Urinary loss of micronutrients in diabetic patients attending a tertiary hospital service

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Abstract

Background/aims: micronutrient deficiency may contribute to a poorer control of diabetes. Thus, the objective of the present study was to assess the urinary excretion of micronutrients in patients with type 2 diabetes mellitus.

Methods: patients with diabetes and controls were assessed regarding food intake, anthropometry, urinary loss of micronutrients and compared by the nonparametric Mann-Whitney test (p<0.05).

Results: nine diabetic volunteers (52 ± 14 years, BMI 30 ± 11 kg/m² and abdominal circumference (AC) of 99 ± 25 cm) and 9 control individuals (51 ± 16 years, BMI 26 ± 5 kg/m² and AC of 90 ± 13 cm) were studied. Higher iron excretion was observed in the diabetic group and higher magnesium excretion in the control group.

Conclusions: the type 2 diabetic patients here studied did not show increased micronutrient excretion in urine when compared to controls.

(Nutr Hosp. 2015;32:678-682) DOI:10.3305/nh.2015.32.2.9074

Key words: Type II diabetes mellitus. Micronutrients.

Introduction

The world prevalence of diabetes mellitus (DM) is 171 million people and it is estimated to reach approximately 299 million in 2025 (WHO, 1997; 2000). According to the estimates of the Ministry of Health, about 11 million people with diabetes live in Brazil1.2. The Brazilian Multicenter Study3 has reported that the prevalence of type 2 diabetes mellitus (DM2) and of glucose intolerance among the adult Brazilian population is 7.6% and 7.8%, respectively. The annual cost for the treatment of these patients has been estimated at R$ 3963/patient4.

Diabetic patients are more predisposed to the development of atherosclerotic diseases, dyslipidemia,
hypothesis, hyperuricemia, renal failure, retinopathy and neuropathy compared to the general population. In addition, these patients may show urinary loss of nutrients such as iron, copper, selenium, chromium and zinc and some authors have suggested that this change in micronutrient levels may contribute to the worsening of glucose homeostasis. Other studies have suggested that increased excretion of some nutrients such as zinc, calcium and protein may be associated with changes in renal function in these patients. These losses are believed to possibly lead to the development of complications such as atherosclerotic disease, dyslipidemia and osteoporosis, among others.

Thus, the objective of the present study was to investigate whether type 2 diabetic patients excrete higher amounts of micronutrients in urine when compared to controls.

Methods

Patients

This was a cross-sectional study conducted in the Diabetes Mellitus Outpatient Clinic of the University Hospital, Faculty of Medicine of Ribeirão Preto (HCFMRP/USP). The study was approved by the Research Ethics Committee of HCFMRP/USP (Protocol nº6228/2009) and did not interfere at any time with the clinical course of the patients or with the ambulatory routine.

Patient sampling was non-probabilistic, by convenience and on a voluntary basis, with recruitment of patients who were willing to participate in the study and who satisfied the inclusion criteria. In addition to the diabetic patients, healthy individuals on the hospital staff were invited to participate in the study as controls and were also recruited by the same sampling method.

The inclusion criteria for diabetic patients were: 1) to have DM and to be under treatment at the Diabetes Mellitus Outpatient Clinic of HCFMRP/USP; and 2) to be older than 18 years.

Only patients with chronic renal disease were excluded.

The inclusion criteria for control subjects were: 1) to have similar weight and height and to be of similar age as the diabetic patients. To this end, the diabetic patients were first recruited and when their group was complete the controls were recruited for appropriate pairing. 2) To be older than 18 years. Subjects with DM and chronic renal diseases were excluded.

Experimental design

The study was first explained to the possible participants and the patients willing to participate gave written informed consent. Next, four 1-liter demineralized flasks containing 10 ml hydrochloric acid were delivered to each participant for collection of 24 hour urine. Also at this first meeting, the food record was delivered and explained to the subjects, who were instructed to fill it out on the day of urine collection, and who also received instructions for urine collection. The food record consisted of the foods, preparations and quantities ingested and the times of ingestion. On the day scheduled for return, the patients delivered the flasks and the food record and were submitted to anthropometric measurements of weight, height and abdominal circumference (AC).

The control subjects were submitted to the same evaluation as the diabetic group. They received four flasks for 24-hour urine collection, recorded the food ingested on the day of urine collection and signed the term of consent. They were also submitted to the anthropometric measurements of weight, height and AC.

The patients’ medical records were also reviewed for information about age (years), time of evolution of DM (years), type of treatment (insulin, hypoglycemic drugs and diet), presence of micro- and macrovascular complications related to DM, and the presence of associated comorbidities.

Anthropometry

Weight, height, body mass index (BMI) and AC were determined as described by Lohman et al. and were compared to the values recommended by the World Health Organization (WHO). AC was measured around the midpoint between the costal margin and the iliac crest during expiration.

Evaluation of food intake

Food intake on the day of urine collection was evaluated by means of the food record and calculated using the Nutwin® software, which provided the nutritional composition of the various foods.

The recommended percentage of macronutrients in relation to the total calorie value was calculated with respect to the baseline energy expenditure obtained by the Harris & Benedict formula (1919), being 15%, 25% and 60% of the basal energy value, respectively. The value, in grams, of these nutrients was obtained by dividing the calculated amount by 41, 9 and 4 kcal, respectively.

The intake of the remaining nutrients was compared to the dietary recommendations of the Dietary Reference Intakes (DRIs) according to patient age.

Preparation of the flasks for urine collection

The flasks and their lids were immersed in nitric acid for 24 hours. The acid was then removed by
simple washing with Milli-q water, with the process being repeated at least ten times. Next, the flasks and lids were removed from the acid solution and completely dried in an oven. Finally, the duly demineralized and labeled flasks containing 10 ml 50% hydrochloric acid were delivered to the volunteers.

Micronutrient determination

Urinary strontium, calcium and zinc concentrations were determined with a Shimadzu AA-6200 atomic absorption spectrophotometer. Nitrogen was determined by pyrochemiluminescence using an Antek – 720 instrument.

Statistical analysis

Data were treated with descriptive statistics and are reported as frequency, mean and standard deviation. The nonparametric Mann-Whitney test was used to compare the diabetic and control groups. The Pearson correlation coefficients were calculated in order to determine the association between the urinary and dietary values of the minerals analyzed. The Statistica® software version 8.0 was used for all analyses.

Results

Eighteen volunteers, 12 women (66%) and 6 men (33%), participated in the study. The DM group consisted of 9 volunteers; the mean (± SD) age of this group was 52 ± 14 years, BMI was 30 ±11 kg/m², AC 99 ± 25 cm, and mean time of disease evolution was 11.3 ± 7 years. Regarding complications, arterial hypertension was observed in 5 patients (28%) and dyslipidemia and obesity in 4 (22%).

The control group also consisted of 9 subjects, 3 males (33%) and 6 females (66%). Mean age was 51 ± 16 years, mean BMI was 26 ± 5 kg/m² and mean AC 90 ± 13 cm. In this group, the prevalence of arterial hypertension was 33%, the prevalence of obesity 22%, and the prevalence of dyslipidemia 11%. There was no significant difference in age or in the anthropometric variables between groups (Table I).

The food recall was obtained only from 16 of the 18 participants since two patients did not agree to record these data. The results are shown in Table II.

It can be seen that the diabetic patients showed excessive protein intake and insufficient calcium and magnesium intake. Conversely, they showed greater meal fractionation along the day and greater fiber intake (fruits and vegetables). The energy intake of most patients was below the basal expenditure. Some inadequacies were also observed in the control group, as depicted in Table I.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Diabetes Group</th>
<th>Control Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal/day)</td>
<td>1206</td>
<td>2407</td>
<td>0.008*</td>
</tr>
<tr>
<td>Protein (g/day)</td>
<td>64</td>
<td>55</td>
<td>0.354</td>
</tr>
<tr>
<td>Lipid (g/day)</td>
<td>33</td>
<td>40</td>
<td>0.004*</td>
</tr>
<tr>
<td>Carbohydrate (g/day)</td>
<td>141</td>
<td>159</td>
<td>0.015</td>
</tr>
<tr>
<td>Calcium (mg/day)</td>
<td>515</td>
<td>548</td>
<td>0.037*</td>
</tr>
<tr>
<td>Phosphorus (mg/day)</td>
<td>822</td>
<td>785</td>
<td>0.105</td>
</tr>
<tr>
<td>Iron (mg/day)</td>
<td>8</td>
<td>7</td>
<td>0.298</td>
</tr>
<tr>
<td>Sodium (mg/day)</td>
<td>570</td>
<td>1062</td>
<td>0.011*</td>
</tr>
<tr>
<td>Potassium (mg/day)</td>
<td>2505</td>
<td>1429</td>
<td>0.820</td>
</tr>
<tr>
<td>Riboflavin (mg/day)</td>
<td>1.03</td>
<td>0.90</td>
<td>0.018*</td>
</tr>
<tr>
<td>Saturated fat (g/day)</td>
<td>7</td>
<td>13</td>
<td>0.002*</td>
</tr>
<tr>
<td>Cholesterol (mg/day)</td>
<td>130</td>
<td>119</td>
<td>0.728</td>
</tr>
<tr>
<td>Folate (mcg/day)</td>
<td>222</td>
<td>172</td>
<td>0.355</td>
</tr>
<tr>
<td>Zinc (mg/day)</td>
<td>6</td>
<td>6</td>
<td>0.083</td>
</tr>
<tr>
<td>Magnesium (mg/day)</td>
<td>217</td>
<td>213</td>
<td>0.083</td>
</tr>
</tbody>
</table>

*Not available in nutritional composition tables; *Statistically significant difference between groups.

Table I

Nutritional composition of the food record corrected for 1000 kcal

Urinary loss of micronutrients in diabetic patients attending a tertiary hospital service

Regarding the urinary excretion of micronutrients, the only nutrient excreted in larger quantities by the diabetic group was iron. This nutrient is believed to generate oxidative stress, understood as an increase in the steady state concentration of reactive oxygen and nitrogen species.26,31. These species cause several types of cell damage including impairment of proteins that regulate or limit extracellular iron uptake. As a consequence of oxidative stress, cell injury occurs (lipid peroxidation) with possible destruction of the membrane and cell death, in parallel to an increased risk to develop DM2.22,35. Besides, oxidative stress has also been shown to contribute to poor glycemic control and to the macro and microvascular complications of diabetes.34. We therefore speculate that increased iron urinary excretion could be a defense mechanism against oxidative stress in type 2 diabetes mellitus.

As is the case for most clinical investigations, the present study had some methodological limitations such as a small sample size. However, to the best of our knowledge, few studies have investigated the loss of various micronutrients in urine by diabetic patients.

Conclusion

We concluded that diabetic patients excrete more iron in urine when compared to non-diabetic subjects.

Acknowledgments

We are grateful to the participants in the study and to Fundação de Amparo à Pesquisa do Estado de São Paulo for financial support (Grant 2010/01101-7).

Disclosure

The authors have no potential conflicts of interest relevant to this article.

Table II

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Diabetes Group</th>
<th>Control Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strontium (µg/total volume)</td>
<td>425±216</td>
<td>485±192</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Iron (µg/total volume)</td>
<td>790±233</td>
<td>545±382</td>
<td>0.012a</td>
</tr>
<tr>
<td>Magnesium (mg/total volume)</td>
<td>103±93</td>
<td>242±204</td>
<td>0.038a</td>
</tr>
<tr>
<td>Zinc (µg/total volume)</td>
<td>575±195</td>
<td>489±245</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Calcium (mg/total volume)</td>
<td>18±9</td>
<td>10±5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Nitrogen (g/total volume)</td>
<td>12±6</td>
<td>17±12</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

a Statistically significant difference between groups; b Not determined.

Discussion

The objective of the present study was to determine the urinary excretion of micronutrients in diabetic patients followed up at a university hospital.

The excess weight of the diabetic group agreed with the data reported by Blackburn in 200220, showing a high prevalence of obesity in patients with DM2. The high AC value detected in the diabetic group is representative of the accumulation of fat in this region, which is intimately related to insulin resistance.21,22.

The food intake of the diabetic group showed various inadequacies such as excessive protein consumption and insufficient calcium and magnesium intake, although these patients showed greater fractionation of the meals and greater consumption of fruits and vegetables which, however, was still below recommended levels23. These results agree with data reported by Mayer-Davis et al24 and Overby et al25. Other diabetic populations have shown inappropriate food consumption, such as mean protein intake above ADA recommendations25 in both Brazilian and international studies.26,27,28,29.

Table II presents the results of urinary nutrient loss. The diabetic group showed a significantly higher iron loss compared to control, whereas the control group excreted more magnesium. When the intake of these nutrients was correlated with their excretion, no correspondence was detected between them.
Author’s contributions
Andressa Feijó da Silva Santos: research project writing, recruitment of the volunteers, data collection and analysis, manuscript writing.
Roberta Deh Souza Santos: recruitment of the volunteers, data collection and analysis, manuscript writing.
Maria Cristina Foss-Freitas: research project writing, recruitment of the volunteers, data collection and analysis, manuscript writing.
Júlio Sérgio Marchini: data analysis, manuscript writing.
Vivian Marques Miguel Suen: research project writing, data analysis, manuscript writing.

References