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Effects of a DASH diet-based Nutritional Intervention Program on Bone Health of Elderly Women

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Abstract

Osteoporosis is a major health problem for older women. To prevent and treat osteoporosis, dietary strategies for calcium and Vitamin D is critical.We investigate the effects of Korean DASH diet education with calcium/vitamin D supplementation on self-efficacy, diet knowledge and compliance, nutrient intakes, bone markers and density in elderly women. A randomized, controlled trial was conducted for 12 weeks. Experimental group(n=26) received diet education and calcium(1200mg)/vitamin D(800 IU) supplementation and control group(n=22), conventional counseling. Diet knowledge(p=.002) and compliance(p<.001) were higher in experimental group than counterparts. Self-efficacy did not change significantly. Osteocalcin, bone density and nutrient intakes showed no significant differences in both groups, but calcium was consumed more in subjects with better comprehensive nutrition intake. Experimental group showed lower CTx(p=.030) than control group. Korean DASH diet education with calcium/vitamin D supplementation was effective in improving diet compliance and decreasing bone resorption among elderly women.

Keywords: Elderly women, DASH diet, Calcium, Vitamin D, Bone turnover marker

1. Introduction

In Korea, the elderly population of persons aged 65 and older has recently shown a rapid increase,and represented 11.8% of the total population as of 2012(The statistics Korea, 2012).

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With a longer life span and an ever-increasing elderly population, osteoporosis prevalence rate has been on the rise, resulting in more bone fractures and higher medical costs, and restricted social life of affected elderly, all of which contribute to public health concerns (Kim, 2011).

According to the 2008 Korea National Health and Nutrition Examination Survey, 15.3% of women in their 50s had osteoporosis and the proportion showed a sharp increase to 59.8% among women in their 70s (Korean Ministry of Health and Welfare, 2009). While various factors are related to osteoporosis, inadequate intake of nutrients that affect bone density was reported as a primary reason for osteoporosis (Park et al., 2010). Among those nutrients, calcium has the greatest impact, however, calcium intake among elderly women aged 65 and older is very low, less than 50% of the recommendation (Korean Ministry of Health and Welfare, 2009).

Dietary Approach to Stop Hypertension (DASH), which focuses on food high incalcium and potassium, was originally designed for regulation of high blood pressure. Its positive effects on bone mineral density have been reported in studies conducted in many countries, including Korea (Kim et al., 2010; Lin et al., 2003). Therefore, if the DASH diet food choices are modified in favor of elderly Korean persons and provided to them (Korean DASH diet), it would be possible to see increased intake of calcium, potassium, and other nutrients that are helpful for bone health. However, unlike young people, older people may have difficulty increasing calcium and potassium intake from food because they may have difficulties in correcting eating habits and may have some degree of dental problems.

From the meta-analysis of effects of calcium supplementation on bonemineral density, the effects were better for those who had consumed less calcium and who were older (Tang, Eslick, Nowson, Smith, & Bensoussan, 2007). Therefore, for maintenance and improvement of bone mineral density, increased nutrient intake and supplementation of calcium from means other than foodis required for elderly women with serious calcium deficiency (Bae et al., 2006). Bolland et al. (2010) reported that calcium supplements increased the risk for cardiovascular disease, however, one study reported opposite results (Wang et al., 2010).

According to a recent large-scale research study with men and women in their 50s, 60, and 70s (Xiao et al. 2013), calcium was related to cardiovascular disease in men, while it did not show an association with cardiovascular or cerebrovascular disease in women.

According to recent recommendations, calcium should be taken with vitamin D rather than calcium alone (Korean Society for Bone and Mineral Research, 2011). However, studies affirming the positive effects of calcium/vitamin D supplementation on bone density in elderly Korean women are lacking.

To induce behavioral changes through diet education, the education program should utilize a practical approach instead of focusing on knowledge delivery (Ju & So, 2008) and would be more effective if based on proper theories (Contento et al., 1995; Kim, 2011; Oh, Kim, You & Chung, 2004). Therefore, in this study, we designed intervention programs using the Information-Motivation-Behavioral skills (IMB) model based on behavior change theories for application to elderly women. The IMB model postulates that if a person is well-informed, motivated to act, and they have the skills to take action, they are more likely to initiate and maintain health-promoting behaviors (Fisher, Fisher, & Harman, 2003). Hence, we intend to implement the Korean DASH diet education program and to investigate the effects of the program and calcium/vitamin D supplementation on bone metabolism mainly through knowledge delivery, motivation, and enhanced self-efficacy that can be readily translated into improved skills to change behaviors.

2. Methods

2.1. Participants

The Institutional Review Board at Seoul National University approved this study (2011-57).

We examined 48 women aged 65 or over who were enrolled in a senior welfare center in Seoul, Korea. A total of 78 elderly people were initially recruited through advertisements in the center. However, at the initial screening, 23 participants were excluded (n=9, male; n=7, incomplete data; n=5, involvement in other research; n=2, cognitive disabilities), leaving 55 eligible subjects.

In the process of this research, a total of seven patients(n=1, surgery; n=4, taking osteoporosis medication; n=2, refuse to participating) were withdrawn, leaving 26 subjects in the experimental group and 22 in the control group for analysis (Figure 1).

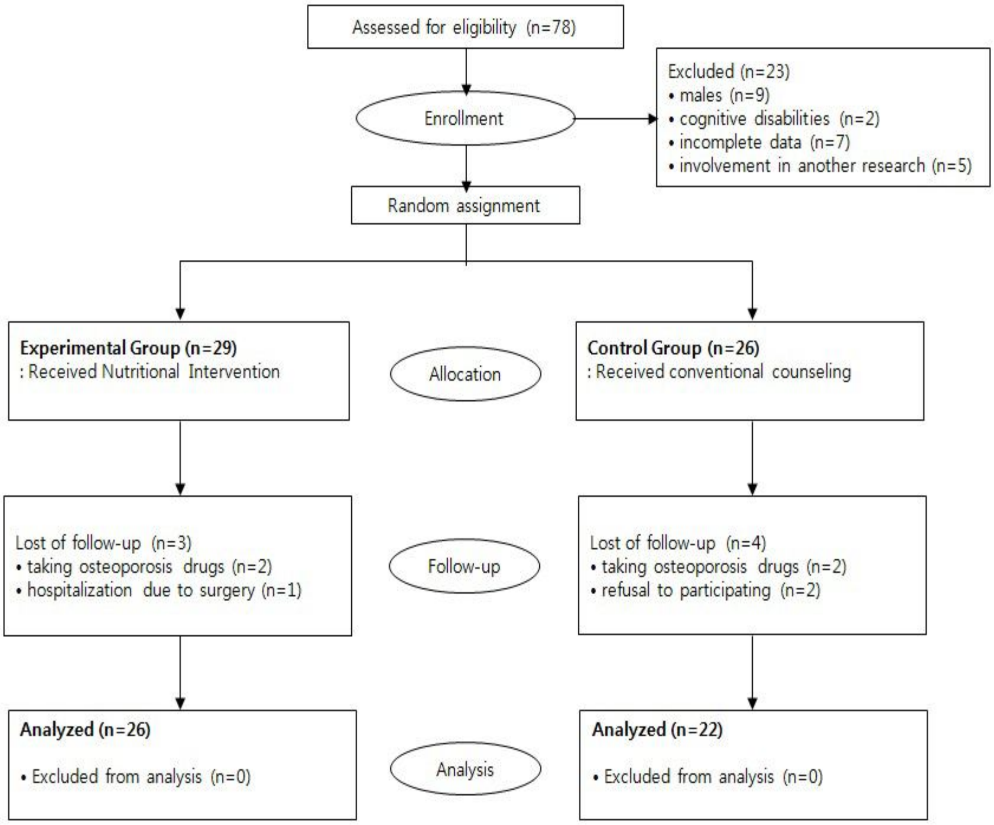

Figure 1. Flow of Participants through the Study

2.2. Study Design and Procedures

This study was conducted with a non-equivalent control group pre- and post-test and quasi-experimental research design for evaluation of the effects of Korean DASH diet education and calcium/vitamin D supplementation on self-efficacy, DASH diet knowledge and compliance, nutrient intake, bone turnover markers, and bone mineral density in elderly women.

Subjects in the experimental group (*n*=26) received Korean DASH diet education and calcium (1200mg)/vitamin D (800 IU) supplements for 12 weeks. The specific details of the intervention program are as follows:

2.2.1. Korean DASH diet Education Program

The Korean DASH diet is a modified DASH diet for Korean foods that can be consumed by elderly Korean persons while retaining DASH's original emphasis on fruits, vegetables, and low-fat milk and dairy products together with whole grains, poultry, fish, and nuts. The diet education program was developed after receiving advice from two nutrition professors and one nursing professor. Diet counseling sessions were conducted 12 times through our center visits (six times) and telephone calls (six times) over 12 weeks. Individual counseling was provided in the center every other week (Table 1), and in those weeks without our visits, telephone counseling was provided in order to encourage diet and calcium supplementation compliance. Educational materials included four-fold leaflets (eight pages) containing 'diet management using the DASH diet (outline for DASH diet), understanding of osteoporosis and osteopenia, methods to increase milk and dairy product intake, methods to increase vegetable and fruit intake, methods to decrease fat intake, calcium-rich foods, and dietary and living habits for prevention of osteoporosis'.

The Korean DASH diet education program was based on the IMB model. The aim of the program was to provide specific guidelines on food choices and preparation for better DASH diet compliance (information), to motivate diet/supplements compliance (motivation) and to teach effective skills through achievement of short-term goals one by one (behavioral skills). In addition, nutrient intake and bone turnover markers are also expected to improve (health outcomes) through change in dietary habits (behavior change).

Table 1. Contents of the Nutritional Intervention Program Used in this Study

Session	Contents of the intervention	Time	Methods
1	· Introduce the program · Educate the DASH diet and importance of taking calcium supplements · Provide calcium (1200mg/D) and Vitamin D (800 IU/D) supplements · Inform probable side effects of the supplements	20 min	·Individual counseling ·Leaflet
2	· Share individual dietary patterns, problems and changeability · Educate osteoporosis and risk of osteoporotic fractures · Pill counts · Provide additional supplements	30 min	·Individual counseling ·Leaflet ·Laboratory report ·Nutrient analysis table
3	· Educate the DASH diet(choosing food items, encouraging compliance) · Provide the DASH guidelines · Pill counts · Provide additional supplements	20 min	·Individual counseling ·Leaflet ·Food models ·Printed material
4	· Set up short-term goals · Instruct how to record a food diary · Pill counts · Provide additional supplements	15 min	·Individual counseling ·Food diary sheet ·Food models
5	· Assess compliance of the DASH diet and find out barriers · Evaluate individual nutrient status from a food diary · Pill counts · Provide additional supplements	15 min	·Individual counseling ·Food diary sheet
6	· Evaluate the achievement of individual short-term goals · Planning strategies for keeping the DASH diet · Pill counts · Provide additional supplements	15 min	·Individual counseling
Post test (after 12 weeks)			
Finishing the program	· Evaluate final results of the program · Compare the pre and post results	10 min	·Laboratory report ·Nutrient analysis table

2.2.2. Calcium/Vitamin D Supplementation

In this study, calcium/vitamin supplementation is defined as the provision of white pills containing 1200m of calcium and 800IU(20µg) of vitamin D to the participants every other week or six times over 12 weeks (Tang et al., 2007). The pills were put into seven-day pill holders for two-week use and provided to participants.

Subjects were instructed to leave the doses skipped in the holders so that compliance could be calculated {(the number provided – the number remaining)/the number provided × 100}. The compliance rate for supplements intake was 90.0% with no report of side effects.

To evaluate the effectiveness of interventions, data were collected pre and post interventions. Three graduate nursing students who had participated in nutrition studies previously conducted one-on-one interviews with the subjectsin order to assess general characteristics and dietary intake records. All participants were required to write food diary records at pre and post interventions. Dietary intake record sheets were handed out to participants one week before the first data collection. Researchers instructed participants how to complete the food records and asked them to include all the foods or snacks and beverages they consumed for the 3 days (2 weekdays and 1 weekend day). Food models and pictures of typical Korean foods were used to specify portion sizes and ways of preparation during instruction. For those who had difficulty writing food diaries, their family members who live with them were asked to write the diary. On the day for other measurements (a week after), the dietary records were collected and reviewed for accuracy and methods of food preparation were evaluated. Real-sized food models were used to help subjects recall the foods they had eaten. Research assistants were given one-hour training in advance for questionnaires and dietary records in order to ensure inter-observer consistency. Any questions raised by assistants about the questionnaires were addressed before conduct of research. Anthropometry and bone density were measured by four undergraduate nursing students who had been trained beforehand for their assigned areas. Data collection for the two cohorts was performed on the same day by research assistants who did not know which subjects belonged to which group. In order to avoid any probable impact on study results, researchers participated only in providing the intervention program, and were not directly involved in data collection.

2.3. Measurements

2.3.1. General Characteristics and Health Information

General characteristics and health information of subjects were obtained through one-on-one interviews with questionnaires.

Participants were interviewed with a questionnaire concerning age, levels of education, living alone or not, monthly expenses (allowance), self-rated economic status, regular exercise, ages at menarche and menopause, parity, history of hormonal replacement treatment, history of fracture after age 50, family history of osteoporosis, and dental problems.

2.3.2. Self-Efficacy

Self-efficacy was measured using the Self-Efficacy Scale (Kang, 1999), which was modified from the Osteoporosis Self-efficacy Scale (Kim, Horan and Gendler, 1991). This scale consists of a 5-point Likert scale,which assesses self-efficacy of exercise (six items) and diet (sixitems), with higher scores indicating higher self-efficacy(12-60 points, Cronbach's α=.90).

2.3.3. DASH Diet Knowledge and Compliance

DASH diet knowledge and compliance measurement tool (Kim et al., 2010) was used after being partly adapted and its content was reviewed for validity by an expert group (two adult nursing professors, one nutrition professor, and two nursing doctors) (CVI=.84, KR20=.70). The dietary knowledge scale is comprised of 10 questions with answers of Yes/No/Don't Know. A correct answer was scored as 1 point and incorrect or Don't Know answers 0 points. Those with higher totals are interpreted as having more knowledge (Kim et al., 2010). The tool for measurement of DASH diet compliance consists of nine questions with 5-point scales (never true/rarely true/neutral/usually true/always true). Participants with higher totals have better compliance with the diet (Kim et al., 2010). The Cronbach's α reliability coefficient of this tool was .68 when it was developed, and is .68 in this study.

2.3.4. Nutrient Intakes

Nutrient intake was measured using participants' three-day dietary records (two week days and one weekend day) using a 24-hour dietary recall method. Average daily intake was calculated using CAN-pro 3.0 (Computer Aided Nutrition Analysis Program version 3.0) (The Korean Nutrition Society, 2007).

Nutrient intake analysis was performed for basic nutrients, including calories, proteins, lipids, and carbohydrates, DASH diet recommendation, including calcium, potassium, and dietary fiber and bone mineral density-related nutrients, including vitamin C, Sodium, and phosphorus. Nutrient intake was analyzed using Estimated average intake (calories), Recommended intake (calcium, phosphorus, proteins, vitamin C), and Adequate intake (potassium, dietary fiber) (The Korean Nutrition Society, 2010). Nutrient deficiencies were defined when the subjects took in <75% of their corresponding Korean dietary reference intake. Excess sodium intake was defined as intake above Korean dietary reference intake levels.

2.3.5. Bone Turnover Markers

Bone turnover markers were analyzed from blood samples obtained after fasting for more than 8 hours (Eone Reference Laboratory).

Electro chemiluminescence Immunoassay (ELISA) was used for assessment of two kinds of bone markers, CTx (C-telopeptide of collagen cross-links) for bone resorption and osteocalcin for bone formation. Since the bone markers have circadian rhythms, blood samples were collected using the same methods at a specific time (from 8am to 11 am) in order to minimize risks for probable errors (Korean Society for Bone and Mineral Research, 2011).

2.3.6. Bone Mineral Density

Bone mineral density was assessed with ultrasound measurements using the Achilles Express Ultrasonometer (GE Lunar Healthcare Corporation, USA). The measured site was calcaneus and recorded in the stiffness index (Kim et al., 2010).The effectiveness of our program was examined by comparison of stiffness indexes taken onthe same side of calcaneus before and after intervention.

2.4. Statistical Analyses

Statistical analyses were performed using PASW Statistics 18.0. General characteristics were analyzed using frequency, percentage, average, and standard deviation. Homogeneity before interventions and variable differences after intervention between the cohorts were assessed using χ^2-test and independent t-test.

Reliability of the tools was evaluated using KR20 and Cronbach's α coefficient. Statistical significance was accepted at *p*<.05.

3. Results

3.1. Homogeneity between Two Cohorts Before Interventions

General characteristics and bone-related information for both groups are shown in Table 2;no statistically significant differences were observed before interventions (Table 2). Although not shown in the table, no significant differences in result-affecting variances, including knowledge, compliance, nutrient intakes, and bone turnover markers were observed between the two groups.

Table 2. Homogeneity of General Characteristics of the Participants (*N*=48)

Characteristics		Exp.(*n*=26) *n* (%) or mean±SD	Con.(*n*=22) *n* (%) or mean±SD	χ^2/*t*	*p*
Age (years)		73.4±4.9	70.7±5.4	1.60	.117
Height (cm)		153.0±5.7	151.3±6.2	1.17	.248
Weight (kg)		59.9±6.3	56.7±7.8	1.60	.116
Body Mass Index (kg/m²)		25.6±3.0	24.7±2.9	0.98	.332
Level of education	No education	10 (38.5)	5 (22.7)	6.25	.166*
	Elementary school or less	13 (50.0)	9 (40.9)		
	Middle school	3 (11.5)	4 (18.2)		
	High school or more	0 (0.0)	4 (18.2)		
Living alone	Yes	11 (42.3)	15 (57.7)	0.05	.827
	No	15 (57.7)	7 (42.3)		
Allowance (won/month)	<100,000	2 (7.7)	4 (18.2)	2.57	.484*
	100,000~<300,000	9 (34.6)	10 (45.5)		
	300,000~<500,000	10 (38.5)	5 (22.7)		
	≥500,000	5 (19.2)	3 (13.6)		
Self-rated economic status	Poor	9 (34.6)	10 (45.5)	1.43	.499*
	Average	15 (57.7)	9 (40.9)		
	Good	2 (7.7)	3 (13.6)		
Regular exercise	Yes	23 (88.5)	18 (81.8)	0.42	.687*
	No	3 (11.5)	4 (8.2)		
Age at menarche (years)		17.2±1.5	16.8±1.7	0.50	.618
Age at menopause (years)		49.1±5.3	47.0±7.1	1.15	.256
Parity		3.3±1.8	3.0±1.2	0.22	.826
History of HRT	Yes	1 (3.9)	4 (18.2)	2.62	.165*
	No	25 (96.1)	18 (81.8)		
History of fracture	Yes	8 (30.8)	6 (27.3)	0.07	.791
	No	18 (69.2)	16 (72.7)		
Family history of osteoporosis	Yes	5 (19.2)	6 (27.3)	0.44	.509
	No	21 (80.8)	16 (72.7)		
Dental problems	Yes	19 (73.1)	16 (72.7)	0.01	.978
	No	7 (26.9)	6 (27.3)		

Exp.=Experimental group; Con.=Control group; SD=Standard deviation

*Calculated using Fisher's exact test

3.2. Self-Efficacy,Knowledge of DASH diet, and Compliance with the Diet

Higher knowledge of the DASH diet scores (p=.002) and compliance scores (p<.002) were observedin the experimental group than in the control group after interventions (Table 3). However, no statistically significant differences in self-efficacy after interventions were observed between the two groups (p=.812) (Table 3).In further analysis, subjects with higher self-efficacy had higher DASH diet compliance (p=.006) and higher calcium supplement adherence rate (p=.015).

Table 3. Comparison of Self-Efficacy, DASH Diet Knowledge, and DASH Diet Compliance after Intervention between the Groups (*N*=48)

Variables		Exp.(*n*=26)	Con.(*n*=22)	*t*	*p*
		mean±SD	mean±SD		
Self-efficacy	Total	40.0±10.2	40.2±9.5	-0.24	.812
	- diet	19.8±5.2	18.9±4.5	0.16	.510
	- exercise	19.7±5.7	21.3±6.2	-0.94	.350
DASH diet knowledge		8.7±1.0	7.7±1.3	3.23	.002
DASH diet compliance		36.9±4.5	30.8±4.7	4.66	<.001

Exp.=Experimental group; Con.=Control group; SD=Standard deviation; DASH=Dietary Approach to Stop Hypertension

3.3. Nutrient Intakes

No statistically significant differences in nutrient intake were observed between the experimental and control groups after intervention (Table 4).

In further analysis of nutrient intake, we divided subjects in the intervention group into two sub-groups, one with higher than recommended calcium intake (normal, ≥75% of Korean dietary reference intake), and the other with lower than recommended calcium intake (deficient, <75% of Korean dietary reference intake) and compared the intake of other nutrients in the two sub-groups. In general, consumption of other nutrients was greater with statistical significance in the normal group than in the deficient group (Table 5). Subjects in the deficient group were older (p=.008) and more often lacked social support (p=.007) compared with those in the normal group (Table 5).

Table 4. Comparison of Nutrient Intake after Interventionbetween the Groups (*N*=48)

Variables	Time	Exp.(*n*=26) mean±SD (%DRIs)	Con.(*n*=22) mean±SD(%DRIs)	*t*	*p*
Calories(kcal)[a]	pre	1493.99±389.16 (93.37)	1542.44±386.13 (96.40)	-0.45	.652
	post	1455.98±392.78 (91.00)	1576.61±572.35 (98.54)	-0.84	.403
Protein (g)[b]	pre	66.09±19.75 (146.87)	59.96±18.69 (133.24)	0.98	.331
	post	60.98±19.57 (135.51)	64.04±28.25 (142.31)	-0.47	.638
Lipid (g)	pre	35.50±13.95	31.81±14.64	0.79	.435
	post	33.98±13.80	37.84±16.51	-0.84	.405
Carbohydrate (g)	pre	231.33±61.78	258.07±59.65	-1.51	.137
	post	229.18±61.79	247.35±88.01	-0.81	.425
Dietary fiber (g)[c]	pre	23.30±8.76 (116.50)	24.60±8.39 (123.00)	-0.61	.547
	post	20.88±8.51 (104.40)	21.12±8.05 (105.60)	-0.09	.932
Calcium (mg)[b]	pre	572.96±246.50 (81.85)	571.98±171.48 (81.71)	-0.05	.963
	post	567.57±226.44 (81.08)	549.01±249.82 (78.43)	0.33	.743
Phosphorus (mg)[b]	pre	1012.34±321.15 (144.62)	970.09±291.01 (138.58)	0.32	.747
	post	959.97±321.37 (137.14)	1011.02±392.56 (144.43)	-0.52	.605
Sodium (mg)[c]	pre	3723.07±1612.86 (186.15)	3529.36±1240.57 (176.47)	0.38	.704
	post	3614.96±1520.17 (180.75)	3399.86±1108.25 (169.99)	0.39	.697
Potassium (mg)[c]	pre	2729.52±1010.29 (77.99)	2804.58±982.10 (80.13)	-0.38	.707
	post	2574.07±1080.06 (73.54)	2662.49±1142.53 (76.07)	-0.14	.892
Vitamin C (mg)[b]	pre	148.35±93.97 (148.35)	153.09±96.00 (153.09)	-0.16	.875
	post	112.98±99.23 (112.98)	108.59±84.58 (108.59)	0.29	.771

Exp.=Experimental group, Con.=Control group, SD=Standard deviation, DRIs=Dietary Reference Intakes

Each nutrient was calculated by reference intake ([a] EAR, Estimated average intake, [b]RI, Recommended intake, [c]AI, Adequate intake)

Table 5. Comparison of General Characteristics, Nutrient Intake, Bone Turnover Markers, and Stiffness Index Between the Two Groups by Level of Calcium Intake in the Experimental Group (*N*=26)

Variables	Normal (*n*=14)	Deficient (*n*=12)	χ^2/t	*p*
	n (%) or mean±SD	*n* (%) or mean±SD		
Nutrient Intakes				
Calories(kcal)[a]	1714.39±246.07	1236.86±372.40	-3.910	.001
Protein (g)[b]	78.27±12.42	51.87±17.18	-4.536	<.001
Lipid (g)	44.25±9.52	25.29±11.14	-4.682	<.001
Carbohydrate (g)	255.84±51.30	202.73±62.52	-2.380	.026
Dietary fiber (g)[c]	27.51±7.37	18.39±7.84	-3.054	.005
Calcium (mg)[b]	737.91±197.28	380.52±130.68	-5.343	<.001
Phosphorus (mg)[b]	1213.54±218.21	777.60±257.88	-4.671	<.001
Sodium (mg)[c]	4570.28±1461.26	2734.66±1187.13	-3.475	.002
Potassium (mg)[c]	3209.51±961.02	2169.53±770.03	-3.009	.006
Vitamin C (mg)[b]	176.89±114.72	114.72±47.64	-1.739	.095
Bone turnover markers				
CTx	0.28±0.11	0.45±0.14	3.357	.003
Osteocalcin	13.52±3.76	18.01±6.39	2.221	.036
Stiffness Index	80.50±11.56	66.42±8.76	-3.451	.002
Social support (ESSI)	20.57±4.94	15.67±3.06	-2.980	.007

Exp.=Experimental group, Con.=Control group, SD=Standard deviation, DRIs=Dietary Reference Intakes
Each nutrient was calculated by reference intake ([a]:EAR, Estimated average intake, [b]RI, Recommended intake, [c]AI, Adequate intake)

3.4. Bone Turnover Markers and Bone Mineral Density

Significantly lower CTx levels were observed in the experimental group than in the control group after intervention (*p*=.030). No significant differences in osteocalcin and bone mineral density (represented by stiffness index) were observed between the two groups before and after intervention (Table 6).

Table 6. Comparison of Bone Turnover Markers and Bone Mineral Density after Interventionbetween the Groups(*N*=48)

Variables	Exp.(n=26)	Con.(n=22)	*t*	*p*
	mean±SD	mean±SD		
CTx (ng/ml)	0.30±0.15	0.40±0.16	-2.24	.030
Osteocalcin (ng/ml)	14.9±5.9	16.7±6.0	-1.08	.286
Stiffness index	71.0±13.3	66.6±11.4	1.22	.229

Exp.=Experimental group; Con.=Control group; SD=Standard deviation; CTx=C-telopeptide of collagen cross-links

4. Discussion

We provided Korean DASH diet education and calcium/vitamin D supplementation to elderly women enrolled in a senior welfare center for 12 weeks and investigated their effectiveness according to improved self-efficacy, DASH diet knowledge and compliance, nutrient intake, bone turnover markers, and bone mineral density.

We observed significantly higher scores in DASH diet knowledge (p=.002) and compliance in the experimental group (p<.001) than in the control group after the intervention. These results proved the effectiveness of the education program,which promoted knowledge enhancement and behavioral changes through providing detailed dietary guidelines and continuous monitoring/feedback for 12 weeks. This result supports the previous research that found the importance of detailed guidelines with knowledge delivery when nutrition education programs are designed for the elderly (Ju& So, 2008).

Self-efficacy, however, did not show significant improvement in the experimental group after the intervention, although subjects with higher self-efficacy had higher DASH diet compliance (p=.006) and higher Ca supplement adherence rate (p=.015). These unexpected findings may have been attributed to several factors. First, it may have been due to ceiling effect of self-efficacy. We found that the self-efficacy scores in our subjects were higher than those reported in previous studies (Kim & Kim, 2005; Shin, Shin, Yi, &Ju, 2005; Shin & Kang, 2002).Second, it may have been resulted from the subjects' old age.

They may have perceived that lifetime dietary behaviors might be too difficult to change, as reported in a previous study (Jung, 2008).Finally, behaviors can also be modified even without changes in self-efficacy, as reported previously (Fisher, Fisher, & Harman, 2003).

We found that intake of milk and dairy products increased after the intervention in the experimental group, supporting the positive effect of DASH diet education. We also found that subjects with high calcium intake showed high Stiffness Index (p=.002) and low osteocalcin (p=.002) and CTx levels (p=.003).

Surprisingly, however, dietary calcium intake did not increase in the experimental group, which may have been due to a decrease in dietary plant calcium intake. In further analysis, we indeed found that dietary plant calcium intake was decreased, although dietary animal calcium intake was significantly increased. The decrease in plant calciumintake may have been due to several factors. First, it may have been due to the dental problems of more than 70 % of the subjects. Actually, subjects with more tooth loss showed less compliance with the DASH diet (p=.016) and the average amount of their plant calcium intake, if not statistically significant, was lower in subjects with tooth loss than in those without tooth loss. The second reason for no increase in dietary plant calciumintake may have been due to the time of year. The research was conducted in the winter and the early spring, when food items rich in plant calcium were scarce and priced very high to afford. Indeed, the price index increased by 6.5% for fresh vegetables and 12.4% for fresh fruits throughout our study (Statistics Korea, 2012).

Considering that plant-based calcium is less absorbable than animal sources and chewing problems inhibit the elderly from consuming plant calcium, conduct of further studies will be neededin order to find ways to increase their intake of animal calcium from milk and dairy products.Moreover, since we found that level of social support, age and other nutrient intakes were directly related to calcium intake (Table 5), public attention for older people with lack of social support are needed.

Interestingly we found no statistically significant differences in bone mineral density between the two groups after interventions (p=.229). It may have been first, due to the short study period. Considering the limited time of 12 weeks for the research, this finding is not surprising (Bonnick & Shulman, 2006; Kim et al., 2001).

Secondly, it may have been due to the urinary calcium loss due to high animal protein diet in our subjects (≥60g/day on average, more than 130% of recommended for elderly women). Although we can't tell for sure this is true or not since we did not measure urinary calcium, previous studies reported that diet high in animal-based protein increases urinary calcium excretion, consequently resulting in bone loss (Melhus et al., 1998; Korean Society for Bone and Mineral Research, 2011).

On the other hand, significant changes in CTx were observed after intervention. It is assumed that CTx had increased before bone mineral density changes were actually taking place (Korean Society for Bone and Mineral Research, 2011). If this study were conducted for a longer period of time, bone mineral density improvement would have been witnessed following the bone turnover marker changes.

However, we observed no changes in osteocalcin after the intervention in the experimental group. The different effect on bone markers may be due to the different speed of changes in bone markers. A previous study reported that CTx level changes more rapidly than that of other bone markers (Kim et al., 2001). Unchanged osteocalcin levels may also have been associated with excessive sodium intake of participants (Lin et al., 2003). In a previous study, Lin et al. examined the effects of the DASH diet and sodium reduction on bone health. Serum osteocalcinwas significantly decreasedwhen sodium intake decreased to intermediate levels(2300/day, American Heart Association Guideline) together with application of the DASH diet. We did not strictly restrict sodium intake of subjects on purpose in order to promote their adherence to the assigned diet. Therefore, excess ivesodium intake was observed in 88.5% of subjects, with an average of above 3600mg, thereby possibly have affected osteocalcin levels in serum.

In conclusion, based on the results, our interventions are believed to have a positive influence on bone turnover in elderly women. This study is significant in that it showed that an IMB-based nutrition intervention program can bring about behavior changes and knowledge enhancement among participants through information deliveryand motivation, hence improvinga bone turnover marker, CTx. Nonetheless, the time was limited for full evaluation of changes in bone turnover marker levels and bone mineral density, and the sample size was small, which raises concerns of selection bias.

Moreover, because we did not study DASH diet education and calcium supplementation separately, we cannot determine the exact reason for this positive effect. However, the goal of this study was to develop a comprehensive intervention program and to confirm its effectiveness. These limitations warrant the need for conduct of extensive research over more than one year with DASH diet meals with sodium restrictions.

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