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Urinary excretion of vitamin B_1, B_2, B_6, niacin, pantothenic acid, folate, and vitamin C correlates with dietary intakes of free-living elderly, female Japanese

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Abstract

We hypothesized that 24-hour urinary excretion of water-soluble vitamins might correlate with their intake in free-living Japanese elderly females aged 70 to 84 years. We performed a cross-sectional study composed of 37 healthy, elderly, Japanese females living freely. All foods and the corresponding weights consumed for 4 consecutive days were recorded accurately. A 24-hour urine sample was collected on the fourth day, and the urinary content of water-soluble vitamins was measured. The urinary levels of all vitamins, except for B_{12} ($r = 0.01$; $P = .936$), were correlated positively with the mean intake over the recent 4 days (vitamin B_1: $r = 0.62$; $P < .001$; vitamin B_2: $r = 0.57$; $P < .001$; vitamin B_6: $r = 0.37$; $P < .005$; niacin: $r = 0.54$; $P < .001$; niacin equivalents: $r = 0.54$; $P < .001$; pantothenic acid: $r = 0.59$; $P < .001$; folate: $r = 0.55$; $P = .001$; and vitamin C: $r = 0.53$; $P < .001$). Mean estimated intakes of water-soluble vitamins calculated using urinary concentrations and recovery rates showed 96% to 107% of their 3-day mean intake, except for vitamin B_{12} (65%). We conclude that urinary levels of water-soluble vitamins, except for B_{12}, reflected their recent intake in free-living Japanese elderly females and could be used as a measure of their intake during the previous few days both for group means and for individual rankings within a group.

Keywords: Urinary levels; Vitamins; Biomarkers; Food intake; Free-living; Elderly
Abbreviations: 4-PIC, 4-pyridoxic acid; ATCC, American-type culture collection; CV, coefficient of variance; HPLC, high-performance liquid chromatography.

1. Introduction

Although water-soluble vitamins are essential micronutrients to maintain vital processes, the potential for vitamin deficiencies in elderly groups has increased because of the increase in the elderly population in Japan and the longevity of the Japanese populace [1]. In elderly people, a lowering of the physiologic or metabolic functions and inadequate food intake could lead to vitamin deficiencies, resulting in sequelae such as malnutrition, osteoporosis, and anemias. Therefore, it is more important for elderly people to monitor nutritional status than for younger generations. A method to easily and accurately evaluate vitamin intake would be expected to be of use for early screening at a primary preventive stage.

Methods using a biomarker for vitamin intake could offer an effective approach to evaluate vitamin status in individuals. Many published studies have investigated urinary vitamin excretion as a biomarker for vitamin intake

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[2-4]. We have reported recently that urinary levels of water-soluble vitamins correlate highly with their intake in Japanese college students in a strictly controlled environment [5,6] and that several days were required to clear administered water-soluble vitamins [7]. Performing a study under free-living conditions without any interventions is the next step to confirm the applicability of the methods using a biomarker. We planned fieldwork in subjects selected from 3 different generations, namely school children, university students, and elderly adults, to assess our hypothesis that 24-hour urinary water-soluble vitamins might correlate with vitamin intake even for free-living individuals. The reason why we chose to investigate using subjects who belong to the 3 generations is that the age-related alterations of B-group vitamin contents in urine, blood, and liver from rats are known [8]. This study covered one of those assessments in elderly females.

In the present study, to examine the association between urinary levels of water-soluble vitamins and their intake in a free-living environment, we used a weighed food record, as previously described [9], for 4 consecutive days to record dietary intake precisely. Although a weighed food record can provide relatively precise information regarding dietary intake compared with other dietary assessment methods [10], very few studies have reported this kind of dietary assessment for free-living elderly adults [11], whereas many studies have used a 24-hour recall method [12], an interview method [13], or a food frequency questionnaire [14]. In the current Dietary Reference Intakes for Japanese 2005 [15], estimated energy requirement and estimated average requirement for elderly people were obtained by extrapolating from the measured value for younger adults. These studies indicated a difficulty in performing a dietary assessment based on a weighed food record for elderly people.

To overcome the problems with a dietary assessment using a weighed food record, we formed a close and cooperative relationship, before starting the study, with targeted elderly subjects who were taking courses at the lifelong learning centers in Kawasaki and Yamato, Japan, by supporting the prolonged dietary education program provided by the center. After obtaining the understanding and support of the subjects as well as staff in the center, we found the subjects to be highly motivated to participate in this study, and eventually, we could perform a dietary assessment using a weighed food record. This is believed to be the first report to show that urinary levels of a number of water-soluble vitamins correlate with their recent intake in free-living Japanese elderly females aged 70 to 84 years.

2. Methods and materials

2.1. Participants

A total of 64 healthy, free-living elderly females aged 70 to 84 years voluntarily participated in this study. The purpose and protocol were explained to all participants before joining the study, and written informed consent was obtained from each participant. We excluded participants diagnosed with the common cold or influenza and those who had taken multivitamin supplements at least once during the previous month. We also used the strict International Study on Macronutrients and Blood Pressure (INTERMAP) criteria for completeness of urine sampling [16,17]; in a collection time outside the 22 to 26-hour range, subjects respond that collection was not complete and total volume of less than 250 mL and creatinine excretion in relation to body weight outside the range of 10.8 to 25.2 mg/kg. In addition, we excluded participants who showed extremely low or high energy intake (<2092 or >16 736 kJ/d) [17]. After these screenings, 37 elderly females were found to be eligible. This study was reviewed and approved by the Ethical Committee of the University of Shiga Prefecture (Japan).

2.2. Dietary records

The dietary assessment took place for a 4-day period in which the participants were living freely and consuming their normal diet. This assessment was performed in the cities of Kawasaki (population > 1 390 000) and Yamato (population > 200 000) in Kanagawa prefecture, Japan, from June 2008 to November 2008. The experimental period was for 4 consecutive days. All food consumed during the 4-day period was recorded using a weighed food record [18]. A digital cooking scale (1 g unit; Tanita Inc, Tokyo, Japan), a set of dietary record forms, a dietary record manual, and a disposable camera were distributed to the participants in advance. Upon entry in the dietary record, the status of food before oral intake was identified as “raw,” “boiled,” “cooked,” “the presence of skin,” “a part of cooking ingredients,” or “with or without seasoning” and coded according to the Fifth Revised and Enlarged Edition of the Standard Tables of Food Composition in Japan [19]. The participants took photographs of the dishes with a disposable camera before and after eating. Several experienced dietitians used the photographs to complete the data and asked participants to resolve any discrepancies or to provide further information when needed. The food that remained after eating was measured by a digital scale and was deducted from the dietary record. Food, nutrient, and energy intakes were calculated using SAS statistical software (version 6.12; SAS Institute, Cary, NC), based on the current Standard Tables of Food Composition in Japan. For vitamin intake, 8 water-soluble vitamins (namely vitamin B_1, vitamin B_2, vitamin B_6, vitamin B_{12}, niacin, pantothenic acid, folate, and vitamin C) were assessed, except for biotin that was not designated in the current Standard Tables of Food Composition in Japan. Because niacin is synthesized from tryptophan, the amount of niacin equivalent was handled separately from niacin. Because 1 mg of nicotinamide is synthesized from 60 mg of tryptophan [20], the niacin equivalent was calculated as the sum of niacin and 1/60 of tryptophan intakes.