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Rapidly exchangeable pool study of zinc in free-living or institutionalized elderly women

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Abstract

Objective: We evaluated the effect of age and institutionalization on zinc metabolism by using a stable isotope technique.

Methods: This was a randomized case-control study. Three groups were recruited: nine young women (group 1, ages 36 ± 1 y) as controls, nine free-living elderly women (group 2, ages 72 ± 2 y), and nine institutionalized women (group 3, ages 73 ± 2 y). Only women were recruited to obtain homogeneous groups. The study was set in a Valence hospital (France) in the geriatric department (headed by Dr. Ferry). The experimental design of the study was reviewed and approved by the local ethical committee, and all participants signed a consent form. No subject dropped out of the study. A zinc stable isotope label (0.73 mg of ^{70}Zn) was injected intravenously into patients and measured by inductively coupled plasma mass spectrometry.

Results: Decay curves of the plasma ^{70}Zn followed a one-compartment kinetic leading to the determination of one pool. The size of this pool suggested that it corresponded to the liver compartment. The size of this pool was significantly smaller in elderly people. ^{70}Zn plasma resident time was significantly longer in elderly individuals, and shorter in institutionalized than in free-living elderly subjects.

Conclusion: These data suggest that the zinc metabolism of elderly women is related to lifestyle or its consequences and to age. Moreover, we have demonstrated that kinetic studies using stable isotopes of zinc can provide novel information on exchangeable zinc pools in clinical situations.

Keywords: Zinc; Elderly; Metabolism; Stable isotopes

Introduction

Increasing attention is being paid to the relation between nutrition and health, particularly with regard to the possible link between nutrition and essential biological functions. For instance, with respect to the role of zinc in immunity, inflammation, oxidative stress, and cell integrity [1], the need to investigate zinc nutritional requirements, status, and metabolism of people as they grow older is an important goal to improve quality of life and prevent accelerating aging. Zinc deficiency during aging can originate from several modifications including increased preference for cereal proteins, decreased energy intake [2], low income, and an impaired zinc intestinal absorption [3]. Assessment of zinc status in elderly people is complicated. Difficulties are present due to a lack of a good marker of zinc status. Serum zinc concentration is not ideal indicator [4]. The specificity of elderly people must be taken into account because they form a heterogeneous population through their health state and their lifestyle. Further, technical difficulties in performing urine or feces collections are encountered in elderly

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people more especially when they are hospitalized, so the accuracy of a mineral metabolism study is suspect in this population. For these reasons, in this study the compartmental analysis of tracer kinetic was used to provide valuable insights into the metabolism of zinc [5]. Although they provide more limited information than radioisotopes, stable isotopes were used because they can ethically be used in humans. Moreover, this technique has been validated in compartment modeling [6]. Stable isotopes of zinc administered intravenously have been used to develop a simple model that exchanges rapidly with plasma [7] for a short or longer period [8].

This study used a stable isotope tracer of zinc (i.e., ^{70}Zn) to determine the very rapidly exchanging plasma pool and the related kinetic data of this element (1 to 6 h) in elderly people. This pool has an important function because it is mainly related to the zinc hepatic compartment. To examine the link between zinc metabolism and lifestyle, three groups were designed: one group of institutionalized elderly subjects, one group of free-living elderly subjects, and one group of young people living in the same area. This study was part of a large research program in which selenium exchangeable pools were also investigated [9].

Materials and methods

To obtain homogeneous groups, only women were recruited. Three groups of subjects who lived in Valence, France were gathered: group 1 consisted of nine healthy young women (age 36 ± 1 y, mean ± standard error of the mean) and served as controls, group 2 consisted of nine free-living elderly women (age 72 ± 2 y), and group 3 consisted of nine institutionalized women (age 73 ± 2 y). No subject had an acute inflammatory process, cancer, digestive malabsorption, liver or renal diseases, or a dementia syndrome according to the criteria of *Diagnostic and Statistical Manual of Mental Disorders, Third Edition*. No subject underwent surgery during the previous 3 mo. All women abstained from taking mineral or vitamin supplements for longer than 3 mo before the study. Average heights were 164, 159, and 154 cm and average weights were 56.6, 67.3, and 62.3 kg for groups 1, 2, and 3 respectively. Thus, values for body mass index (weight divided by height squared) were 21.0 ± 0.7, 26.7 ± 1.2, and 26.4 ± 1.3 kg/m^2 for groups 1, 2, and 3, respectively. A medical examination was performed by a physician just before blood tests. Blood tests before the study were performed to assess subjects' nutritional state (albumin and transthyretin) and inflammatory state (C-reactive protein, α_1-acid glycoprotein). These parameters were necessary to calculate the Protein and Inflammatory Nutritional Index, which has been previously validated in elderly people as an inflammatory index that considers the nutritional state [10].

The experimental design of the study was reviewed and approved by the local ethical committee, and all participants signed a consent form.

Preparation of ^{70}Zn stable isotope

Stable isotopes ^{70}Zn and ^{74}Se were infused. ^{70}Zn, as zinc oxide (enriched to 73.4% abundance), was a gift from the Nestlé Research Center (Lausanne, Switzerland). Zinc oxide was dissolved in 30% HCl (Normatom, Prolabo, Paris, France) to obtain zinc chloride. The product was mixed, the pH was adjusted to 6.4 by $NAHCO_3/Na_2CO_3$ buffer, and isotonic sodium chloride was added to complete the volume. This preparation was performed under sterile conditions. Sterilization and pyrogen testing were performed at the hospital pharmacy (Hospital A Michallon, Grenoble, France), where the doses were dispensed in individual, sealed, sterile vials (10-mL volume).

Experimental design

In the morning, subjects who had fasted since 8:00 PM the previous evening arrived at the exploration unit of the hospital. An accurate weighed dose of enriched isotopes was administered intravenously to each subject, and the dose provided 0.73 mg of ^{70}Zn and 100 μg of ^{74}Se in a 10-mL volume. An indwelling catheter was placed in an arm vein and a fasting blood sample (15 mL) was drawn into a zinc-free polypropylene syringe and immediately transferred to polypropylene tubes without trace elements. Five more samples (15 mL) were taken at 1, 2, 4, 5, and 6 h after ^{70}Zn infusion. Plasma was separated out by centrifugation for 10 min. Just after isotope infusion, subjects received a light breakfast (tea or coffee and a piece of bread with butter) just before the dietary investigation by a dietitian. Two types of investigations were conducted: a dietary history for control and free-living elderly subjects and a 3-d weighed food record for the institutionalized elderly. Dietary history was based on a quantitative food frequency technique over a 6-mo period. Photographs were used to quantify food portions. Each interview lasted 1 to 2 h and subjects were questioned about their usual foods and beverages during different meals. For each food, the result was expressed as grams per day. Foods were gathered as 72 items and then converted in nutrients. The conversion was performed by using INSERM data that were used previously in the Val de Marne epidemiologic study [11].

Weighed food intake was recorded for institutionalized subjects including food served but not eaten. From the menu and with the technical help of the cook, food ingredients of each dish were obtained and expressed as grams per day. Ingredients were also converted to nutrients by using the same table as used for the dietary history.