http:// ijp.mums.ac.ir
Original Article (Pages: 1767-1775)

Comparison of Growth Parameters, Apgar Scores, the Blood Zinc, Magnesium, Calcium and Phosphorus between Gestational Diabetic and Non-diabetic Pregnant Women

Mohammad Keshvari-Delavar[1], *Hassan Mozaffari-Khosravi [2,3], Azadeh Nadjarzadeh[4,5], Zahra Farhadian[6], Salman Khazaei[7], Shahab Rezaeian[8]

[1]MSc of Public Health in Nutrition, International Compus, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [2]Professor, Department of Nutrition, Health Faculty, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [3]Yazd Diabetic Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [4]Assistant Professor, Department of Nutrition, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [5]Food and Nutrition Security Research Center, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. [6]MSc in Food Science and Technology, Ghods branch, Islamic Azad University, Tehran, Iran. [7]Department of Epidemiology, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran. [8]Social Development & Health Promotion Research Center, Gonabad University of Medical Sciences, Gonabad, Iran.

Abstract

Background: Due to little attention to the combined effect of diabetes and pregnancy on mother an infant's microelements in literatures. This study aimed to compare newborns growth parameters, Apgar score, the cord blood zinc, magnesium, calcium and phosphor between pregnant women with and without gestational diabetes mellitus.

Materials and Methods: This prospective cohort study was conducted in Hamadan city, Iran, during 2013-14. Gestational diabetes considered as exposure and 20 women with gestational diabetes were individually matched with the 20 non-diabetic pregnant women in terms of the variables age, number of pregnancies, and type of delivery were included in this study. The cord blood and mother vein blood samples were taken immediately after delivery.

Results: The mean of newborn's head circumference was 34.85±0.9 cm and 33.90±0.97 cm in mothers with gestational diabetes and non- diabetic mothers respectively (P<0.05). The mean of cord blood calcium was 9.81±0.6 mg/dl in the exposed group and 10.23±0.4 mg/dl in the control group (P<0.05) and these figures for zinc were 79.05±13.1 mg/dl in the exposed group and 86.96±11.6 mg/dl in the control group (P<0.05).

Conclusion: This prospective cohort study showed the imbalance of some micronutrient in cord blood of mothers with gestational diabetes in comparison to non-diabetic mothers. Therefore in pregnant women with gestational diabetes should be more attention to be paid the concentrations of microelements.

Key Words: Calcium, Gestational diabetes, Magnesium, Phosphorus, Pregnant women, Zinc.

*Please cite this article as: Keshvari-Delavar M, Mozaffari-Khosravi H, Nadjarzadeh A, Farhadian Z, Khazaei S, Rezaeian Sh. Comparison of Growth Parameters, Apgar Scores, the Blood Zinc, Magnesium, Calcium and Phosphorus between Gestational Diabetic and Non-diabetic Pregnant Women. Int J Pediatr 2016; 4(5): 1767-75.

Corresponding Author:
Dr. Hassan Mozaffari-Khosravi, Department of Nutrition, Health Faculty, Shahid Sadoughi University of Medical Sciences, Bahonar square, Yazd, Iran. Fax: +98-351 7258413.

Email: mozaffari.kh@gmail.com

Received date Jan 10, 2016 ; Accepted date: Feb 22, 2016

1- INTRODUCTION

Gestational diabetes mellitus (GDM) refers to a condition in which glucose intolerance creates during pregnancy and about 40 percent of the pregnant women will be affected with diabetes during lifetime (1). Numerous factors have been reported as the potential causes of increased incidence of GDM such as age, pre-pregnancy weight, family history of diabetes mellitus, race and increase the body's resistance to insulin due to increased secretion of the hormones estrogen and progesterone (2). On the other hand, gestational diabetes may increase fetal mortality so women at risk of GDM should be evaluated for diabetes in weeks 24 to 28 of pregnancy (3).

Various studies showed that level of some of the major and essential trace elements varies in pregnant women with disorder of blood sugar and could lead to some complications (4, 5). Borella et al. showed that a slight, but significant, increase in plasma zinc observed in diabetes pregnant women, probably as a result of reduced zinc uptake by the fetus (6). Also result of a study, indicated that hypomagnesemia results specifically from a reduction in tubular absorption of magnesium (7). A population-based cohort study (8) revealed that folic acid supplementation might help to prevent pre-eclampsia and small for gestational age. In addition, another systematic review showed that zinc supplementation during pregnancy is associated with a 14% reduction in premature deliveries (9). On the other hand, infants of diabetic mothers also have many problems. They are suffering from long- term greater adiposity and adverse cardio-metabolic health (10).

Some studies have shown that micronutrient deficiency is one of the serious issues in many countries for pregnant women. Essential trace elements such as zinc and manganese are vital elements for growth, protein and carbohydrate metabolism, gene transcription, endocrine function and the transfer of nutrients in humans. The deficiency of these essential trace elements could have devastating effects on the health of the mother, fetus and newborn (8, 11, 12). Other studies have shown that diabetes mellitus and pregnancy can have combined effects and caused both physiological and pathological disturbances in concentrations of macro and microelements and therefore caused fetal variations (7, 13). But majority of articles have investigated the effects of pregnancy or diabetes mellitus on mineral metabolism, and little attention has been paid to the combined effects of diabetes and pregnancy, due to increased prevalence of GDM and its consequences on the mother and newborn' health in Iran, therefore this study aimed to compare newborns growth parameters, Apgar score, the cord blood zinc, magnesium, calcium and phosphorus between pregnant women with and without gestational diabetes mellitus.

2- MATERIALS AND METHODS

2-1. Design and participants

The local Human Subject Review Board of Yazd University of Medical Sciences approved this study. This prospective cohort study was conducted during 2013-2014 in Hamadan city, Iran (**Figure.1**). The study population was pregnant women who were admitted in the Fatemieh hospital of Hamadan. The exposed group was 20 women with gestational diabetes and control group were 20 non-diabetic pregnant women. The exposed were individually matched with the associated controls in terms of the variables age, number of pregnancies, and type of delivery. Inclusion criteria for the study were:

- lack of previous history of diabetes in the mother,

- affliction to gestational diabetes, availability of pregnancy records, and
- relevant tests and having complete course of pregnancy.

Mothers who were not willing to cooperate or have had insulin injection during pregnancy, history of abortion, history of antioxidant drugs consumption during pregnancy or history of digestive and kidney diseases were excluded from the study.

Fig.1: Location of Hamadan city, Iran

2-2. Measurements tool

Data collection tool was a checklist consisting of demographic and anthropometric information of the mother and her newborn including age, height, current weight, pre-pregnancy weight, body mass index (BMI), postpartum weight, sugar level (at different stages), the number of previous deliveries, smoking status, drug consumption, digestive disorders, history of abortion, and type of delivery.

Information relating to mother's blood sugar status at different stages was obtained from laboratory records. Body weight of mothers was measured in kilograms using a carriage scales device with Beurer brand and model MS50 without shoes and with minimal clothes.

Sampling was done with the informed consent of mothers, and was performed by nurses. Mothers with gestational diabetes and control groups sampled both in a hospital. Height of mothers was measured without shoes in centimeters using a tape measure. Weight of newborns was measured using a carriage scales Kubota and head circumference size was measured with a tape measure. The height of newborns was measured by height gauges in lying mode with legs straight. After delivery, 4 ml cord blood was taken from the end of umbilical cord and also from mother's cubital vein. All tubes and sampler head were washed with acid and deionized water to be free of elements. Complete taken blood was centrifuged after transferring the laboratory and the obtained serum was carefully collected inside the washed polyethylene tubes with lids and was stored at -20°C up doing analysis. The colorimetric method was used to determine phosphorus, calcium, zinc and magnesium concentrations.

2-3. Statistical Analysis

Data were analyzed using SPSS software version 19. The student t-test was used to compare the mean of two quantitative variables and the Chi-square test was used to investigate the association of qualitative variables. Also to determine the effect of exposure GDM on micronutrients in blood of mother and her newborn, linear regression was used. Also to determine the correlation between the studied variables, the Pearson correlation coefficient was used. The significance level was considered as P-value less than 0.05.

3- RESULTS

Out of 20 subjects in exposed group 65% were lived in urban areas while in control group this proportion was 50%. 80% of people in the exposed group and 90% in the control group were housekeeper. In the exposed group 25% had higher than diploma, compared with

10% in the control group. The proportion of demographic characteristics between exposed and a control group is shown in (**Table.1**). In both groups 75% of deliveries were natural delivery and 25% of them were cesarean section. Also there was no significant difference between mothers' job, education and location status in two groups.

The mean of variables among mothers and newborn (such as height, weight and some micronutrients concentration in cord blood of newborns and mothers vein blood) by exposed and control groups are presented in (**Table.2**). There was no significant difference between mean of height, pre-pregnancy weight and weight of mothers in two groups. The mean of mother's BMI in exposed group was significantly higher than that control group (P=0.037). The mean of gestational age was also significantly different in the exposed and control groups (38.5±1.1 and 39.5±1.1 weeks, respectively). There was no significant difference between mean of mother blood calcium, phosphorus, magnesium and zinc in two groups (P<0.05). There was no significant difference between mean of height, weight, magnesium, and Apgar score of newborns in two groups. The mean of head circumference size in newborns of GDM mothers was significantly higher than those of non-GDM mothers (P=0.003). The mean of cord blood calcium was 9.81±0.6 mg/dl in the newborns of GDM mothers and 10.23±0.4 mg/dl in the newborns of non-GDM mothers that this difference was significant (P= 0.018). The mean of cord blood zinc was 79.05±13.1 mg/dl in the newborns of GDM mother and 86.96±11.6 mg/dl in the newborns of non GDM mother that this difference was relatively significant (P=0.05).

There was a weak uphill (positive) linear relationship between mother zinc level and pre-pregnancy weight (r=0.35) and gestational age (r=0.31). Therefore increase in pre-pregnancy weight and gestational age is associated with increase in mother zinc level. There was also a relatively direct correlation between new born Apgar and newborn zinc level (r=0.36). In addition, there was a moderate uphill (positive) correlation between newborn zinc level and pre-pregnancy weight (r=0.52) and newborn weight (r=0.58).

Linear regression model in (**Table.3**) showed that GDM is positively associated with the concentration of phosphor in newborns (P=0.08), and negatively associated with the concentration of mother's calcium (P=0.068), newborns' calcium (P=0.018), and newborns' zinc (P=0.05). Regression coefficients represent the mean change in micronutrient in blood for change in the predictor variable (Exposed vs. control group).

Table1: Distribution of the demographic characteristics between Exposed and control groups

Variables		Exposed group (%)	Control group (%)	Total	P-value
Location status	Urban	13(65)	10(50)	23(57.5)	0.33
	Rural	7(35)	10(50)	17(42.5)	
Mothers' Job	Home keeper	16(80)	18(90)	34(85)	0.66
	Employee	4(20)	2(10)	6(15)	
Education	Illiterate	3(15)	2(10)	5(12.5)	0.35
	Under Diploma	12(60)	16(80)	28(70)	
	Higher than Diploma	5(25)	2(10)	7(17.5)	

Table 2: Comparison of characteristic variables and blood components level betwean two GDM and nondiabetic mothers

Variables		Exposed group	Control group	P-value
		Mean±SD	Mean±SD	
Maternal variables	Height	159±4	160.6±6	0.34
	Weight	76.1±5.6	73.2±6.1	0.13
	BMI	30.12±2.19	28.48±2.58	0.04
	Weight before pregnancy	62.2±5.93	63.05±6.33	0.66
	Gestational Age	38.5±1.14	39.5±1.05	0.00
	Calcium	9.14±0.49	9.4±0.37	0.06
	Phosphor	4.26±0.65	4.05±0.91	0.42
	Magnesium	1.84±0.15	1.86±0.19	0.71
	Zinc	67.44±12.1	73.34±10.8	0.11
Newborn variables	Height	50.35±2.2	28.8±1.76	0.75
	Weight	3424±517.5	3362.5±324	0.66
	Head circumference	34.85±0.93	33.9±0.97	0.00
	Apgar Score	8.9±0.3	0.9±0.2	0.17
	Cord blood Calcium	9.81±0.61	10.23±0.45	0.01
	Cord blood phosphor	0.2±1.2	5.99±0.88	0.08
	Cord blood Magnesium	1.96±0.26	1.91±0.17	0.43
	Cord blood Zinc	79.05±13.1	86.96±11.65	0.05

Table 3: Effect of GDM status on micronutrients in the blood of mother and newborns

Micronutrient in blood		B	P-value	0.95% CI	
				Lower	Upper
Mother	Calcium	-0.26	0.06	-0.49	-0.03
	Phosphor	0.2	0.41	-0.22	0.62
	Magnesium	-0.2	0.71	-0.11	0.07
	Zinc	-5.9	0.11	-12	0.22
Newborns	Calcium	-0.42	0.01	-0.7	-0.13
	Phosphor	0.62	0.08	0.034	1.2
	Magnesium	0.06	0.43	0.06	0.17
	Zinc	-7.9	0.05	-14.5	-1.3

B= Regression coefficients; CI= Confidence Intervals.

4- DISCUSSION

In the present study, comparison of growth parameters, Apgar score, mother blood phosphorus, calcium, zinc, magnesium, and umbilical cord between women with and without gestational diabetes has been discussed. The mean of calcium, phosphorus, magnesium and zinc in mothers of both groups had no significant difference.

The gestational age and BMI of mothers were significant difference in both groups. The mean of calcium and zinc of newborns were significant difference between two groups. But the mean of magnesium and phosphorus had no significant difference.

The importance and relationship between the amount of zinc in mother blood and its relationship with the amount of zinc in newborn umbilical cord, fetal age, and newborn birth weight have been reported in previous studies (14, 15).

The amount of zinc of neonatal umbilical cord (0.85±0.3) was significantly more than the amount of blood zinc of mothers (0.47±0.24) (14). This result has also reported in another study (15). The importance of amount of zinc has expressed in another study suggesting that amount of body zinc element of mothers affects the level of serum leptin (16). Leptin is produced by adipose tissue in the human body and reduces appetite and hence prevents excess obesity.

Mother's age is also one of the factors that can have an impact on the amount of body zinc. In a study, amount of body zinc of mothers of age group 24 to 28 years has been more than amount of body zinc of mothers of age group 18 to 23 years (11). An inverse relationship has also shown between amount of zinc of newborn umbilical cord and fetal age. So that, amount of umbilical cord zinc decreased with increasing fetal age (17). Although in the present study the concentration of zinc of neonatal umbilical cord of GDM mothers was less than this amount in neonatal umbilical cord of non-GDM mothers, but there was not significant. In a study in Pakistan, the mean of zinc in the blood samples of diabetic mothers and their newborns was significantly less than the mean of blood zinc of healthy mothers and their newborns (14). Another study in Kuwait was found no significant difference between the mean of stored body zinc of mothers with gestational diabetes and healthy mothers group (610 vs. 666 microg/l, respectively) (8). The lower levels of body zinc affects on the function of pancreas which is responsible for the production and secretion of insulin (18). It is expected that amount of body zinc in diabetic patients to be less than healthy individuals (19). In accordance with our results, previous studies have also reported a relationship between zinc reception and Apgar score (20).

In the present study, similar to previous studies (8, 14), the mean of birth weight of newborns of diabetic mothers was more than the mean of birth weight of newborns of healthy mothers. Although, our results indicated that zinc supplement of pregnant mothers have not affect on fetal size, birth weight and incidence of premature pregnancies, the clinical trial study has shown that fetal growth depends on amount of body zinc of mother (21). In addition, another review study on 20 clinical trials revealed that zinc level has significantly relationship with a decline of about 14 percent of premature births (22). Also zinc levels deficiency in diabetic patients causes several problems such as cardiovascular problems and also increase oxidation of lipids (18). Up to now, there is no strong reasons to prove the usefulness of zinc recommendation as supplement for mother and fetus (23) and the reason of slight increase zinc absorption during pregnancy is not also completely clear. On the other hand, severe zinc deficiency leads to a decreased appetite, growth lower than normal, impaired wound healing and also short stature. Therefore, hygienic policy makers can prevent further problems with designing regular training programs at different levels of hygienic and therapeutic centers such as Health House, urban and rural Health Centers. Also due to the limited effect of zinc supplementation during pregnancy, extensive studies should be done to identify ways of improve the nutritional status of women (24).

Magnesium is one of the essential micronutrient that has many effects on the body. During pregnancy and lactation, the need for this substance will increase. Nutrition of pregnant women is very important in the process of fetal growth, and previous studies have shown that essential elements deficiency such as zinc, magnesium and chromium causes glucose intolerance in the body and will cause diabetes complications (25). Also the existence of magnesium in the body is essential for insulin secretion and synthesis.

A study to determine the status of magnesium, copper and zinc of dietary of diabetics and non-diabetics showed that serum magnesium, copper and zinc concentration has significant difference between diabetics and non-diabetics (7). So that for instance, serum zinc and magnesium levels of diabetics were less than non-diabetics (7). The study also

showed that decreased levels of zinc and magnesium and increased levels of copper in serum of diabetics was not related to their diet and its reason should be sought in other factors such as urinary excretion, factors intervention in the absorption and exploitation and individual circumstances (7). On the other hand, the significant relationship between magnesium reception from diet and reduce the risk of type 2 diabetes especially in overweight women has been shown (26). In the present study the concentration of magnesium in diabetic mothers was less than healthy mothers, however, this amount was not significant. Also some studies of the past decades showed a significant difference between cord magnesium concentration of newborns of diabetic mothers and the concentration of this substance in cord of newborns of healthy mothers (21).

Moreover diabetes in pregnant women can significantly affect on birth weight, newborn head circumference size, and the concentration of essential substances such as newborn magnesium, phosphorus and calcium (21). In this regard, previous studies have shown that calcium plus vitamin D supplementation in women with GDM have beneficial effects on their metabolic profile (22). Another study in Japan showed that serum levels of magnesium in diabetics are significantly lower than healthy persons (23). Magnesium deficiency in daily diet can affect on incidence of diabetes and its complications (24). The reason of the high incidence of magnesium deficiency in diabetes is not clear, but it may be because of increasing renal excretion, reducing consumption or magnesium absorption disorder in diabetics compared with healthy persons. A study was conducted on diabetics that showed there is a relationship between magnesium urinary excretion and glucose urinary excretion. Also in this study, the cause of hypnosis in diabetics, osmotic diuresis and acidosis was recognized (25).

4-1. Limitation

The major limitation of this study was small sample size and therefore lack of enough power to detect significant relation between variables. Thus more caution is needed in interpretation of the results.

5- CONCLUSION

This study showed that imbalance of some micronutrient in cord of newborns of mothers with gestational diabetes play a role in newborn health as a probable risk factor on micronutrient status and also head circumference size of neonates born in these mothers. In this study, amount of zinc and calcium in umbilical cord of newborns of mothers with gestational diabetes was significantly less than control group, that given the important roles of these two substances, it can conclude that proper imbalance of these micronutrient can have probable risks for the future health of newborn. Therefore should be more attention to be paid the concentrations of microelements in pregnant women with gestational diabetes and also health staffs.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENT

This study is part of the thesis master's degree in nutrition. We would like to thank the Vice-chancellor of Education as well as the Vice-chancellor of Research and Technology, Yazd University of Medical Sciences, who approved this study and also staffs of Fatimah hospital- Hamadan, for Participation in data collection.

7- FUNDING STATEMENT

Vice-chancellor of Research and Technologyof Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

8- REFERENCES

1. DeVita VT, Lawrence TS, Rosenberg SA. Cancer: principles and practice of oncology-advances in oncology: Lippincott Williams & Wilkins; 2010.

2. Harirchi I, Kolahdoozan S, Karbakhsh M, Chegini N, Mohseni S, Montazeri A, et al. Twenty years of breast cancer in Iran: downstaging without a formal screening program. Annals of oncology 2011;22(1):93-7.

3. World Health Organization. Cancer Country Profiles, 2014. Avilable at: http/: www.who.int/entity/cancer/country-profiles/irn_en.pdf.

4. Black R. Micronutrient deficiency-an underlying cause of morbidity and mortality. Bull World Health Organ 2003;81(2):79.

5. Scholl TO. Iron status during pregnancy: setting the stage for mother and infant. Am J Clin Nutr 2005;81(5):1218S-22S.

6. Borella P, Szilagyi A, Than G, Csaba I, Giardino A, Facchinetti F. Maternal plasma concentrations of magnesium, calcium, zinc and copper in normal and pathological pregnancies. Science of the total environment 1990;99(1):67-76.

7. Hans CP, Sialy R, Bansal DD. Magnesium deficiency and diabetes mellitus. Current Science-Bangalore 2002;83(12):1456-63.

8. Kim MW, Ahn KH, Ryu KJ, Hong SC, Lee JS, Nava-Ocampo AA, et al. Preventive effects of folic acid supplementation on adverse maternal and fetal outcomes. PLoS One 2014;9(5):e97273.

9. Mahomed K, Bhutta Z, Middleton P. Zinc supplementation for improving pregnancy and infant outcome. Cochrane Database Syst Rev 2007(2):CD000230.

10. Fraser A, Lawlor DA. Long-term health outcomes in offspring born to women with diabetes in pregnancy. Curr Diab Rep 2014;14(5):489.

11. Srivastava S, Mehrotra PK, Srivastava SP, Siddiqui MK. Some essential elements in maternal and cord blood in relation to birth weight and gestational age of the baby. Biol Trace Elem Res 2002;86(2):97-105.

12. Perveen S, Altaf W, Vohra N, Bautista ML, Harper RG, Wapnir RA. Effect of gestational age on cord blood plasma copper, zinc, magnesium and albumin. Early Hum Dev 2002;69(1-2):15-23.

13. Smith M, Moser-Veillon P, Nagey D, Douglas L, Smith J. Blood and urinary zinc changes after a glucose challenge in early and late pregnancies. The American Journal of Clinical Nutrition 1988;48(3):664-70.

14. Afridi HI, Kazi TG, Kazi N, Baig JA, Jamali MK, Arain MB, et al. Status of essential trace metals in biological samples of diabetic mother and their neonates. Arch Gynecol Obstet 2009;280(3):415-23.

15. Di Silvestro RA. Zinc in relation to diabetes and oxidative disease. J Nutr 2000;130(5S Suppl):1509S-11S.

16. Ozdemir U, Gulturk S, Aker A, Guvenal T, Imir G, Erselcan T. Correlation between birth weight, leptin, zinc and copper levels in maternal and cord blood. J Physiol Biochem 2007;63(2):121-8.

17. Merialdi M, Caulfield LE, Zavaleta N. Randomized controlled trial of prenatal zinc supplementation and the development of fetal heart rate. Am J ObstetGynecol 2004;190:1106-12.

18. de Benoist B, Darnton-Hill I, Davidsson L, Fontaine O, Hotz C. Conclusions of the Joint Report WHO/UNICEF/IAEA/IZINCG Interagency meeting on zinc status indicators. Food NutrBull 2007;28(3 Suppl):S480-4.

19. Chaffee BW, King JC. Effect of zinc supplementation on pregnancy and infant outcomes: a systematic review. Paediatr Perinat Epidemiol 2012; 26(Suppl 1):118-37.

20. Chen MD, Lin PY, Tsou CT, Wang JJ, Lin WH. Selected metals status in patients with noninsulindependent diabetes mellitus. Biol Trace Elem Res 1995;50:119-24.

21. Speich M, Murat A, Auget JL, Bousquet B, Arnaud P. Magnesium, Total Calcium, Phosphorus, Copper, and Zinc in Plasma and Erythrocytes of Venous Cord Blood from Infants of Diabetic Mothers: Comparison with a Reference Group by

Logistic Discriminant Analysis. ClinChem 1992;38(10):2002-7.

22. Asemi Z, Karamali M, Esmaillzadeh A. Effects of calcium–vitamin D co-supplementation on glycaemic control, inflammation and oxidative stress in gestational diabetes: a randomised placebo-controlled trial. Diabetologia 2014;57(9):1798-806.

23. Nagase N. Hypertension and serum Mg in the patients with diabetes and coronary heart disease. HypertensRes 1996;19(Suppl 1):S65-8.

24. Singh RB, Niaz MA, Moshiri M, Zheng G, Zhu S. Magnesium status and risk of coronary artery disease in rural and urban populations with variable magnesium consumption. Magnes Res 1997;10(3):205-13.

25. Garber AJ. Magnesium utilization survey in selected patients with diabetes. Clinther 1996;18(2):285-94.

26. Song Y, Manson JE, Buring JE, Liu S. Dietary magnesium intake in relation to plasma insulin levels and risk of type 2 diabetes in women. Diabetes Care 2004;27(1):59-65.