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Fruit and Vegetable Intake and Bone Mineral Density in Residents of Villages Surrounding Tehran

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Abstract
Osteoporosis is a major health problem because of the large health care costs associated with its clinical consequences. It is therefore of great importance to identify modifiable risk factors. We investigated association between fruit and vegetables intake and bone mineral density in rural population of Tehran surroundings. Subjects were a subgroup of a large study on prevalence and causes of vitamin D deficiency in rural population surrounding Tehran, capital of Iran. Fruit and vegetable intake of 82 subjects whose bone mineral density (BMD) was measured and had a 24 hour food recall, was assessed. Weight and height were measured by standard methods. BMD was measured by Dual X-Ray (DXL) (Calscan) method at the heels. Osteopenia and osteoporosis rate in women older than 50 years were 55.5% and 33.3% and in men were 69.2% and 7.7%, respectively. Fruit intake was not correlated with BMD. Vegetable intake was positively associated with BMD just in women. According to interquartile range of vegetable intake women were grouped as those consuming less than 1.5 servings of vegetables per day and those consuming more. The women reported consuming more than 1.5 serving of vegetables had significantly higher *T*-score (-1.1±0.8 compared with -1.9±1.0, *P*<0.01). Those consumed more vegetables had high intake of some nutrients such as vitamin C, vitamin A, potassium, magnesium, zinc, folate, iron, sodium, calcium and phosphorus but none of them except for vitamin A (r= 0.03, *P*<0.05) was correlated with BMD. High consumption of vegetables positively affected bone mineral density in rural women and daily intake of at least 1.5 servings of vegetables could positively affect osteoporosis prevention.

Keywords: *Osteoporosis, Fracture, Bone mineral density*

Introduction
With the advancement of medicine and availability of facilities, the number of infectious diseases and deaths decreased a lot. But non-communicable diseases as well as chronic diseases have continued to spread. Fifty nine percent of 56.5 million deaths per year are due to these non-communicable and chronic diseases (1). Osteoporosis is one of these non-communicable diseases that occur mostly in the elderly. Researchers speculate that by the year 2050 the prevalence of osteoporosis will increase (2) not only due to an increased older population but also due to undesirable changes in life style and diet (3).

The therapy of osteoporosis lies in its prevention. Two mechanisms principally determine adult bone health: the maximum attainment of peak bone mass during growth; and the rate of bone loss with advancing age. Both mechanisms are believed to be determined by a combination of genetic, endocrine, mechanical and nutritional factors, with extensive interactions between them. Nutritional factors are of particular importance because they are modifiable.
Fruit and vegetables are important components of a healthy diet. According to World Health Report 2002, low fruit and vegetables consumption is one of the five major causes of non-communicable diseases that lead to 2.7

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million deaths annually (4). Low fruit and vegetable intake is estimated to cause about 31% of ischemic heart disease and 11% of stroke, worldwide (5).

Increased consumption of fruit and vegetables can also help preventing of osteoporosis. Cross-sectional studies have shown that increased intake of some of the major micronutrients in fruits and vegetables such as potassium, magnesium, vitamin C, and carotenoids is associated with higher bone mineral density (BMD) (6-12). Plausible mechanisms for the effects include a lower dietary acid load and the promotion of a positive calcium balance from high potassium and magnesium intake (13). A plant-based diet has been suggested to have a lower acid load, whereas animal products increase acidity (14). Acidosis may also inhibit osteoblast function and increase osteoclast activity, thus limiting bone formation and increasing bone loss (15).

The aim of this research project was to evaluate the influence of fruit and vegetable intakes on bone mineral density in rural population of Tehran surrounding villages.

Materials and Methods

Subjects Subjects were a subgroup of another cross sectional research on prevalence and causes of vitamin D deficiency in villages surrounding Tehran which was done in the winter 2003. In the original study, six villages among all villages surrounding Tehran were randomly selected. In each village, a complete population list was obtained from the health center and 60 subjects between the ages 10-80 were randomly selected. The number of people in each age group was approximately equal. Exclusion criteria include chronic diseases such as cancer, liver or kidney disease, endocrine disorders (thyroid, parathyroid, and adrenal), skeletal disorders, fractures within the previous 3 months, bedridden for 4 continuous weeks at any time, smoking more than 10 cigarettes per day, drinking more than 1 glass of alcohol a day for more than 5 years, drug addictions, being professional athlete, taking drugs altering metabolism of calcium, vitamin D, or bone and gynecological disorders such as early menopause or amennorhea. From 360 subjects studied in the original study, Fruit and vegetable intake of 82 subjects whose bone mineral density (BMD) was measured and had a 24 hour food recall, was assessed.

Anthropomotry Body weight was measured on a balance-beam scale to the nearest 0.5 kg. Height was measured by a plastic tape attached to the wall to the nearest 0.5 cm. Body mass index (BMI) was calculated by the following formula: [(weight (kg)/ (height (m) ^{2})].

BMD measurement BMD measures were taken by Dual X-Ray (DXL) (Calscan) method at the heels. According to World Health Organization definition based on *T*-score, which is the number of standard deviations from the mean (average) value of BMD in a young normal person, subjects were grouped as osteoporotic, osteopenic and normal.

Dietary Intake Usual dietary intake of the original study population was assessed using a 24-hour food recall and a 93-item food frequency questionnaire. In the present study just data of the 24-hour food recall were used. For the 24-hour food recall, a nutritionist asked the subject to name all the food and drink consumed during the previous 24 hour and assisted the respondent in estimating portion sizes. By using the manual for household measures, cooking yield factors and edible portion of foods the amount of consumed foods and drinks was converted to grams and analyzed using NUTRIBASE 5 CLINICAL EDITION software (version 5.13; CyberSoft Inc, Phoenix, AZ). NUTRIBASE was used to estimate daily micronutrients as well as food group intake including milk and milk products, grain products, meat and meat alternatives, fats and sweets, fruit, and vegetables.

Statistical Analysis Data was analyzed using Statistical Program for Social Sciences (SPSS) (version 11.5). Student *t*-test was used to compare means and chi square test was used to compare frequency of variables. Pearson correlations were calculated among each food group, each nutrient and for BMD. Forward stepwise multiple regression models was used to test for significance of those food groups and nutrients which were correlated with bone mineral density, adjusting for the confounding effects of age, weight, height and BMI. A *P*-value of <0.05 was considered significant.

Results

The characteristics of the study population according to sex groups are shown in Table1. Sixty-two percent of the subjects were women and the rest of them were men. Height and BMI differed significantly between two sex groups.

Men in comparison with women had higher energy intake (2608±964 kcal versus 2178±868 kcal, *P*<0.05) and consumed more servings of milk and milk products, meat and meat alternatives and cereals and grains (Table 2).

In women older than 50 years the rate of osteopenia and osteoporosis was 55.6% and 33.3%, respectively. This rate in men was 69.2% and 7.7%, respectively. Relative risk of osteoporosis for women was 4.33.

BMD was positively correlated with vegetable intake in women. In men there was no evidence of an effect of any of the evaluated food groups so the collected data on men were not used in further analysis. Relationship between vegetable intakes was evaluated separately from fruit intakes because no significant correlation with BMD was observed for this food group.

Mean± SD of daily vegetable intake in osteoporotic and normal subjects was 1.26±0.87 and 2.32±1.97 servings, respectively. Median of vegetable intake in osteporotic subjects was 1.12 servings a day and the intequartile range of intake was 1.4 servings which was used to group subjects as low intake (<1.5 servings/d) and high intake (≥1.5 servings/d).

Fifty-three percent of women reported consuming ≥1.5 servings of vegetables a day. The consumption groups did not differ significantly with respect to age, height, weight and BMI. BMD in the high intake group was significantly higher than the low intake group (-1.1±0.8 versus -1.9±1.0, *P*<0.01). Reported intake of food groups in women according to vegetable consumption groups are shown in Table3. Higher vegetables intake was associated with higher energy (2560±816 kcal versus 1748±722 kcal, *P*<0/001).

The report of higher vegetables intake was associated to higher intake of some nutrients including vitamin A, vitamin C, folate, calcium, phosphorus, copper, iron, sodium, magnesium, potassium and zinc (Table 4). However, none of these nutrients except for vitamin A (r= 0.3, *P*<0.05), was significantly correlated with BMD.

Table 1: Characteristics of subjects according to sex groups

	Women (n = 51)	**Men (n = 31)**	**p-value**
Age (y)	34.8±12.7*	41.9±20	0.051
Height (cm)	158.9±6.1**	167.2±7.9	0.000
Weight (kg)	66.3±13.3	66.616.9	0.93
2 BMI (kg/m)	26.3±5.2**	23.7±5.1	0.032
T-score	-1.5±0.9	-1.4±0.9	0.6

* Means±SD
** Significantly different from men group, *P*<0.05 (Student's *t* test)

Table 2: Reported intake of food groups according to sex groups

Food group	Women (n = 51)	Men (n =31)	*P*-value
Milk and milk products			
Means±SDs	1.9±2.2*	3.2±2.4	0.012
Minimum	1.3	2.4	
Maximum	2.5	4.1	
Fruits			
Means±SDs	2.2±2.4	1.4±1.7	0.091
Minimum	1.6	0.8	
Maximum	2.9	2.0	
Vegetables			
Means±SDs	2.3±2.1	1.9±1.3	0.44
Minimum	1.7	1.5	
Maximum	2.8	2.4	
Meat and meat alternatives			
Means±SDs	3.8±2.9*	6.1±3.3	0.001
Minimum	2.9	4.9	
Maximum	4.6	7.3	
Grain products			
Means±SD	12.9±5.8*	15.9±5.8	0.020
Minimum	11.2	13.9	
Maximum	14.5	18.1	
Fats and sweets			
Means±SDs	12.5±7.1	12.9±10.4	
Minimum	10.5	9.2	
Maximum	14.5	16.8	

* Significantly different from men group, $P<0.05$ (Student's *t* test)

Table 3: Reported intake of food groups according to vegetable consumption group in women

	Consumption groups		
Food group	Low (n = 24)	High (n = 27)	*P*-value
Milk and milk products			
Means±SDs	1.6±2	2.2±2.4	0.3
Minimum	0.7	1.3	
Maximum	2.4	3.2	
Fruits			
Means±SDs	1.5±1.9	2.9±2.6*	0.04
Minimum	0.7	1.9	
Maximum	2.3	3.9	
Vegetables			
Means±SDs	0.8±0.4	3.6±2.1*	0.000
Minimum	0.6	2.7	
Maximum	0.9	4.4	
Meat and meat alternatives			
Means±SDs	2.9±1.8	4.5±3.4*	0.05
Minimum	2.2	3.2	
Maximum	3.7	5.9	
Grain products			
Means±SDs	11.1±5.2	14.4±5.9*	0.04
Minimum	8.9	12.1	
Maximum	13.3	16.8	
Fats and sweets			
Means±SDs	9.9±5.9	14.7±7.3*	0.015
Minimum	7.5	7.5	
Maximum	12.5	12.5	

* Significantly different from low-consumption group, $P<0.05$ (Student's *t* test)

Table 4: Nutrient intakes according to vegetable consumption group in women

	Consumption groups		
Nutrients	Low (n = 24)	High (n = 27)	*P*-value
Vitamin A (μg RE)	299.6±199.9*	766.2±661.6**	0.002
Vitamin C (mg)	94.8±104.6	190.0±117.3**	0.004
Vitamin D (IU)	33.2±19.1	43.0±41.6	0.555
Vitamin K (μg)	2.4±0.6	3.6±1.6	0.344
Folate (mg)	244.4±143.2	391.7±147.6**	0.009
Calcium (mg)	509.1±343.0	807.0±433.4**	0.01
Phosphorus (mg)	759.1±365.9	1186.1±493.0**	0.001
Copper (mg)	1.1±0.5	1.9±0.7**	0.000
Iron (mg)	13.0±6.8	19.9±10.1**	0.007
Magnesium (mg)	208.4±104.1	330.2±110.9**	0.000
Sodium (mg)	3405.5±1827.8	4777.7±1827.3**	0.01
Potassium (mg)	1764.0±826.2	3241.1±1049.0**	0.000
Zinc (mg)	7.1±3.3	11.0±4.1**	0.001

* Means±SD
** Significantly different from low-consumption group, $P<0.05$ (Student's *t* test)

Discussion

Osteoporosis has emerged as one of the most common diseases in the aged population. Studies have shown that genetic and lifestyle factors can describe the differences in BMD and prevalence of osteoporosis worldwide. Lifestyle especially physical activity and nutrition have great impact on bone mineral density. Osteoporosis is sometimes considered as a consequence of modernization which makes great changes in lifestyle habits. Many studies have compared the BMD, as the predictor of fracture risk, between rural and urban populations. The results are conflicting. Some studies have shown higher BMD in rural subjects than urban subjects (16-17), but some others could not show any difference (18).

Results of the present study also show no significant difference for BMD measures in rural subjects in compare with urban population (19-20). Although more research is needed to make exact conclusions, the observed results can be described in many ways. One of the most important factors is the difference in methodology. In the Iranian Multicenter Osteoporosis Study (IMOS), BMD of urban subjects was measured by DEXA method while DXL method was used for rural subjects.

In the present study we examined the association between fruit and vegetable intakes and BMD. The results show that 10-80 y-old rural women who reported consuming at least 1.5 servings of vegetables a day have, in comparison with similar women who reported lower intake, higher BMD after control for age, weight, height and BMI. No significant correlation between BMD and fruits intake was observed.

In most of cross-sectional studies, combined effects of fruit and vegetable intakes on bone health was assessed and positive association between intake of these two food groups and BMD was seen (6-11) but some other studies could not show any effects of fruit and vegetable intakes, combined or separately (21). In the present study we evaluated the effect of vegetable intake separately because no significant relation between fruit intake and BMD was observed. In order to evaluate the dietary intake of the subjects we used a single 24-hour food recall. Studies have used different methods including food record (10) and food frequency questionnaire (7-9). Use of different techniques and validity and reliability of methods can explain the difference in reported results. Absence of any relation between BMD and fruit intake may be due to low consumption of fruits.

Vegetable intake was associated with BMD just in women that may be due to small number of men subjects or that they had not report their actual intake. In the Framingham osteoporosis Study 1% greater BMD at the femoral neck was reported for each fruit or vegetable intake (6, 11). Also, men with a diet high in fruit, vegetables, and cereal had significantly greater BMD than did men with other dietary patterns (8).

We showed that at least 1.5 servings of vegetables is enough for an increase in BMD of women. Using Interquartile range of vegetables intake as a cut-off, instead of general recommendations of the Food Guide Pyramid (22), helped us making more sound recommendations for the target population. In other studies 1 serving of fruits or vegetables for the 69-79 year old subjects (6,11) and 3 servings for children were effective (10, 23-24).

Women reported higher vegetable intake also had higher intake of other food groups as well as some nutrients including vitamin A, vitamin C, folate, calcium, phosphorus, copper, iron, sodium, magnesium, potassium and zinc but just vitamin A intake was positively associated with BMD. Pre-formed vitamin A (retinol) is found in animal sources and studies have shown its negative effect on BMD (24-25). But carotenoids which are precursor of vitamin A and are abundant in fruits and vegetables, are positively associate to BMD (9). Nutrition software that we used in this study was not able to separate retinol and carotenoids content of foods. However, there was a positive relation between vitamin A intake and fruit and vegetable consumption which indicates that most of the vitamin A intake of the subjects was in form of carotenoids.

One of the mechanisms that explain the effects of fruit and vegetable intake on bone health is the acid-base hypothesis. Studies have shown that low fruit and vegetable intake is associated with high metabolic acid load (26-27). In humans with normal kidney function, the acid-base balance is dependent on the ability of kidneys to excrete excess acid and the availability of a base for buffering (28). Fruit and vegetables provide a natural source of base to buffer the acid produced by other dietary components. In the acute phase, potassium and sodium contained in the blood-fluid barrier are the first line of defense for buffering metabolic acidosis, and thus they spare the bone tissue (28). In a chronic state of metabolic acidosis, bone crystals are dissolved to provide calcium, carbonate and citrate for buffering (28). Much of the work to support these observations has been done in adults or animal models (29-30). However, studies in rats have shown that giving vegetable concentrates protected bone independent of the potassium content, as this remained after buffering with potassium citrate. The author suggests that these vegetable extracts may contain other, yet unknown, pharmacologically active compounds (31-32).

Whereas our study was the first study to evaluate the effect of fruit and vegetables intake on BMD rural population of Iran, it did have limitations such as small number of subjects and also using a single 24-hour food recall. Although the BMD measures of DXL method is comparable to that of DEXA technique but it does not show all the results. However, densitometers used in the DEXA technique are not portable and in the most studies that subjects referral to a densitometry center is impossible, DXL technique is used. This study was a part of the Iranians Multicentre Osteoporosis Study (IMOS) which was conducted by Endocrinology and Metabolism Research Center (EMRC) and Ministry of Health and Medical Education during 2000-2004. Analysis of the complete data with larger number of subjects and biochemical specimens is being done by EMRC.

In summary, we showed that high consumption of vegetables positively affect bone mineral density in rural women. Thus, regular consumption of vegetables could be an efficient alternative means to protect against osteoporosis. However, before such a recommendation can be given, the amounts necessary to obtain an effect must be established in a clinical intervention study.

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