

Effect Of Diabetes Mellitus On Trace Elements Concentrations In Egyptian Diabetic Patients

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Abstract

Introduction: Diabetes mellitus is considered a primary cause of diabetic complications and is associated with impaired trace elements.

Aim of the Work: study effect of diabetes mellitus on Ttrace elements levels.

Material and Method: The study was conducted on 90 persons (30 Control, 30 Type I, 30 Ttype II). Diabetic patients with complications were excluded. Serum (or plasma) levels of Zn, Cu, Mg, Mn, Cr and Se were measured. Blood samples were collected in metal-free tubes from patients and controls after overnight fast. Weight and height were recorded.

Result and Discussion: Zn, Mg, Se level in type I diabetics showed no significant difference. Cu and Mn concentrations were significantly higher in both type I, II than controls. Zn, Se and Mg levels were significantly decreased in type II than control. Cr concentration were significantly lower in both type I, II than control. Mn is the most influential variable among the tested variables.

Conclusion: Diabetes can alter copper, zinc, magnesium, manganese, chromium and selenium levels and it needs further investigation.

Keywords: Trace Elements, Diabetes Mellitus, Zinc, Copper, Manganese, Magnesium, Chromium & Selenium.

Introduction

Diabetes mellitus is associated with impaired trace elements. Alterations in serum (or plasma) concentrations of several trace elements have been reported to occur in both type I and II diabetes mellitus. These micronutrients are suspected to have a role in the pathogenesis and progression of the disease (Zargar *et al.*, 2002). Zinc (Zn) is an essential mineral that is required for various cellular functions. Zn help in insulin absorption (Chausmer, 1998). Its abnormal metabolism is related to certain disorders such as diabetic complications. Levine *et al.* (1983) observed that the genetically insulin-resistant, diabetic mice demonstrate tissue zn deficiency. Zinc has an important role in the control of carbohydrate metabolism, and diabetic patients are at risk for zinc deficiency. Molecular and cellular studies have demonstrated several roles for zinc in insulin production and the consequent actions of insulin on metabolism. Copper (Cu) deficiency results in swelling and subsequent disruption of mitochondria of

metabolically active tissues like hepatocytes and pancreatic acinar cells. Magnesium (Mg), the second most abundant intracellular cation, is indispensable to cellular metabolism. Mg is known to play an important role in carbohydrate metabolism and its imbalance has been implicated in diabetes mellitus both as a cause and a consequence (Paolisso *et al.*, 1990). Direct association of trace elements in relation to human disease has been observed in many research studies. The role of trace elements in some of the metabolic dysfunctions is not clear. Trace elements are uniquely required for growth and maintenance of life and health. Lack or an inadequate supply of such nutrients produces a functional impairment or can result in disease. The clinical significance and evaluation of trace elements such as Zn, Cu, Mn and Mg in regard to different diseases including diabetes mellitus remain conflicting as well as controversial and many questions still remain unanswered. Magnesium and zinc are nutritional

minerals that play crucial roles in the regulation of carbohydrate and lipid metabolism (Anetor *et al.*, 2002).

Aim of the work

The studies of zinc (Zn), copper (Cu), magnesium (Mg), manganese (Mn) chromium (Cr) and selenium (Se) levels in diabetic patients have led to contradictory findings. In the present study we tried to study the effect of diabetes mellitus on trace elements levels (Zn, Cu, Mg, Mn, Cr & Se) in serum of Egyptian diabetic patients.

Material and Methods

The study consisted of analysis of serum levels of Zn, Cu, Mg, Mn, Cr and Se in Egyptian patients with diabetes mellitus. The experimental group(s) consisted of 60 patients (30 Type I, 30 Type II). The control group consisted of 30 healthy volunteers with no general complications and receiving no medication. They were matched for age and sex. Age range: 30-45 years. Patients were selected from governmental and nongovernmental organization in Cairo who attended the diabetic clinics and were taking insulin (IDDM); pills or pills and insulin (NIDDM). The diagnosis of type 1 & 2 diabetes mellitus is based on the criteria of the expert committee on the diagnosis of diabetes Mellitus (2000). Diabetic patients with complications were excluded according to their medical history. None of the study subjects had taken any vitamin or mineral supplements. Blood samples were collected in metal-free tubes from patients and controls after an overnight fast. Serum was collected by centrifugation and stored in metal-free tubes at -70°C . Minerals were measured in the ash using atomic absorption, unicam 929 (AOAC 1984). Glucose was determined according to Trinder (1969).

Preparation Of The Samples (Serum)

Samples for: Cu, Zn, Mn and Mg were prepared according to Price (1972), Cr was prepared according to Victor *et al.* (1994), Se was prepared according to Lloyd *et al.* (1982).

Anthropometrics measurements

Weight and height were measured in indoor clothing without shoes and body mass index (BMI) was calculated where $\text{BMI} = \text{wt (kg)}/\text{ht (m}^2\text{)}$.

Statistical Analysis

Data are expressed as mean \pm se. Data were assessed by t-test (Avram 1964; Steel and Torrie 1969). The correlation coefficients were determined by Pearson's simple linear regression analysis (Steel and Torrie 1969). Statistical significance was accepted at $P < 0.05$. Multiple linear regressions were done using SPSS 13 package.

Results

Data of table (1) & figure (1) shows the characteristic of diabetic and control subjects. Data of table (1) reveal that no significant difference was found between the mean ages, and BMI of diabetic patients (type I & II) and control persons or between type I & II. Data of table (1) reveal that blood glucose level of diabetic patients (type I & II) are significantly higher than control group.

Data of table (2,4) & figure (1) shows the concentration of Zn, Cu level and Cu/Zn ratio of diabetic and control subjects. Data of table (2) reveal that Zn level of diabetic patients (IDDM) shows no significant change when compared with the control group, while NIDDM shows a significant decrease when compared with control or IDDM group ($P < 0.01$ & 0.01). Data of table (2) reveal that Cu level, Cu/Zn ratio of diabetic patients (IDDM, NIDDM) shows significant increase when compared with the control group, and the increase was higher in NIDDM. Cu shows insignificant change when compared with control group, while Cu/Zn ratio showed a significant change when compared with IDDM group ($P < 0.01$).

Data of table (3,4) & figure (1) shows the concentration of Mg, Mn, Se and Cr of diabetic and control subjects. Data of table (3) reveal that Mg & Se level of diabetic patients (IDDM) shows insignificant change when compared with the control group, while NIDDM shows a significant decrease when compared with the control

group (P<0.01). Data of table (3) reveal that mn level of diabetic patients (iddm, niddm) shows significant increase (P<0.01) when compared with the control group, and the increase was higher in niddm. Cr (iddm, NIDDM) shows significant decrease when compared with the control group (P<0.01). Mg & Mn showed insignificant difference when comparing iddm with niddm group, while Se & Cr showed the opposite i.e. significant difference was observed when comparing iddm with niddm group (IDDM > NIDDM group).

Correlation Coefficient

No significant correlations were found between most variables with some exception. Correlation was found between

Cr and Se (r= -0.505; P<0.004 for control group; r=-0.90; P<0.000 for diabetic type II group). No significant correlation between glucose and zn was found which agree with (Anetor *et al.*, 2002). No significant correlation between glucose and mg was found which agree with Anetor *et al.* (2002).

Multiple Linear Regression Analysis

In multiple linear regression analysis using stepwise analysis model, the independent variable (s) were: weight, height, BMI, Cu, Zn, Mg, Mn, Se, Cr the dependent variable was glucose. Table (5) shows that mn is the most influential variables among the tested variables.

Table (1): Characteristics of the diabetic patients

	Age (Y)			BMI (kg/m ²)			Blood Glucose		
	Control	Type I (D ₁)	Type II (D ₂)	Control	Type I (D ₁)	Type II (D ₂)	Control	TYPE I (D ₁)	TYPE II (D ₂)
Mean±SE	38.84±1.30	38.43±1.17	37.75±1.26	23.64±0.47	23.47±0.51	23.38±0.57	88.82±3.16	213.32±6.36	229.15±7.04
D vs C	P≤	NS	NS		NS	NS		0.01	0.01
D ₁ vs D ₂	P≤		NS			NS			NS

Ns: Non significant, Very highly significant, P<0.001

Table (2): Zn, Cu level and Cu/Zn ratio of the diabetic patients

	Control	Type I	Type II	Control	Type I	Type II	Control	Type I	Type II
	Zn			Cu			Cu/Zn		
Mean	0.92	0.94	0.78	1.02	1.20	1.32	1.13	1.30	1.77
±SE	0.02	0.02	0.03	0.05	0.05	0.05	0.06	0.07	0.11
%		+ 2.58	- 14.63		+17.69	+ 28.50		+14.99	+ 56.90
P<	D vs C		Ns		0.01	0.01		NS	0.01
	D ₁ vs D ₂		0.01			NS			0.01

Ns: Non significant, Highly significant (P<0.01),

Table (3): Mg, Mn, Se and Cr level of the diabetic patients

	Control	Type I	Type II	Control	Type I	Type II	Control	Type I	Type II	Control	Type I	Type II
	Mg			Mn			Se			Cr		
Mean	19.18	17.64	16.38	13.69	27.67	29.44	6.61	6.32	5.74	4.02	3.52	3.02
±SE	0.27	0.74	0.70	0.19	0.85	0.43	0.10	0.16	0.23	0.16	0.11	0.05
%		-8.04	-14.60		+102.16	+115.09		-4.26	-13.07		-12.36	-24.74
P<	D vs C	Ns	0.01		0.01	0.01		Ns	0.01		0.01	0.01
	D ₁ vs D ₂		Ns			Ns		0.05				0.01

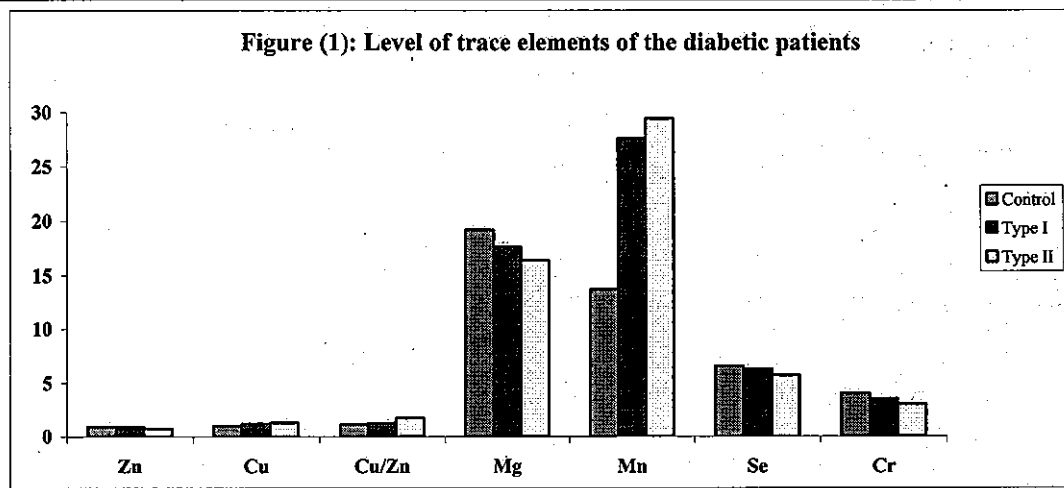
Ns: Non significant, Significant (P<0.043), Very highly significant (P<0.001-P<0.0003)

Table (4) Micronutrient status of diabetic patients

	IDDM	NIDDM
Zn	Ns	--↓
Cu	+↑	+↑
Cu/zn	+ns	+↑
Mg	--ns	--↓
Mn	+↑	+↑
Se	--ns	--↓
Cr	--↓	--↓

Table (5): Predictors of effect of diabetes mellitus on trace elements using glucose as the dependent variable.

Variables	R ²	R change	Beta	T-value	P	F test	P <
Mn	0.783		0.874	19.465	0.000		
Mn and wt	0.821	0.038	0.200	4.466	0.000		
Constant (-129.062)						205.517	0.000



Discussion

Trace elements status (concentration) is altered in the diabetic state, although the factors affecting trace element homeostasis in this condition are not well understood. Diabetes mellitus can disturb the metabolism of zinc, copper, and selenium. The studies of selenium (Se), zinc (Zn) and copper (Cu) levels in diabetic patients have led to contradictory findings as the possible relationship between the degree of diabetic control and the changes in mineral contents (Mertz, 1981; Ruiz *et al.*, 1998).

Zinc (Zn) is an essential element for many enzymes involved in human metabolism and plays a role in the biosynthesis and storage of insulin in β-

cells. Insulin is stored in the β-cells as hexameric crystal containing a variable number of zinc molecules. This crystal is released into the portal venous system at the time of β-cells degranulation. Variation of the zn: insulin ratio within this crystal has been shown to alter its antigenic properties (Arquilla *et al.*, 1978 a). Arquilla *et al.* (1978 b) stated that zinc is capable of modulating insulin action, and zn also, enhances hepatic pending of insulin while zn deficiency lead to increase insulin resistance. The mean serum zinc level of type II is decreased when compared to the control one (P< 0.01). A decrease in serum Zn may be the result of inadequate dietary

Zn, anorexia, vomiting or various drugs. In addition, a substance known as leukocyte endogenous mediator released from leukocytes during inflammation acts to redistribute the body zinc from the serum to the liver and may produce a drop in serum zn. Zn is mainly bound to albumin, the concentration of which is much more stable. Hypozincemia in diabetes mellitus may be due to altered zinc metabolism or tissue deficiency (Garg *et al.*, 1994). The decrease of plasma zinc can reflect a deficient storage or a chronic hyper secretion of insulin in hyperglycemic patients. Kinlaw *et al.* (1983) stated that decrease of Zn might be due to excessive urinary losses uncompensated by increased gastrointestinal absorption. Zinc deficiency has several potential clinical implication as impairment of wound healing, cell-mediated immunity and to cause functional, anatomical and biochemical defects in the retina (Allen *et al.*, 1981; and Leure-dePree, 1982). Mateo *et al.* (1987) think that the quotient zinc/copper might play a role in the pathogenesis of the arteriosclerosis in diabetes. Diabetes mellitus affects zinc homeostasis in various ways, although it is most probably the hyperglycemia rather than any primary lesion related to diabetes which is responsible for the increased urinary loss and decrease in total body zinc (Raz and Havivi, 1989). The decreased concentration of both mg and zn level in type-2 diabetic mellitus probably suggest lower antioxidant status (Anetor *et al.*, 2002). It is known that certain inorganic trace elements such as vanadium, zinc, chromium, copper, iron, potassium, sodium, and nickel play an important role in the maintenance of normoglycemia by activating the beta-cells of the pancreas (Narendhirakannan *et al.*, 2005). Our results for zinc (zn) levels in type i agree with Ruiz *et al.* (1998); Zargar *et al.* (2002). Our results for zn in type II agree with Anetor *et al.*, (2002) and Al-Marouf & Al-Sharbati (2006).

Copper (Cu) is an essential trace element, plays an important role in cytochrome oxidase function at the terminal end of the mitochondria. Plasma Cu is mainly bound to ceruloplasmin, an acute phase protein, which can change owing to a variety of conditions not directly related to

copper metabolism. Conflicting results have been reported regarding the Cu level in type I diabetes mellitus, both elevated as well as decreased plasma copper concentrations had been reported (Isbir *et al.*, 1994; and Brun *et al.*, 1992). Fujimoto (1987) stated that copper is not considered to be an important factor in diabetes mellitus due to insignificant change in his study. Our results for cu level in type ii agree with Zargar *et al.* (1998).

Car *et al.* (1992) stated that although the cu/zn ratio was higher in both groups of diabetic (type I & II) patients, it is not related to chronic diabetic complications.

Diabetes mellitus may be associated with magnesium depletion, which in turn may contribute to metabolic complications of diabetes including vascular disease and osteoporosis. Magnesium (Mg) has a potential role in the pathogenesis of disease states such as hypertension and diabetic complications (Resnick *et al.*, 1991 and Grafton *et al.*, 1992). Mg is an important cofactor in numerous intracellular enzymatic reactions including glucose metabolism. Diabetic patients are susceptible to mg depletion and this may be due to glucosuria by causing excessive urinary loss, or due to nutritional factors or hyperinsulinemia (maltezos *et al.*, 2004). Our results for mg level in type i agree with Tuvemo *et al.* (1997); and Zargar *et al.*, (2002). Our results for mg levels in type II agree with Anetor *et al.* (2002).

Insulin or agents that can mimic its action (insulin-mimetics) are necessary to promote the entry of glucose into tissues where the glucose can either be converted into energy or stored for later use. In recent years, selenium has been shown to mediate a number of insulin-like actions both *in vivo* and *in vitro*. These insulin-like actions include stimulating glucose uptake and regulating metabolic processes such as glycolysis, gluconeogenesis, fatty acid synthesis and the pentose phosphate pathway. The mechanism by which selenium is capable of mimicking insulin is not clear; however, reports indicate that selenium does activate key proteins involved in the insulin-signal cascade. Various proteins in the insulin-signal cascade have been shown to be necessary for different insulin-regulated events.

Selenium acts as an insulin-mimetic (Stapleton, 2000). Selenium shows insulin-mimic properties both *in vitro* and *in vivo*. The decreased levels of selenium in sera of diabetic patients (type II) suggest the possible role of glutathione peroxidase activity (Kljai and Runje, 2001). Our results for selenium levels in type I disagree with Ruiz *et al.* (1998). Our results for selenium levels in type II agree with Navarro *et al.* (1999).

Chromium (Cr) is an essential element, contained in gtf (glucose tolerance factor), mainly affects saccharides, it potentiates insulin action via interaction with insulin receptor on the cell surface. The cr level was significantly decreased in diabetic patients compared to controls which agrees with Fujimoto (1987); Zima *et al.* (1998); and Ekmekcioglu *et al.* (2001). Fujimoto (1987) reported that chromium might play an important role in advanced diabetes mellitus. Racek (2003) stated that after absorption of cr in the gastrointestinal tract, Cr is most likely transported to cells bound to the plasma protein called transferrin. Insulin initiates chromium transport into the cells where it is bound to the oligopeptide apochromodulin. This oligopeptide combined with four chromium (III) atoms forms chromodulin, which is important for amplifying the insulin signaling effect. After binding to insulin-activated receptor, chromodulin increases tyrosine kinase activity by one order. This enzyme forms a part of intracellular portion of insulin receptor.

conclusion:

Diabetes can alter copper, zinc, magnesium, manganese, chromium and selenium levels. It is not known whether differences in trace element status are a consequence of diabetes, or alternatively, whether they contribute to the expression of the disease.

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تأثير مرض البول السكري على تركيز المعادن النادرة في مرضى البول السكري المصريين

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المقدمة: يعتبر مرض البول السكري سبب رئيسي في مضاعفات مرض السكر وهو مصحوب بتغيرات في تركيزات الأملاح النادرة.

الهدف: دراسة تأثير مرض البول السكري على تركيزات المعادن النادرة.

الطرق و المواد: تمت التجربة على 90 شخص موزعين كالتالي: (30 شخص طبيعي ، 30 مصابين بمرض البول السكري من النوع الأول ، 30 مصابين بمرض البول السكري من النوع الثاني) . تم تقدير العناصر الآتية: زنك - نحاس - ماغنسيوم - منجنيز - كروم - سيلينيوم . تم استبعاد الأشخاص الذين لديهم مضاعفات . تم تجميع العينات في أنابيب خاصة بعد فترة الصيام. تم قياس الوزن والطول.

النتيجة: لا يوجد تغيير معنوي في تركيز الزنك ، الماغنسيوم ، السيلينيوم بالنسبة لمرضى النوع الأول. لوحظ وجود ارتفاع معنوي في تركيز النحاس ، المنجنيز بالنسبة لمرضى النوع الأول و الثاني والعكس صحيح بالنسبة للكروم. كما لوحظ وجود انخفاض معنوي في تركيز الزنك - الماغنسيوم - السيلينيوم في مرضى النوع الثاني. وجد أن عنصر المنجنيز أكثر العناصر تأثرا بمرض البول السكري.

الاستنتاج: مرضى البول السكري يمكن أن يؤثر ويغير من تركيز العناصر مثل : زنك - نحاس - ماغنسيوم - منجنيز - كروم - سيلينيوم .