Nutrition Research and Practice (*Nutr Res Pract*) 2010;4(5):421-427
DOI: 10.4162/nrp.2010.4.5.421

Vegetable and fruit intake and its relevance with serum osteocalcin and urinary deoxypyridinoline in Korean adults

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Abstract

The purpose of this study was to evaluate the daily vegetable and fruit intake status of Korean adults and to examine the relationship of vegetable and fruit intake with bone metabolism. The vegetable and fruit intake of 542 healthy male and female adults was analyzed. Then, by selecting 51 targets from the subjects, the relation of vegetable and fruit intake with serum calcium, osteocalcin and deoxypyridinoline (DPD) excretion in urine was examined. The total vegetable intake per day was 397.7 g and 333.5 g by men and women respectively for the age group of 20-29, 366.9 g and 309.2 g respectively for the age group of 30-49, 378.4 g and 325.9 g respectively for the age group of 50-64. Of vegetable varieties, leafy and stem vegetables displayed the highest intake. The order of major intake items of vegetables and fruits was found to be Chinese cabbage kimchi, onion, radish, cucumber, and welsh onion for the age group of 20-29, watermelon, Chinese cabbage kimchi, peach, potato, and onion for the age group of 30-49 and watermelon, Chinese cabbage kimchi, tomato, potato, and peach for the age group of 50-64. Of 51 targets, β-carotene intake displayed a significantly negative correlation with serum osteocalcin. While caloric intake as well as protein, carbohydrate, calcium, phosphorous, zinc and total food intake displayed a significantly negative correlation with DPD excretion in urine, tuber vegetable intake displayed a significantly positive correlation with DPD excretion in urine. In the future, a study will be necessary to accurately explain the relevance of vegetable and fruit intake with bone mineral density and bone metabolism. Also, efforts will be required to increase vegetable and fruit intake.

Key Words: Vegetables, fruits, Korean adults, osteocalcin, deoxypyridinoline

Introduction

The traditional Korean diet has been centered on vegetables. For the Korean diet, the position of vegetables, as a side dish, is very important. According to the Korea National Health and Nutrition Examination Survey (KNHANES) 2005, vegetable intake per day per person was 327.0 g, which was higher than 321.1 g of cereal intake. It was also found to be the highest intake quantity of all food groups [1]. Vegetables have high contents of dietary fiber as well as nutrients and bio-active substances, such as carotinoid, folic acid and vitamin C [2]. In particular, antioxidant substances in vegetables suppress formation of free radicals inside the human body and control activation of free radicals formed by external factors, such as ultraviolet rays, smoking and ozone. As a result, antioxidant substances have been proven to play a role in preventing such diseases as cardiac disorders, diabetes and cancer, which are caused by free radicals [3,4].

Cross-sectional research analyzing meal intakes for one day and blood lipid concentrations of 345 healthy Korean male and female adults reported that the serum cholesterol level was significantly lower in Korean adults with sufficient vegetable intake of 427 g a day than in those with insufficient vegetable intake [5]. Another study reported that the risk of cardiovascular diseases became lower as fruit and vegetable intake increased [6] and that the diabetics with high intake of vegetables, fruits and beans had lower mortality due to cardiovascular diseases [7]. The World Cancer Research Fund (WCRF) conducted a study on the relation of fruit and vegetable intake with the risk of cancer. Based on the results, WCRF recommends fruit and vegetable intake of at least 600 g a day for group health improvement (at least 400 g for individual health improvement) [8].

KNHANES conducted over the years continuously reports that calcium is a nutrient that always falls short of the recommended intake level. As such, insufficient calcium intake is one of the most prominent nutritional issues of the Korean people. Despite the diet becoming more affluent and westernized, a survey conducted recently indicated that calcium intake was only 76.3% of the recommended level and therefore was evaluated as insufficient [1]. Calcium is extremely important for bone health, and the source foods of calcium are limited to milk, dairy

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Received April 13, 2010, Revised May 26, 2010, Accepted May 26, 2010

products and fish eaten whole with the bones. However, intake rates of food sources supplying calcium are not sufficient in the Korean diet. As a result, there is a limitation in emphasizing only the nutritional value of calcium for the health of bones. Therefore, a study is required to establish measures for nutrition management that is suitable to the Korean diet and can supplement the insufficient calcium intake.

A study reports that intake of vegetables and fruits play a positive role in bone metabolism [9,10]. In a 4-year tracking study, Tucker *et al.* [11] reported that decrease of bone density was found to be lower as intake of vegetables and fruits were higher both in men and women. This study explained that it was because vegetables and fruits contained large quantities of dietary properties generating alkali in human body. In addition, vegetables and fruits are rich in vitamin C contents, and therefore, are known to accelerate collagen synthesis [12] and to stimulate activation of alkaline phosphatase, the bone formation factor [13]. As such, intake of vegetables and fruits is being proposed as one of the nutrition management methods to solve the problems regarding bone health. However, in Korea with high levels of daily vegetable intake, there is yet to be a study reporting detailed intake quantities per vegetable group let alone a study to validate the relevance of vegetable and fruit intake with bone metabolism.

Therefore, the objectives of this study were first, to evaluate the status of daily vegetable and fruit intakes by Korean adults and second, to validate the relevance of vegetable and fruit intakes with bone metabolism. For this, vegetable and fruit intakes by 542 healthy male and female adults was analyzed and comparatively evaluated per gender and age group. In addition, by selecting some of the study targets, the relevance of vegetable and fruit intake with serum osteocalcin and excretion of DPD in urine was investigated.

Subjects and Methods

Subjects and period

A dietary intake survey was conducted from August 1 to August 30, 2007 on 542 healthy men and women who agreed to participate in the survey after being given sufficient explanations about the objectives and contents as well as the procedures of conducting the study. None took any drugs and medicines including nutritional supplement. Fifty-one subjects aged 20-29 (Men: 23, Women: 28), which corresponded to approximately 10% of the total survey targets, were selected and their blood and urine samples were collected.

Dietary intake survey

A dietary intake survey was conducted using the 24-hour recall method through individual interview by trained researchers. That is, the types and quantities of all food items and food materials ingested as breakfast, lunch, dinner, and snacks from first awaking in the morning to bedtime at night on the day before the survey were investigated. Researchers assisted subjects to recall the accurate quantities of food items eaten by presenting them with food samples and photographs. Results of the dietary intake survey were analyzed in terms of the quantities of nutrient intake by using Can-Pro 3.0 (The Korean Nutrition Society, 2005). In addition, intake quantities were analyzed per food group, such as vegetables, fruits and mushrooms. As for vegetables, intake quantities were analyzed per leafy and stem vegetables, tuber vegetables, and fruit vegetables. Leafy and stem vegetables are those of which the leaves and stems are used for intake, such as Chinese cabbage, cabbage, lettuce, spinach, dropwort, and asparagus. Tuber vegetables are those of which the roots are used for intake, such as radish, turnip, carrot, burdock, lotus root, potato, garlic, and ginger. Fruit vegetables are those of which the fruits are used for intake, such as cucumber, pumpkin, red, and green pepper, tomato, eggplant, corn and peas.

Blood and urine sample collection and analysis

Of the 51 targets selected, urine samples were collected for 24 hours after the dietary intake survey. During the morning of the following day while the targets were on an empty stomach, 15 ml of venous blood were collected using a vacuum tube. The collected blood samples were centrifuged for 15 minutes at 3,000 rpm to separate out the serum. After wet decomposition with a microwave digestion system (Ethos touch control, Milestone Inc., Italy), the amount of serum calcium was analyzed using the iCAP 6500 ICP-AES (Thermoelemental Ltd., UK). Serum osteocalcin was measured with the 1470 Wizard (PerkinElmer, Finland) using OSTEO-RIACT kit (CIS, France) by immunoradiometric assay. Urine was collected while protecting it from sunlight and was used for DPD analysis immediately after collection. The DPD contents in urine were analyzed with an IMMULITE (DPC, USA) using Pyrilinks-D (DPC, USA) by solid phase chemiluminescent enzyme-labeled immunoassay. Creatinine contents were analyzed with a HITACHI 7600-210 & HITACHI 7180 (HITACHI, Japan) using a CRE-HR kit (WAKO, Japan) by the Jaffe reaction.

Statistical analysis

For all results of this survey, the mean and standard deviation values were calculated using SAS version 9.1 (SAS Inc., Cary, NC, USA). For comparison between male and female subjects, significance was examined with the Student's unpaired t-test. One-way ANOVA was utilized to compare the three age groups: 20-29, 30-49 and 50-64 years of age. As for the correlation of each variable, significance was examined with Pearson's correlation coefficient. Examination of all statistical significances was carried out at the level of $\alpha = 0.05$.

Results

General characteristics of the subjects per age group

General characteristics of the subjects per age group are as shown in Table 1. In all age groups, heights and weights of women were significantly lower than those of men. As age increased, height was significantly smaller and BMI was significantly higher. In particular, while the BMI of women was significantly lower than that of men in the age group of 20-29, there was no significant difference between men and women in the age groups of 30-49 and 50-64.

Nutrient intakes of the subjects per age group

Daily caloric and nutrient intakes of the subjects per age group are as shown in Table 2. In the age group of 20-29, the caloric intake by men was 2,288.5 kcal and 1,795.4 kcal by women. In the age group of 30-49, it was 2,022.8 kcal and 1,522.0 kcal, respectively. In the age group of 50-64, the caloric intake by men and women was 1,763.0 kcal and 1584.0 kcal, respectively. As for intake of most nutrients including caloric intake, the levels were found to be higher for men than women in the age groups of 20-29 and 30-49. However, in the age group of 50-64, there was no significant difference between men and women. In addition, nutrient intake was found to decrease as age increased.

Vegetable and fruit intakes of the subjects per age group

The vegetable and fruit intakes of the subjects per age group are as shown in Table 3. The total vegetable intake per day in the 20-29 group was 397.7 g by men and 333.5 g by women. In the age group of 30-49, it was 366.9 g and 309.2 g, respectively. In the age group of 50-64, the intake amounts were 378.4 g and 325.9 g by men and women, respectively. Among the varieties of vegetables, leafy and stem vegetables demonstrated the highest intake. In the age groups of 30-49 and 50-64, the intake of leafy and stem vegetables by men was significantly higher than that by women. As age increased, intakes of tuber vegetables and mushrooms significantly decreased. On the other hand, intakes of fruit vegetables and fruits significantly increased.

The major sources of vegetables and fruits for the subjects per age group are as shown in Table 4. The order of the major sources is Chinese cabbage kimchi, onion, radish, cucumber, and

Table 1. General characteristics of the subjects by age group

Variables	20~29 years			30~49 years			50~64 years			Significance[3)]
	Men (n = 78)	Women (n = 86)	Total (n = 164)	Men (n = 68)	Women (n = 109)	Total (n = 177)	Men (n = 88)	Women (n = 113)	Total (n = 201)	
Age (yr)	24.0 ± 2.6[1)]	22.1 ± 2.0***[2)]	23.0 ± 2.5[c4)]	42.7 ± 4.6	41.3 ± 5.5	41.9 ± 5.2[b]	57.3 ± 4.5	56.9 ± 4.3	57.1 ± 4.4[a]	$P < 0.001$
Height (cm)	173.7 ± 4.9	162.5 ± 4.3***	167.9 ± 7.2[a]	168.3 ± 7.9	156.6 ± 5.7***	161.1 ± 8.7[b]	165.9 ± 5.7	153.2 ± 6.0***	158.9 ± 8.6[c]	$P < 0.001$
Weight (kg)	70.0 ± 12.0	55.2 ± 7.5***	62.2 ± 12.3	70.1 ± 9.8	59.8 ± 12.7***	63.8 ± 12.7	68.7 ± 9.2	59.6 ± 8.9***	63.6 ± 10.1	NS[5)]
BMI (kg/m^2)	23.2 ± 3.8	20.9 ± 2.7***	22.0 ± 3.4[b]	24.7 ± 3.0	24.4 ± 4.6	24.5 ± 4.0[a]	25.0 ± 3.1	25.3 ± 3.3	25.2 ± 3.2[a]	$P < 0.001$

1) Mean ± SD
2) Significantly different form men and women of the same age group by independent *t* test ***$P < 0.001$
3) Significance as determined by ANOVA test according to age group
4) Means with different superscript letters are significantly different from each other by Duncan's multiple range test.
5) Not significant

Table 2. Daily nutrient intakes of the subjects by age group

Nutrients	20~29 years			30~49 years			50~64 years			Significance[3)]
	Men (n = 78)	Women (n = 86)	Total (n = 164)	Men (n = 68)	Women (n = 109)	Total (n = 177)	Men (n = 88)	Women (n = 113)	Total (n = 201)	
Energy (kcal)	2,288.5 ± 789.0[1)]	1,795.4 ± 569.8***[2)]	2,029.9 ± 724.1[a4)]	2,022.8 ± 779.0	1,522.0 ± 464.1***	1,714.4 ± 650.3[b]	1,763.0 ± 537.9	1,584.0 ± 812.1	1,662.4 ± 709.3[b]	$P < 0.001$
Protein (g)	94.3 ± 38.9	73.6 ± 29.6***	83.4 ± 35.8[a]	79.7 ± 36.1	59.2 ± 22.0***	67.1 ± 29.9[b]	68.7 ± 28.9	62.0 ± 39.2	65.0 ± 35.2[b]	$P < 0.001$
Fat (g)	75.5 ± 30.8	58.0 ± 22.0***	66.4 ± 27.9[a]	45.6 ± 33.8	33.7 ± 18.8**	38.2 ± 26.2[b]	32.9 ± 23.4	33.0 ± 29.8	32.9 ± 27.1[b]	$P < 0.001$
Carbohydrate (g)	302.4 ± 102.9	242.1 ± 83.8***	270.8 ± 97.9	294.4 ± 89.4	241.0 ± 82.2***	261.5 ± 88.7	276.7 ± 75.0	258.6 ± 117.7	266.5 ± 101.4	NS[5)]
Calcium (mg)	617.8 ± 297.4	525.0 ± 294.6*	569.2 ± 298.7[a]	529.0 ± 318.5	440.3 ± 249.0	474.4 ± 280.2[b]	479.7 ± 249.8	431.4 ± 242.0	452.5 ± 246.0[b]	$P < 0.001$
Phosphorus (mg)	1,231.5 ± 483.7	1,009.7 ± 412.5**	1,115.2 ± 460.0[a]	1,101.8 ± 438.4	865.1 ± 337.8***	956.0 ± 395.6[b]	975.3 ± 379.5	871.7 ± 502.0	917.1 ± 454.3[b]	$P < 0.001$
Sodium (mg)	5,539.3 ± 2,607.0	4,241.0 ± 2,144.2***	4,858.5 ± 2,455.8[a]	4,829.5 ± 1,998.5	3,463.2 ± 1,743.3***	3,988.1 ± 1,956.9[b]	4,173.6 ± 1,905.0	3,640.9 ± 2,094.9	3,874.1 ± 2,026.4[b]	$P < 0.001$
Potassium (mg)	2,989.0 ± 1,425.7	2,602.6 ± 1,213.8	2,786.4 ± 1,328.9	2,936.3 ± 1,177.6	2,378.2 ± 941.2**	2,592.6 ± 1,070.3	2,719.9 ± 1,146.8	2,518.3 ± 1,468.3	2,606.6 ± 1,337.7	NS
Iron (mg)	15.4 ± 6.4	12.5 ± 5.4**	13.9 ± 6.1	15.1 ± 7.1	11.7 ± 5.4***	13.0 ± 6.3	14.6 ± 6.5	12.8 ± 7.4	13.6 ± 7.1	NS
Zinc (mg)	11.0 ± 5.9	8.6 ± 3.4**	9.7 ± 4.9[a]	9.4 ± 4.0	7.5 ± 2.7**	8.2 ± 3.4[b]	9.3 ± 3.7	8.0 ± 4.0*	8.6 ± 3.9[b]	$P < 0.01$
β-carotene (μg)	4,542.7 ± 2,879.1	4,045.4 ± 2,855.9	4,281.9 ± 2,869.0[a]	3,537.4 ± 2,734.8	3,099.5 ± 2,438.6	3,267.7 ± 2,557.7[b]	3,693.8 ± 3,902.1	3,263.5 ± 2,560.6	3,451.9 ± 3,215.7[b]	$P < 0.01$
Vitamin C (mg)	103.5 ± 74.5	84.1 ± 58.8	93.3 ± 67.2	93.2 ± 68.8	74.0 ± 43.6*	81.4 ± 55.3	91.5 ± 68.1	79.6 ± 56.6	84.8 ± 62.0	NS

1) Mean ± SD
2) Significantly different form men and women of the same age group by independent *t* test *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$
3) Significance as determined by ANOVA test according to age group
4) Means with different superscript letters are significantly different from each other by Duncan's multiple range test.
5) Not significant

Table 3. Vegetables and fruits consumption of the subjects by age group

Variables	20~29 years			30~49 years			50~64 years			Significance[3)]
	Men (n = 78)	Women (n = 86)	Total (n = 164)	Men (n = 68)	Women (n = 109)	Total (n = 177)	Men (n = 88)	Women (n = 113)	Total (n = 201)	
Total foods (g)	1,445.8 ± 626.4[1)]	1,175.3 ± 471.9**[2)]	1,303.9 ± 565.5	1,573.3 ± 790.7	1,163.4 ± 537.2***	1,320.9 ± 674.6	1,298.1 ± 592.4	1,172.5 ± 696.3	1,227.5 ± 654.2	NS[5)]
Vegetables (g)	397.7 ± 259.3	333.5 ± 184.4	364.0 ± 224.8	366.9 ± 189.3	309.2 ± 182.4*	331.4 ± 186.7	378.4 ± 240.8	325.9 ± 233.0	348.9 ± 237.3	NS
Leafy & stem vegetables (g)	183.3 ± 120.0	151.1 ± 116.0	166.4 ± 118.6	186.6 ± 117.8	128.7 ± 93.0***	151.0 ± 106.7	171.3 ± 96.4	128.9 ± 97.6**	147.5 ± 99.1	NS
Tuber vegetables (g)	148.8 ± 119.2	135.7 ± 92.0	141.9 ± 105.7[a4)]	111.7 ± 97.1	101.8 ± 110.6	105.6 ± 105.4[b]	98.4 ± 110.2	88.4 ± 96.8	92.7 ± 102.7[b]	$P < 0.001$
Fruit vegetables (g)	65.5 ± 88.8	46.7 ± 50.7	55.6 ± 71.8[b]	68.5 ± 76.5	78.6 ± 93.0	74.7 ± 86.9[b]	108.7 ± 185.3	108.6 ± 151.7	108.7 ± 166.8[a]	$P < 0.001$
Fruits (g)	64.2 ± 108.8	68.5 ± 167.2	66.4 ± 142.0[b]	219.8 ± 372.2	189.3 ± 345.7	201.0 ± 355.4[a]	172.6 ± 402.9	188.4 ± 375.8	181.5 ± 387.0[a]	$P < 0.001$
Mushrooms (g)	9.3 ± 20.1	5.1 ± 13.0	7.1 ± 16.9[a]	2.3 ± 11.1	2.1 ± 7.1	2.2 ± 8.8[b]	1.9 ± 6.9	1.5 ± 6.0	1.7 ± 6.4[b]	$P < 0.001$

1) Mean ± SD
2) Significantly different form men and women of the same age group by independent t test $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$
3) Significance as determined by ANOVA test according to age group
4) Means with different superscript letters are significantly different from each other by Duncan's multiple range test.
5) Not significant

Table 4. Top 20 items of vegetables and fruits of the subjects by age group

Rank	20~29 years				30~49 years				50~64 years			
	Items	intake (g/day)	% of total intake		Items	intake (g/day)	% of total intake		Items	intake (g/day)	% of total intake	
1	Kimchi, Chinese cabbage	77.2	17.7	(17.7)[1)]	Watermelon	108.4	20.3	(20.3)	Watermelon	115.7	21.8	(21.8)
2	Onion	34.1	7.8	(25.4)	Kimchi, Chinese cabbage	77.2	14.5	(34.7)	Kimchi, Chinese cabbage	69.3	13.0	(34.8)
3	Radish	21.4	4.9	(30.3)	Peach	41.2	7.7	(42.4)	Tomato	35.0	6.6	(41.3)
4	Cucumber	18.1	4.1	(34.5)	Potato	26.7	5.0	(47.4)	Potato	28.5	5.3	(46.7)
5	Welsh onion	17.1	3.9	(38.4)	Onion	21.6	4.0	(51.5)	Peach	25.5	4.8	(51.5)
6	Carrot	17.0	3.9	(42.2)	Radish	21.4	4.0	(55.5)	Oriental melon	24.2	4.5	(56.0)
7	Water melon	15.6	3.6	(45.8)	Grape	15.6	2.9	(58.4)	Radish	21.0	4.0	(60.0)
8	Soybean sprout	14.2	3.3	(49.1)	Cucumber	15.4	2.9	(61.3)	Onion	20.2	3.8	(63.8)
9	Cabbage	10.5	2.4	(51.5)	Kimchi, radish	14.0	2.6	(63.9)	Pepper, green	17.5	3.3	(67.1)
10	Spinach	8.8	2.0	(53.5)	Tomato	13.5	2.5	(66.4)	Cucumber	16.4	3.1	(70.1)
11	Pumpkin	8.8	2.0	(55.5)	Pepper, green	12.1	2.3	(68.7)	Kimchi, radish	14.3	2.7	(72.8)
12	Sweet potato	8.5	2.0	(57.4)	Oriental melon	11.2	2.1	(70.8)	Welsh onion	11.8	2.2	(75.0)
13	Pepper, green	7.8	1.8	(59.2)	Pumpkin	10.4	2.0	(72.7)	Lettuce	10.7	2.0	(77.1)
14	Strawberry	7.8	1.8	(61.0)	Welsh onion	9.8	1.8	(74.6)	Pumpkin	10.4	2.0	(79.0)
15	Garlic	7.0	1.6	(62.6)	Sweet potato	8.6	1.6	(76.2)	Eggplant	8.6	1.6	(80.6)
16	Apple	6.7	1.5	(64.1)	Carrot	7.1	1.3	(77.5)	Soybean sprout	6.3	1.2	(81.8)
17	Lettuce	6.4	1.5	(65.6)	Soybean sprout	6.9	1.3	(78.8)	Garlic	5.7	1.1	(82.9)
18	Citrus fruit	6.1	1.4	(67.0)	Apple	6.1	1.1	(79.9)	Cabbage	5.4	1.0	(83.9)
19	Mungbean sprout	5.8	1.3	(68.3)	Lettuce	5.6	1.0	(81.0)	Carrot	4.3	0.8	(84.7)
20	Tomato	5.2	1.2	(69.5)	Cabbage	5.3	1.0	(82.0)	Pumpkin leaves	3.7	0.7	(85.4)
	Others	134.5	30.5	(100.0)	Others	105.3	18.0	(100.0)	Others	77.8	14.6	(100.0)
	Total	437.5	100		Total	543.6	100		Total	532.0	100	

1) Cumulative percent

welsh onion in the age group of 20-29. In the age group of 30-49, the order is watermelon, Chinese cabbage kimchi, peach, potato, and onion. In the age group of 50-64, the order is watermelon, Chinese cabbage kimchi, tomato, potato, and peach.

General characteristics and bone metabolism indices of selected subjects

General characteristics and bone metabolism indices of some targets are as shown in Table 5. The average age was 24.7 for men and 22.8 for women. The height, weight and BMI were 173.2 cm, 73.6 kg, and 24.6 kg/m^2 for men while it was 160.8

Table 5. General characteristics, calcium and osteocalcin in serum, and urinary deoxypyridinoline excretion of selected subjects

variables	men (n = 23)	women (n = 28)	total (n = 51)
age (yr)	24.7 ± 2.41)	22.8 ± 0.8**2)	23.6 ± 2.0
height (cm)	173.2 ± 4.1	160.8 ± 4.0***	166.4 ± 7.4
weight (kg)	73.6 ± 12.7	55.5 ± 6.7***	63.6 ± 13.3
bmi (kg/m2)	24.6 ± 4.2	21.6 ± 2.4**	23.0 ± 3.7
serum ca (mg/dl)	9.4 ± 0.4	9.3 ± 0.2	9.3 ± 0.3
serum osteocalcin (ng/ml)	28.7 ± 8.2	21.8 ± 3.8***	24.9 ± 7.0
urinary dpd (nmol/mmol creatinine)	5.2 ± 1.3	7.8 ± 1.7***	6.7 ± 2.0

1) mean ± SD
2) significantly different form men and women of the same age group by independent t test $^{**}P < 0.01$, $^{***}P < 0.001$

Table 6. Pearson correlation coefficient between dietary variables and markers of bone metabolism in selected subjects

Dietary variables	Serum Ca	Serum osteocalcin	Urinary DPD
Energy	0.039	-0.133	-0.307*
Protein	0.060	-0.142	-0.287*
Fat	-0.124	-0.121	-0.207
Carbohydrate	0.046	-0.097	-0.277*
Calcium	0.133	-0.194	-0.297*
Phosphorus	0.125	-0.221	-0.322*
Sodium	0.128	-0.188	-0.266
Potassium	-0.011	-0.268	-0.101
Iron	0.027	-0.095	-0.272
Zinc	0.225	-0.158	-0.303*
β-carotene	-0.079	-0.319*	0.039
Vitamin C	0.065	-0.159	-0.041
Total foods	0.139	-0.138	-0.277*
Vegetables	-0.248	-0.252	0.075
Leafy & stem vegetables	-0.069	-0.250	-0.215
Tuber vegetables	-0.265	-0.136	0.291*
Fruit vegetables	-0.183	-0.225	-0.130
Fruits	0.163	-0.063	0.042
Mushrooms	-0.062	-0.094	-0.203

*$P < 0.05$

cm, 55.5 kg and 21.6 kg/m^2 for women. Serum calcium level was 9.4 mg/dl for men and 9.3 mg/dl women. As such, there was no significant difference between the sexes. Serum osteocalcin was significantly higher in men (28.7 ng/ml) than in women (21.8 ng/ml). However, the DPD excretion in urine was significantly lower in men (5.2 nmol/mmol creatinine) than in women (7.8 nmol/mmol creatinine).

Relevance of nutrient, vegetable and fruit intakes with bone metabolism indices of selected subjects

The relevance of nutrient, vegetable and fruit intakes with bone metabolism indices of some targets is as shown in Table 6. β-carotene intake displayed a significantly negative correlation with serum osteocalcin. While calorie, protein, carbohydrate, calcium, phosphorus, and zinc as well as total food intake displayed a significantly negative correlation with DPD excretion in urine, the intake of tuber vegetables displayed a significantly positive correlation with DPD excretion in urine.

Discussion

The diet of a country determines the characteristics of food intake pattern, and this exerts a significant impact on the outbreak of diseases within the country. In particular, vegetable and fruit intakes are known to prevent diseases of which the incidence is higher in the recent times, such as cardiac disorders, diabetes and cancer. Accordingly, the traditional Korean diet that centers on vegetables is being assessed favorably. However, recent changes in diet for greater convenience, such as processed foods, have caused the intake of vegetables to decrease. Therefore, in order to maintain an optimal diet and increase the added values, a study is necessary to continuously evaluate the intakes of vegetables and fruits and to verify the usefulness of the intake of these food items.

Currently, KNHANES evaluates food intake by classifying food items into 13 groups [1]. The 13 food groups contain vegetables and fruits. However, evaluation of detailed groups of vegetables is not being conducted. This makes it difficult to achieve diverse evaluations of vegetables. Kwon *et al.* [14], using the data of KNHANES, reanalyzed and reported the intake quantities of fruits and vegetables for people aged 30 or older in terms of preventing chronic diseases. In this study, vegetables were classified into salted and unsalted vegetables. The salted vegetables included kimchi and pickled dishes. Unsalted vegetables included mushrooms, seaweeds and vegetables while potatoes, sweet potatoes and salted vegetables were excluded. Also, the vegetables and fruits did not include juices. As such, the current criteria of classifying vegetables slightly differ according to the perspectives of sitology and dietetics. This results in each researcher employing slightly different classification criteria. Therefore, in order to achieve an accurate evaluation of vegetable intake, a study has been needed to standardize the classification criteria. In this study, the intakes of vegetables, mushrooms and fruits were analyzed by including all food items of each food group. In addition, vegetables with high intake levels and large varieties were subdivided into leafy and stem vegetables, tuber vegetables, and fruit vegetables. Then, the intake of each was evaluated.

The recent KNHANES reported that the daily average vegetable, fruit and mushroom intake by the entire nation was 327.0 g, 87.4 g and 4.4 g respectively. As for vegetable intake per age group, it was reported to be 336.9 g by those aged 20-29, 389.5 g by those aged 30-49 and 385.5 g by those aged 50-64. The study by Kwon *et al*. [14] to reanalyze the same data for people aged 30 or older reported that the intake quantities of salted vegetables, unsalted vegetables and fruits were 151 g, 237 g and 70.7 g, respectively. Comparing these two results to analyze the same data for the similar age group, the intake of vegetables was found to be similar. However, fruit intake was lower in the report by Kwon *et al*. [14]. This could have been caused by the exclusion of juices. In this study, the intake quantities of vegetables, fruits and mushrooms were found to be 364 g, 66.4 g and 7.1 g for the age group of 20-29, 331.4 g, 201 g and 2.2 g for the age group of 30-49, and 348.9 g, 181.5 g and 1.7 g for the age group of 50-64. Comparing these against the results of KNHANES, the vegetable intake by those aged 20-29 in this study was higher. However, vegetable intake by those aged 30 or older was found to be lower. On the other hand, fruit intake by those aged 30 or older was more than double the figure indicated by KNHANES. This large difference was because KNHANES 2005 was conducted in April-May during which fruit production was low, while this study was carried out in summer during which fruit production was high. While vegetable intake by the age group of 20-29 in this study was higher than that of those aged 30 or older, fruit intake by the age group of 20-29 was very low. This is also indicated by the fact that the top-ingested source of vegetable and fruit item was Chinese cabbage kimchi for the age group of 20-29, while it was watermelon for the age group of 30-64. Most of the targets aged 20 to 29 who participated in this study were students of colleges located in the countryside. Therefore, the living environment, such as having to cook for themselves and to travel long distances to school, could have led to lower fruit intake.

There is still no accurate standard of vegetable and fruit intake which has been established in Korea. For a meal plan of 2,000 kcal, it is recommended to take 5-7 servings of vegetables and 2 servings of fruits. Although the weight of a single serving differs per food item, it is 70 g for many vegetables and 100 g or 200 g for fruits. Accordingly, daily vegetable and fruit intakes are estimated at approximately 350-490 g and 300 g, respectively. Based on these figures, vegetable and fruit intake by this survey targets is slightly lower and this indicates a necessity to increase vegetable and fruit intake.

Calcium intake by Korean people is evaluated to be insufficient. This is because of the low intake of milk and dairy products, the major sources of calcium. The Framingham Heart Study is a cross-sectional cohort study, which has been conducted since 1948 for the purpose of preventing cardiac disorder [15]. With the recent increase of an aging population and, accordingly, an emphasis on the importance of bone health, the results of the Framingham osteoporosis study to measure bone density and to find related factors among the Framingham cohorts were reported [16]. The cross-sectional and longitudinal analysis of the relevance of bone density of 345 men and 562 women aged 69-97 with dietary factors analyzed through a food frequency questionnaire (FFQ) indicated that both vegetable and fruit intakes were significantly influencing factors [11]. Bone mineral density also displayed significantly positive relevance with potassium and magnesium intake which can be explained by the relation of bone mineral density to vegetable and fruit intake as potassium and magnesium are rich in vegetables and fruits. In addition, the highest ranking source food items of potassium and magnesium were found to be potatoes and rye bread [16]. The Northern Ireland Young Heart Project investigated the relevance of bone mineral density with vegetable and fruit intake by 1,345 male and female adolescents aged 12 and 15 [17]. The result of this investigation showed a significantly positive correlation between fruit intake and bone mineral density in 12-year-old female adolescents. In a study analyzing the relationship between bone mineral density and the intake of 30 food items of 291 pre-menopausal Japanese women aged 40-55, there was a significant positive correlation between bone mineral density and the intake of brightly-colored vegetables, mushrooms and fruits [18]. As such, in Korea, where there is weakness in bone health due to a lack of calcium intake, the diverse study results in recent times reporting that vegetable and fruit intake exerts a positive impact on bone density and bone metabolism are of high importance.

In this study, several bone metabolism indices were measured for 51 subjects, which correspond to 10% of the 542 survey targets for whom the vegetables and fruits intake was investigated. Then, the relevance with dietary factors centering on vegetable and fruit intake was discussed. As for the report that serum calcium maintains homeostasis regardless of calcium and dietary intake [19], serum calcium did not display significant correlation with all dietary factors. On the other hand, serum osteocalcin displayed significantly negative correlation with β-carotene intake. In addition, while calorie, protein, carbohydrate, calcium, phosphorous, and zinc as well as total food intake displayed a significantly negative correlation with DPD excretion in urine, the intake of tuber vegetables displayed a significantly positive correlation with DPD excretion in urine. Osteocalcin is a protein that displays singular characteristics in bones and dentins. Formed by osteoblasts, osteocalcin is used as an indicator in studies discussing bone conditions of osteoporosis patients [20]. Serum osteocalcin is positively interpreted to imply an increase of bone formation in younger people. However, it has been reported to display a negative correlation with bone mineral density after menopause, and therefore, implies increased bone turnover [21]. DPD is found only in bone tissues. Destroyed by osteoclasts, DPD flows out of osteocyte and is excreted through urine [22]. Therefore, DPD excretion in urine is known as a biochemical indicator of osteolytic lesion that increases in post-menopausal women or osteoporotic patients [23]. The analysis on relevance of vegetable and fruit intake with bone metabolism indices in this study indicated that there was no distinct relationship with the exception of tuber vegetable intake showing significantly positive correlation with DPD excretion in urine. In contrast, total calorie and nutrient intakes were found to have significantly negative relevance with DPD excretion in urine.

This study has a number of limitations that make it difficult to clearly explain the relation of vegetable and fruit intake with bone metabolism. First, a number and age of survey targets for analysis of bone metabolism indices are small and restricted with 20-29 years. And it will be necessary to analyze more diverse bone metabolism indices including bone mineral density in more wide age groups. Second, as aforementioned, sufficient reconsideration and standardization are necessary to classify vegetables and fruits. In this study, potatoes and sweet potatoes with high intake levels belong to the tuber vegetable group and this may have affected the significant relevance between tuber vegetable intake and DPD excretion in urine. Also, results of this study cannot be clearly interpreted as the previous studies reporting that vegetables and fruits had high contents of isoflavone and vitamin C as well as large quantities of dietary properties that generated alkali inside the human body and therefore played positive roles in bone metabolism [9-13]. However, although the traditional Korean diet is characterized as having a high vegetable-intake level, this study was conducted while vegetable consumption has been decreasing and showed insufficient vegetable and fruit intake levels. Therefore, together with a continuous study to clearly explain the relevance of vegetable and fruit intake with bone mineral density and bone metabolism, future efforts will be necessary to increase vegetable and fruit intake.

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