DOI: 10.7860/JCDR/2013/5464.3335

Original Article

Biochemistry Section

Trace Elements in Diabetes Mellitus

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ABSTRACT

Introduction: Diabetes Mellitus is the commonest major metabolic disease and most prevalent diseases worldwide. Its related morbidity is due to its micro and macro angiopathic complications.

Aim: The aim of this study was to measure and compare the serum levels of zinc and magnesium in normal individuals and in diabetic patients.

Method: Analysis of minerals was done in plasma by using a Varian Spectra AA 220 model atomic absorption spectrophotometer.

Result: Our observations showed a definite lowering of serum magnesium ($p<0.001$) and serum zinc levels ($p<0.001$) were significant in diabetic group.

Conclusion: The cause of diabetic hypomagnesaemia is multifactorial. An altered metabolism, a poor glycaemic control and osmotic diuresis may be contributory factors. Decreased serum zinc levels in diabetes may be caused by an increase in urinary loss. These decreased levels of trace elements cause disturbances in glucose transport across cell membrane lead to insufficient formation and secretion of insulin by pancreas which compromise in the antioxidant defense mechanisms.

Key words: Diabetes Mellitus, Antioxidants, Zinc, Magnesium

INTRODUCTION

The term, 'diabetes mellitus' describes a metabolic disorder of multiple aetiology, which is characterised by chronic hyperglycaemia, with disturbances of carbohydrate, fat and protein metabolism, which result from defects in insulin secretion, insulin action, or both. The effects of diabetes mellitus include long term damage, dysfunction and failure of various organs. Death may result from acute metabolic decompensation, while a long standing metabolic derangement is frequently associated with permanent and irreversible functional and structural changes in the cells of the body, with those of the vascular system being particularly susceptible.

A relationship was observed between diabetes mellitus and trace elements in many research studies [1]. In many cases, an alteration in the metabolism of these minerals was demonstrated [2-5]. Insulin action was reported to be potentiated by some trace elements like chromium, magnesium, vanadium, zinc, manganese, molybdenum and selenium [6]. Proposed mechanisms of enhancement of insulin action by trace elements include activation of insulin receptor sites [7], serving as cofactors or components for enzyme systems which are involved in glucose metabolism [8], increasing insulin sensitivity and acting as antioxidants for preventing tissue peroxidation [9].

The most dominant feature of the metabolism in diabetes is an abnormally high concentration of blood glucose [10]. The function of zinc in the body metabolism is based on its enzymatic affinity and way of a zn-enzyme complex or metallo-enzyme. In humans and animals, diabetes causes disturbances in this vital trace element. [11] Zinc is required for insulin synthesis and storage and insulin is secreted as zinc crystals. It maintains the structural integrity of insulin [3]. Zinc has an important role in modulating the immune system and its dysfunction in diabetes mellitus may be related in part to the status of zinc [12].

Magnesium has an important role in the phosphorylation reactions of glucose and its metabolism. Its deficiency has been implicated in insulin resistance, carbohydrate intolerance, dislipidaemia and complications of diabetes [13]. The association between diabetes mellitus and hypomagnesaemia is compelling, because of its wide ranging impact on diabetic control.

It is not known whether trace element status leads to disease or whether diseases sets in due to deficiency of trace elements [14]. Although it is generally believed that a strict metabolic control delays the development of late complications in diabetes mellitus [15]. Type 2 Diabetes mellitus and metabolic syndrome are important risk factors for atherosclerosis and further complications [16].

Hence, in this study, we evaluated the levels of zinc and magnesium in diabetic patients, in an effort to evaluate the status of these elements in such patients.

MATERIAL AND METHODS

In the present study, fasting blood sugar, zinc and magnesium levels were estimated in the blood samples of 80 patients, among which 40 patients without diabetes were taken as controls and 40 patients with diabetes mellitus were considered as cases.

Criteria for selection of patients: Individuals who were 35 years to 60 years old and who were of both sexes were selected for this study and they were divided into two groups. The controls formed Group-1 and patients who had diabetes for more than 5 years were considered as Group 2, who are not taking any kind of trace element supplements. Samples with haemolysis and jaundice were excluded.

Glucose was estimated by GOD-POD method. This method was used, because of its specificity, reliability and simplicity. Analysis of minerals was done in plasma by using a Varian Spectra AA 220 model atomic absorption spectrophotometer.

RESULTS

The studies were carried out on 40 normal controls and 40 diabetic patients.

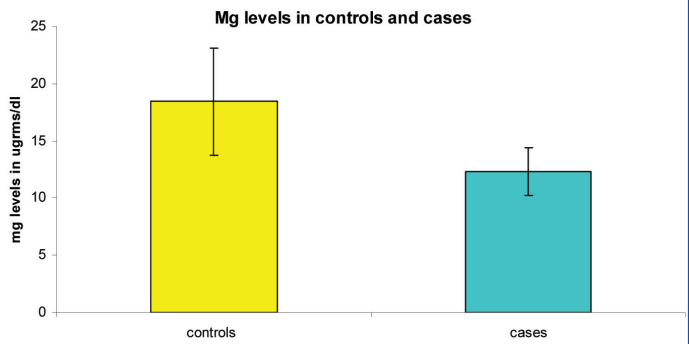
Serum magnesium level in diabetic patients was12.30 ± 2.10 µ gm/ml, which was were significantly lower ($p< 0.001$) than that of the controls, the value being 18.49 ± 4.76 µ gm/ml.

Group	Mean ± SD	S.E
Group-I Normal controls	82.36±14.3	2.868
Group-II Diabetic patient	145.76+54.44	10.88

[Table/Fig-1]: The Mean ± SD of fasting Blood glucose level (mg%)

Group	Mean ± SD	S.E
Group-I Normal controls	18.49±4.76	0.952
Group-II Diabetic patient	12.3±2.1	0.421

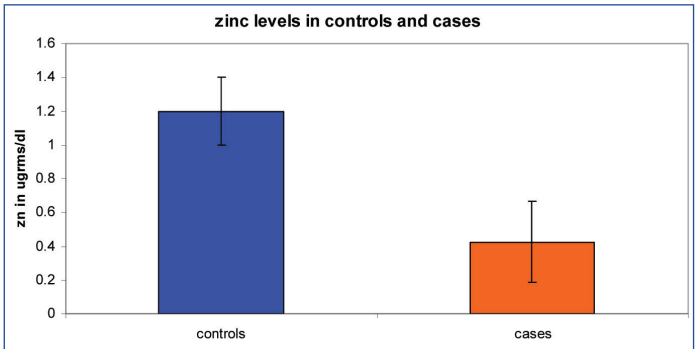
[Table/Fig-2]: The Mean ± S.D of Serum Magnesium levels (µgms/ml) in various study Groups



[Table/Fig-3]: Comparison of Mean values of Serum Magnesium levels (µgms/ml) in the groups

Group	Mean ± SD	S.E
Group-I Normal controls	1.2±0.202	0.0404
Group-II Diabetic patient	0.425±0.246	0.0492

[Table/Fig-4]: The Mean ± S.D of Serum Zinc levels (µgms/ml) in study Groups



[Table/Fig-5]: Comparison of Mean values of Serum Zinc (µgms/ml) in the study Groups

Serum zinc level of Group II was significantly lower (0.425 ± 0.24 µ gm/ml) than that of the control group (1.20 ± 0.202 µ gm/ml). (p< 0.001)

DISCUSSION

In order to understand the role and status of trace elements in diabetic patients, this study was undertaken to compare the serum zinc and magnesium levels in normals and diabetic patients . Serum magnesium and zinc levels were found to be decreased in patients with diabetes as compared to those in normal controls.

Magnesium is an essential ion which is involved in glucose homeostasis at multiple levels. A complex interplay exists between magnesium and glucose metabolisms. It plays an important role in the activities of various enzymes which are involved in glucose oxidation, and it may play a role in the release of insulin [17-19]. It is mainly intracellular and its uptake is stimulated by insulin [19,20]. A cellular magnesium deficiency causes reduction of inositol transport and depletion. This can alter the activity of membrane bound sodium, potassium ATPase [21,22], which is involved in the maintenance of gradients of sodium and potassium and in glucose transport. Low levels of magnesium can reduce secretion of insulin by the pancreas [23].

Our observations showed a definite lowering of serum magnesium in diabetic patients (p<0.001), which was in correlation with findings of Berhane Seyoum et al., [24] Chetan P.Hans et al.,[25] Monika K et al., [8].

The cause of diabetic hypomagnesaemia is multifactorial [26]. Osmotic actions of glycosuria and hyperglycaemia may work together in causing hypomagnesaemia and hyperglycaemia per se alone, which are known to depress the net tubular reabsorption of magnesium in normal humans [22,24,25,27].

Zinc is an essential trace element and it is important in glucose metabolism. It is a component of many enzymes and it plays an important role in the maintenance of several tissue functions [19]. The relationship between diabetes, insulin and zinc is complex, with no clear cause and effect relationships. Zinc plays a clear role in the synthesis, storage and secretion of insulin, as well as conformational integrity of insulin in the hexameric form. It has the ability to regulate insulin receptor intracellular events that determine glucose tolerance and the ability to support a normal pancreatic reaction to a glucose load [28]. It has a protective effect against β cell destruction and it has well known antiviral effects. The complications of diabetes may be mediated, at least in part, through oxidative stress, and zinc plays a key role in the cellular anti oxidative defense [29]. Hence, it has been suggested that an abnormal zinc metabolism may play a role in the pathogenesis of diabetes and some of its complications [10].

In the present study, serum zinc levels were found to be significantly lowered in diabetic group (p<0.001), which was in correlation with findings of Chausmer AB et al., [3] A C Nsonwu et al., [14] and Alena Viktorinovaa et al., [30].

The cause of decreased serum zinc levels in diabetes may be an increase in urinary loss. Hyperglycaemia has been postulated to interfere with the active transport of zinc back in to the tubular cells [14, 3]. Other possible causes may be disturbed metabolisms of zinc metalloenzymes and an abnormal binding of zinc to tissue proteins, which cause hyperzincuria. Zinc has been found to enhance the effectiveness of insulin in–vitro and hence, a zinc deficiency may aggravate the insulin resistance in type II diabetes. This may cause complications [19,31]. Antioxidant enzymes such as oxide desmutase, catalase and peroxidase require zinc [32].

Hence, these trace element deficiencies appear to be an additional risk factor in the development and progress of disease and they contribute to the pathogenesis of diabetes mellitus and its complications. Their repletion may be an effective therapeutic intervention in prevention of the progression of the diabetes and its complications, along with a glycaemic control and control of other risk factors [33].

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FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Dec 15, 2012**
Date of Peer Review: **Jul 02, 2013**
Date of Acceptance: **Jul 04, 2013**
Date of Publishing: **Sept 10, 2013**