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Mi-Hyun Kim PhD, Jung Sun Lee PhD, RD & Mary Ann Johnson PhD

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Original Research

Poor Socioeconomic and Nutritional Status Are Associated with Osteoporosis in Korean Postmenopausal Women: Data from the Fourth Korea National Health and Nutrition Examination Survey (KNHANES) 2009

Mi-Hyun Kim, PhD, Jung Sun Lee, PhD, RD, Mary Ann Johnson, PhD

Department of Food and Nutrition, Korea National University of Transportation, Jeungpeyong-gun, KOREA (M.-H.K.); Department of Foods and Nutrition, University of Georgia, Athens, Georgia (J.S.L., M.A.J.)

Objective: As the population ages, osteoporosis is a growing global public health problem. This study examined potential risk factors associated with osteoporosis in a nationally representative sample of Korean postmenopausal women.

Methods: This study used data from a nationally representative sample of Korean menopausal women participating in the Korea National Health and Nutrition Examination Survey KNHANES 2009 ($n = 1467$; mean age $\pm$ SE $= 65.2 \pm 0.3$ years). Bone mineral density of total femur, femoral neck, and spine was measured by dual-energy X-ray absorptiometry. Osteoporosis was determined as t-score of -2.5 or below in at least 1 of the 3 sites. Menopausal status was confirmed by self-reports.

Results: About 41% of the study sample met the criteria for osteoporosis. Poor socioeconomic status, lower BMI, and shorter estrogen exposure duration were significantly associated with osteoporosis in the study sample. Poor dietary intake was also related to osteoporosis. In the age- and energy-adjusted logistic regression models, participants consuming less protein, vitamin B2, or vitamin C than the estimated average requirement (EAR) showed higher odds of having osteoporosis than their counterparts. Participants consuming no milk or milk products had 45% increased odds of having osteoporosis than those consuming milk or milk products.

Conclusion: The findings of this study suggest several risk factors associated with osteoporosis, which can be addressed in the development and implementation of tailored nutritional interventions to promote the bone health of Korean postmenopausal women.

INTRODUCTION

Osteoporosis is a significant public health problem in South Korea. According to the bone mineral density (BMD) data collected in the Fourth Korea National Health and Nutrition Examination Survey (KNHANES) 2009, about 39% and 8% of South Korean women and men aged 50 and over had osteoporosis, respectively [1]. These rates are almost four times higher than those in the U.S. population, at about 10% and 2%, respectively [2]. Also, the number of osteoporosis-related fractures significantly increased during the period of 2005–2008 in South Korea [3]. The residual lifetime probability of osteoporosis-related fractures at the age of 50 was 59.5% for women and 23.8% for men in South Korea in 2008 [3]. Given the rapidly growing older population, insufficient calcium intake, reduced physical activity, and increased sedentary behaviors in South Korea [1,4], it is projected that osteoporosis may become more prevalent in the near future.

Several small studies have reported the characteristics of Korean women with osteoporosis [4,5]. However, very little has been reported about the characteristics of Korean women with osteoporosis using nationally representative data such as the KNHANES, which started assessing BMD in mid-2008 (KNHANES IV-2) [6]. One study using the KNHANES 2008–2009 reported that osteoporosis is highly prevalent (39.1%) in Korean premenopausal women, but is underdiagnosed (62.5%) and undertreated (76.5%) [7].

Address correspondence to: Mi-Hyun Kim, PhD, Food and Nutrition, Korea National University of Transportation, 61 Daehak-ro, Jeungpyeong-gun, 368-701, Republic of Korea. E-mail: mhkim1129@ut.ac.kr

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Osteoporosis was more prevalent among Korean women who were older and physically inactive and had lower body weight, poor calcium intake, and low educational levels; however, the awareness and treatment of osteoporosis in these women were similar to or lower than in women without osteoporosis [7].

A better understanding of the risk factors of osteoporosis in South Korean women is critical to developing effective interventions with the goal of promoting bone health and prevention of osteoporosis. The purpose of this study was to examine the risk factors associated with osteoporosis in a nationally representative sample of Korean postmenopausal women using the KNHANES 2009. The particular focus of this study was to explore various risk factors of osteoporosis identified in previous research, mostly conducted in Western countries, including poor dietary intake of key nutrients (e.g., calcium, vitamin D, protein, phosphorus, sodium, and vitamin K) [8,9], low physical activity [4,10], low body weight [4,5,10,11], insufficient estrogen exposure time in a woman's life (e.g., later menarche, early menopause, and no history of estrogen replacement therapy) [4,12], and poor lifestyle characteristics (e.g., smoking) [10].

METHODS

The data used for this study were from the KNHANES 2009. The KNHANES was designed to obtain nationally representative information on nutritional and health status in the South Korean population (aged $\geq$1 year), and was conducted by the Korea Centers for Disease and Control (KCDC) [6]. The study protocol of KNHANES was approved by the KCDC Institutional Review Board. The KNHANES 2009 is composed of three parts: Health Interview survey, Health Examination survey, and Nutrition survey. Both the Nutrition survey and the Health Interview survey were conducted by trained interviewers [6]. The Health Interview survey collected self-reported data on sociodemographic information; disease; health behaviors including smoking and drinking status; and the level, duration, and weekly frequency of physical activity. The Health Examination survey assessed anthropometry, blood and urine tests, and various health check-ups as well as measuring BMD [6]. The KNHANES 2009 data were collected from January to December 2009 [6]. A total of 10,533 people (4843 men and 5690 women) participated in the KNHANES 2009 [6].

Menopausal Status

Menopausal status was determined based on the responses to the question, "Are you currently postmenopausal?" If a participant reported, "yes," she was considered postmenopausal. Postmenopausal status was defined as not having had a period for 12 consecutive months.

Osteoporosis

Osteoporosis was determined based on the BMD measurement of the total femur, femoral neck, and spine with dual-energy X-ray absorptiometry (DEXA; Hologic Discovery, Hologic, Marlborough, MA, USA). Using the World Health Organization definition, osteoporosis was defined as a t-score of -2.5 or below in at least 1 of the 3 sites [13]. Asian standard data were used as a reference [13]. Participants were divided into two groups: osteoporosis and nonosteoporosis (*t*-score is greater than 2.5 for all 3 sites).

Potential Risk Factors

Potential risk factors were selected based on the risk factors shown to be associated with osteoporosis in previous research, including those based on the KNHANES data [4,5,7–12]. Five major domains of risk factors were considered, including anthropometry, sociodemographic characteristics, lifestyle characteristics, health status, and dietary intake. Weight was measured to the nearest 0.1 kg unit using a Seca 225 (Seca, German) and height was measured to the nearest 0.1 cm unit using a GL-6000-20 stadiometer (G-tech, Gyeonggido, Korea) following standard protocols [6]. Body mass index (BMI) was calculated as body weight (kilograms) divided by height (meters squared) and was categorized as underweight ($<$18.5), normal (18.5 to 24.9), or overweight (over 25) [14]. Sociodemographic characteristics included age (50–59, 60-69, or $\geq$70), residence area (rural vs urban), household income (low, medium-low, medium-high, or high based on quartiles of reported household income), and educational level (elementary school graduate or lower, middle school graduate, high school graduate, or university graduate or higher). Lifestyle characteristics included smoking status (current smoker, former smoker, or never smoker), drinking status (consumed alcohol during lifetime vs never consumed alcohol during lifetime), practicing moderate-level physical activity at least 30 minutes 5 times per week, use of vitamin or mineral supplements and functional food, and using nutrition facts label information. We used the raw data from KNHANES to determine the practice of moderate-level physical activity, which was formulated by using 2 serial questions on the duration and frequency of activity.

Health status data included self-reported information on health status (i.e., good, fair, or poor), chewing (i.e., not uncomfortable, moderate, or uncomfortable), bone-related diseases (i.e., osteoarthritis, rheumatoid arthritis, or back pain), and age of menarche and menopause. The age of menarche (i.e., $<$14, 14–15, 16–17, or $\geq$18) and menopause (i.e., $<$45, 45–49, 50–54, or $\geq$55) was categorized into 1 of 4 categories based on their means (15.8 ± 0.1 and 49.2 ± 0.1, respectively) and distributions. Presence of selected diseases, including diabetes, hypercholesterolemia, hypertriglyceridemia, and anemia, was determined based on blood test results from the

Health Examination. Diabetes was defined as having a fasting blood glucose level of 126 mg/dl and over, or having a clinical diagnosis or taking medicine for blood glucose control. Hypercholesterolemia was defined as total blood cholesterol of 240 mg/dL and over after an 8-hour fast or taking medicine for reducing blood cholesterol [6]. Hypertriglyceridemia was defined as blood triglycerides 200 mg/dL and over after a 12-hour fast [6].

Dietary intake was assessed by using a single-day 24-hour dietary recall conducted by trained dietitians. To reduce recall errors and to help participants report the volume and dimensions of the food items consumed, various procedures were used, including the multipass method, food models, and a two-dimensional model of actual-size traditional bowels/pots and food shapes [6]. Nutrient intake was calculated by using Korean Food Composition data [15]. Nutrient intake status was evaluated by Dietary Reference Intakes for Koreans 2010 [16]. To evaluate the adequacy of nutrient intake of the participants, we determined whether a participant consumed less than the estimated energy requirement (EER) for energy and estimated average requirement (EAR) for the selected nutrients (protein, vitamin A, vitamin B_1, vitamin B_2, niacin, vitamin C, calcium, phosphorus and iron) [16]. We also determined whether participants consumed any of the five selected food groups (pulses, fruits, meats/meat products, fish/shellfish, and milk/milk products). These five food groups are major food sources providing key nutrients for bone health (e.g., protein, calcium, vitamin B_2, and vitamin C), as reported in the literature [15,17].

Analytic Study Sample

For the purpose of this study, the analytic study sample included Korean postmenopausal women aged 50 years and older. Among the 5690 women, 2073 women were aged 50 years and over and 1655 women had experienced menopause naturally. Among these postmenopausal women, we excluded 187 women (14.5%) with missing data on these study variables: BMI, BMD, history of estrogen replacement therapy, smoking and drinking status, and dietary intake. The final analytic sample was 1467 Korean postmenopausal women aged 50 years and older. Of note, there were significant differences between the women who were included and excluded in the analytic sample for age, but not for weight status. Women who were excluded from the study were more likely to be older.

Statistical Analysis

To describe the characteristics of the study sample by osteoporosis, descriptive statistics were calculated, including frequency, proportion, and standard error. X^2 tests were used to compare the potential risk factors between Korean postmenopausal women with and without osteoporosis. Logistic regression models were used to examine the association between potential risk factors and osteoporosis. As age is significantly associated with osteoporosis, as well as other potential risk factors, age-adjusted logistic regression analyses were conducted. Finally, the multivariate logistic regression model was developed while adjusting for age as well as other significant risk factors (i.e., BMI, history of estrogen replacement therapy, drinking alcohol and smoking status). For the logistic regression models to examine the relationship between risk factors related to dietary intake and osteoporosis, total energy intake was also adjusted as it related to other nutrient intakes. All analyses accounted for the complex survey design that consisted of multistage, stratified, and clustered sampling. All statistical analyses were performed using survey procedures of SAS software (version 9.2, SAS Institute, Cary, NC) and the level of significance was set at $p < 0.05$.

RESULTS

Korean postmenopausal women with osteoporosis tended to be older and were more likely to have poor socioeconomic status, poor health and dental status, and shorter duration of estrogen exposure (i.e., later menarche, early menopause, and no history of estrogen replacement therapy). They were also less likely to report using vitamin or mineral supplements and they report less desirable lifestyles (e.g., smoking, drinking alcohol, not practicing a moderate level of physical activity, and not checking nutrition facts labels when shopping for foods) than those without osteoporosis (Table 1). The Korean menopausal women with osteoporosis also had other selected health conditions, including diabetes (18.1%), hypercholesterolemia (19.4%), hypertriglyceridemia (18.9%), and anemia (16.1%). Based on the age-adjusted logistic regression models, BMI, menopause age, smoking and drinking status, and history of estrogen replacement therapy were significantly related with having osteoporosis in Korean postmenopausal women (Table 1). When these significant risk factors were considered in the multivariate logistic regression model, lower BMI, no history of estrogen replacement therapy, consuming alcohol during lifetime, and being a former smoker were still significantly associated with having osteoporosis (Table 2). For example, underweight participants (BMI < 18.5) showed 12.79 times increased odds of having osteoporosis compared with normal-weight participants (95% CI 3.43–47.77). The history of estrogen replacement therapy reduced the odds of having osteoporosis to 0.4 (95% CI 0.24–0.66). Participants having experience of drinking alcohol and smoking had 1.66 times (CI 1.22–2.26) and 2.55 times (CI 1.17–5.54) increased odds of having osteoporosis than the referents, respectively.

In terms of dietary risk factors (Table 3), the participants with osteoporosis were less likely to consume selected nutrients than EER (for energy) or EAR (for the other nutrients) compared to those without osteoporosis. Similarly,

Table 1. Sociodemographic, Lifestyle, and Health Characteristics of Korean Postmenopausal Women

	Non-osteoporosis			Osteoporosis				Age-Adjusted	95% Confidence
	n	Weighted %[b]	± SE	*n*	Weighted %	± SE	*p* value[c]	Odds Ratio	Interval
Total ($n = 1467$)[d]	841	58.74	± 1.48	626	41.26	± 1.48			
Sociodemographic characteristics									
Age ($n = 1467$)[e]									
50–59	364	43.53	± 2.14	62	9.64	± 1.23	$p < 0.001$		
60–69	317	38.76	± 1.97	221	36.86	± 2.09			
70+	160	17.70	± 1.34	343	53.50	± 2.17			
Household income ($n = 1449$)									
High	168	20.46	± 1.82	64	11.50	± 1.82	$p < 0.001$	Referent	
Medium-high	167	20.72	± 1.61	88	14.96	± 1.60		1.12	0.66–1.88
Medium-low	213	25.46	± 1.63	146	23.26	± 1.80		1.18	0.74–1.87
Low	282	33.35	± 1.92	321	50.27	± 2.58		1.11	0.71–1.73
Education level ($n = 1461$)									
College or over	55	6.97	± 1.16	15	2.89	± 0.80	$p < 0.001$	Referent	
High school	130	14.77	± 1.42	38	6.89	± 1.16		1.05	0.43–2.54
Middle school	140	16.86	± 1.40	41	0.57	± 7.88		1.17	0.49–2.81
Elementary or under	514	59.40	± 2.11	528	82.34	± 1.99		1.66	0.76–3.64
Residing area ($n = 1467$)									
Urban	562	73.17	± 3.44	350	63.82	± 4.05	$p < 0.01$	Referent	
Rural	279	26.83	± 3.44	276	36.18	± 4.05		1.11	0.85–1.45
Health characteristics									
BMI[f] ($n = 1467$)									
<18.5	5	0.44	± 0.22	32	4.60	± 0.99	$p < 0.001$	8.59[g]	2.88–25.61
18.5–24.9	462	57.53	± 2.26	416	65.10	± 2.26		Referent	
≥25	374	42.03	± 2.23	178	30.29	± 2.22		0.72[g]	0.55–0.94
Age at menarche($n = 1415$)									
<14	117	16.07	± 1.43	52	9.44	± 1.44	$p < 0.001$	Referent	
14–15	261	34.23	± 2.13	150	25.76	± 2.00		0.98	0.60–1.58
16–17	310	34.99	± 1.88	243	40.92	± 2.52		1.28	0.79–2.08
≥18	128	14.71	± 1.56	154	23.88	± 2.04		1.60	0.94–2.74
Age at menopause ($n = 1376$)									
<45	87	10.17	± 1.18	118	20.66	± 1.88	$p < 0.001$	Referent	
45–49	273	32.71	± 2.03	223	38.99	± 2.46		0.95	0.64–1.40
50–54	370	48.35	± 1.90	184	33.31	± 2.33		0.56[g]	0.38–0.83
≥55	80	8.77	± 1.19	41	7.04	± 1.25		0.58[g]	0.34–0.97
Self-reported health status ($n = 1463$)									
Good	257	30.94	± 1.96	187	30.76	± 2.12	$pp < 0.01$	Referent	
Fair	267	33.41	± 2.26	142	24.49	± 2.22		0.87	0.60–1.26
Poor	316	35.65	± 1.99	294	44.75	± 2.31		1.11	0.79–1.55
Chewing problem ($n = 1467$)									
Not uncomfortable	305	36.98	± 2.15	188	32.40	± 2.45	$p < 0.001$	Referent	
Normal	138	17.37	± 1.42	63	8.56	± 1.10		0.65	0.41–1.02
Uncomfortable	305	36.98	± 2.15	188	32.40	± 2.45		1.04	0.76–1.44
Disease presence by health checkup									
Diabetes ($n = 1122$)	131	15.97	± 1.59	95	18.10	± 2.13	NS	0.80	0.54–1.19
Hypercholsetrolemia ($n = 1353$)	194	24.21	± 1.68	108	19.38	± 2.11	NS	0.84	0.59–1.20
Hypertiglyceridemia ($n = 1152$)	103	15.26	± 1.75	94	18.94	± 2.03	NS	1.42	0.95–2.11
Anemia ($n = 1365$)	80	10.04	± 1.26	96	16.14	± 1.92	$p < 0.01$	1.05	0.71–1.56
Experience of other bone disease									
Osteoarthritis ($n = 1467$)	327	36.07	± 1.92	252	39.48	± 2.35	NS	0.79	0.59–1.06
Rheumatoid arthritis ($n = 1467$)	56	6.54	± 0.99	41	6.32	± 1.04	NS	0.87	0.52–1.45
Back pain ($n = 1467$)	435	48.43	± 2.22	367	55.55	± 2.33	$p < 0.05$	0.92	0.70–1.23
Experience of estrogen therapy ($n = 1467$)	164	19.07	± 1.75	36	6.50	± 1.28	$p < 0.001$	0.43[g]	0.26–0.69
Lifestyles									
Experience of drinking alcohol in their life ($n = 1467$)	279	31.23	± 1.64	313	48.85	± 2.33	$p < 0.001$	1.65[g]	1.23–2.20

(*continued on next page*)

Table 1. Sociodemographic, Lifestyle, and Health Characteristics of Korean Postmenopausal Women *(Continued)*

	Non-osteoporosis			Osteoporosis					95%
								Age-Adjusted	Confidence
	n	Weighted %[b]	± SE	*n*	Weighted %	± SE	*p* value[c]	Odds Ratio	Interval
Smoking status ($n = 1467$)									
Nonsmoker	787	92.77	± 1.10	552	86.83	± 1.42	$p < 0.001$	Referent	
Current smoker	31	4.45	± 0.95	33	4.79	± 0.93		2.21[g]	1.07–4.59
Former smoker	23	2.78	± 0.66	41	8.38	± 1.31		0.98	0.52–1.84
Practice of moderate activity ($n = 1466$)	114	15.10	± 1.46	51	8.32	± 1.38	$p < 0.001$	0.74	0.46–1.21
Taking vitamin or minerals ($n = 1434$)	204	25.54	± 1.84	111	19.13	± 1.94	$p < 0.01$	0.79	0.56–1.12
Practice of checking nutrition facts ($n = 1467$)									
Yes	100	13.15	± 1.52	29	6.68	± 1.31	$p < 0.001$	Referent	
No	414	51.90	± 2.30	154	25.42	± 2.43		0.64	0.36–1.14
I don't know what the nutrition facts are	327	34.95	± 2.19	443	67.90	± 2.83		1.10	0.61–1.98
Experience of nutrition education ($n = 1459$)	78	8.75	± 1.07	35	6.64	± 1.33	NS	0.81	0.45–1.47

[a]Osteoporosis was determined based on bone mineral density data at three sites using the World Health Initiative (WHI) guidelines (*t*-score<-2.5).
[b]Because of rounding, weighted percentage may not add up to 100%.
[c]χ^2 tests were used to examine differences between participants with and without osteoporosis.
[d]Unweighted sample size.
[e]Different sample sizes used for analysis due to missing values.
[f]Measured weight and height were used to calculate body mass index.
[g]Significant difference between those with and without osteoporosis, $p < 0.05$.

they were less likely to consume any amount of pulse, fruits, meats or meat products, fish or shellfish, and milk or milk products than those without osteoporosis (Table 3). These significant relationships between the selected nutrient and food group intakes and osteoporosis remained even after controlling for age and energy intake in the multivariate logistic regression models. The Korean postmenopausal women consuming less than the EAR for protein, vitamin B_2, and vitamin C showed 1.49 times (95% CI 1.06–2.11), 1.57 times (95% CI 1.09–2.26), and 1.49 times (95% CI 1.10–2.03) increased odds of having osteoporosis than those who consumed equal or greater than the EAR, respectively. Among the selected food groups, no consumption of milk or milk products was the only significant risk factor of osteoporosis.

DISCUSSION

About 41% of the study sample met the criteria for osteoporosis, which was higher than that reported in the nationally representative sample of Korean women, including those who were premenopausal and had surgical menopause or

Table 2. Association Between Potential Risk Factors and Osteoporosis[a] in Korean Postmenopausal Women

	Adjusted Odds Ratio[b] ($n = 1467$)[e]	95% Confidence Interval
BMI[d]		
<18.5	12.79[e]	3.43–47.77
18.58–24.9 (Referent)	Referent	
≥25	0.53[e]	0.40–0.72
History of estrogen replacement therapy	0.40[e]	0.24–0.66
Yes		
No	Referent	
Consumed alcohol during lifetime	1.66[e]	1.22–2.26
Yes		
No	Referent	
Smoking status		
Never smoker (Referent)	Referent	
Former smoker	2.55[e]	1.17–5.54
Current smoker	1.10	0.55–2.16

[a]Osteoporosis was determined based on bone mineral density data at three sites using the Women's Health Initiative (WHI) guidelines (*t*-score < -2.5).
[b]The multivariate logistic model was adjusted for age and other significant risk factors (i.e., BMI, experience of estrogen therapy, drinking and smoking status).
[c]Unweighted sample size.
[d]Measured weight and height were used to calculate BMI.
[e]Significant difference between those with and without osteoporosis, $p < 0.05$.

Table 3. Association Between Dietary Intake and Osteoporosis[a] in Korean Postmenopausal Women

	Nonosteoporosis				Osteoporosis						
	n	Weighted %[b]	±	SE	*n*	Weighted %	±	SE	*p* value[c]	Adjusted[d] Odds Ratio	95% Confidence Interval
Consumption < EER or EAR[ef] (n = 1467)[g]											
Energy[h]	297	37.05	±	2.14	266	43.86	±	2.36	$p<0.05$	1.08	0.73–1.59
Protein	211	25.48	±	1.93	266	41.20	±	2.65	$p<0.001$	1.49[h]	1.06–2.11
Vitamin A	366	43.56	±	1.98	366	57.99	±	2.54	$p<0.001$	1.28	0.96–1.72
Vitamin B_1	453	54.23	±	2.31	415	65.70	±	2.11	$p<0.001$	1.07	0.76–1.51
Vitamin B_2	553	64.19	±	1.90	497	78.44	±	1.94	$p<0.001$	1.57[h]	1.09–2.26
Niacin	423	50.10	±	2.21	413	64.79	±	2.57	$p<0.001$	1.21	0.86–1.72
Vitamin C	405	47.25	±	2.15	406	64.60	±	2.24	$p<0.001$	1.49[h]	1.10–2.03
Calcium	670	78.47	±	1.54	543	85.95	±	1.64	$p<0.01$	1.39	0.94–2.07
Phosphorus	129	13.71	±	1.29	171	27.45	±	2.21	$p<0.001$	1.39	0.94–2.07
Iron	155	17.44	±	1.58	193	28.79	±	2.32	$p<0.001$	1.31	0.90–1.92
No consumption[i] ($n = 1467$)[g]											
Pulse	236	26.98	±	1.83	228	34.10	±	2.31	$p<0.05$	1.31	0.98–1.76
Fruits	321	36.76	±	2.22	317	47.36	±	2.7	$p<0.001$	1.08	0.81–1.45
Meats and meat products	431	50.10	±	2.14	379	58.19	±	2.39	$p<0.01$	0.99	0.74–1.31
Fish and shellfishes	179	20.44	±	1.93	194	29.52	±	2.19	$p<0.001$	1.34	0.97–1.87
Milk and milk products	636	74.31	±	1.78	529	83.40	±	1.60	$p<0.001$	1.45[h]	1.02–2.07

[a]Osteoporosis was determined based on BMD data at three sites using the Women's Health Initiative (WHI) guidelines (t-score < -2.5).

[b]Because of rounding, weighted percentage may not add up to 100%.

[c]χ^2 tests were used to examine differences between participants with and without osteoporosis.

[d]Multivariate logistic models were used while adjusting for age and energy intake.

[e]EAR from Dietary Reference Intakes for Koreans 2010.

[f]Referents are participants who consumed each nutrient equal to and greater than EER (for energy) or EAR (for the other nutrients).

[g]Unweighted sample size.

[h]Significant difference between those with and without osteoporosis, $p < 0.05$.

[i]Referents are participants who consumed any amount of each food group.

hysterectomy (39%) [1]. The findings of this study suggest several implications for future research and interventions to promote bone health in Korean postmenopausal women. Inadequate nutrient intake is one of the most important modifiable risk factors of osteoporosis. Insufficient calcium intake has long been one of the significant nutritional issues of Korean people. Calcium-rich food sources are mostly limited to milk or milk products and small boney fish in the Korean diet, and traditionally the consumption of milk or milk products by Koreans has been much lower than that in Western countries [18]. In this study, 86% of the participants with osteoporosis consumed calcium less than the EAR (590 mg for Korean women aged 50–64, 570 mg for Korean women over 65), and more than 80% reported not consuming milk or milk products. These results are similar to those based on local [18] or recent KNHANES data [1].

In addition, Korean postmenopausal women with osteoporosis tend to have inadequate intake of other key nutrients essential for bone health including energy, protein, vitamin A, vitamin B_1, vitamin B_2, niacin, vitamin C, phosphorus, and iron. Previous studies have shown positive or negative effects of dietary protein on bone health [8,20,21]. According to Zhong et al., total calcium intake alone was not associated with risk of fracture among postmenopausal women ≥50 years old, and adequate total calcium intake in the presence of inadequate dietary protein intake may not be protective against fracture [21]. Adequate intake of both calcium and protein intake should be emphasized for postmenopausal women in Korea.

The Korean women with osteoporosis were more likely to reside in rural areas and to have a lower household income and educational level. The regional differences in BMD or hip fracture rate were not consistent among previous studies. Higher BMD or lower hip fracture rate was found in rural areas compared with urban areas of Western countries [22–24]. However, a study in northern Iran showed a significantly higher prevalence of osteoporosis among women living in rural areas than women in urban areas [25]. In China, however, the prevalence of osteoporosis did not show the rural–urban differences [26]. It was suspected that the rural residents were more likely to participate in outdoor activities and thus to have more exposure to sunshine (promotes vitamin D synthesis), while they had poorer economic conditions and less consumption of dairy products or other calcium-rich foods.

Since the inclusion of BMD assessment using DEXA in the KNHANES in 2009, there has been increased interest in and awareness of osteoporosis in South Korea. However, currently available nutrition interventions are mostly confined to a one-time nutrition education and distribution of calcium supplements. Given the high prevalence of osteoporosis among

Korean postmenopausal women, especially with poor socioeconomic and nutritional status, it is critical to develop well-designed sustainable nutrition interventions to improve the bone health of Korean women at high risk of osteoporosis. When developing a nutrition intervention program tailored to Korean postmenopausal women to improve bone health, it is necessary to consider the following. Lower economic status of Korean postmenopausal women with osteoporosis may lead to insufficient dietary intake and supplement use, which are essential for healthy bones [27]. In particular, Korean postmenopausal women residing in rural areas with poorer socioeconomic conditions need special attention. The interventions need to address the sources of key nutrients for bone health and the ability to afford them in a target population, then provide practical guidance on how to achieve adequate intake of important nutrients through both dietary intake and the use of dietary supplements including calcium and vitamin D, which may positively influence BMD in postmenopausal women [9,10,28].

Some of the risk factors identified in this study can be used to screen for those at high risk of poor nutritional status and osteoporosis and in need of appropriate nutrition interventions. For example, those in the osteoporosis group were more likely to report chewing problems than their counterparts, suggesting that poor dental status may lead to limited type and amount of food consumption [29,30]. A tailored nutrition intervention could provide information on preparation methods to modify the food consistency to make some food easier to consume, and on the type and form of high-nutrient-density foods and dietary supplements essential for improving bone health.

Our study is not without limitations. First, the cross-sectional nature of this study does not allow us to determine causal relationships between various risk factors and osteoporosis. Second, dietary intake data estimated based on a single-day 24-hour recall may not capture long-term intake patterns. Lastly, this study examined previously identified risk factors available in the dataset and, therefore, was limited to include some important factors such as vitamin D intake and dietary supplements that were not assessed originally in KNHANES 2009. However, to our knowledge, this is the first study to explore various risk factors reflecting different lifestyles, health status, and dietary/nutrient intake of Korean postmenopausal women using nationally representative data. The findings and lessons learned from this study can shed light on how previously identified risk factors for osteoporosis studies mostly conducted in Western countries may play a role in the development of osteoporosis among postmenopausal women in Eastern/Asian countries who tend to consume more cereals but less meat and dairy products than those in Western countries. Such understanding is critical to identify targeted strategies to promote bone health among postmenopausal women in Eastern/Asian counties.

CONCLUSION

Osteoporosis is highly prevalent in Korean postmenopausal women, especially among those with poorer socioeconomic status living in rural areas. Risk factors associated with osteoporosis in Korean postmenopausal women include lower BMI, no history of estrogen replacement therapy, drinking alcohol, smoking, nonconsumption of milk or milk products, and inadequate intake of calcium, protein, vitamin B_2, and vitamin C. These findings may serve as a foundation for planning and implementing nutritional intervention programs for the prevention and management of osteoporosis among Korean postmenopausal women.

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