Original Article

Trace mineral status and glycaemic control in Nigerians with type 2 diabetes

K I Akhuemokhan, A Eregie, and O A Fasanmade

Abstract

Diabetes has been shown to be associated with abnormalities in the metabolism of micronutrients, especially chromium, zinc, copper, magnesium, and manganese. People with type 2 diabetes attending the Diabetes Clinic of the University of Benin Teaching Hospital, were recruited to examine the relationship between trace mineral status and glycaemic control. A total of 120 persons were studied, mean (±SD) age was 54±7 years and mean duration of diabetes 4±4 years. Serum chromium level correlated inversely with fasting blood glucose (FBG) and HbA_{1c}, unlike the serum concentration of zinc which had no significant correlation with either FBG or HbA_{1c}. People with diabetes should be encouraged to eat local specific foods rich in chromium.

Introduction

Micronutrients have been investigated as potential preventive and therapeutic agents for type 2 diabetes and for common complications of diabetes[1,2] In particular, diabetes has been shown to be associated with abnormalities in the metabolism of zinc, chromium, copper, magnesium and manganese.[3,4] The serum concentration of chromium and zinc has been found to be lower than non-diabetic controls[4,5] and impairment of chromium and zinc status has been reported as an aggravating factors in the progression of diabetes.[6,7]

Peoople with type 2 diabetes have greater excretion of chromium and lower tissue levels of chromium than non-diabetic controls.[8] In addition, chromium is difficult to convert into usable forms in people with diabetes.[8] Supplemental chromium given to type 2 diabetic patients has yielded positive effects on blood glucose, insulin, lipid, and glycated haemoglobin levels.[9] Patients with diabetes have been found to have hyperzincuria compared with non-diabetic controls.[10] Zinc deficiency is associated with a number of metabolic disturbances including impaired glucose tolerance, insulin degradation, and reduced pancreatic insulin content.[11]

The objective of this study was to evaluate serum chromium and zinc status in patients with type 2 diabetes and correlate this with glycaemic control in a Nigerian population.

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Patients and methods

This study was carried out in the Diabetes Clinic of the University of Benin Teaching Hospital (UBTH), Benin City, Nigeria over a 4-month period. Patients with type 2 diabetes attending the clinic who met the inclusion criteria, were recruited consecutively at presentation with informed consent. The study was approved by the Ethics Committee of the UBTH.

Proteinuria, hypoproteinaemia and pregnancy were exclusion criteria. Patients on drugs such as chelating agents, ethambutol, D-penicillamine, or oral contraceptive pills were also excluded. The study was cross-sectional in design. Questionnaires were administered to subjects to obtain socio-demographic information. Subjects had a detailed physical examination, and blood was collected for fasting blood glucose (FBG), serum lipid profile, serum chromium and zinc, serum urea and creatinine (after an overnight fast of 8–10 hours). HbA_{1c} was measured by means of a DCA2000 analyser machine, whilst an atomic absorption spectrophotometer (AAS) with a data processing unit was used to measure the serum zinc and chromium. The SPSS statistical software was used for analysis. Differences were significant when the p-value was <0.05. Pearson's correlation was used to link the different variables with zinc and chromium.

Results

A total number of 120 haemoglobin A_{1c} (HbA_{1c}) patients-were studied (see Table 1). The mean (±SD) age was 54±7 years – males 54±8 and females 54±7 years. The mean duration of diabetes was 4±4 years (range 1–23 years). Of the study group, 91 (76%) patients were on a combination of diet therapy and multiple oral hypoglycaemic drugs, 21(17%) were on insulin and diet therapy, 6 (5%) were on a single oral hypoglycaemic drug and diet alone, while 2 (2%) patients were on diet therapy only. The mean body mass index (BMI) was 29.8±5 kg/m^2 (males 30.1±4.6 and females 29.5±5.6). The mean waist circumference was 94.3± 11.1 cm while the mean waist to hip ratio was 0.94±0.06.

The prevalence of hypertension was found to be 62% (74 patients), while the prevalence of chromium deficiency was 67% (80 patients) and that of zinc was 60% (72 patients). The mean serum level of chromium was 0.4±0.2 µ/L (males 0.4±0.2 µ/L and females 0.4±0.2 µ/L. The mean concentration of zinc was 3.4±13.3 µ/L, with a median of 1.0 (males 2.6 (±4.3) with a median of 1.0, and females 4.3±18.4 with a median of 1.0). The mean FBG was 8.4±4.2 mmol/L, and the HbA_{1c} was 8.8±2.7% males (see Table 1). A total of 37% (45 patients) had an HbA_{1c} <7%, and 62% (75 persons) had an HbA_{1c} ≥7%. Serum chromium concentration correlated inversely with FBG and HbA_{1c}, unlike the serum concentration of zinc which had no significant correlation with FBG and HbA_{1c}. Correlation curves for zinc and chromium with HbA_{1c} are shown in Figures 1 and 2.

Table 1 Characteristics of the study subjects (mean±SD)

Indices	Male (n=60)	Female (n=60)	Both (n=120)
Age (years)	54±8	54±7	54±7
Duration of diabetes (years)	4±4	5±4	4±4
BMI (kg/m^2)	29.8±5.1	30.1±4.6	29.5±5.6
FBG (mmol/L)	8.3±3.7	8.5±4.5	8.4±4.2
HbA_{1c} (%)	8.8±2.8	8.8±2.7	8.8±2.7
Chromium (µ/L)	0.4±0.2	0.4±0.2	0.4±0.2
Zinc (µ/L)	2.6±4.3	4.3±18.4	3.4±13.3

Figure 1 Correlation between serum chromium and HbA_{1c} ($p<0.01$)

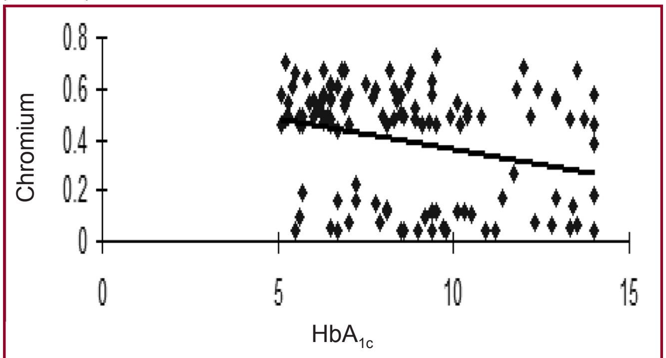
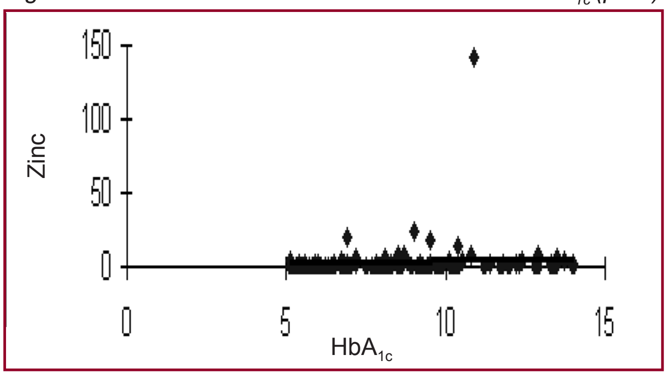


Figure 2 Correlation between serum zinc and HbA_{1c} (pNS)



Discussion

Diabetes has become an international healthcare crisis that requires new approaches to prevention and treatment. Diabetes management should begin with exercise and diet.[12] From the rigidly controlled semi-starvation diets in ancient times, through to the 70%:20%:10% diet (for fat, protein and carbohydrate respectively), to the present 'all-food-can-fit' regimens, we have arrived at nutrition science as we know it today – 'medical nutrition therapy'.[12] Dietary modification, the simplest and cheapest form of diabetes treatment, is the primary therapy in type 2 diabetes.[13]

Diabetes has been show to be associated with abnormalities in the metabolism of chromium and zinc. Impairment of chromium and zinc status has been reported as aggravating factors in the progression of diabetes. Chromium is a cofactor in the action of insulin and it potentiates the action of insulin.[14–17] As such it may improve blood glucose levels in individuals with a tendency towards blood glucose fluctuations associated with diabetes (hyperglycaemia). Thus, it may not be surprising to find (as noted in this study) an inverse relationship between serum chromium levels and blood glucose control.

Zinc and insulin concentrations in the pancreas change in the same direction in a variety of situations in humans.[18] Zinc is useful in the synthesis, storage, and secretion of insulin.[19] Zinc may improve glycaemia, and a restored zinc status in patients with type 2 diabetes may counteract the deleterious effects of oxidative stress, helping to prevent complications associated with diabetes.[20] However, no correlation was found between zinc and glycaemic control in this study.

Traditionally, eating fresh grains, fruits, sea food, and vegetables grown in nutrient-rich soil, has been the primary supply for the full spectrum of ionically charged minerals. If agricultural systems fail to provide enough products containing adequate quantities of all nutrients during all seasons, dysfunctional food systems result that cannot support healthy lives and this is the case for many agricultural systems in many developing nations.[21]

Unfortunately, naturally occurring, nutrient-rich soil is almost non-existent on commercial farms. Aggressive farming techniques have stripped most trace minerals from the soil, and the use of nitrogenous fertilisers in agriculture is relatively cheap, and is therefore the foundation of modern farming methods.[22,23] Re-mineralisation of the soil on the other hand is very expensive. When people consume a diet derived from such depleted crops, the intake of essential trace minerals becomes inadequate, which may lead to poor health and disease.[24] Refining of carbohydrate foods also causes a sharp drop in the concentration of various vitamins and minerals.[24]

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