was done using Chi-Square test or Fisher's Exact test. A probability (p) value of <0.05 was considered as significant and p >0.05 was considered as insignificant.

Ethical Consideration: Written informed consent was obtained from every participant. Prior to commencement of the study, approval of the Ethical Committee of Sylhet M.A.G Osmani Medical College, Sylhet was taken.

Results

The mean age was 51.53 ± 9.49 years (range 36 to 70 years) in diabetics group and was 49.25 ± 9.18 years (range 35 to 70 years) in control group; difference was not significant (t=1.277; p=0.205). In diabetics group, 20 (36.6%) patients were aged 41 to 50 years and 51 to 60 years; 8 (14.5%) patients were up to 40 years and 7(12.7%) patients were between 61 to 70 years, it was 22 (40.0%), 19 (34.5%), 8 (14.5%) and 6 (10.9%) respectively in non-diabetics group; difference was not significant (χ^2=0.198; p=0.978) (Table-I).

In diabetics group, 28 (50.9%) persons were male and 27 (49.1%) persons were female; whereas in non-diabetics group, 27 (49.1%) persons were male and 28 (50.9%) persons were female; difference was not significant (χ^2=0.036; p=0.849) (Table-I).

The mean body mass index (BMI) was 24.33 ± 2.73 kg/M^2 in diabetic group and 24.49 ± 2.21 kg/M^2 in non-diabetic group. Body mass index did not differ significantly between diabetic and non-diabetic groups (t=-0.332; p=0.741) (Figure-1).

The mean serum magnesium level was 1.67 ± 0.41 mg/dl in diabetic group and 2.02 ± 0.40 mg/dl in non-diabetic group; difference was statistically significant (t=-5.450; p=0.001) (Figure-2).

Hypomagnesaemia was more frequent in diabetic group [22 (40.0%) versus 2 (3.6%), χ^2=21.318; p<0.001], whereas normal serum magnesium levels were more frequent in non-diabetic group 52 (94.5%) versus 31 (56.4%), χ^2=21.318; p<0.001]; however hypermagnesaemia did not differ significantly between two groups 2 (3.6%) versus 1 (1.8%), p=1.000] (Table-II).

Table I. Distribution of the participants according to demographic characteristics

Demographic characteristics	Study group		p-value
	Diabetic (n=55)	Non-diabetic (n=55)	
Age			
≤40 years	8 (14.5%)	8 (14.5%)	†p=0.978
41-50 years	20 (36.6%)	22 (40.0%)	
51-60 years	20 (36.6%)	19 (34.5%)	
61-70 years	7 (12.7%)	6 (10.9%)	
Mean ± SD	51.53 ± 9.49	49.25 ± 9.18	*p=0.205
Sex			
Male	28 (50.9%)	27 (49.1%)	†p=0.849
Female	27 (49.1%)	28 (50.9%)	

*Unpaired t-test and †Chi-Square (χ^2) tests were applied to analyse the data.

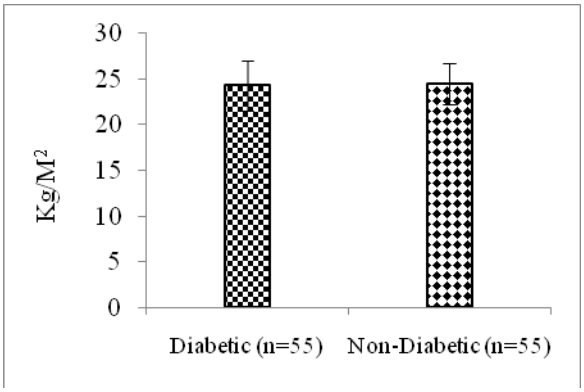

Figure-1: Distribution of the participants according to body mass index (BMI). *Unpaired 't' test was employed to find out the level of significance.

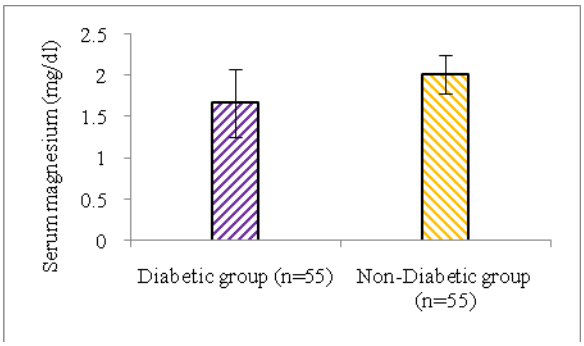

Figure-2: Distribution of the participants according to serum magnesium.
*Unpaired 't' tests were employed to find out the level of significance.

Table-II: Comparison of status of serum magnesium between diabetic and non-diabetic subjects

Status of serum magnesium	Study Subjects		p value
	Diabetic (n=55)	Non-diabetic (n=55)	
Hypomagnesaemia	22 (40.0%)	2 (3.6%)	*p<0.001
Hypermagnesaemia	2 (3.6%)	1 (1.8%)	†p=1.000
Normal	31 (56.4%)	52 (94.5%)	*p<0.001

*Chi-Square (χ^2) test, †Fisher's Exact tests were employed to find out the level of significance.

Discussion

Both intracellular and extracellular magnesium deficiencies are commonly linked to type 2 diabetes. Type 2 diabetic patients frequently have an overt clinical hypomagnesemia.[16] Patients with Type 2 diabetes experience adverse effects on insulin sensitivity and glucose homeostasis when magnesium levels are low. Due to changes in Na-K-ATP gradients, decreased pancreatic insulin secretion, impaired postreceptor insulin signalling, and modified insulin-insulin receptor interactions, it has been proposed that magnesium deficiency may cause different cellular glucose transport. It has been demonstrated that low magnesium levels harm signalling receptors and tyrosine kinase activity.[17] According to reports, poor reabsorption and increased renal excretion of magnesium are the reasons behind the association between hypomagnesemia and Type 2 diabetes mellitus (T2DM). [18]

This study showed that the mean age of the participants was 51.53 ± 9.49 years in diabetic group and was 49.25 ± 9.18 years in control group; difference was not significant (p=0.205). This result was almost similar to other studies.[13,18]

In this study slight male preponderance of diabetic patients (50.9%) and there was no statistically significant difference of sex between two groups (p=0.849). This result correlated with Kulkarni et al.[19] Several other studies also reported male preponderance of diabetic patients.[13,20,21] In contrast to these results Masood et al.[22] reported female preponderance of diabetic patients (66.7%).

In the present study the mean body mass index (BMI) was 24.33 ± 2.73 kg/M^2 in diabetic group and 24.49 ± 2.21 kg/M^2 in non-diabetic group; difference was not significant (p=0.741). This result correlated with Dalai et al.[9] which reported that mean body mass index (BMI) was 23.17 ± 4.78 kg/M^2 in diabetic group and 22.46 ± 3.63 kg/M^2 in non-diabetic group; difference was not significant (p=0.313).

The mean serum magnesium level was lower (1.67 ± 0.41 mg/dl) in diabetic group compared

to non-diabetic group (2.02 ± 0.40 mg/dl); difference was statistically significant (p=0.001). Karim et al.[23] supported this result that serum magnesium was significantly lower in diabetics compared to non-diabetic groups (p=0.031). Several other studies also supported this result that serum magnesium was significantly lower in diabetics compared to non-diabetic groups.[5,24,25,26] But Ruhul-Kabir et al.[13] found that serum magnesium was lower in diabetics (2.23 ± 0.50 mg/dl) compared to non-diabetic groups (2.27 ± 0.40 mg/dl) but did not differ significantly (p=0.582).

In this study hypomagnesaemia was more frequent in diabetic group [22 (40.0%) versus 2 (3.6%), p<0.001]. This result was in agreement with the study of Murthy and Palvai,[7] which reported hypomagnesemia was seen in 38.6% of the cases whereas only 2.9% of the controls had hypomagnesemia (p<0.05). Several others studies also supported this result.[12,26] But Dalai et al.[9] found that no significant difference in rates of hypomagnesaemia between diabetic patients and controls (20% and 16% respectively) (p=1.0). Ruhul-Kabir et al.[13] also found that hypomagnesaemia was more in diabetics (26.2%) compared to non-diabetic groups (12.3%) but did not differ significantly (p=074).

It has been reported that inadequate glycemic control can be caused by and result from hypomagnesemia. [27] Hypomagnesemia in patients with Type 2 diabetes mellitus may result from or contribute to elevated insulin resistance. Low dietary intake, poor magnesium absorption in comparison to healthy individuals, or increased urinary loss (osmotic diuresis) could be the cause of the high prevalence of hypomagnesemia. [28] The limitations of the study were: (1) This study was conducted in a single tertiary level hospital and (2) Sample size was small due to limitation of time.

Conclusion

Serum magnesium level is lower and hypomagnesaemia is more frequent in diabetics compared to the healthy subjects. However, further multi-centered study with larger sample size is warranted.

References:

1. Kennedy MSN, Masharani U. Pancreatic hormones and antidiabetic drugs. In: Katzung BG, ed. Basic and Clinical Pharmacology. 14th ed. New York: The McGraw-Hill Companies. 2018; p. 751.
2. American Diabetic Association. Classification and Diagnosis of Diabetes. Diabetes Care 2021;44(Suppl. 1):S15–33.
3. International Diabetes Federation. IDF Diabetes Atlas. 9th ed. IDF: Brussels Belgium. 2019. Retrieved from: http://www.diabetesatlas.org. Accessed on 01 Dec 2021.
4. Akhtar S, Nasir JA, Sarwar A, Nasr N, Javed A, Majeed R, et al. Prevalence of diabetes and pre-diabetes in Bangladesh: a systematic review and meta- analysis. BMJ Open 2020;10(9):e036086.
5. Manonmani M, Manimekalai K. A Study of Serum Magnesium Level in Type 2 Diabetes Mellitus Patients. J Diabetes Mellitus 2018;8(02):20-6.
6. Noor MM, Nazir Q, Khan TM, Gillani S, Abbasi MA, Rauf A, et al. Association Between Low Serum Magnesium Level and Type 2 Diabetes Mellitus in Abbottabad. J Ayub Med Coll Abbottabad 2019; 31(2):226-9.
7. Murthy PSVR, Palvai K. A Study of Serum Magnesium Levels in Type 2 Diabetes Mellitus. Int J Sci Stud 2019;6(10):92-8.
8. Ramadass S, Basu S, Srinivasan AR. Serum magnesium levels as an indicator of status of Diabetes Mellitus type 2. Diabetes Metab Syndr: Clin Res Rev 2015;9(1):42–5.
9. Dalai SP, Meher LK, Hui PK, Panda S. Prevalence of Hypomagnesaemia and Its Correlation with Insulin Resistance and Glycemic Status in Patients with Type 2 DM. Int J Curr Adv Res 2017;6(4):3439-43.
10. Parlapally RP, Kumari KR, Jyothi SA. Serum Magnesium Levels in Type 2 Diabetes Mellitus. Int J Sci Stud 2016; 4(5):176-179.
11. Ferdousi S, Mollah FH, Mia MAR. Serum Levels of Zinc and Magnesium in Newly Diagnosed Type-2 Diabetic Subjects. Bangladesh J Med Biochem 2010;3(2):46-9.

12. Sahoo A, Pradhan B. Serum Magnesium Status among Type 2 Diabetes Mellitus and Its Chronic Complications. J Med Sci Clin Res 2019;7(5):207-13.
13. Ruhul-Kabir M, Kamrul-Hasan ABM, Burhan-Uddin SA, Majumder M, Rahman H, Nazmul-Islam AFM. Serum magnesium status and its correlation with insulin resistance in newly diagnosed patients with type 2 diabetes mellitus. Sri Lanka J Diabetes Endocrinol Metab 2019;9(1):11–7.
14. Tiwari D, Kumar N, Alam R, Khan MM. Evaluation of serum magnesium and zinc levels in patients with Type 2 diabetes mellitus. Int J Clin Biochem Rese 2017;4(3):245-8.
15. El Kateb M, Topf JM. Disorders of Magnesium Metabolism. In: Lerma EV, Sparks MA, Topf JM. eds. Nephrology secrets. 4th ed. Philadelphia: Elsevier. 2019; p. 541.
16. Barbagallo M, Dominguez LJ. Magnesium and type 2 diabetes. World J Diabetes 2015;6(10):1152-7.
17. Reddy BS, Pavuluri P, Chandan TS, Shetty P. Correlation between magnesium levels and HbA1C in controlled and uncontrolled type 2 diabetes. Int J Contemp Med Res 2018;5(11): K1-4.
18. Belhasan O, Sheriff D. Serum Magnesium Levels in Type 2 Diabetic Libyan Patients. J Pancreas 2017;18(2):121-4.
19. Kulkarni AG, Shendge SK, Shinde V. Study of Serum Magnesium Levels in Types 2 Diabetes Mellitus. IOSR J Dent Med Sci 2014;13(4 Ver. VII):115-9.
20. Mishra S, Padmanaban P, Deepti GN, Sarkar G, Sumathi S, Toora BD. 2012. Serum Magnesium and Dyslipidemia in Type-2 Diabetes Mellitus. Biomed Res 2012;23(2):295-300.
21. Prabhu R, Kunche S. Study of Serum Magnesium and HbA1c in Type 2 Diabetes Mellitus Patients. Int J Sci Res 2015;4(6):1521-4.
22. Masood N, Baloch GH, Ghori RA, Memon IA, Memon MA, Memon MS. Serum Zinc and Magnesium in Type-2 Diabetic Patients. J Coll Physicians Surg Pak 2019;19(8):483-6.
23. Karim R, Nargis W, Begum KA, Subhan SS, Uddin MN. 2014. Serum lipid profile, serum magnesium and fasting serum glucose in newly diagnosed type 2 diabetic subjects. Bangladesh J Med Biochem 2014;7(1): 4-8.
24. Gupta BB, Vaidya SA, Bhandari M, Behl S, Kosta S. Evaluate the differences in serum magnesium levels and lipid profile with correlation of hemoglobin A1C levels in type 2 diabetes patients: a case control study. Int J Res Med Sci 2019; 7(10): 3874-7.
25. Hussain KSA. Serum lipid profile and serum magnesium levels in newly diagnosed type 2 diabetic subjects and normal individuals: a case control study. Int J Adv Med 2018;5(4):825-7.
26. Khan LA, Alam AM, Ali L, Goswami A, Hassan Z, Sattar S, et al. Serum and urinary magnesium in young diabetic subjects in Bangladesh. Am J Clin Nutr 1999;69(1):70-3.
27. Siddiqui MU, Ali I, Zakariya M, Asghar SP, Ahmed MR, Ibrahim GH. Frequency of hypomagnesemia in patients with uncontrolled type II Diabetes mellitus. Pak Armed Forces Med J 2016; 66(6): 845-50.
28. Sales CH, Pedrosa Lde F. Magnesium Diabetes Mellitus: Their Relation. Clin Nutrition 2006;25:554-62.