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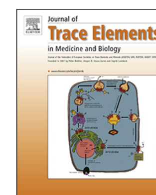

Nutrition

Plasma zinc in institutionalized elderly individuals: Relation with immune and cardiometabolic biomarkers

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ABSTRACT

Changes in zinc metabolism caused by aging and the institutionalization process may contribute to zinc deficiency in elderly individuals. Hypozincemia results in changes in glycemic, lipid, and inflammatory profiles. The aim of this study was to evaluate plasma zinc concentrations and their relationships with sociodemographic, dietary, inflammatory, and cardiometabolic biomarkers in institutionalized elderly individuals. A cross-sectional study was carried out including 255 elderly adults living in nursing homes. The associations between plasma zinc and dietary zinc intake, sociodemographic indicators, and glycemic, lipid, and inflammatory biomarkers were evaluated. Independent variables were analyzed according to quartiles of plasma zinc concentrations (Q1: < 71.1 μg/dL; Q2: 71.1–83.3 μg/dL; Q3: < 83.3–93.7 μg/dL; Q4: > 93.7 μg/dL). The relationship between plasma zinc concentrations and predictor variables was also tested. In Q1, higher concentrations of the following variables were observed, compared with those in other quartiles: total cholesterol and low-density lipoprotein cholesterol (LDL-c; Q1 > Q2, Q3, Q4; all $p < 0.001$); triglycerides (Q1 > Q3, Q4; all $p < 0.001$); interleukin (IL)-6 (Q1 > Q3, Q4; $p = 0.024$ and $p = 0.010$, respectively); tumor necrosis factor (TNF)-α (Q1 > Q3, $p = 0.003$). A significant reduction in plasma zinc concentrations was observed with increasing age-adjusted institutionalization time (Δ = − 0.10; 95% confidence interval [CI]: −0.18 to −0.01). The concentrations of total cholesterol (Δ = − 0.19; 95% CI: −0.23 to −0.15), LDL-c (Δ = − 0.19; 95% CI: −0.23 to −0.15), triglycerides (Δ = − 0.11; 95% CI: −0.16 to −0.06), IL-6 (Δ = − 1.41; 95% CI: −2.64 to −0.18), and TNF-α (Δ = − 1.04; 95% CI: −1.71 to −0.36) were also significantly increased. In conclusion, decreased plasma zinc concentrations were associated with longer institutionalization time and worse lipid and inflammatory profiles in elderly institutionalized individuals.

1. Introduction

Zinc deficiency in elderly individuals is related to inadequate dietary intake, deficient intestinal absorption, medication use, and chronic disease [1]. Institutionalization can have a positive impact on the quality of life of elderly individuals. However, institutionalization can also change the way of life of individuals, such as through the standardization of eating practices, leading to nutritional deficiencies, such as zinc deficiency [2].

Aging also causes deregulation of zinc homeostasis, with reduced expression of Zrt- and Irt-like proteins and increased expression of zinc transporter and metallothioneins [3,4]. Decreased plasma zinc

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concentrations lead to impairment of zinc-dependent functions in the immune system and antioxidant protection [5].

Zinc deficiency leads to dysregulation in the adaptive immune system, resulting in increased synthesis of pro-inflammatory cytokines, such as interleukin (IL)-6 and tumor necrosis factor (TNF)-α; this process is known as “inflamm-aging” [3,6]. Moreover, zinc deficiency increases susceptibility to infections [4] and may be related to excess free fatty acids in the bloodstream. When binding affinities of long-chain fatty acids exceed those of plasma Zn^{2+}, the binding of fatty acids to serum albumin is likely to diminish serum albumin Zn^{2+}-binding [7]. Thus, the binding of free fatty acids to albumin increases free Zn^{2+} concentrations, promoting cellular uptake of zinc, and decreasing plasma zinc concentrations [7,8]. Low plasma zinc concentrations stimulate lipolysis and reduce the use of fatty acids in the mitochondria and peroxisomes. Increased free fatty acid concentrations stimulate the synthesis of very-low-density lipoprotein (VLDL), which in excess contributes to hypertriglyceridemia, thereby increasing low-density lipoprotein cholesterol (LDL-c) production and reducing high-density lipoprotein cholesterol (HDL-c) production [9,10]. Zinc deficiency can also lead to hyperglycemia and insulin resistance [11].

However, few studies have evaluated zinc status in institutionalized elderly individuals. Here, we evaluated plasma zinc concentrations and their relationships with sociodemographic, dietary, immunological, and cardiometabolic biomarkers in institutionalized elderly individuals.

2. Materials and methods

2.1. Study design and population

This analytical, cross-sectional study was conducted between November 2013 and April 2014. At the time of data collection, 393 elderly individuals were enrolled in 13 nursing homes in the municipality of Natal, north-eastern Brazil. Nine institutions agreed to participate in the study (304 individuals). All individuals who were at least 60 years old and who lived in these nursing homes were included. Elderly individuals with difficult venous access were excluded. Twenty-four elderly individuals or their guardians refused to participate in the study; 14 elderly individuals were excluded due to venous access difficulty; 11 were lost due to blood hemolysis, internment, or death; and 117 individuals had missing data from incomplete records and/or insufficient blood samples. Therefore, data collection was complete for 138 participants. Missing data for the 117 individuals were imputed, with a final study population of 255 individuals (Fig. 1).

Participants were recruited through contact with nursing home directors, the elderly, and their families. Information on the objectives and steps of the study were provided. Sociodemographic, clinical, and lifestyle data were collected from participating nursing homes. A technical team with training in the standardization of instruments to be used in the data collection was involved.

The study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte (UFRN; protocol 263/11; CAAE 0290.0.051.000-11). All participants or their guardians provided written informed consent for participation in the study.

2.2. Sociodemographic variables

Data concerning sex, age, and date of admission to the nursing home were obtained from records. We calculated the age-adjusted institutionalization time to determine how much of the period of old age (in percentages; designated as the time after reaching 60 years of age) the elderly individuals has been institutionalized, according to the following formula:

Age-adjusted institutionalization time = $\frac{\text{data collection year} - \text{nursing home admittance year}}{\text{age in years} - 60} \times 100$

This correction was performed based on the fact that the age influenced health status. Thus, considering individuals with the same institutionalization time, those who entered nursing homes with more advanced age could have more health problems due to age and not the time of institutionalization.

2.3. Biochemical analyses

Blood was collected by venepuncture after a 12–14-h overnight fasting period. Glucose and lipid profile analyses were performed by the colorimetric method using Labtest Diagnóstica kits. HbA1c (glycated hemoglobin) was also analyzed by the colorimetric method (Trivelli modified) using a semi-automatic analyzer (model Bio-200; Barueri, Brazil). LDL-c concentrations were obtained using Friedewald’s formula [12]. C-reactive protein (CRP), TNF-α, and IL-6 were analyzed by chemiluminescence using Immulite 1000 (Malvern, USA), and Siemens kits. The following reference values were used: fasting glucose (70–99 mg/dL) [13], HbA1c (5.3–8.0% according to the manufacturer’s recommendations), total cholesterol (< 200 mg/dL), HDL-c (> 60 mg/dL), LDL-c (< 100 mg/dL), triglycerides (< 150 mg/dL) [11], CRP (< 10 mg/dL), IL-6 (< 3.4 pg/mL), and TNF-α (< 8.1 pg/mL according to the manufacturer’s recommendations).

2.4. Plasma zinc analysis

Blood samples for zinc analysis were placed in demineralized tubes containing 100 μL of 30% sodium citrate solution and separated into plasma. Plasma zinc was determined by atomic absorption spectrophotometry, using a Spectra Varian AA-240 instrument (Varian Medical Systems, Inc., Milpitas, CA, USA). To minimize mineral contamination, all glassware and plastic containers used during blood collection and zinc analysis were carefully demineralized in a 20% nitric acid bath for at least 12 h and rinsed 10 times with ultrapure water (Direct-Q 3 Water Purification Systems; Merck Millipore, Darmstadt, Germany). We calibrated the assay using the following working conditions: wavelength, 231.9 nm; slit width, 1.0 nm; current, 5.0 mA; expansion factor, 1.0; and sample flow, 5 mL/min. A standard zinc solution (Tritisol; Merck) was used to define the points of the calibration curve, which included concentrations of 0.10, 0.25, 0.50, 0.75, and 1.00 μg/mL. The standard curve was prepared with the addition of 5% glycerol. Seronorm Trace Elements Serum L-1 solution (SERO AS, Billingstad, Norway; Reference 201405, Lot 0,903,106) was used as a reference for zinc analysis.

Plasma zinc concentrations were determined according to the method described by Rodrigues et al. [14]. The results obtained were analyzed according to the distribution of plasma zinc concentrations in quartiles.

2.5. Dietary analysis of zinc

Food and dietary intake data were obtained by direct weighing of food. The methodological proceedings were developed using a Balmak electronic scale (Santa Bárbara D'Oeste, Brazil), with a capacity of 300 kg and precision of 50 g (for pans and refractory). A Mark “S” electronic scale (São Paulo, Brazil), with a capacity of 3.2 kg and precision of 0.1 g, was used to weigh food and servings. Liquid foods were measured using 100- and 500-mL plastic beakers. The quantity of food consumed (in grams) was determined based on the difference between the offered and rejected quantities. Data were collected on two separate days with an interval of 30–45 days. We performed dietary analysis using Virtual Nutri Plus software, version 1.0. New preparations and foods, along with their nutritional composition, were added to the database as necessary. Energy consumption was calculated from the average values obtained on both data collection days.

Dietary zinc values were adjusted based on intra- and interpersonal variability and energy. One-way analysis of variance (ANOVA) was used to determine intrapersonal variability, and estimates of intra- and interpersonal variances were based on the resulting quadratic means [15]. In order to control the confounding factors inherent in total

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