Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2018, 7(5): 23-28

Evaluation of Magnesium Level and Its Correlation with Other Biochemical Markers among Type-2 Diabetic Participants

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ABSTRACT

Background and objective: *The incidence of diabetes mellitus is considered as a major global medical issue around the world in the recent years. Magnesium deficiency has a negative influence on glucose metabolism and plays a critical role in the initiation of diabetic complications. Hence, in the current study, we attempt to explore the level of magnesium ion and other biochemical markers in diabetic participants and to probe credential signs and the association between correlations with other biochemical markers studied in diabetic participants.* ***Subjects and methods:*** *The current study included 80 participants, out of which two groups were formed: 40 healthy participants with normal blood glucose level, 40 type 2 diabetes participants. Systolic blood pressure, diastolic blood pressure, glycated hemoglobin (HbA1c), fasting blood sugar (FBS), electrolyte profile (sodium, potassium, and magnesium), blood urea nitrogen (BUN), and creatinine were evaluated. Moreover, lipid profile (total cholesterol, triglycerides, and HDL-cholesterol) and the correlation between serum magnesium level and biochemical markers among diabetic participants were assayed.* ***Results:*** *Diabetic participants were characterized by a remarkable elevation in the FBS, HbA1c, BUN, creatinine level, potassium and a significant alteration in lipid profile as compared to healthy participants, while diabetic participants showed a significant decline in the sodium and magnesium levels as compared to healthy participants. Moreover, significant negative correlations were noticed with low serum magnesium and total cholesterol level, HDL-cholesterol, and potassium in diabetic participants.* ***Conclusion:*** *The alterations in lipid and electrolyte profiles observed in diabetic participants have great potential as a diagnostic tool in clinical practice especially hypomagnesaemia which was widespread among our diabetic participants and its correlations with other biochemical markers studied bears important clinical implications in achieving better control of the risk of diabetic complications.*

Keywords: Hypomagnesaemia, Diabetes mellitus, Metabolism, Correlation, Lipid, Electrolyte

INTRODUCTION

Diabetes mellitus is a metabolic disorder due to deficiency or misuse of insulin manifested through hyperglycemia [1]. The incidence of diabetes mellitus (DM) is considered as a major global medical issue around the world in the recent years [2,3]. According to the International Diabetes Federation in 2015, about 415 million of adults are type 2 diabetic patients, while it is estimated that by 2040 about 642 million will have diabetes [4]. Diabetes mellitus is associated with several complications such as hypertension, kidney disease, hyperlipidemia, and cardiovascular disease [5,6].

Diabetes mellitus is correlated with an imbalance in the metabolism of micronutrients. One of these micronutrients is magnesium. Magnesium is one of the intracellular cations in the body which plays a crucial role in many essential metabolic pathways such as cellular energy metabolism, regulation of ion transport and neuromuscular transmission [7]. Moreover, magnesium ion plays a critical role in lipid metabolism due to its essential co-factor in various enzymatic pathways such as in cholesterol metabolism where HMG-CoA reductase requires Mg^{2+} for its metabolic regulation [8]. Also, magnesium plays a critical role in the regulation of lipoprotein lipase and lecithin cholesterol acyltransferase (LCAT) activities [9].

The kidney plays a critical role in the regulation of magnesium and the maintenance of its level in the blood [10].

Magnesium has been considered as an ameliorative mediator in the treatment of diabetes mellitus and for common complications of diabetes mellitus. Magnesium is an important factor for insulin secretion and insulin action [11].

Previous studies have reported that magnesium deficiency impaired insulin secretion and reduced peripheral insulin sensitivity effects [12]. So, there is a close relationship between metabolic control of diabetes mellitus and impaired magnesium homeostasis. Magnesium deficiency has a negative influence on glucose metabolism and insulin sensitive diabetic subjects as well as on the initiation of diabetic complications. So, the current study attempts to explore the level of magnesium ion and other biochemical markers in diabetic participants and to probe credential signs and the association between correlations with other biochemical markers studied in diabetic participants.

PATIENTS AND METHODS

The present investigation incorporated 80 participants, out of which two groups were formed: 40 (20 males and 20 females) healthy participants, 40 (25 males and 15 females) type 2 diabetes patients. All the subjects provided with informed written consent before ingoing the investigational practice. All procedures followed were in accordance with the ethical standards and with the Helsinki declaration.

Diabetic participants were diagnosed according to the following criteria: fasting blood glucose $\geq$ 7 mmol/l and HbA1c $\geq$ 6.5%. Blood pressure (systolic and diastolic) was recorded. The age of the patients was within 36-70 years. Participants who have the history of cardiac dysfunctions, chronic inflammatory diseases, hypothyroidism, or any other disease were excluded from our study.

Blood samples from all participants were collected after 10-12 hours fasting, centrifuged and serum was aspirated, and stored at -20°C for subsequent biochemical analysis. Biochemical investigations of fasting blood glucose, lipid profile (total cholesterol, triglycerides, and HDL-cholesterol), blood urea nitrogen, creatinine, sodium, potassium, and magnesium were assayed according to manufacturer's instructions by using the automatic analyzer, ROCHE module Cobas 6000 (C-501 and C-601). The HbA1c assay was determined according to the manufacturer's protocol by using a kit from Crescent, KSA.

Statistical Analysis

The data analysis was performed using statistical software SPSS version 18.0 (SPSS Inc., Chicago, IL, USA). Data was presented as a mean ± standard error. Statistical analysis was performed using one-way ANOVA, and means was compared using Duncan's multiple range tests as a post-hoc test at 5% probability level. $p<0.05$ was considered statistically significant.

RESULTS

Out of 40 diabetic participants, 25 (62.5%) were males and 15 (37.5%) were females whereas, 20 (50%) were males and 20 (50%) females in the healthy control group. Systolic blood pressure (SBP) was significantly ($p<0.001$) high in diabetic participants as compared to healthy participants. Whereas, diastolic blood pressure (DBP) increased in diabetic participants insignificantly as compared to healthy participants. Demographic data of the study participants are clarified in Table 1.

Table 1 Demographic data of the healthy and diabetic participants (Mean ± Std. error)

Parameter	Healthy participants (n=40)	Diabetic participants (n=40)
Gender (M/F)	20/20	25/15
SBP(mmHg)	128.75 ± 0.86	149.90*** ± 1.91
DBP(mmHg)	80.03 ± 0.69	81.80 ± 1.06

M: male; F: Female; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; ***$p<0.001$ as compared to healthy participants

Alterations in the levels of fasting blood sugar (FBS), glycated hemoglobin (HbA1c) and lipid profile among healthy and diabetic participants were depicted in Table 2. Diabetic participants showed a remarkable ($p<0.001$) elevation in fasting blood sugar, glycated hemoglobin, total cholesterol and triglycerides levels as compared to that of healthy participants. Whereas, diabetic participants showed significantly ($p<0.001$) decline in the level of HDL-cholesterol in comparison to healthy participants, as shown in Table 2.

Table 2 Levels of fasting blood glucose, HbA1c, and lipid profile in healthy and diabetic participants (Mean ± Std. error)

Parameter	Healthy participants (n=40)	Diabetic participants (n=40)
FBS (mmol/l)	5.05 ± 0.11	8.97*** ± 0.20
HbA1c (%)	5.02 ± 0.13	8.27*** ± 0.13
Total cholesterol (mmol/l)	3.72 ± 0.09	5.03*** ± 0.10
Triglycerides (mmol/l)	1.24 ± 0.07	2.36*** ± 0.10
HDL-cholesterol (mmol/l)	1.26 ± 0.04	0.85*** ± 0.04
FBS: fasting blood sugar; HbA1c: glycated hemoglobin; HDL: High-density lipoprotein; ***p< 0.001 as compared to healthy participants		

Kidney function and electrolyte profile were assessed by evaluating the levels of blood urea nitrogen (BUN), creatinine, sodium (Na^+), potassium (K^+), and magnesium (Mg^{2+}), as summarized in Table 3. There was a significant elevation in the levels of BUN, creatinine, and potassium in diabetic participants as compared to healthy participants (Table 3). On the other hand, a remarkable and noticeable ($p<0.001$) decline was found in the levels of sodium and magnesium in diabetic participants as compared to healthy participants, as depicted in Table 3.

Table 3 Kidney profile and electrolyte profile in healthy and diabetic participants (Mean ± Std. error)

Parameter	Healthy participants (n=40)	Diabetic participants (n=40)
BUN (mmol/l)	4.32 ± 0.19	7.88*** ± 0.35
Creatinine(µmol/l)	75.52 ± 2.09	167.15*** ± 8.45
Sodium (mmo/l)	140.20 ± 0.41	135.39*** ± 0.48
Potassium (mmol/l)	4.29 ± 0.06	4.80*** ± 0.10
Magnesium (mmol/l)	0.97 ± 0.02	0.74*** ± 0.01
***p< 0.001 as compared to healthy participants		

Table 4 illustrates the correlation coefficients (Pearson) between serum magnesium (Mg^{2+}) and other biochemical markers in diabetic participants. Relatively higher values of fasting blood sugar (FBS), glycated hemoglobin (HbA1c), and creatinine were observed in diabetic participants with a low level of serum magnesium (Mg^{2+}) but the magnitude of the negative correlation between serum Mg and previous markers was low and non-significant. However, high level of serum cholesterol was significantly correlated with serum Mg ($r=-0.94$; $p<0.05$). Low level of serum HDL-cholesterol was significantly correlated with serum Mg ($r=-0.27$; $p<0.05$). Also, high level of serum potassium was significantly correlated with serum magnesium ($r=-0.40$; $P<0.01$), as shown in Table 4.

Table 4 Biochemical correlation between serum magnesium level and biochemical markers among diabetic participants (n=40)

Biochemical markers	Magnesium level	
	Correlation coefficient (r) value	p-value
FBG(mmol/l)	-0.03	NS
HbA1c (%)	-0.07	NS
Total cholesterol (mmol/l)	-0.29	p<0.05
Triglycerides (mmol/l)	0.15	NS
HDL-cholesterol (mmol/l)	-0.27	p<0.05
BUN (mmol/l)	0.16	NS
Creatinine(µmol/l)	-0.15	NS
Sodium (mmo/l)	0.08	NS
Potassium (mmol/l)	-0.4	p<0.01
NS: Non-significant; p<0.05 considered significant; p<0.01 considered highly significant		

DISCUSSION

Electrolyte imbalance found in diabetics is a remarkable diagnostic tool in clinical practice and has a significant impact on the risk of contracting diabetes complications [13]. Hence, our present investigation was an attempt to investigate the levels of electrolyte profile and other biochemical markers in diabetic participants and to clarify the credential signs and the biochemical correlations between magnesium and other biochemical markers studied in diabetic participants. In our study, out of 80 participants, two groups were formed; 40 healthy participants with normal blood glucose level and 40 diabetic participants with abnormal glucose level and glycated hemoglobin.

The current investigation revealed remarkable elevation of fasting blood sugar and HbA1c in the diabetic participants as compared to healthy participants. These results are in harmony with the findings of the studies reporting that hyperglycemia and elevated glycated hemoglobin have been observed in diabetic subjects [1,14].

Diabetic patients exhibited an alteration in lipid profile and characterized by significant elevation in total cholesterol and triglycerides as compared to healthy participants. Also, diabetic subjects showed a remarkable decline in HDL-cholesterol. These findings run parallel to those previous studies reporting that diabetic patients showed significant alterations in lipid profile levels which played a critical role in the development of dyslipidemia and other diabetic complications [1,15,16]. There are many factors contributing to the alterations in lipid profile in diabetic subjects, including hyperglycemia and insulin deficiency or resistance [17]. A decline in HDL-cholesterol level in diabetic subjects increased the risk of cardiovascular disease, due to a sensitive marker for an elevated level of atherogenic triglyceride-rich lipoproteins [18,19].

Blood urea nitrogen and creatinine are the simplest way to monitor kidney function [20]. The current study showed a significant elevation of blood urea nitrogen and creatinine levels in diabetic participants as compared to healthy participants, our findings run parallel to those previous reports stating that the high glucose level in diabetic state causes severe imbalance between protein metabolism and negative nitrogen balance, which in turn clarifies the elevated blood urea nitrogen and creatinine levels in blood of diabetic patients [19,21].

Significant alterations in electrolyte profile were observed in diabetic participants, sodium and magnesium level decreased, whereas a remarkable elevation in the level of potassium was noticed in diabetic participants. Our results are consistent with previous reports stating that the hyponatremia and hypomagnesaemia observed in diabetic subjects related to the osmotic diuresis is due to hyperglycemia and insulin resistance which in turn enhances urinary sodium and magnesium loss in response to the elevated level of glucose [22,23].

Regarding the biochemical correlation between serum magnesium and other biochemical markers studied, a remarkable correlation of blood magnesium with serum total cholesterol and HDL-cholesterol were detected in diabetic participants. The association of magnesium with lipid dysfunction appears conceivable as it is an essential co-factor in lipid metabolism. Our findings are consistent with who reported that there is a strong association between hypomagnesaemia and lipid profile in diabetic patients [24].

Moreover, the lower serum Mg levels are correlated with an alteration with renal function profile in diabetic subjects and revealed that serum magnesium has a highly significant and non-significant negative correlation with serum potassium and creatinine levels, respectively. Consistent with our findings, Yossef, et al., Pham, et al., and Dasgupta, et al., concluded that hypomagnesaemia in diabetic patients is considered as a novel predictor of end-stage renal disease [25-27].

CONCLUSION

The alterations in lipid and electrolyte profiles observed in diabetic participants have great potential as a diagnostic tool in clinical practice especially hypomagnesaemia which was widespread among our diabetic subjects and its correlations with other biochemical markers study bears important clinical implications in achieving better control of the risk of diabetic complications.

DECLARATIONS

Conflict of Interest

The authors have disclosed no conflict of interest, financial or otherwise.

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