Relationship of nutrient intakes and bone mineral density of elderly women in Daegu, Korea

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Abstract

The purpose of this study was to examine the relationship between nutrient intake and bone mineral density (BMD) of elderly women in Daegu, Korea. In this study, the bone mineral densities of 101 elderly women in Daegu were measured, and their nutrient intake, dietary habits, and maternal factors were determined through a survey. The subjects were divided into the normal group, the osteopenia group, and osteoporosis group to find out if there is a correlation between bone mineral density and maternal factors, dietary habits, and nutrient intake through their T-scores, analyzed according to the standards of WHO. Classification by T-scores of the participants were the normal group 25.7%, the osteopenia group 39.6%, the osteoporosis group 34.7%. Menopause age of the osteoporosis group was lower, postmenopausal period was longer, and last delivery age was significantly higher than the normal group (p<0.05). Osteoporosis group had a lower percentage of 'everyday' fruit and vegetable intakes and higher percentage of 'never' dairy intake than of the normal group. Vitamin A, vitamin B_1, and vitamin B_2 intakes of participants in the osteoporosis group were lower than those in the normal group (p<0.05). In conclusion, nutritional education is necessary to encourage high intake of milk and vegetables and fruits along with calcium, vitamin A, B_1, and B_1 intakes and low intake of sodium for the prevention of elderly women's osteoporosis.

Key Words: Elderly women, nutrient intake, bone mineral density (BMD)

Introduction

The rates of increase in the number of elderly people in Korea, or those aged 65 or above, against the total Korean population over the past years were very high: 5.7% in 1994, 7.2% in 2000, 8.3% in 2003, and 8.7% in 2004. People who are 65 years old or above now represent more than 7% of the country's total population, which signals the advent of an aging society, and the projection that people in this age bracket will comprise 14% of the country's population in 2022 indicates that Korea will already have an aged society in that year (Ministry of Health and Welfare, 2005). The truth of this matter would be readily seen if it would be considered that the average life expectancy of the women in Korea is 80.1 years, and that their postmenopausal life is almost over 30 years long (Ministry of Health and Welfare, 2005). After menopause, the secretion of the female hormone estrogen decreases, resulting in the risk of developing osteoporosis due to the loss of bone mass (Kim, 2001). No less than 1.3 million osteoporosis-related fracture cases occur in the U.S. every year, including 530,000 spine fractures, with the possibility of spine fractures for 1/3 of the women who are 65 years old or above (Gordon, 1988). The possibility of incurring an osteoporosis-related fracture in a whole lifetime was estimated to be about 40% (Preisinger *et al.*, 1995), and the death rate

due to osteoporosis-related fracture is higher than the death rate due to breast cancer or uterine cancer (Tenenhouse *et al.,* 2000). This explains why osteoporosis and osteoporosis-related fractures are drawing a lot of attention as a health problem in the U.S. According to the report of NOF (National Osteoporosis Foundation, 2002), 44 million men and women aged 50 years and above were threatened by osteoporosis in 2002, 80% of which were females, and these numbers are expected to increase to 52 million in 2010 and to 61 million in 2020. Fracture incidence reportedly has race-based differences, and age-adjusted hip fracture incidence was lower for all three Asian-American groups than for whites. For females, the standardized fracture ratio relative to whites was 30.1 for Chinese, 73.2 for Japanese, and 52.8 for Koreans (Lauderdale *et al.,* 1997).

According to a 2001 study on 50 to 79-year-old Japanese women, the prevalence rate of osteoporosis in that year for such women was 38% for the spine and 11.6% for the femoral neck (Iki *et al*., 2001). A study on Chinese women living in Hong Kong showed a significantly higher osteoporosis prevalence rate for older women: 10% for women in their fifties and 45% for those in their sixties (Ho *et al.,* 2001).

There are no statistical data available on the prevalence rate of osteoporosis in Korea, but it is known that the bone mineral density of Korean women is about 10% lower than that of

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Western women (Kang, 1998), and that the rate of diminution of the Korean women's bone mineral density after menopause is higher than that of the women in other countries (Koh *et al.*, 1992). In a study on 1,448 Korean women aged 40 years and above, the prevalence rates of osteoporosis were found to be 19.4%, 10.8%, and 6.7% for the spine, femoral neck, and total femur bone mineral density, respectively. In the case of the women who were 50 years old or above, the prevalence rates were 23.1%, 13.0%, and 7.6%, respectively (Lee *et al.*, 2002). In addition, in a study on 1,020 Korean women who were in their premenopausal period, the prevalence of osteoporosis was found to be 9.8% for the spine and 1.4% for the femoral neck (Kim *et al.*, 2002). The osteopenia was 30.7% for the spine and 24.4% for the femoral neck. The subjects had relatively low prevalence of osteoporosis. Since the total subjects had not experienced menopause or were in the early menopausal period, and the ages of the subjects ranged from 49 to 54 years. Among them, 507 subjects were premenopausal women.

However, the study for rural females reported high prevalence of osteopenia or osteoporosis (Kim *et al.*, 2000). It is reported that 86.4% of the rural female subjects aged 50 years or above in their study had osteopenia or osteoporosis. The percentages of old women over aged 60 years in their study who had osteopenia or osteoporosis were 91.7%.

A study on the relationship between nutrition and bone mineral density showed that the bone mineral density of elderly people is related to their overall nutrition (Kim, 2001), and a study on menopausal women showed that almost all the nutrition intakes of these women have a positive correlation with their bone mineral density (Lee *et al.*, 1992). Calcium intake, in particular, was found to have a significant effect on bone mineral density. The minimum calcium intake needed for minimizing the decrease of bone mineral density is estimated to be about 600 mg (Lee *et al.*, 2005). According to the results of the Korea National Health and Nutrition Survey (Ministry of Health and Welfare, 2001), the average calcium intake of 65-year-olds or above in Korea in 2001 was 515.5 mg, which was far less than the EAR (estimated average requirement) of 580 mg and the RI (recommended intake) of 800 mg, and the actual absorption was estimated to be far less than the intake because the calcium intake was mainly through vegetables, which have a low calcium absorption rate (Korea Health Industry Development Institute, 2002). The environmental factors associated with poor skeleton metabolism include smoking (Jeng *et al.*, 2000; Slemenda *et al.*, 1992), alcohol, coffee, sodium, and the regularity of meals (Lee & Son, 2004), in addition to improper nutrition.

In this study, the nutrient intakes and dietary habits of elderly women in Daegu were investigated, and the data that were obtained were analyzed to determine if there is a relationship between such factors and these women's bone mineral density. This is expected that results can be used as the basic data to nutritional intervention for prevention of osteoporosis.

Subjects and Methods

Subjects and period

The survey was performed at a clinic center from May 2005 to August 2005 in Daegu. The subject of this research was 110 respondents of a survey carried out on the elderly women from 65 to 80-years-old who visited to check bone mineral density voluntarily. The analysis was conducted using verified 101 cases among the total samples.

Contents and methods

1) Anthropometric measurement

The height (cm) and weight (kg) of the subjects were measured using a height and weight-measuring instrument (FANICS MEASURING SYSTEM, HM-170, 1999), and their BMI [body mass index = weight (kg) / height (m^2)], which reflects the body fat more accurately than the standard weight does, was calculated from the height and weight values. The body fat rate (fat %) was also measured using an automatic fat-measuring instrument's, a body fat monitor HBF-302 (Hongil Medical, 2004).

2) Measurement of the bone mineral density

The bone mineral densities of the subjects were measured using Lunar's dual-energy X-ray absorptiometry (DEXA), and the diagnoses were conducted according to WHO standards: the bone mineral density was classified as normal if the T-score (calculated by dividing the difference between the individual bone mineral density and the maximum bone mineral density of a young adult by the standard deviation of the normal bone mineral density) was above -1.0; osteopenia was adjudged to exist if the T-score was between -1.0 and -2.5; and osteoporosis was adjudged to exist if the T-score was -2.5 or below.

3) General characteristics, dietary habits, and frequency

The survey carried out on trained researcher through individually interviews. Subjects were asked to provide information on maternal factors such as age, menarche, menopause, and children, and dietary habits such as the regularity of the eating time, the frequency of the intake of vegetables and fruits, and the frequency of the intake of dairy foods.

4) Daily food intake levels

To determine the subjects' nutrient intake levels, they were interviewed individually using the 24-hour (one-day) recall method. Their daily energy and nutritional intakes were calculated by inputting the collected nutritional intake data into the professional-use CAN-pro (Computer-aided Nutrition Analysis, version 3.0) developed by Korea Nutrition Society, and were compared with the EAR (estimated average requirement), RI (recommended intake), and AI (adequate intake) values provided by KDRIs (Dietary Reference Intake for Koreans).

Statistical analysis

Statistical analysis was conducted using the SAS program. The frequency count, percentage, mean and standard deviation were calculated for all the variables, and when the results of ANOVA test were found to be significant, they were verified through Duncan's multiple-range test ($\alpha = 0.05$).

Results

Classification of bone mineral density

Based on the WHO standards, bone mineral density was classified in this study as normal, osteopenia and osteoporosis. The subjects of this study were the elderly women from 65 to 80-years-old in the city. The bone mineral density of the subjects is as follows. The group that was found to have normal bone mineral densities represented 25.7% of the subjects, the osteopenia group 39.6%, and the osteoporosis group 34.7% (Table 1).

Comparison of anthropometric measurements according to bone mineral density

Table 2 shows the results of the comparison of the anthropometric measurements according to bone mineral density. The average age of the normal group was 71.1, 72.3 for the osteopenia group and 73.6 for the osteoporosis group. The average heights of the normal group, the osteopenia group, and the osteoporosis group were 151.3 cm, 149.7 cm, and 149.7 cm, respectively, and their average weights were 56.2 kg, 55.0 kg, and 54.1 kg, respectively, with no significant difference among the groups. The average BMIs (body mass indexes) in the normal group, the osteopenia group, and the osteoporosis group were 24.5 kg/m^2, 24.5 kg/m^2, and 24.4 kg/m^2, respectively, and the average body fat rates were 33.0 %, 32.5 %, and 33.3 %, respectively, with no significant difference among the groups.

Table 1. Classification of the subjects according to their T-scores

Variables	Item	n (%)
Normal	T-scores > -1	26 (25.7)
Osteopenia	-1 ≥ T-scores < -2.5	40 (39.6)
Osteoporosis	-2.5 ≥ T-scores	37 (34.7)
Total		101 (100.0)

Table 2. Anthropometric measurements according to the bone mineral densities of the subjects

Variables	Normal (n=26)	Osteopenia (n=40)	Osteoporosis (n=35)
Age (years)	71.1 ± 4.3[1]	72.3 ± 4.5	72.8 ± 4.1
Height (cm)	151.3 ± 5.0	149.7 ± 6.1	149.7 ± 5.2
Weight (kg)	56.2 ± 5.8	55.0 ± 5.5	54.1 ± 6.6
BMI[2] (kg/m^2)	24.5 ± 1.8	24.5 ± 1.8	24.4 ± 2.5
Percent body fat (%)	33.0 ± 4.3	32.5 ± 3.2	32.9 ± 2.9

[1] Mean ± SD
[2] BMI (body mass index) = weight (kg) / height (m^2)

Table 3. Menarche, menopausal state, and maternal factors according to the bone mineral density of the subjects

Variables	Normal (n=26)	Osteopenia (n=40)	Osteoporosis (n=35)
Menarche age (years)	17.3 ± 1.6[1]	16.4 ± 1.3	17.0 ± 1.5
Age of menopause (years)	48.1 ± 6.9^{a}[2]	46.9 ± 5.1^{ab}	45.5 ± 4.4^{b}
Postmenopausal period (years)	23.0 ± 9.4^{b}	25.3 ± 6.7^{ab}	27.4 ± 6.0^{a}
Number of children	4.6 ± 0.9	4.5 ± 1.4	4.2 ± 1.2
Last-child-delivery age (years)	33.3 ± 3.7^{a}	35.7 ± 3.9^{ab}	33.9 ± 4.9^{a}

[1] Mean ± SD
[2] The values with different superscripts in the same row are significantly different at p<0.05.

Comparison of maternal factors according to bone mineral density

Table 3 shows the results of the comparison of the maternal factors according to bone mineral density. The average menarche ages of the normal group, the osteopenia group, and the osteoporosis group were 17.3, 16.4, and 17.0, respectively. There is no significant difference among the groups on average menarche ages. The average menopause ages of the normal group, the osteopenia group, and the osteoporosis group were 48.1, 46.9, and 45.5, respectively, and the normal group had a somewhat high value although this had no statistical significance. The postmenopausal periods were 23.0 years long for the normal group, 25.3 years long for the osteopenia group, and 27.4 years long for the osteoporosis group, which showed a significant difference between the normal group and the osteoporosis group (p<0.05) but no significant difference between the normal group and the osteopenia group. The average numbers of children were 4.6 for the normal group, 4.5 for the osteopenia group, and 4.2 for the osteoporosis group, with no significant difference among the groups. The last-child-delivery ages of the normal group, the osteopenia group, and the osteoporosis group were 33.27, 35.7, and 33.9, respectively, with no significant difference among the groups.

Dietary habits of the subjects according to the classification of their bone mineral density

Based on the results of the comparison of the subjects' bone mineral density levels (Table 4), the rates of their regular diets were determined to be 53.9% for the normal group, 52.5% for the osteopenia group, and 54.1% for the osteoporosis group. The rates of their daily intake of 200 ml milk or above were 7.7% for the normal group, 5.0% for the osteopenia group, and 8.5% for the osteoporosis group; and the rates of the intake of 4-5 200 ml glasses of milk/week were 23.1% for the normal group, 10.0% for the osteopenia group, and 11.4% for the osteoporosis group. The rates of the non-intake of milk were 7.7% for the normal group, 25.0% for the osteopenia group, and 20.0% for the osteoporosis group, with no statistical significance. As for the intake of fruits and vegetables, one intake was recognized to be 70 g or more of fruits and 60-70 g or more of vegetables.

Table 4. Dietary habits according to the bone mineral density of the subjects
n(%)

Variables	Total (n=101)	Normal (n=26)	Osteopenia (n=40)	Osteoporosis (n=35)
Regularity of meal time				
Regular	55(53.4)	14(53.9)	21(52.5)	19(54.3)
Irregular	48(46.6)	12(46.1)	19(47.5)	16(45.7)
Milk intake				
Everyday	7(6.8)	2(7.7)	2(5.0)	3(8.5)
4-5/week	19(18.5)	6(23.1)	9(22.5)	4(11.4)
2-3/week	14(13.6)	6(23.1)	4(10.0)	4(11.4)
1/week	44(42.6)	10(38.4)	15(37.5)	17(48.7)
Never	19(18.5)	2(7.7)	10(25.0)	7(20.0)
Fruit and vegetable Intake				
Everyday	2(1.9)	2(7.7)	0(0.0)	0(0.0)
4-5/week	35(34.0)	5(19.2)	19(47.5)	10(28.5)
2-3/week	26(25.2)	9(34.6)	5(12.5)	11(31.5)
1/week	34(33.0)	8(30.8)	16(40.0)	10(28.5)
Never	6(5.9)	2(7.7)	0(0.0)	4(11.5)

The daily intakes (%) were 7.7% for the normal group and none for the osteopenia and osteoporosis groups. The percentage of the non-intake of fruits and vegetables were 7.7% for the normal group and 10.8% for the osteoporosis group.

Comparison of nutrient intakes according to bone mineral density

The nutrient intakes (determined through the 24-hour recall method) according to the bone mineral density are shown in Table 5. The nutrient intakes of the subjects were 1505.0 kcal for the normal group, 1481.9 kcal for the osteopenia group, and 1484.3 kcal for the osteoporosis group, with no significant difference among them. There was no significant difference between the three groups' intakes of protein, lipid, carbohydrate, calcium, phosphorous, and potassium, and the vitamin A, B_1, and B_2 intakes were significantly higher in the normal group than in the osteopenia and osteoporosis groups. The intake of cholesterol was lower, though, in the normal group than in the osteopenia or osteoporosis group.

Table 6 shows the intakes of nutrients as rates against the recommended intake (RI) or the adequate intake (AI). All the groups had less calcium, vitamin B_1, vitamin B_6, and folate than the RI, and the intakes of fibrin and potassium were far lower than the AI, while the intake of sodium was very high.

The calcium intakes compared to the RI were 86.1% for the normal group, 79.4% for the osteopenia group, and 79.8 % for the osteoporosis group, with all the groups recording less than the recommended intakes, having no significant difference due to the bone mineral density. The vitamin A intake levels against the RI were 141.2% for the normal group, 107.5% for the osteopenia group, and 111.7% for the osteoporosis group, with all the groups satisfying the RI. The vitamin A intake of the normal group was significantly higher, though, than those of the osteopenia group and of the osteoporosis group (p<0.05). The vitamin B_1 intakes of the normal group, the osteopenia group,

Table 5. Daily nutrient intake according to bone mineral density

Nutrient	Normal (n=26)	Osteopenia (n=40)	Osteoporosis (n=35)
Energy (kcal)	1505.0 ± 217.2[1]	1481.9 ± 207.1	1484.3 ± 219.9
Carbohydrate (g)	243.2 ± 33.1	252.7 ± 29.7	246.0 ± 36.9
Protein (g)	81.8 ± 19.5	73.8 ± 17.9	78.3 ± 16.6
Fat (g)	37.7 ± 15.3	32.6 ± 41.0	35.3 ± 13.3
Fiber (g)	6.7 ± 1.8	6.4 ± 2.2	6.3 ± 1.9
Ca (mg)	688.6 ± 305.7	635.4 ± 186.8	638.7 ± 169.9
P (mg)	922.3 ± 216.9	835.8 ± 174.5	878.7 ± 214.9
Fe (mg)	17.2 ± 5.1	17.8 ± 7.5	16.7 ± 5.7
Na (mg)	5085.9 ± 1128.9	4886.8 ± 1233.0	4876.2 ± 1168.9
K (mg)	2653.8 ± 622.9	2668.6 ± 595.5	2652.2 ± 587.6
Zinc (mg)	7.7 ± 1.3	7.5 ± 1.8	7.7 ± 1.4
Vit A (µg RE)	846.9 ± 438.5[a2]	645.3 ± 354.6[b]	670.1 ± 304.0[b]
Vit B_1 (mg)	1.0 ± 0.2[a]	0.9 ± 0.2[b]	0.9 ± 0.2[b]
Vit B_2 (mg)	1.0 ± 0.3[a]	0.8 ± 0.2[b]	0.9 ± 0.2[b]
Vit B_6 (mg)	2.6 ± 1.6	2.1 ± 1.2	2.4 ± 1.3
Niacin (mg)	13.5 ± 3.2	12.9 ± 3.6	13.2 ± 3.0
Vit C (mg)	76.2 ± 25.2	70.0 ± 21.0	75.7 ± 24.5
Folate (µg)	242.5 ± 60.3	243.7 ± 66.1	244.5 ± 61.9
Vit E (mg)	16.2 ± 15.1	12.2 ± 7.4	13.0 ± 7.3
Cholesterol (mg)	358.5 ± 257.1[a]	233.0 ± 179.2[b]	311.1 ± 196.2[ab]

[1] Mean±SD
[2] The values with different superscripts in the same row are significantly different at p<0.05.

Table 6. Daily nutrient intake according to bone mineral density of the subjects as expressed by the percentage of the Korean DRI[1]

Nutrient	DRI	Normal (n=26)	Osteopenia (n=40)	Osteoporosis (n=35)
Protein (g)	RI[2]	181.9 ± 43.2[4]	164.0 ± 39.7	173.9 ± 37.0
Fiber (g)	AI[3]	30.4 ± 8.3	29.3 ± 10.2	28.8 ± 8.5
Ca (mg)	RI	86.1 ± 38.2	79.4 ± 23.4	79.8 ± 21.2
P (mg)	RI	131.8 ± 31.0	119.4 ± 24.9	125.6 ± 30.7
Fe (mg)	RI	190.8 ± 56.2	198.5 ± 83.2	185.1 ± 62.9
Na (mg)	AI	423.8 ± 94.1	407.2 ± 102.8	406.4 ± 97.4
K (mg)	AI	56.5 ± 13.3	56.8 ± 12.7	56.4 ± 12.5
Zinc (mg)	RI	110.3 ± 19.1	106.5 ± 25.5	109.4 ± 20.5
Vit A (µg RE)	RI	141.2 ± 73.1[a]	107.5 ± 59.1[b]	111.7 ± 50.7[b]
Vit B_1 (mg)	RI	92.2 ± 19.3[a5]	78.6 ± 17.7[b]	79.5 ± 21.2[b]
Vit B_2 (mg)	RI	187.7 ± 113.3[a]	147.3 ± 87.6[b]	171.4 ± 94.2[b]
Vit B_6 (mg)	RI	96.7 ± 23.1	91.8 ± 25.7	94.3 ± 21.6
Niacin (mg)	RI	233.8 ± 55.6	210.9 ± 51.0	223.7 ± 47.5
Vit C (mg)	RI	108.9 ± 36.0	99.9 ± 30.0	108.1 ± 34.9
Folate (µg)	RI	60.6 ± 18.4	60.9 ± 16.5	61.1 ± 15.5

[1] DRI (dietary reference intakes for Koreans)
[2] RI (recommended intake)
[3] AI (adequate intake)
[4] Mean ± SD
[5] The values with different superscripts in the same row are significantly different at p<0.05.

and the osteoporosis group were 1.0 mg, 0.9 mg, and 0.9 mg, respectively, which represented 92.2%, 78.6%, and 80.6% of the RI. As such, the vitamin B_1 intakes of all the groups were lower than the RI. The normal group had a significantly higher vitamin B_1 intake level, though, than the osteopenia group and the

Table 7. Daily nutrient intake according to the bone mineral density of the subjects as expressed by the percentage of the Korean EAR[1]

Nutrient	Normal (n=26) %EAR	Osteopenia (n=40) %EAR	Osteoporosis (n=35) %EAR
Energy (kcal)	94.1 ± 13.6[2]	92.6 ± 12.9	92.7 ± 13.7
Protein (g)	233.8 ± 55.6	210.9 ± 51.0	223.7 ± 47.5
Ca (mg)	118.7 ± 52.7	109.5 ± 32.2	110.1 ± 29.3
P (mg)	159.0 ± 37.4	144.1 ± 30.1	151.5 ± 37.1
Fe (mg)	245.3 ± 72.2	255.3 ± 107.0	238.1 ± 80.9
Zinc (mg)	128.7 ± 22.3	124.2 ± 29.8	127.6 ± 23.9
Vit A (μg RE)	197.0 ± 102.0[a3]	150.1 ± 82.5[b]	155.9 ± 70.7[b]
Vit B_1 (mg)	112.7 ± 23.5[a]	96.1 ± 21.6[b]	97.1 ± 25.9[b]
Vit B_2 (mg)	99.3 ± 25.7[a]	83.6 ± 20.5[b]	87.2 ± 20.7[b]
Vit B_6 (mg)	219.1 ± 132.1	171.9 ± 102.2	200.0 ± 109.9
Niacin (mg)	123.0 ± 29.5	116.8 ± 32.8	120.7 ± 27.4
Vit C (mg)	101.6 ± 33.6	93.3 ± 28.0	100.9 ± 32.6
Folate (μg)	75.8 ± 23.0	76.2 ± 20.6	76.4 ± 19.4

[1] EAR (estimated average requirement)
[2] Mean ± SD
[3] The values with different superscripts in the same row are significantly different at $p < 0.05$.

osteoporosis group ($p<0.05$). The vitamin B_2 intakes of the normal group, the osteopenia group, and the osteoporosis group were 1.0 mg, 0.8 mg, and 0.9 mg, respectively, which were somewhat higher than the RI. The normal group had a significantly higher vitamin B_1 intake level, though, than the osteopenia and osteoporosis groups ($p<0.05$). The folate intakes were 242.5 μg for the normal group, 243.7 μg for the osteopenia group, and 244.5 μg for the osteoporosis group, which represented 60.6%, 60.9%, and 61.1% of the RI, respectively, with no significant difference among the groups but showing a somewhat low intake level in all of them. All the groups had more than four times as much sodium (Na) as the AI, while the potassium (K) intakes were 56.5% for the normal group, 56.8% for the osteopenia group, and 56.4% for the osteoporosis group, all very low values. The cholesterol intakes of the normal group, the osteopenia group, and the osteoporosis group were 358.5 mg, 233.0 mg, and 311.1 mg, respectively, with a significant difference between the normal group and the osteopenia group.

Table 7 shows the rate of nutrient intake of the old women in Daegu against the EAR. The protein, Ca, P, Fe, zinc, vitamin A, vitamin B_6, and niacin intakes of all the groups were more than 100% of the EAR. The vitamin A intakes of the osteopenia and osteoporosis groups were significantly low, however, in terms of %EAR ($p<0.05$). Energy was somewhat insufficient in all the groups compared to the EAR, and folate was low, within the range of 75.8-76.4% of the EAR. In the case of vitamin B_1, the normal group had more than the EAR, but the osteopenia group had only 96.1% while the osteoporosis group had only 97.1%, which represented a significantly lower %EAR than that of the normal group. For vitamin B_2, the normal group had 99.3%, while the osteopenia group had 83.6% and the osteoporosis group 87.2%, less than the EAR, representing a significantly lower %EAR compared to that of the normal group ($p<0.05$). Vitamin C intake showed no significant difference among the groups, but the intake of the osteopenia group was

lower than the EAR.

Discussion

In the study conducted by Kim *et al.* (2000), it was reported that 10% of the subjects who were 60 years old or above maintained a normal bone mineral density, and that 85.5% of the old male subjects and 91.7% of the old female subjects had osteopenia or osteoporosis. Contrary to the results of the previous study, 74.3% of the old female subjects in this study were found to have osteopenia or osteoporosis, with the average age of the subjects being 72, showing a relatively low osteoporosis rate.

The subjects of this study were female in the ages from 65 to 80 years old. By comparing the average age according to the bone mineral density by group, it was not found the influence of age on osteoporosis. There was no significant difference, though, in the other factors (height, weight, BMI, and body fat) according to bone mineral density.

According to the Korea National Health and Nutrition Survey (Ministry of Health and Welfare, 2001), the average menarche age was 16.7 years, and the average menopause age was 48 years, for women who were 65 years old or above. The menarche age then was similar to that established in the previous study, but the total average of the menopause age was 47 years, which was 1 year less than the national average. In particular, the osteoporosis group had a younger menarche age than the normal group, and its menopause age was 2.6 years less than that of the normal group, but the osteoporosis group had a 5.1-year-longer menopause period than the normal group did, which implies that menopause age or menopause period influences the health of a person's skeleton.

In this study on the dietary habits of elderly women according to the classification of their bone mineral density, no difference was found among the groups in terms of eating regularity. However, in terms of the frequency of their intake of dairy products, the people who 'never' intake had 3.2 times of osteopenia and 2.6 times of osteoporosis than those of normal group. In terms of the intake of vegetables and fruits, both osteopenia and osteoporosis group did not have 'everyday' intake people. However, the osteopenia group had 11.4% of 'never' answer. Since the sample size of this study is not enough to have a significant result, the sample size should be increased in the next study.

The previous study reported the relationship of frequency of vegetables and fruits (Bae & Sung, 2005). In addition, it also coincided with the report by Celia *et al.* (2006), that there was a significant positive relationship between the intake of vegetables and fruits and the bone mineral densities of the spine and femur, and with the report by Susan *et al.* (2000), that the bone mineral densities of those who have a high intake of vegetables and fruits were high. According to Tucker *et al.* (1999), vegetables and fruits help keep the bone mineral density

at its normal level because they include many alimentary ingredients that produce alkaline metabolite in a body, and R. Jajoo *et al*. (2006) reported that alkaline metabolite decreases the total acid drainage rate in the body, thereby lowering the PTH in the blood, the bone absorption, and the calcium drainage.

In addition, Franceschi (1992) reported that vitamin C in vegetables and fruits act as coenzymes for the hydroxylation of lysine and proline, which synthesize the collagen protein composing the skeleton (Franceschi, 1992). According to Katherine *et al.* (2002), magnesium, potassium, vitamin C, and vitamin K, which are abundant in vegetables and fruits, have an effect on the bones. In a study on rural women in Japan who have not had menopause, the BMD was found to be higher in those who had a high intake of fish, vegetables, and fruits and a low intake of meat and processed foods (Kazutoshi *et al*., 2005) than in those who had the opposite.

There was no significant difference among the groups in this study in terms of their calcium intake, according to the comparison of the nutrient intakes by bone mineral density. The calcium intakes were 688.6 mg for the normal group, 635.4 mg for the osteopenia group, and 638.7 mg for the osteoporosis group, which were somewhat higher than the EAR of Korea in 2005, but all the groups had less than the 800 mg RI (normal group: 86.1%; osteopenia group: 79.4%; osteoporosis group: 79.8%). Therefore, all the older-women groups had insufficient calcium. This suggests that the calcium intake of senile women, who have a high osteoporosis onset risk, should be increased, and that nutrition education programs with the aim of increasing the calcium intake to prevent the onset of osteoporosis should be offered, especially to the elderly.

It was recently reported that calcium helps keep a person's bone mineral density at the normal level and influences bone metabolism by helping drain the total acid in the body (Sebastian *et al*., 1994). Both the normal group and the osteoporosis group in this study had far less potassium than the AI presented in the nutritional standards of Korea in 2005 (4700 mg/day): the normal group had 56.4%, and the osteoporosis group 56.9%. Meanwhile, their sodium intakes were 423% and 406% of the AI, respectively, which were very high. If a high-sodium diet is considered disadvantageous to bone mineral density (Goulding & Campbell, 1983), education on increased potassium intake is necessary to improve the drainage of sodium. Since the risk of hypertension increases as a person becomes older, sufficient potassium intake is important. The dietary fiber AI for old people in the country's nutritional standards is 22 g/d, but the intakes of the subjects in this study were 6.3 g for the normal group, 6.4±2.2 g for the osteopenia group, and 6.4±1.8 g for the osteoporosis group, which were very insufficient (normal group: 30.9% of the AI; osteopenia group: 29.3%; and osteoporosis group: 28.8%).

The vitamin A intake of the normal group was higher than those of the osteopenia and osteoporosis groups. All the groups had insufficient vitamin B_2 and folate intakes, which must be addressed through related education.

In summary, the osteoporosis group had a higher average age, a lower menopause age, and a longer postmenopausal period than the normal group, with a significant difference. The osteopenia and osteoporosis groups had lower intake percentage of milk, vegetables and fruits than the normal group. And, the vitamin A, B_1, and B_2 intakes were significantly higher in the normal group than in the osteopenia and osteoporosis groups. Furthermore, all the groups had less calcium, vitamin B_1, vitamin B_6, and folic acid than the RI; their fiber and potassium intakes were far lower than the AI; and their sodium intake was very high.

In conclusion, nutritional education is necessary to encourage the high intake of milk and vegetables and fruits along with calcium, vitamin A, B_1, and B_2 intakes and the low intake of sodium for the prevention of osteoporosis in elderly women's osteoporosis.

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