Original Article

Deficient dietary vitamin K intake among elderly nursing home residents in Hong Kong

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There is strong evidence supporting the importance of vitamin K in bone health and the aetiological role of vitamin K deficiency in osteoporosis. In view of the common occurrence of osteoporosis among older subjects in Hong Kong, we have studied the dietary vitamin K intakes in 100 residents of a nursing home (43 men, 57 women; median age 81.0 years) and 88 free-living subjects attending a day care centre (13 men, 75 women; median age 71.5 years). The subjects were interviewed and the average vitamin K intake in the preceding week was estimated, using a diet recall questionnaire modified from our previous surveys of dietary patterns in local Chinese people. The median vitamin K intake was much lower in nursing home residents than in free-living subjects (4.50 *vs* 488.09 μg/day or 0.13 *vs* 8.74 μg/kg/day, $P < 0.001$). An intake that was below the recommended daily intake was far more common among nursing home residents (86.0 *vs* 11.4%, $P < 0.001$). Among nursing home residents, there was a negative correlation between age and vitamin K intake ($r = -0.217$, $P = 0.030$), but there was a positive correlation between body weight and vitamin K intake ($r = 0.244$, $P = 0.015$). No such relationship was seen among free-living subjects. Elderly nursing home residents in this study generally had a poor dietary vitamin K intake and might therefore be predisposed to osteoporosis. The importance of green leafy vegetables as a rich source of vitamin K should be emphasised.

Key words: Chinese, elderly, green leaf, Hong Kong, nursing home, osteoporosis, vegetables, vitamin K.

Introduction

Vitamin K is a cofactor for the post-translational synthesis of γ-carboxyglutamic acid (Gla) in vitamin K-dependent proteins. These include proteins of the bone matrix (osteocalcin, matrix-Gla protein and protein S), proteins involved in blood coagulation (factors II, VII, IX and X) and coagulation-inhibiting proteins C and S.[1] Therefore, vitamin K is important both for bone health and normal blood coagulation.[2]

The human vitamin K supply originates mainly from the diet.[1,2] The most abundant form of dietary vitamin K is phylloquinone (vitamin K_1). Menaquinones (vitamin K_2) have a more restricted distribution. The biggest question regarding nutritional sources of vitamin K is whether humans can utilise the potentially large pool of menaquinones synthesised by the colonic flora.[3] Dietary sources therefore are crucial for maintaining adequate vitamin K status. The recommended dietary intake (RDI) of vitamin K for adults is 1 μg/kg.[4]

In Europe, nutritional vitamin K intake decreased substantially with age.[5] In Hong Kong, partly because of a greater prevalence of chronic diseases and disability, nursing home residents were more likely to have poor dietary consumption than free-living elderly.[6] With the expansion of the food composition database that includes Chinese dietary items,[7] we have studied the vitamin K intake of older subjects living at home or in a nursing home.

Subjects and methods

This study has been approved by the district administrator of the geriatric services concerned. Between March and April 1997, 100 residents of a nursing home and 88 subjects regularly attending a day care centre in Hong Kong were invited to participate in this dietary survey. This nursing home had

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Accepted 2 April 2001

Part of this work was presented at the Fourth Congress of Parenteral and Enteral Nutrition Society of Asia, 9–12 December 1998, Hong Kong.

an in-house catering service supervised by a catering manager. The menus for the main meals, including fruits and snacks, were designed on a weekly basis, taking into consideration the residents' preferences and the nutritional values of the foods. The residents could also eat their own foods brought by their relatives. All the subjects in this study were Chinese and had reasonable cognitive function and mobility levels. All were willing to participate after the purpose of the survey was explained. Subjects with communication problems were not included.

The interview was conducted by SLST, a geriatrician with a special interest in nutrition, and DMYW, a graduate in nutritional science. The average vitamin K intake in the preceding week was estimated, using a diet recall questionnaire of similar design to that used previously in the local Chinese population.[7] Vitamin K-containing food items were divided into 10 main groups: beverages and proprietary formulae, egg white and yolk, cooking oils, fruits, cereals, dairy products, meats, animal viscera, vegetables, and seaweeds, seagrass and sealettuce. The amount of food taken was quantified and vitamin K intake/day calculated. The age, sex and body weight of each participant were noted. The vitamin K intake/kg body weight was also calculated and the proportion of patients having an intake less than the RDI for adults (1 μg/kg)[4] determined.

All the data are expressed as medians and ranges. Significance of difference for all variables was tested by the Mann–Whitney Test or Pearson's Chi-Squared test, where appropriate. Correlation between two variables was determined by Spearman's analysis. *P*-values of less than 0.05 (two-tailed) were considered to be statistically significant.

Results

The demographics and vitamin K intakes of the two groups of subjects are shown in Table 1. There was a female predominance within the two groups, especially among the free-living subjects (85.2 *vs* 57.0%, $P < 0.001$). Free-living subjects were also younger (71.5 *vs* 81.0 years, $P < 0.001$) and heavier (58.2 *vs* 52.3 kg, $P < 0.001$) than the nursing home residents. The daily vitamin K intake among free-living subjects was 108 times that of nursing home residents (488.09 *vs* 4.50 μg, $P < 0.001$). After adjustment for body weight, the daily vitamin K intake among free-living subjects was still 67 times that of nursing home residents (8.74 *vs* 0.13 μg/kg, $P < 0.001$). An intake that was below the RDI was far more common among nursing home residents than free-living subjects (86.0 *vs* 11.4%, $P < 0.001$).

Among nursing home residents, there was a negative correlation between age and vitamin K intake ($r = –0.217$, $P = 0.030$) but a positive correlation between body weight and vitamin K intake ($r = 0.244$, $P = 0.015$). However, after adjustment for body weight, no significant relationship between age and vitamin K intake was seen ($r = –0.060$, $P = 0.555$). Among free-living subjects, dietary vitamin K intake was not related to either age ($r = –0.067$, $P = 0.537$) or body weight ($r = 0.166$, $P = 0.122$). After adjustment for body weight, no correlation between vitamin K intake and age was seen ($r = –0.064$, $P = 0.555$).

Discussion

Phylloquinone is considered the main dietary source of vitamin K for humans.[1,2] It is found mainly in green leafy vegetables, certain legumes and some vegetable oils such as rapeseed and soyabean oils. Menaquinones are found in animal livers and some fermented products, including cheese. The colonic flora also produce menaquinones. However, given that these highly lipophilic compounds are tightly bound to the bacterial membranes and require bile salts for their absorption, it is difficult to envisage how the colonic pool of menaquinones can be made available for absorption.[3]

Several observations provide strong support for the importance of vitamin K in bone health and the aetiological role of vitamin K deficiency in osteoporosis. Postmenopausal women with reduced bone mineral density have lower serum levels of phylloquinone and menaquinones than those with normal bone density.[8] Not surprisingly, poor vitamin K intake is associated with increased risk of hip fracture.[9,10] Several studies have reported lower serum levels of phylloquinone[11,12] and menaquinones[12,13] in those with osteoporotic fractures when compared to control subjects. Postmenopausal women with higher serum levels of under-γ-carboxylated osteocalcin are at a higher risk of hip fracture.[14] In postmenopausal women, vitamin K supplements increase the markers of bone formation but decrease the markers of bone resorption.[15] Vitamin K supplements may prevent the development of new fractures in postmenopausal women.[16] Vitamin K supplements can ameliorate the osteopenia in vitamin D- and vitamin K-deficient stroke patients.[17] Increased vitamin K intake in female elite athletes is associated with an increased calcium-binding capacity of osteocalcin and bone

Table 1. Demographics and daily vitamin K intake in two groups of subjects in Hong Kong

	Free-living subjects ($n = 88$)	Nursing home residents ($n = 100$)	*P*-value
Ratio of men : women	13 : 75	43 : 57	< 0.001
Age (mean years, range)	71.5, 53–87	81.0, 61–101	< 0.001
Bodyweight (mean kg, range)	58.2, 45.9–77.3	52.3, 28.7–79.1	< 0.001
Vitamin K intake (mean μg, range)	488.09, 1.52–7775.85	4.50, 1.68–197.68	< 0.001
Vitamin K intake/kg bodyweight (mean μg/kg, range)	8.74, 0.03–127.53	0.13, 0.03–4.98	< 0.001
Vitamin K intake < 1 μg/kg (*n*, %)	10, 11.4%	86, 86%	< 0.001

formation markers, but decreased bone resorption markers.[18]

In view of the role of vitamin K in bone health and the common occurrence of osteoporosis among older subjects in Hong Kong,[19] it is important to find out if some elderly subjects have a deficient dietary vitamin K intake. In this study, we have clearly shown that nursing home residents had a much lower vitamin K intake compared with free-living subjects (Table 1). Their median daily intake was only 0.13 μg/kg, which was 1.5% of that of free-living subjects. Moreover, as much as 86.0% of residents, but only 11.4% of free-living subjects, had an intake that was below the RDI of 1 μg/kg. Since complete carboxylation of osteocalcin requires an intake that is higher than the current RDI,[4] the daily vitamin K intake in the great majority of nursing home residents was insufficient to maintain normal bone health. Therefore, these nursing home residents might be at a higher risk of developing osteoporosis.

Ideally, serum levels of phylloquinone and menaquinones were also used for assessing the vitamin K nutritional status of our subjects, as in previous studies of the aetiological role of vitamin K in osteoporosis.[8,11–13] However, daily vitamin K intake estimated from a food questionnaire was well related to vitamin K status in healthy young subjects.[20] A significant relationship between phylloquinone intake estimated by a food questionnaire and circulating plasma phylloquinone levels was also seen in postmenopausal women.[21] These results are in accordance with studies that showed a decrease in plasma phylloquinone levels during dietary phylloquinone restriction[22,23] and an increase in plasma phylloquinone levels during dietary phylloquinone supplementation.[24,25] Hence, vitamin K intake estimated by a food frequency questionnaire is a useful index of vitamin K status in older subjects.

Our finding of a deficient vitamin K intake among nursing home residents is also a concern because of its importance in blood coagulation and anticoagulant therapy. Since vitamin K is required in the synthesis of vitamin K-dependent clotting factors,[2] elderly subjects with severe vitamin K deficiency might be at risk of coagulopathy, with or without bleeding complications. This has been reported in critically ill, hospitalised patients and contributory factors include inadequate diet, malabsorption, antibiotic therapy, renal and hepatic dysfunction and recent surgery.[26] Warfarin competitively antagonises vitamin K and its anticoagulant effect is affected by the dietary vitamin K intake.[27] Hence, elderly subjects with a deficient intake may be even more sensitive to the anticoagulant effect of warfarin.[28]

There may be several reasons why nursing home residents were much more likely to have a deficient intake of vitamin K. The poor dietary intake of nursing home residents was probably due to the greater prevalence of chronic illnesses, with concomitant anorexia.[6] On the other hand, the better meal environment enjoyed by free-living subjects might contribute to their greater dietary consumption. Improved meal environment has been shown to improve dietary intake.[29] Subjects with dental problems may avoid vegetables and other food items that require more chewing.[30] The choices in the menu are limited and may be deficient in vitamin K. Appropriate treatment for elderly subjects with dental problems will improve their dietary intake, and hence, their nutritional status as a whole.[31]

If subjects with a deficient vitamin K intake can be readily identified using simple demographics, such as age and body weight, those particularly at risk should be monitored more closely. Among the nursing home residents, there was a negative correlation between age and vitamin K intake ($r = –0.217$, $P = 0.030$), but there was a positive correlation between body weight and vitamin K intake ($r = 0.244$, $P = 0.015$). In other words, a deficient dietary vitamin K intake was more likely among older and lighter subjects.

There is strong evidence supporting the importance of vitamin K in bone health and the aetiological role of vitamin K deficiency in osteoporosis. Elderly nursing home residents in this study generally had a poor dietary vitamin K intake and might therefore be at a higher risk of developing osteoporosis. The importance of green leafy vegetables as a rich source of vitamin K should be emphasised.

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