Potential Impact of Nutritional Knowledge on Dietary Intake and Bone Mineral Density among Japanese Women

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ABSTRACT

Nutrition education is important for preventing the incidence and/or progression of osteoporosis. This study was designed to comprehensively assess the correlation among levels of knowledge about ‘good-for-bone’ food, dietary intake and Bone Mineral Density (BMD) in an open educational program. The study population included 32 healthy women (Mean age, 54.0±17.4 years), who were divided into 3 groups: ≤39 years (N = 5), 40-59 years (N = 14) and ≥60 years (N = 13). All the participants answered a questionnaire containing questions on what they considered as ‘good-for-bone’ food. In addition, dietary records were analysed and BMD of the calcaneus was measured using ultrasonographic bone densitometry. The results showed that all the age groups before attending the lecture considered milk or dairy products as the most popular good-for-bone food (30/32 participants), followed by fish (24/32). Green vegetables (10/32) and seaweed (8/32) were considered as good-for-bone food only by women above 50 years of age. BMD values showed correlation with the estimated intake of zinc, mushrooms and root crops but not with calcium, vitamin D, or K. Although, most women knew that milk and dairy products protect bones because of their rich calcium content, extensive knowledge regarding the roles of other vitamins and minerals was necessary to prepare and consume balanced diets that are appropriate for lifelong bone health. This study also highlighted the importance of zinc intake in BMD.

Key words: Nutrition, dietary intake, osteoporosis, bone mineral density, zinc

INTRODUCTION

It has been widely accepted that balanced dietary intake of calcium and vitamins, such as D and K, is essential for maintaining bone health in humans regardless of age (Huncharek et al., 2008; Ahmadieh and Arabi, 2011). Hence, most of the health education strategies, e.g., in nursery, schools or in public open lectures, for preventing growth disturbances or osteoporosis have focused on the importance of these minerals and vitamins (Meunier, 1998; NIH, 2000; Gennari, 2001; Tussing and Chapman-Novakofski, 2005; Manios et al., 2007). In particular, calcium constitutes bone cortex and vitamin D is essential for calcium absorption in the intestine and thus they are known to be the nutritional factors that are central to maintain bone health (Gallagher et al., 1979). As a result, most Japanese are now aware of the importance of minerals and vitamins and are thus encouraged to increase their calcium and vitamin D intake, possibly expecting that these dietary supplements alone would improve their bone health. Nevertheless, milk consumption is
decreasing in Japan (market data available in: Japan Dairy Association Co., http://www.jmilk.jp/index.html) whereas the number of patients with osteoporosis in Japan is steadily increasing (Sugimoto et al., 1994; Yoshimura et al., 2005), mainly because of the increase in the longevity of the aging society, thus, resulting in a heavier social burden (Arai et al., 2012). Therefore, promotion of bone health and prevention of osteoporosis are the main public health focus in Japan, with an objective of properly educating the society, especially in terms of the nutritional value of different kinds of food.

This pilot study aimed to investigate (1) which food or nutritional factors are generally considered to be bone protective and (2) how the frequency of particular food intake would correlate with bone health among Japanese women to establish better nutritional educational systems for the prevention of osteoporosis.

MATERIALS AND METHODS

Subjects: An open educational program was set in Sagami Women’s University once a month from May to July 2011. The course included: (1) lectures on bones, osteoporosis and nutritional facts; (2) surveys of diet records; (3) evaluation of body composition and bone mineral density (BMD) and (4) cooking. A total of 33 healthy subjects (one man and 32 women; age range, 17-76 years; mean age 54.45 years) attended the course. All the participants answered a questionnaire that included a question regarding what they considered as good-for-bone food. None of the participants were prescribed any drugs against osteoporosis.

Of the participants, all the 32 women were subjected to the following analyses. For this, the 32 women were divided into 3 groups: ≤39 years (N = 5), 40-59 years (N = 14) and ≥60 years (N = 13).

This study was approved for implementation by the institutional ethics review board.

Questionnaire: The subjects were asked to answer the questionnaire sheets according to knowledge/attitudes/behaviour and practice model containing questions on provided images and insights regarding food and daily activities, e.g., “which food do you think is good for bone health?”

Dietary records: Dietary intake was assessed using a 24 h recall method and a brief self-administered dietary history questionnaire (BDHQ), which was only employed in adult subjects. The 24 h recall method was conducted with the help of trained registered dietitians and students of Faculty of Nutritional Science, Sagami Women’s University. In this method, the participants reported all the foods and beverages consumed, except plain drinking water, during the last 24 h.

The BDHQ was developed and has been generally accepted and used for assessing individual nutrient intake levels (Sasaki et al., 1998).

The values relating to food composition (Table 1) were checked against the standard tables of food composition in Japan, published by the ministry of education, culture, sports, science and technology in Japan, 2010 (http://fooddb.jp/index.html).

Bone densitometry: The BMD of the calcaneus of all the subjects was measured using ultrasonographic bone densitometer (Venus III™, Tanita Co. Ltd, Tokyo, Japan) according to the manufacturer’s instructions.

Data analysis: The data were analysed using SPSS Statistics Base™ver.18 for Windows (IBM Japan, Tokyo, Japan). Pearson’s correlation coefficient test was used to assess the associations among the different scores. A p<0.05 was considered statistically significant.
RESULTS

Calcium was the most popular nutrient for bone health: The results of the questionnaire containing images and questions on insights of various food items as good-for-bone food are summarised in Table 1. As expected, it is shown that most participants from all the generations considered milk or dairy products as the most popular good-for-bone food. For example, 26 of the 33 subjects recognised milk (including skimmed milk) as a good beverage for their bone. Besides milk, dairy products, yogurt, cheese and butter were separately indicated as good-for-bone food by most of the participants. With the exception of butter, the abovementioned products were recognised by the participants as rich sources of calcium (Table 1).

Fish, especially small fish (kazakana, the Japanese colloquial expression for small, edible fish such as the sardine) was also identified to be good for bones. A total of 28 participants, from ages 17 to 76 years, wrote fish, small fish, or sardine as their answer. Usually, Japanese eat these small fish bones and hence, these fish are regarded as sources of calcium (Table 1).

Fifteen of the 33 participants indicated that green leafy vegetables were good for their bones; moreover, the majority of them nominated komatsuna (Japanese mustard spinach) followed by spinach to be good for bones. However, these answers were only observed among participants above 52 years of age. None of the participants from the youngest age group named any vegetables as good sources for bone health and maintenance. In addition, seaweed (8 of 33 participants) was also considered to be a good-for-bone food by women above 50 years of age.
Table 2: Correlation between daily food intake (g day⁻¹) and BMD

<table>
<thead>
<tr>
<th>Dietary intake (g day⁻¹)</th>
<th>BMD</th>
<th>Within same age group</th>
<th>YAM</th>
<th>Pearson's correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root crops</td>
<td>0.414</td>
<td>0.018*</td>
<td>0.187</td>
<td>0.304</td>
<td></td>
</tr>
<tr>
<td>Mushrooms</td>
<td>0.501</td>
<td>0.003*</td>
<td>0.125</td>
<td>0.406</td>
<td></td>
</tr>
<tr>
<td>Pork and beef</td>
<td>0.369</td>
<td>0.038*</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

NA: Not available, YAM: 20-year-old young adult, *p<0.05

Table 3: Correlation between the frequency of daily food consumption and BMD

<table>
<thead>
<tr>
<th>Dietary intake (g day⁻¹)</th>
<th>BMD</th>
<th>Within the same age group</th>
<th>YAM</th>
<th>Pearson's correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>0.372</td>
<td>0.096*</td>
<td>0.125</td>
<td>0.494</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.142</td>
<td>0.438</td>
<td>-0.046</td>
<td>0.801</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.220</td>
<td>0.220</td>
<td>0.007</td>
<td>0.909</td>
<td></td>
</tr>
<tr>
<td>Vitamin K</td>
<td>0.015</td>
<td>0.002</td>
<td>-0.058</td>
<td>0.702</td>
<td></td>
</tr>
<tr>
<td>Vitamin D</td>
<td>0.244</td>
<td>0.179</td>
<td>-0.048</td>
<td>0.794</td>
<td></td>
</tr>
<tr>
<td>PUFA</td>
<td>0.460</td>
<td>0.136</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

YAM: 20-year-old young adult, *p<0.05

Correlation between BMD and nutrient intake: For all the participants, BMD of the calcaneus was measured using ultrasonography and dietary intake was examined using the BDHQ method. The correlation between BMD and daily nutritional intake was then analysed using only the data obtained from female participants (N = 32) in order to eliminating possible gender bias.

The results of the multivariate statistical analyses are summarised in Table 2 and 3. Table 2 showed that consumption of root crops, mushrooms and beef and pork (the option in the questionnaire was simply beef and pork because this study did not discriminate between the intake of 2 types of meat) had a correlation with the BMD levels observed within the same age group. However, the significance was not apparent when the relative BMD values were compared with those of a 20-year-old young adult (YAM).

This study also analysed the correlation between BMD and the intake frequency of a panel of nutrients, including multiple vitamins, trace minerals and fatty acids. The results showed that BMD was correlated with zinc intake, with the frequency of dietary zinc intake being higher among individuals with higher BMD values than those in the same age group. However, this significance also disappeared when the values were compared with those of YAM. Besides zinc, no correlation was observed between BMD and intake of other nutrients such as calcium, phosphorus, retinol, β-carotene, vitamin C, or lipid. Moreover, there was no significant correlation between muscle mass and BMD or between muscle mass and zinc intake (data not shown).

DISCUSSION

Although balanced nutrition plays an important role in the prevention of osteoporosis, knowledge concerning each ingredient or food item is still vague. This study focused on (1) how people recognise food items that would be good for their bone health and (2) how the actual dietary intake influences an individual's BMD in a setting based on the participation at a seminar series held at a nutrition university.

Many other studies on nutrition and bone have reported the relationship between single nutrients (e.g., calcium) and bone mineral density. However, present study stressed on the
importance of balanced diet, which would reflect health-conscious lifestyle. Specifically, we used 24 h recall method and also BDHQ questionnaire. The former protocol reflects dietary intake just before the inquiry (i.e., short period), whereas the latter indicates the intake frequency during the last several months before the investigation (i.e., long period). By combining the two different methods, we found that the intake frequency of zinc, a trace mineral nutrient with considerable dairy variation, was most correlated with BMD. This finding may thus uniquely suggested that balanced intake of a broad range of nutritional factors, rather than an excessive intake of any particular single element, would be the key to maintain BMD.

This study showed that milk and dairy products are the most popular sources of calcium, regardless of the age of the participants. The custom to consume milk or dairy products everyday is relatively new in Japan; it was initiated only after World War II, mainly to augment malnutrition among children. Today, milk is the most common foodstuff presented in nutrition education sessions in Japan, which cater to all generations of its society. This study confirmed the prevalence and effectiveness of educating the Japanese society on proper nutrition. However, the impact of increased milk consumption on the incidence of fracture or osteoporosis still remains elusive (Kalkwarf et al., 2003; Winzenberg et al., 2003; Huncharek et al., 2008). Because low-calcium diets often accompany additional nutrient deficiencies (e.g., phosphorus, magnesium, iron and zinc) and low energy, the combined insufficiency of these nutrients, rather than calcium alone, may lead to a failure in achieving high peak bone mass during puberty, which is a critical period for the development of bone health (Rozen et al., 2001).

Because Japan is a country surrounded by water, many people particularly consume fish, especially small fish such as sardines, which is regarded as a good source of calcium. In fact, fish contain calcium and vitamin D as shown in Table 1. Moreover, a recent study reported that fish consumption might protect bone loss (Farina et al., 2011).

Other examples of the answer to 'good-for-bone food' included green vegetables. Japanese mustard spinach (komatsuna) was the most frequent answer, followed by spinach. These food items were observed to be popular among participants aged 50 years and above but not in the younger participants. This result may be attributed to the fact that vegetables are commonly recognised as a source of vitamin C and that the potential role of green vegetables in bone health has not been widely recognised in the Japanese society. However, komatsuna contains a rich amount of calcium (170 mg/100 g) higher than that in spinach (49 mg/100 g) in addition to vitamin C (39 mg/100 g) (cf. 35 mg/100 mg in spinach). Therefore, young individuals should realise that such green vegetables are a good source of bone-specific nutrients.

This study also investigated the relationship between BMD of the calcaneus and the participants' daily consumption of food and beverage. Multivariate analyses showed a correlation between the consumption frequency of root crops, mushrooms and zinc and the BMD values. The zinc plays an importance role in the maintenance of bone health, which has been pointed out recently (Farrell et al., 2009; Arikant et al., 2011). Specifically, zinc may suppress osteoclastogenesis by inhibiting Receptor Activator of Nuclear Factor-κ B (RANK) expression (Hie et al., 2011). In this regard, the dietary intake of zinc has been reported to weakly but significantly correlate with serum zinc concentration (Al-Numair, 2006). However, it is not clearly understood how the high zinc levels are correlated with high BMD values.

Bone health may not be maintained or improved by consuming a single particular nutrient. This study suggests that the intake of root crops, which usually require manual cutting and simmering, reflect the health-conscious family attitude that is strongly related to home-made meals. Indeed, root crops are often used in Japan as nimono (delicately boiled combination of root crops, e.g., soy products) or kinpira (combination of deep-fried tofu, root crops and hijiki seaweed). In addition,
although the frequency of consuming any single nutrient other than zinc was not shown to have a significant correlation with BMD, this study showed that a positive correlation existed between the frequency of zinc intake and the consumption of calcium, magnesium, vitamin D, K and polyunsaturated fatty acid (PUFA), respectively (data not shown). Thus, the results of this study may support the concept that a balanced intake of multiple nutrients and not the excessive intake of a single particular nutrient in everyday life, would generally result in healthy bones. In this regard, it may be interesting to compare our study to a report by Kolahi et al. (2011); in the study they assessed physical activity and food frequency as well as BMD of volunteer postmenopausal Iranian women. They reported summarizing the food frequency questionnaire that subjects with a normal BMD are more likely to consume diets high in dairy products, vegetables, fish, egg and butter. The authors showed that the mean intake of leafy green vegetables, dairy product, fish and eggs in normal women was significantly higher than osteoporotic ones. In contrast, a negative correlation between the mean intake of sugar and BMD has been suggested by the study and also by a study from Saudi Arabia (Alsaif et al., 2007). Thus, the studies in different countries cooperatively support the importance of balanced food intake for prevention of osteoporosis and promotion of bone health.

CONCLUSION

In conclusion, the results showed that although most Japanese women know that milk and dairy products protect bones by providing high amounts of calcium, extensive knowledge regarding the roles of other vitamins and minerals is also necessary to prepare and consume balanced diets that are appropriate for a lifelong bone health.

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