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Original Article

Serum Zinc Levels in Children and Adolescents with Type-1 Diabetes Mellitus

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Abstract

Background: There have been very few studies, with contradictory results, on the zinc status of children and adolescents with type-1 diabetes mellitus. The objective of this cross-sectional study was to determine zinc status based on the serum zinc concentration in type-1 diabetic children and adolescents and compare it with that of healthy controls.

Methods: Thirty children and adolescents with type-1 diabetes mellitus, aged 6 to 18 years, and 30 age- and sex-matched healthy controls participated in the study. Serum zinc, fasting blood sugar, hemoglobin A_{1c} and serum albumin were measured by flame atomic absorption spectrophotometry, enzymatic colorimetry, ion-exchange chromatography and colorimetry using bromocresol green methods, respectively.

Results: No statistically significant difference was found in the mean serum zinc concentration between diabetic patients and healthy controls (111.0 ± 3.1 and 107.1 ± 3.8 mg/dl respectively, *P*= 0.4). No correlations were found between the serum zinc levels and fasting blood sugar, hemoglobin $A_{1c,}$ or the duration of the disease in the patients.

Conclusion: The zinc levels of diabetic children and adolescents are not noticeably different compared to those of healthy controls and are independent of glycemic control and the duration of the disease.

Keywords: Zinc, Type-1 diabetes mellitus, Children, Adolescents, Hemoglobin A_{1c}

Introduction

Several studies have shown changes in zinc status and metabolism in both type-1 and type-2 diabetes mellitus patients (1-3). Some investigators have reported unusual urinary zinc excretion in both types (4-6) and, consequently, considered the possibility of its deficiency. However, zinc deficiency in diabetic patients has not been well demonstrated (7).Zinc is an essential trace element with a vital role in metabolism, particularly as a cofactor of many enzymes, required for natural metabolic processes, growth and development. Therefore, it is of great importance in childhood and adolescence (8, 9). Reports in the literature on the zinc status of children and adolescents with type-1 diabetes mellitus (T1DM) are limited and contain contradictory results. Some investigators have shown decreased serum zinc concentrations (10, 11), while others have found elevated levels (12, 13), as compared to non-diabetic controls; a few have observed no changes (14, 15). No study has been reported to date on the zinc status of children and adolescents with T1DM in Iran, a large country greatly varied with regard to ethnic, genetic, environmental, ecological and dietary characteristics. The objective of this study was to determine zinc status based on the serum zinc concentration in children and adolescents with T1DM and compare it with that of healthy controls.

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Materials and Methods

Study design

Thirty children and adolescents with T1DM (diagnosed by a pediatric endocrinologist), 6 to 18 years old (patient group), including 13 girls and 17 boys and 30 weight-, height-, body mass index-, age- and sex-matched healthy children (control group) participated in this cross-sectional study. The patients were randomly selected from among those with active files in Namazi Medical Teaching Center, one of the main teaching hospitals of Shiraz University of Medical Sciences in Shiraz, Iran. They had no other systemic disease and were taking no medication that would interact with zinc metabolism; they were taking only insulin. The controls were apparently healthy children taking no zinc supplement. None of the participants had taken vitamin and mineral supplements for at least 3 months before initiation of the study.

Measurements

Fasting blood samples were taken from all participants at 7:30 A.M. and analyzed for serum zinc, fasting blood sugar (FBS), hemoglobin A_{1c} (HbA_{1c}) and serum albumin. Serum zinc, FBS, HbA_{1c} and serum albumin were measured by flame atomic absorption spectrophotometry, enzymatic colorimetry, ion-exchange chromatography and colorimetry using bromocresol green, respectively. Since energy and nutrient intakes may affect the serum zinc concentration, the daily energy and nutrient (protein, fiber, calcium, iron, zinc) intakes were measured using three 24-hour dietary recalls (2 week days and a holiday) and the food processor 2 (FP2) software.

Ethical considerations

Informed consent was taken from the parents, and the protocol was approved by the Ethics Committee of the Nutrition and Biochemistry Department, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran.

Statistical analysis

Data are expressed as mean and standard error of mean (SEM). For inter-group comparison of the variables the independent *t*-test was used. If the data were skewed but other criteria were met, nonparametric Mann-Whitney U test was used to detect differences between groups. The correlation test and Pearson coefficient were used to determine the association between serum zinc levels and FBS, HbA_{1c} or the duration of diabetes. Statistical analyses were performed using SPSS 11.5. A value of $P<0.05$ was considered as significant in all statistical analyses.

Results

No differences were found between the patient and the control groups with respect to weight, height, body mass index or dietary energy, protein, calcium, fiber, iron or zinc intakes. Mean values for HbA_{1c}, FBS, serum albumin, and the duration of diabetes of the patients and controls are shown in Table 1. As expected, the FBS and HbA_{1c} levels were significantly higher in the diabetics. The serum albumin level was not significantly different between the two groups. Further analysis of the data showed no statistically significant difference in serum zinc levels between diabetic patients and healthy controls. Also, subdividing the data according to sex showed no significant difference in serum zinc levels between patient and control groups (Table 2). Serum zinc levels in both the patients and the controls were in the normal range (only one healthy control had serum zinc deficiency (<70 mg/dl)). Dietary intake data showed that, as compared to RDA, 62.1% of the patients and 60% of the controls had a low zinc intake. No correlations were found between the serum zinc levels and FBS, HbA_{1c} or the duration of the disease in diabetic patients.

Table 3 shows the serum zinc concentration in diabetic patients according to glycemic control and the duration of diabetes. No statistically significant difference was found in serum zinc levels between the patients with good glycemic control (HbA1c ≤ 9%) and those with poor glycemic control (HbA1c > 9%). Nor was there any difference with regard to the duration of the disease (≤1 year and >1 year).

Table 1: HbA1c, FBS and serum albumin in diabetic patients and healthy controls and the duration of diabetes in patients

	Diabetic patients Mean ± SEM	Healthy controls Mean ± SEM	*P*-value
Hb1Ac (%)	8.7 ± 0.4	6.5 ± 0.1	<0.001
FBS (mg/dl)	221.9 ± 20.9	82.6 ± 1.8	<0.001
Serum albumin (g/dl)	4.8 ± 0/05	4.9 ± 0.1	0.2
The duration of diabetes (month)	30.5 ± 4.7	-	-

HbA1c, Hemoglobin A_{1c}
FBS, Fasting blood sugar
SEM, Standard error of mean

Table 2: Serum zinc concentration in diabetic patients and healthy controls

		Diabetic patients Mean ± SEM	Healthy controls Mean ± SEM	*P*-value
Serum zinc (mg/dl)	Male	112.8 ± 4.8	109.8 ± 4.6	0.6
	Female	108.5 ± 3.5	103.6 ± 6.6	0.5
	Total	111.0 ± 3.1	107.1 ± 3.8	0.4

SEM, Standard error of mean

Table 3: Serum zinc concentration in diabetic patients according to glycemic control and the duration of diabetes.

		Serum zinc mg/dl		*P*-value
		N	Mean ± SEM	
Glycemic control	HbA1c ≤ 9%	20	113.1 ± 3.3	
	HbA1c > 9%	10	106.7 ± 6.6	0.4
The duration of diabetes	≤1 year	10	111.6 ± 5.8	
	>1 year	20	110.6 ± 3.7	0.8

N, number of cases
SEM, Standard error of mean
HbA_{1c}, Hemoglobin A_{1c}

Discussion

In this study no statistically significant difference was found in serum zinc levels between children and adolescents with TIDM and healthy controls. Several studies on animal models of diabetes and humans with diabetes have been reported in the literature in which plasma or serum zinc concentration has been used as an indicator of zinc status, but the results have been contradictory (3,16-19). Furthermore, there are very few studies specifically on children and adolescents with T1DM, and these studies show contradictory results (10-15). Our results confirm the findings of some studies (14, 15), in which no difference in serum zinc concentration was observed between children and adolescents with T1DM and healthy controls. However, some investigators have reported lower (10, 11) or higher (12, 13) serum zinc levels in T1DM children. Probable reasons for these contradictory findings could be differences in the presence or absence of glycemic control, duration of diabetes, or the amount of zinc intake among the patients. However, in this study no correlations were found between serum zinc levels and HbA_{1c} or the duration of the disease. Jansen et al. (20) have hypothesized that the plasma zinc concentration may be related to the duration of the disease, such that the initial elevation of the plasma levels at the onset of the disease (when beta cell destruction occurs) is followed afterwards by a drop when elevated urinary zinc excretion overcomes the release of zinc from beta cells. This hypothesis is supported by the negative correlation between the duration of T1DM and plasma/serum zinc concentration in some studies (3, 21). However, in our study no significant correlation was found between the two variables. Even when we subdivided the diabetics according to their duration of the disease, nothing changed.

The possible relationship between zinc and diabetes mellitus has been of interest to many investigators since it was understood that zinc was part of the insulin complex. The most consistent finding of the animal and human studies on this subject so far is hyperzincuria (20). This has prompted some scientists to advance hypotheses stating that diabetics may develop zinc deficiency. However, none of our patients was zinc-deficient. It is to be noted that the assessment of borderline zinc deficiency is more dif

ficult due to the non-existence of frank clinical signs and reliable, well-defined, sensitive and specific laboratory indicators. In contrast to some other nutrients, there are no zinc reserves in the human body. As a result, when there is an insufficient dietary intake of zinc, problems can be expected. For example, the growth rate in children or the zinc excretion in adults is reduced in an effort to maintain zinc levels of tissues and homeostasis; consequently no apparent biochemical or functional changes occur (22, 23). In our study, 62.1% of the patients and 60% of the healthy controls had a low zinc intake compared to the respective RDA. Thus, despite normal serum zinc levels the possibility of borderline zinc deficiency in both groups cannot be ruled out.

In conclusion, the serum zinc levels of these diabetic children and adolescents were not noticeably different compared to those of healthy controls and were independent of glycemic control and the duration of the disease. Diabetic patients were not zinc-deficient based on their serum levels, despite the fact that the dietary zinc intake of about 60% of them was low. Certainly more research is required to shed more light on the subject.

Ethical Considerations

Ethical issue principles including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the authors.

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