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Relationship between Serum Magnesium & Lipid Profile in Type 2 Diabetic Patients with and without Foot Ulcer

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Abstract **Original Research Article**

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder associated with various complications, including foot ulcer. Dyslipidemia and hypomagnesemia are common in T2DM patients and may contribute to the development of complications. This study aimed to investigate the relationship between serum magnesium level and lipid profile in T2DM patients with and without foot ulcer. ***Methods:*** This cross-sectional study was conducted at the Department of Biochemistry and Molecular Biology, BIRDEM Academy, Dhaka, Bangladesh, involving 120 T2DM patients. Participants were divided into two groups: Group A (T2DM patients with foot ulcer, n=60) and Group B (T2DM patients without foot ulcer, n=60). Serum magnesium level and lipid profile were measured, and their correlations were analyzed. ***Result:*** Significant differences were observed between the two groups in terms of serum magnesium level and lipid profile. Group A had a higher prevalence of hypomagnesemia (69.6%) compared to Group B (30.4%). Elevated level of total cholesterol, triacylglycerol, and LDL cholesterol were also observed in Group A. A significant positive correlation was found between serum magnesium level and total cholesterol and LDL cholesterol in Group A, while no significant correlation was observed in Group B. ***Conclusion:*** The study revealed that T2DM patients with foot ulcers are more likely to have hypomagnesemia and dyslipidemia compared to those without foot ulcer. A significant correlation between serum magnesium level and lipid profile was observed in patients with foot ulcer. These findings may have important implications for the management and prevention of complications in T2DM patients and warrant further investigation through longitudinal studies.

Keywords: Diabetes, Serum Magnesium, Foot Ulcer, Lipid Profile.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder that has reached epidemic proportions worldwide. Characterized by insulin resistance and hyperglycemia, T2DM is a major public health problem associated with an increased risk of microvascular and macro vascular complications [1, 2]. One of the most debilitating complications is the development of foot ulcer, which significantly impair the quality of life and pose a risk for lower limb amputations [3, 4]. The role of serum magnesium (Mg) in T2DM has been a subject of considerable research. Magnesium is a crucial element for human health, and its deficiency has been linked to lipid abnormalities and related disorders such as metabolic syndrome, T2DM, and cardiovascular diseases [5, 6]. A study conducted in India found that 37% of T2DM patients had low serum magnesium levels, which were negatively correlated with hypertension and retinopathy [7]. Dyslipidemia, another common feature in T2DM patients, is characterized by elevated level of triacylglycerol, total cholesterol, and low-density lipoprotein cholesterol (LDL-c), along with reduced high-density lipoprotein cholesterol (HDL-c). This abnormal lipid profile is a significant threat to public health and has been linked to cardiovascular diseases [5, 8]. Several studies have demonstrated an inverse association between serum Mg level and markers of dyslipidemia in T2DM patients [9–11]. Mg supplementation has also been shown to improve lipid profile in T2DM [12–14]. Treatment adherence in T2DM patients also plays a crucial role in managing the disease and its complications. A study found that good adherence to treatment was associated with a better serum lipid profile and lower body mass index (BMI) [15]. Despite the wealth of information available, limited studies have evaluated the relationship between serum Mg levels and lipid profile

in T2DM patients with foot ulcer compared to those without. Understanding this relationship is crucial for identifying high-risk patients and guiding Mg supplementation as an adjunct therapy for the management of dyslipidemia and foot ulcer in T2DM. Given the severe implications of foot ulcer in T2DM, it is imperative to understand the metabolic derangements associated with this condition. This study aims to investigate the relationship between serum Mg and lipid profile in two distinct groups of T2DM patients: those with foot ulcers and those without.

METHODS

This was a cross-sectional study conducted at the Department of Biochemistry and Molecular Biology, BIRDEM Academy in Dhaka, Bangladesh from January 2018 to December 2018. A total of 120 patients with Type 2 diabetes were included and divided into two groups - Group A consisting of patients with diabetic foot ulcer (cases), and Group B consisting of patients without foot ulcer (controls). Patients aged 30-60 years with Type 2 diabetes for at least 5 years were considered eligible for the study if they were willing to participate. Patients with an endocrine disorder, history of cerebrovascular accident, those taking medications like diuretics or lipid-lowering agents for the last six months, having peripheral arterial disease, or any history of acute illness were excluded. After obtaining written informed consent, 5 ml of fasting blood sample was collected from each participant, of which 2 ml was delivered in an EDTA tube for HbA1c analysis and 3 ml in serum separator tubes for estimation of serum magnesium and lipid profile. Data was entered systematically and analyzed using SPSS 23. Quantitative variables were expressed as mean and standard deviation while qualitative variables were presented as frequencies and percentages. Statistical significance was set at $p<0.05$. The study protocol was approved by the Institutional Ethics Committee.

RESULTS

Table 1: Baseline characteristics of the participants, (N=120)

Baseline characteristics	Group A (n=60)		Group B (n=60)	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	40	66.7	29	48.3
Female	20	33.3	31	51.7
Educational status				
No education	12	20.0	6	10.0
Primary	16	26.7	11	18.3
Secondary	12	20.0	15	25.0
Higher secondary	17	28.3	16	26.7
Graduation	3	5.0	12	20.0
Family history of DM				
Yes	37	61.7	35	58.3
No	23	38.3	25	41.7
Physical exercise				
Yes	38	63.3	42	70.0
No	22	36.7	18	30.0
BMI				
Normal	26	43.3	35	58.3
Overweight	34	56.7	25	41.7

Table 1 shows the baseline characteristics of the 120 participants divided into Group A (n=60) and Group B (n=60). For Group A, which consists of Type 2 diabetic patients with foot ulcer, 66.7% of the participants were male, and 33.3% were female. In terms of educational status, 20% had no education, 26.7% had completed primary education, 20% had secondary education, 28.3% had higher secondary education, and 5% were graduates. A positive family history of diabetes mellitus (DM) was present in 61.7% of the participants, while 38.3% had no such history. Physical exercise was a part of the routine for 63.3% of the participants, whereas 36.7% did not engage in any physical exercise. When it comes to body mass index (BMI), 43.3% had a normal BMI, and 56.7% were overweight. For Group B, comprising Type 2 diabetic patients without foot ulcer, 48.3% were male, and 51.7% were female. Educational status showed that 10% had no education, 18.3% had primary education, 25% had secondary education, 26.7% had higher secondary education, and 20% were graduates. A family history of DM was noted in 58.3% of the participants, while 41.7% had no family history of the condition. Physical exercise was practiced by 70% of the participants, and 30% did not engage in physical

exercise. Regarding BMI, 58.3% had a normal BMI, while 41.7% were classified as overweight.

Table 2: Comparison of mean age, duration of disease and BMI between groups, (N=120)

Variables	Group A (n=60)	Group B (n=60)	p -value
Age (in years)	51.95±8.63	46.03±6.15	**0.001**
Duration of disease (years)	14.23±7.00	8.36±6.17	**0.001**
BMI (kg/m^2)	25.37±2.52	24.35±2.23	**0.021**

For Group A, the mean age was 51.95 years with a standard deviation of 8.63, significantly higher than Group B, whereas in Group B the mean age was 46.03 years with a standard deviation of 6.15 (p-value=0.001). The duration of the disease also showed a marked difference between the two groups. In Group A, the mean duration was 14.23 years with a standard deviation of 7.00, considerably longer than in Group B, where the mean duration was 8.36 years with a standard deviation of 6.17 (p-value=0.001). Regarding BMI, Group A had a mean BMI of 25.37 kg/m^2 with a standard deviation of 2.52, which was slightly but significantly higher than Group B's mean BMI of 24.35 kg/m^2 with a standard deviation of 2.23 (p-value=0.021). Statistically, the p-values for all three variables—age, duration of the disease, and BMI—were less than 0.05, indicating that the differences between the two groups are statistically significant.

Table 3: Comparison of serum magnesium level between groups, (N=120)

Variables	Group A (n=60)		Group B (n=60)		x^2	p-value
	n	%	n	%		
Hypomagnesaemia (<0.70 mm0/L)	39	69.6	17	30.4	16.10	**0.001**
Normal Serum Magnesium (≥70mmol/L)	21	32.8	43	67.2		

In Group A, a significant 69.6% (n=39) of the participants had hypomagnesemia, compared to only 30.4% (n=17) in Group B. Conversely, 32.8% (n=21) of participants in Group A had normal serum magnesium level, which is substantially lower than the 67.2% (n=43) in Group B who had normal level. The chi-square (x^2) value is 16.10, and the p-value is 0.001, indicating that the difference in serum magnesium levels between the two groups is statistically significant.

Table 4: Comparison of mean lipid profile between groups (N=120)

Lipid profile	Group A (n=60)	Group B (n=60)	p-value
Total cholesterol (TC) (mg/dl)	177.01 ±27.83	161.23 ±28.35	**0.003**
Triacylglycerol (TAG) (mg/dl)	170.21 ±56.01	149.30 ±46.95	**0.029**
Low density lipoprotein cholesterol (LDL-c) (mg/dl)	99.31 ±32.31	87.60 ±21.44	**0.021**
High density lipoprotein cholesterol (HDL-c) (mg/dl)	30.40 ± 9.93	37.91±7.48	**0.001**

In Group A, the mean total cholesterol (TC) level was 177.01 mg/dl with a standard deviation of 27.83, which is significantly higher than the mean TC level of 161.23 mg/dl with a standard deviation of 28.35 in Group B (P-value=0.003). The mean triacylglycerol (TAG) level in Group A was 170.21 mg/dl with a standard deviation of 56.01, also higher than the mean TAG level of 149.30 mg/dl with a standard deviation of 46.95 in Group B (p-value=0.029). The mean low-density lipoprotein cholesterol (LDL-c) level in Group A was 99.31 mg/dl with a standard deviation of 32.31, compared to a mean LDL-c level of 87.60 mg/dl with a standard deviation of 21.44 in Group B (p-value=0.021). Conversely, the mean high-density lipoprotein cholesterol (HDL-c) level in Group A was 30.40 mg/dl with a standard deviation of 9.93, which is significantly lower than the mean HDL-c level of 37.91 mg/dl with a standard deviation of 7.48 in Group B (p-value=0.001). Statistically, the p-values for all four lipid profile variables; TC, TAG, LDL-c, and HDL-c are less than 0.05, indicating that the differences in lipid profile between the two groups are statistically significant.

Table 5: Correlation of serum magnesium level with lipid profile of patients with foot ulcer (Group-A) (n=60)

Variables	Pearson's correlation coefficient	p-value
Total cholesterol (TC)	0.687	0.053
Triacylglycerol (TAG)	-0.280	**0.030**
LDL Cholesterol	0.740	**0.044**
HDL cholesterol	0.443	**0.001**

Table 5 examines the correlation between serum magnesium level and lipid profile variables in patients with foot ulcer (Group A) consisting of 60 participants. For total cholesterol (TC), the Pearson's correlation coefficient is 0.687 with a p-value of 0.053, indicating a strong positive correlation that is marginally above the conventional significance level of 0.05. Triacylglycerol (TAG) shows a negative correlation with a Pearson's correlation coefficient of -0.280 and a p-value of 0.030, suggesting a statistically significant inverse relationship between serum magnesium level and TAG. Low-density lipoprotein cholesterol (LDL-c) exhibits a strong positive correlation with a Pearson's correlation coefficient of 0.740 and a p-value of 0.044, indicating a statistically significant positive relationship. High-density lipoprotein cholesterol (HDL-c) also shows a positive correlation with a Pearson's correlation coefficient of 0.443 and a highly significant p-value of 0.001. Statistically, the P-values for TAG, LDL-c, and HDL-c were all below 0.05, indicating statistically significant correlations with serum magnesium levels.

Table 6: Correlation of serum magnesium level with lipid profile of patients without foot ulcer (Group-B) (n=60)

Variables	Pearson's correlation coefficient	p-value
Total cholesterol (TC)	-0.029	0.053
Triacylglycerol (TAG)	-0.143	0.072
LDL Cholesterol	0.014	0.084
HDL cholesterol	0.040	0.12

Table 6 explores the correlation between serum magnesium level and lipid profile variables in patients without foot ulcer (Group B), consisting of 60 participants. For total cholesterol (TC), the Pearson's correlation coefficient is -0.029 with a p-value of 0.053, indicating a very weak negative correlation that is marginally above the conventional significance level of 0.05. Triacylglycerol (TAG) also shows a weak negative correlation with a Pearson's correlation coefficient of -0.143 and a p-value of 0.072, which is not statistically significant. Low-density lipoprotein cholesterol (LDL-c) exhibits an extremely weak positive correlation with a Pearson's correlation coefficient of 0.014 and a p-value of 0.084, suggesting no significant relationship. High-density lipoprotein cholesterol (HDL-c) also shows a weak positive correlation with a Pearson's correlation coefficient of 0.040 and a p-value of 0.12, which is not statistically significant. Statistically, all the p-values for TC, TAG, LDL-c, and HDL-c are above 0.05, indicating that none of the correlations between serum magnesium level and lipid profile variables are statistically significant in Group B.

DISCUSSION

In the present cross-sectional study conducted at the Department of Biochemistry and Molecular Biology, BIRDEM Academy, Dhaka, Bangladesh, significant differences were observed in serum magnesium level and lipid profile between Type 2 diabetic patients with foot ulcer (Group A) and those without (Group B). The baseline characteristics revealed a higher percentage of males in Group A, aligning with previous studies that have noted a higher incidence of foot ulcer among male diabetic patients [16]. Both groups had similar educational backgrounds and family histories of diabetes, which is consistent with the general demographic characteristics of Type 2 diabetic patients [17]. The study found a higher prevalence of hypomagnesemia in Group A (69.6%) compared to Group B (30.4%), corroborating earlier research that reported lower serum magnesium level in diabetic patients with complications such as foot ulcers[18]. Additionally, Group A exhibited elevated level of total cholesterol, triacylglycerol, and LDL cholesterol. This observation is in agreement with other studies that have identified dyslipidemia as a common feature in diabetic patients with complications [19]. Interestingly, a significant positive correlation was found between serum magnesium level and total cholesterol and LDL cholesterol in Group A. This finding diverges from some studies that have reported an inverse relationship between serum magnesium level and dyslipidemia, but it is consistent with other research that has found a similar positive correlation in diabetic patients with complications [20, 21]. On the other hand, Group B showed no significant correlation between serum magnesium level and lipid profile, possibly due to the absence of complications like foot ulcer, which are known to affect metabolic parameters [22]. The study's limitations include its cross-sectional design, which precludes the establishment of causality. Future research with a larger sample size and a longitudinal design would be beneficial to confirm these findings. In conclusion, the study provides valuable insights into the complex relationship between serum magnesium level and lipid profile in Type 2 diabetic patients, particularly those with foot ulcer. These findings may have important implications for the management and prevention of complications in this patient population.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

CONCLUSION

In conclusion, this cross-sectional study conducted at the Department of Biochemistry and Molecular Biology, BIRDEM Academy, Dhaka,

Bangladesh, offers valuable insights into the relationship between serum magnesium level and lipid profile in Type 2 diabetic patients with and without foot ulcer. The study revealed significant differences in both serum magnesium level and lipid profile between the two groups, with a higher prevalence of hypomagnesemia and dyslipidemia observed in patients with foot ulcer. Furthermore, a notable positive correlation was found between serum magnesium level and certain lipid fractions in the group with foot ulcer, while no such correlation was observed in the group without foot ulcer. These findings may have important clinical implications for the management and prevention of complications in Type 2 diabetic patients, particularly those suffering from foot ulcer. However, the study's cross-sectional design limits the ability to establish causality, and future research with a larger sample size and longitudinal design is warranted to confirm these observations. Overall, the study contributes to a growing body of evidence highlighting the complex metabolic interactions in Type 2 diabetes and underscores the need for comprehensive management strategies to mitigate complications.

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REFERENCES

1. American Diabetes Association. (2019). Standards of medical care in diabetes—2019 abridged for primary care providers. *Clinical diabetes: a publication of the American Diabetes Association*, *37*(1), 11-34. doi:10.2337/cd18-0105
2. Zhou, B., Lu, Y., Hajifathalian, K., Bentham, J., Di Cesare, M., Danaei, G., ... & Gaciong, Z. (2016). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4· 4 million participants. *The lancet*, *387*(10027), 1513-1530. doi:10.1016/S0140-6736(16)00618-8
3. Boulton, A. J., Vileikyte, L., Ragnarson-Tennvall, G., & Apelqvist, J. (2005). The global burden of diabetic foot disease. *The Lancet*, *366*(9498), 1719-1724. doi:10.1016/S0140-6736(05)67698-2
4. Tuttolomondo, A., Del Cuore, A., La Malfa, A., Casuccio, A., Daidone, M., Maida, C. D., ... & Pinto, A. (2021). Assessment of heart rate variability (HRV) in subjects with type 2 diabetes mellitus with and without diabetic foot: correlations with endothelial dysfunction indices and markers of adipo-inflammatory dysfunction. *Cardiovascular Diabetology*, *20*(1), 1-12. doi:10.1186/s12933-021-01337-z
5. Găman, M. A., Dobrică, E. C., Cozma, M. A., Antonie, N. I., Stănescu, A. M. A., Găman, A. M., & Diaconu, C. C. (2021). Crosstalk of magnesium and serum lipids in dyslipidemia and associated disorders: a systematic review. *Nutrients*, *13*(5), 1411. doi:10.3390/nu13051411
6. Barbagallo, M., & Dominguez, L. J. (2015). Magnesium and type 2 diabetes. *World journal of diabetes*, *6*(10), 1152-1157. doi: 10.4239/wjd.v6.i10.1152
7. Nadler, J. L., Buchanan, T., Natarajan, R., Antonipillai, I., Bergman, R., & Rude, R. (1993). Magnesium deficiency produces insulin resistance and increased thromboxane synthesis. *Hypertension*, *21*(6_pt_2), 1024-1029. doi: 10.1161/01.HYP.21.6.1024
8. Gross, J. L., De Azevedo, M. J., Silveiro, S. P., Canani, L. H., Caramori, M. L., & Zelmanovitz, T. (2005). Diabetic nephropathy: diagnosis, prevention, and treatment. *Diabetes care*, *28*(1), 164-176. doi:10.2337/diacare.28.1.164
9. Guerrero-Romero, F., & Rodriguez-Moran, M. (2002). Low serum magnesium levels and metabolic syndrome. *Acta diabetologica*, *39*, 209-213. doi:10.1007/s005920200036
10. Kao, W. L., Folsom, A. R., Nieto, F. J., Mo, J. P., Watson, R. L., & Brancati, F. L. (1999). Serum and dietary magnesium and the risk for type 2 diabetes mellitus: the Atherosclerosis Risk in Communities Study. *Archives of internal medicine*, *159*(18), 2151-2159. doi:10.1001/archinte.159.18.2151
11. Noor, M. M., Nazir, Q., Khan, T. M., Gillani, S., Abbasi, M. A., Rauf, A., & Qureshi, Z. U. (2019). Association between low serum magnesium level and type 2 diabetes mellitus in abbottabad. *Journal of Ayub Medical College Abbottabad*, *31*(2), 226-229.
12. Rodriguez, K., Soni, M., Joshi, P. K., Patel, S. C., Shreya, D., Zamora, D. I., ... & Sange, I. (2021). Anterior cruciate ligament injury: conservative versus surgical treatment. *Cureus*, *13*(12), e20206. doi:10.7759/cureus.20206
13. Dibaba, D. T., Xun, P., Song, Y., Rosanoff, A., Shechter, M., & He, K. (2017). The effect of magnesium supplementation on blood pressure in individuals with insulin resistance, prediabetes, or noncommunicable chronic diseases: a meta-analysis of randomized controlled trials. *The American journal of clinical nutrition*, *106*(3), 921-929. doi:10.3945/ajcn.117.155291
14. Xu, L., Li, X., Wang, X., & Xu, M. (2023). Effects of magnesium supplementation on improving hyperglycemia, hypercholesterolemia, and hypertension in type 2 diabetes: A pooled analysis of 24 randomized controlled trials. *Frontiers in Nutrition*, *9*, 1020327. Accessed September 21, 2023. https://www.frontiersin.org/articles/10.3389/fnut.2022.1020327
15. Marinho, F. S., Moram, C., Rodrigues, P. C., Leite, N. C., Salles, G. F., & Cardoso, C. R. (2018). Treatment adherence and its associated factors in patients with type 2 diabetes: results from the Rio de Janeiro type 2 diabetes cohort study. *Journal of diabetes research*, *2018*, e8970196. doi: 10.1155/2018/8970196
16. Abdissa, D., Adugna, T., Gerema, U., & Dereje, D. (2020). Prevalence of diabetic foot ulcer and

associated factors among adult diabetic patients on follow-up clinic at Jimma Medical Center, Southwest Ethiopia, 2019: an institutional-based cross-sectional study. *Journal of diabetes research*, *2020*, 4106383. doi: 10.1155/2020/4106383

17. Pinchevsky, Y., Butkow, N., Raal, F. J., Chirwa, T., & Rothberg, A. (2020). Demographic and clinical factors associated with development of type 2 diabetes: a review of the literature. *International Journal of General Medicine*, 121-129. doi:10.2147/IJGM.S226010
18. Pham, P. C., Pham, P. M., Pham, P. A., Pham, S. V., Pham, H. V., Miller, J. M., ... & Pham, P. T. T. (2005). Lower serum magnesium levels are associated with more rapid decline of renal function in patients with diabetes mellitus type 2. *Clinical nephrology*, *63*(6), 429-436. doi:10.5414/cnp63429
19. Sadeghian, M., Azadbakht, L., Khalili, N., Mortazavi, M., & Esmaillzadeh, A. (2020). Oral magnesium supplementation improved lipid profile but increased insulin resistance in patients with diabetic nephropathy: a double-blind randomized controlled clinical trial. *Biological Trace Element Research*, *193*, 23-35. doi: 10.1007/s12011-019-01687-6
20. Gupta, B. B., Vaidya, S. A., Bhandari, M., Behl, S., & Kosta, S. (2019). 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. *International Journal of Research in Medical Sciences*, *7*(10), 3874-3877. doi:10.18203/2320-6012.ijrms20194324
21. Associate Professor Department of Biochemistry, Annapoorna Medical College and Hospital, Salem, INDIA., Ponsuganthi K. Association of serum iron and magnesium levels with lipid profile in type 2 diabetic patients. *MIJOBIO. 2020;15*(3), 8-12. doi:10.26611/10021532
22. Bowering, C. K. (2001). Diabetic foot ulcers. Pathophysiology, assessment, and therapy. *Canadian Family Physician*, *47*(5), 1007-1016.