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Research Article

The Effect of Magnesium Supplementation on Hba1c Level and Lipid Profile Among Type 2 Diabetics

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Abstract

Background: Diabetic patients usually suffer from magnesium deficiency. Increased magnesium intake may improve insulin secretion and glycemic control, and improves lipid profile. Magnesium supplementation has a clinically beneficial effect on glycemic control in type 2 diabetics. Oral magnesium supplementation has been shown to be effective in raising serum or plasma magnesium which contributes to glycemic control and improved lipid profile. The aim of this study was to evaluate the evidence of the effect of oral magnesium supplementation on glycemic control and lipid profile in patients with Type 2 diabetes.

Material and Methods: 41 individuals participated in this study 19 healthy and 22 were divided into 2 groups: group 1(control n=19 healthy) and group 2 (treatment n=22 with Type 2 diabetes) were divided into 3 subgroups depending on HbA1c values. Both groups were given given 350 mg/day oral magnesium supplementation for 8 weeks. HbA1c, TC, TG, HDL and LDL were measured in the beginning and at the end of the trial duration.

Results: 8 weeks of Magnesium supplementation increased serum Magnesium in group 2 by 22.9% and level of HbA1c was significantly lower in both groups but the reductions were greater in 3 treatment sub-groups (20.8%). The difference in post-intervention with Magnesium supplementation in sub-groups and control group was significant ($P<0.05$). Magnesium supplementation improved lipid profile in both groups. It decreased TC (16%), TG (15.8 %), LDL-C (20.9 %) and increased HDL-C (20.6%) and subsequently improved LDL-C/HDL-C ratio. The difference between control and treatment groups of all parameters was statistically significant.

Conclusion: Oral Magnesium supplementation for 8 weeks shown to be effective in reducing HbA1c, TC, TG, LDL levels and raising HDL level in patients with Type 2 diabetes and can be considered as prevention and treatment of DM type 2 and its complications. The daily diet should include a dietary source of magnesium or a supplement.

Keywords: Magnesium; HbA1c; LDL-C; TG; TC; HDL-C

Introduction

Magnesium is an abundant macro-element in the human body and plays an important role in many biological processes. Normal magnesium values are between 1.8–2.3 mg/dL and its deficiency is defined as a drop in its normal serum concentrations below 1.7 mg/dL [1]. Magnesium deficiency can cause many chronic diseases such as Diabetes, hypertension, and cardiovascular diseases. The most common health issue which associated to Magnesium deficiency is Diabetes Mellitus in addition to many other problems [2]. It's estimated that one-third of type 2 diabetics have low levels of Magnesium which is caused mainly by enhanced renal excretion of Magnesium [3]. There are several causes for low Magnesium levels in diabetics including diets low in Magnesium, osmotic diuresis that leads to high renal excretion of Magnesium, These deficits have been also linked to other complications such as development of atherosclerosis, [4,5] and in patients with coronary atherosclerosis, a Magnesium deficit has been related to an atherogenic lipid profile [6].

Many studies have shown that Magnesium supplementation improves insulin sensitivity [7]. Dietary supplementation with Magnesium in addition to classical therapies for diabetes may help in prevention or delaying of diabetic complications [8]. Oral Magnesium supplementation improves insulin sensitivity and metabolic control in type 2 diabetics with lower serum Magnesium levels. It has also been shown that it has beneficial effect on lipid profile of diabetic patients [9,10].

The aim of this study was to measure the levels of Magnesium in serum of type 2 diabetics and to find out its relationship to Hba1c and lipid profile. The other aim was to evaluate the effect of oral Magnesium supplementation on the improvement in Hba1c values and in lipid profile parameters.

Material and Methods

The study was carried out between March and May 2018 on 41 type 2 diabetic participants (21 males and 20 females). The inclu-

sion criteria for enrolled participants were: previous diagnosis with Type 2 diabetes, age between 28 and 58 years, males and females. Whereas the exclusion criteria were: Patients who have renal disease diagnosed by serum urea and creatinine test, diuretics usage in the last 2 weeks and patients with persistent diarrhea and vomiting.

The participants were divided into 2 groups:

- **Group I:** Control group consisted of 19 participants which had 9 males and 10 females. The participants of this group were healthy and their HbA1c and lipid profile values were within the normal range.
- **Group II:** Study group consisted of 22 Participants. This group had 12 males and 10 females.

The second group or the study group was divided into 3 subgroups according to the HbA1c values as follows:

- **Subgroup 1:** HbA1c 6 - 7 (7 participants)
- **Subgroup 2:** HbA1c 7-8 (7 participants)
- **Subgroup 3:** HbA1c > 8 (8 participants).

In order to measure Magnesium serum value and lipid profile, COBAS Intergra 400 plus (Roche, Germany) was used during this study.

Prior to enrollment in this study, a signed consent was obtained from all participants. Blood samples were drawn twice from all participants at the beginning and at the end of this study in order to measure serum Magnesium, HbA1c, and lipid profile. A professional nurse drew blood samples under supervision of lab supervisor. 300 mg Magnesium of oral Magnesium oxide supplementation were given daily for 8 weeks (Magnesium oxide was manufactured by Douglas lab (USA) 250 tablets per container.

All data were statistically analyzed using SPSS 15.0 for windows (SPSS Inc., Chicago, IL). Age and serum Magnesium, LDL-C, HDL-C, TG, TC of participants were expressed as the mean ± SD and median (range), and improvements in Magnesium levels, Hba1c levels and lipid profile were expressed as percentage and a P value of < 0.05 was considered significant.

Results

The results of this study have shown that the mean age of the participants was 43.18 ± 15.29 years and the mean serum Magnesium level among all participants before supplementation was 1.61 ± 0.46 mg/dL. According to the cut-off level of normal serum Magnesium (1.7 mg/dL) the values indicate that most participants (88.3%) were magnesium deficient. Before supplementation, they were more deficient females than males (89.3 % and 87.2 % respectively).

Serum Magnesium level has gone up after supplementation among all participants from 1.61 ± 0.46 mg/dL to 1.64 ± 0.51 mg/dL. The highest increase were among females (11.8%) comparing with males (4.6%). When comparing groups, the study group had the highest increase in serum Magnesium level comparing with the control group. The increase was 22.5 % and 1.9 % respectively and the difference was statistically significant (P < 0.05). These results are shown in Table 1 and Table 2.

	Males	Improvement	Females	Improvement	All participants	Improvement
Before	1.53 ± 0.41	4.6 %	1.36 ± 0.33	19.1 %	1.61 ± 0.46	8 %
After	1.59 ± 0.43 [c]		1.62 ± 0.41 [a]		1.74 ± 0.51 [b]	

Table 1: Serum Magnesium levels differences between genders before and after supplementation.

* Different letter denotes significant difference (P < 0.05).

	Group1	% improvement	Group 2	% improvement
Before	1.61 ± 0.53	1.9 %	1.38 ± 0.49	22.9 %
After	1.64 ± 0.61 [b]		1.79 ± 0.56 [a]	

Table 2: The improvement in serum Magnesium level in groups after supplementation.

* Different letter denotes significant difference (P < 0.05).

The data demonstrated in Table 3, has shown strong correlations between serum Magnesium and HbA1c values within groups (control and study groups) alike. Supplementation of Magnesium resulted in 8.8% improvement in HbA1c values in group I (Healthy group) whereas the highest improvement (20.8 % reduction) was seen among participants who had Hba1c higher than 8 followed by those with HbA1c values 7-8 and the slightest decrease was in sub-group with HbA1c values 6-7. The difference was statistically significant between group I and II (P < 0.05).

Table 4 shows that there was statistically significant difference in TG between group I and group II (P < 0.05). The reduction in TG value in group I was 6.9%. This reduction was higher in group II after Magnesium supplementation.

HbA1c Values	Group I		Group II					
	Healthy		HbA1c 6- 7		HbA1c 7- 8		HbA1c > 8	
Before	5.7 ± 1.23	8.8 %	6.9 ± 1.54	10.1 %	7.8 ± 1.67	17.9 %	9.6 ± 1.69	20.8 %
After	5.3 ± 1.11 [d]		6.2 ± 1.43 [c]		6.4 ± 1.53 [b]		7.6 ± 1.45 [a]	

Table 3: The effect of Magnesium supplementation on HbA1c values.

* Different letter denotes significant difference (*P<0.05*).

Group		Supplementation	Mean serum TG	% Improvement
Group I	Healthy	Before	175.1 ± 23.4	6.9
		After	163 ± 21.2 [b]	
Group II	HbA1c 6-7	Before	171.8 ± 23.2	4.8
		After	163.6 ± 20.9 [b]	
	HbA1c 7-8	Before	174.4 ± 27.1	11.9
		After	153.6 ± 25.3 [a]	
	HbA1c >8	Before	179.2 ± 26.1	15.8
		After	150.8 ± 19.2 [a]	

Table 4: Mean Serum TG of the groups before and after supplementation.

* Different letter denotes significant difference (*P< 0.05*).

Supplementation of Magnesium resulted in improvement in low density lipoprotein (LDL-C) value in both groups. But this improvement was greater in group II and especially in those with mean serum HbA1c more than 8. The reduction was 20.9 %. The difference was statistically significant (P < 0.05). The results are shown in table 5.

With regard to total cholesterol, the data obtained from this study showed that Magnesium supplementation improved total cholesterol in group II only. The reduction was greater in subgroup 3 (Hba1c >8) and the reduction was 16% comparing to -0.7% in group I. The difference was statistically significant (P < 0.05) as seen in table 6.

Group		Supplementation	Mean Serum LDL-C	% Improvement
Group I	Healthy	Before	141.7 ± 18.3	6.9
		After	131.9 ± 18.1 [d]	
Group II	HbA1c 6-7	Before	139.8 ± 17.3	6.2
		After	131.2 ± 15.8 [c]	
	HbA1c 7-8	Before	133.7 ± 15.6	4.7
		After	127.4 ± 16.2 [b]	
	HbA1c >8	Before	151.6 ± 14.1	20.9
		After	119.9 ± 11.3 [a]	

Table 5: Serum LDL-C improvements of the groups.

* Different letter denotes significant difference (*P< 0.05*).

Group		Supplementation	Mean Serum TC	% Improvement
Group I	Healthy	Before	215.6 ± 19.3	- 0.7
		After	217.2 ± 18.6 [d]	
Group II	HbA1c 6-7	Before	223.4 ± 18.3	5.6
		After	210.8 ± 17.4 [c]	
	HbA1c 7-8	Before	231.5 ± 16.2	11.5
		After	204.8 ± 16.1 [b]	
	HbA1c >8	Before	232.6 ± 16.9	16
		After	195.4 ± 14.8 [a]	

Table 6: Serum TC improvements of the groups.

* Different letter denotes significant difference (*P< 0.05*).

Table 7 shows that Magnesium supplementation is positively correlated with high density lipoprotein (HDL-C). The increase was in both groups (I and II) but the highest increase was in group II and more specifically in those with HbA1c value more than 8. The difference was statistically significant ($P < 0.05$).

As Magnesium supplementation has improved mean LDL-C, HDL-C and total cholesterol (TC) values, these improvements have been reflected in LDL-C/HDL-C ratio as shown in table 8. The best ratio was in group II.

Group		Supplementation	Mean Serum HDL-C	% Improvement
Group I	Healthy	Before	40.8 ± 2.8	8.5
		After	44.6 ± 2.1 [c]	
Group II	HbA1c 6-7	Before	40.1 ± 2.4	4.3
		After	41.9 ± 2.4 [d]	
	HbA1c 7-8	Before	40.1 ± 1.9	14.3
		After	46.8 ± 2.2 [b]	
	HbA1c >8	Before	40.2 ± 2.7	20.6
		After	50.6 ± 2.9 [a]	

Table 7: Serum HDL-C improvements of groups.

* Different letter denotes significant difference (*P< 0.05*).

Group		Supplementation	LDL-C/HDL-C Ratio	% Improvement
Group I	Healthy	Before	3.47	13.5
		After	3 [c]	
Group II	HbA1c 6-7	Before	3.48	14.1
		After	3.05 [d]	
	HbA1c 7-8	Before	3.33	18.3
		After	2.72 [b]	
	HbA1c >8	Before	3.11	24.1
		After	2.36 [a]	

Table 8: LDL-C/HDL-C ratio of the groups.

Discussion

To the best of our knowledge, this is a pioneer study to link Magnesium supplementation to improvement of glucose level and lipid profile parameters in order to reduce diabetic complications .As many studies have demonstrated that Magnesium is an important cation which plays a significant role in glucose and insulin metabolism, mainly through its impact on tyrosine kinase enzyme. Magnesium may also directly affect glucose transporter protein activity 4 and regulate glucose translocation into the cell. The data obtained from this study that Magnesium supplementation positively correlated with reduction in HbA1c values. This finding is similar to study carried out by Galli-Tsinopoulou., *et al.* [11]. Ramadass., *et al.* [12] Sinha and Sen [13] showed similar results in adult patients with type 2 diabetes.

There was statistically significant difference in serum lipids level after Magnesium supplementation in the study group (group II). Magnesium supplementation reduced mean serum TG, TC, and LDL-C levels but increases HDL-C levels. The best results were in group II and more specifically in those with HbA1c level higher than 8. These outcomes are in concordance with [13] and Mishra., *et al*. [14]. Guerrero-Romero and Rodríguez-Morán [8] showed that in type 2 diabetics, low magnesium is linked with low levels of HDL.

The data obtained from this study showed that there was statistically significant difference in serum Magnesium level before and after Magnesium supplementation being higher after Magnesium supplementation with mean ± SD of Magnesium was 1.64 ± 0.61 Magnesium/dL before Magnesium supplementation versus 1.79 ± 0.56 Magnesium/dL after Magnesium supplementation ($P < 0.05$). This is in agreement with Rodriguez-Moran and Guerrero- Romero [8] in type 2 diabetic adults revealed that there is a significant increase in serum Magnesium after a period of oral Magnesium supplementation who revealed increase in serum Magnesium level with Magnesium supplementation (500 Magnesium twice daily of Magnesium Oxide) for 24 weeks in adult patients with type 1 diabetes.

Our study showed that there was a significant difference between HbA1c before and after Magnesium supplementation as mean value of HbA1c after supplementation. The greater improvement in HbA1c values was in group II in those with HbA1c value higher than 8. This indicates that oral Magnesium supplementation may play a good role on glycemic control diabetes [14]. This result is concordant with Rodriguez-Moran and Guerrero-Romero [8] who showed that Magnesium chloride supplementation resulted in significant reduction of HbA1c.

Lopez-Ridaura., *et al.* [15] also showed that Magnesium supplementation decreases the risk of type 2 diabetes in adult population.

Meta-analysis study was done by Simental-Mendía., *et al.* [16] to observe the effect of oral Magnesium supplementation on insulin sensitivity and glucose control in both diabetic and non-diabetic individuals. In this study, there was a significant difference in lipid parameters after oral Magnesium supplementation. This is in agreement with Djurhuus., *et al.* [17] and [18] observed decreased atherogenic lipid fractions (total cholesterol, LDL, and Apo lipoprotein B), with Magnesium supplementation. Also Lal., *et al*. [19] observed a significant fall in serum total cholesterol, LDL, and triglycerides and a rise in HDL 4 to 8 weeks after Magnesium supplementation which consistent with our study also Solati., *et al.* [20-23] showed a significant reduction in LDL in Magnesium supplemented diabetic patients.

Conclusion

This study have shown that Magnesium deficiency is widely spread in type 2 diabetics, and it is supplementation is correlated with glycemic control and lipid profile. The study has also concluded that correction of low Magnesium in type 2 diabetics with oral Magnesium supplements is associated with optimization of glycemic control and improvement in lipid profile. Therefore, Magnesium supplementation can be used as prevention of type 2 diabetes or as a tool of glycemic control and improvement of lipid profile parameters among type 2 diabetics and as a prevention of diabetic complications such as cardiovascular diseases.

Recommendations

As it has shown that Magnesium plays an important role in improving HbA1c level in general and glycemic control in particular in type 2 diabetics and also has an important role in reducing LDL-C, TC, TG levels and increasing HDL-C levels. It's recommended that our meals should contain adequate amount of magnesium from its natural resource. If this difficult, supplements remain another option. The RDA for Magnesium is 310–420 mg for adults depending on age and gender. The main Magnesium sources are Whole Wheat, spinach, quinoa, almonds, cashews, peanuts, dark Chocolate, black Beans, edamame and avocado.

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