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Discordance in Secular Trends of Bone Mineral Density Measurements in Different Ages of Postmenopausal Women

Kwang Yoon Kim ,^{1*} Jaesun Park ,¹ Sungwon Yang ,¹ Junghwa Shin ,^{1†}
Ji Hyun Park ,² Bumhee Park ,^{2,3} and Bom Taeck Kim ¹

¹Department of Family Practice and Community Health, Ajou University School of Medicine, Suwon, Korea

²Office of Biostatistics, Medical Research Collaborating Center, Ajou Research Institute for Innovative Medicine, Ajou University Hospital, Suwon, Korea

³Department of Biomedical Informatics, Ajou University School of Medicine, Suwon, Korea



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Address for Correspondence:

Bom Taeck Kim, MD, PhD

Department of Family Practice and
Community Health, Ajou University School of
Medicine, 164 World cup-ro, Yeongtong-gu,
Suwon 16499, Republic of Korea.
Email: lovesong@ajou.ac.kr

*Current affiliation: Department of Family
Medicine & Health Promotion Center,
Myeongju Hospital, Yongin, Korea

†Current affiliation: Department of family
medicine, Korea University Ansan Hospital,
Ansan, Korea

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ORCID iDs

Kwang Yoon Kim
<https://orcid.org/0000-0001-9844-9540>

Jaesun Park
<https://orcid.org/0000-0003-1536-0271>

Sungwon Yang
<https://orcid.org/0000-0003-3296-9783>

<https://jkms.org>

ABSTRACT

Background: Age-adjusted bone mineral density (BMD) in postmenopausal women decreases in developed countries whereas incidence of osteoporotic fracture decreases or remains stable. We investigated secular trends of bone density from 2008 to 2017 among different age groups of postmenopausal women.

Methods: We analyzed BMD data obtained from health check-ups of 4,905 postmenopausal women during three survey cycles from 2008 to 2017. We divided them into 3 groups by age (50–59 years, 60–69 years, and 70 years or more) and observed the transition of lumbar and femoral BMD in each group, before and after adjusting for variables that may affect BMD.

Results: Age-adjusted BMD, bone mineral content (BMC), and T-score demonstrated a declining trend over the survey period at lumbar spine (–2.8%), femur neck (–3.5%) and total femur (–4.3%), respectively. In the analysis for the age groups, the BMD, BMC, and T-score presented linear declining trend (–6.1%) in younger postmenopausal women while women aged over 70 or more showed linear increasing trends (+6.3%) at lumbar spine during the survey period. Femoral neck and total femur BMD demonstrated a declining linear trend only in the 50–59 and 60–69 years groups (–5.5%, –5.2%, respectively), but not in the 70 years or more group.

Conclusion: BMD in younger postmenopausal women has decreased considerably but has increased or plateaued in elderly women. This discordance of BMD trends among different age groups may contribute to decreased incidence of osteoporotic fracture despite a recent declining BMD trend in postmenopausal women.

Keywords: BMD; Fracture Risk; Secular Trend; Postmenopausal Osteoporosis

INTRODUCTION

Osteoporosis is a systemic skeletal disorder characterized by decreased bone mineral density (BMD), compromised bone strength, and increased vulnerability to fragility fractures.¹ In general, BMD consistently shows an inverse relationship with osteoporotic fracture risk.^{2,3}

Junghwa Shin 

<https://orcid.org/0000-0002-4151-8952>

Ji Hyun Park 

<https://orcid.org/0000-0003-4182-7170>

Bumhee Park 

<https://orcid.org/0000-0002-5271-1571>

Bom Taek Kim 

<https://orcid.org/0000-0002-0395-0410>

Disclosure

The authors have no potential conflicts of interest to disclose.

Data Availability Statement

The data that support the findings of this study are not publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author on reasonable request.

Author Contributions

Conceptualization: Kim KY, Yang S, Kim BT. Data curation: Kim KY, Park J. Formal analysis: Park JH, Park B. Investigation: Shin J. Methodology: Kim KY, Park J, Kim BT. Project administration: Kim KY, Kim BT. Supervision: Kim BT. Validation: Kim BT. Writing - original draft: Kim KY, Park J, Kim BT. Writing - review & editing: Kim KY, Kim BT.

The word secular is a descriptive word used to indicate certain activities that develop over the long period and remain consistent over time. Therefore, the secular trends are those the researchers expect to remain altering in the same direction over the long term.

Investigating the secular trend of BMD is important to predict the future trend of osteoporotic fractures. However, prior studies were mainly preceded to clarify the trend of osteoporotic fracture rather than the trend of BMD. These series of studies conducted in many countries including the United States, Canada, Australia, Italy, and Denmark,⁴⁻⁹ revealed a decreasing or remaining osteoporotic fracture trend in recent years. Therefore, many researchers anticipated that the trend of BMD would demonstrate an improving trend. However, a study analyzing the National Health and Nutrition Examination Survey (NHANES) data raised an interesting question with the report of a declining secular trend of BMD at the femur in postmenopausal women¹⁰ despite published evidence that age-adjusted incidence of osteoporotic fracture decreases or remains stable lately in developed countries. It is not clear whether a decrease in age-adjusted BMD is an actual occurrence, and if it is, how this trend will affect the rate of osteoporotic fracture in the future. We investigated the trend of lumbar and femoral BMD in postmenopausal women from 2008 to 2017 to predict the trajectory of osteoporotic fractures in the future. Additionally, we explored the contributors for the discrepancy between the trend of BMD and the trend of osteoporotic fracture by investigating them in different age groups during the survey period.

METHODS

Study participants

The present study analyzed the BMD data of 5,628 postmenopausal subjects aged 50 years and older, who had health check-ups in three survey cycles 2008–2009, 2012–2013, and 2016–2017 in Ajou University Hospital, Suwon, South Korea. The exclusion criteria were: subjects diagnosed with osteoporotic fractures; with renal diseases or estimated glomerular filtration rate < 60 mL/min/1.73 m²; with impaired liver function defined as a serum alanine transaminase (ALT) or serum alanine aminotransferase level three times the upper limit of the normal range or more; presence of hepatitis or cirrhosis; with endocrine disease such as hyperthyroidism and hypothyroidism; history of gastric resection; subjects receiving chemotherapy for cancer treatment; conditions associated with the malabsorption of nutrients such as inflammatory bowel disease; subjects on medications that could affect bone mineral metabolism, such as anticonvulsants, thiazides, diuretics, selective serotonin reuptake inhibitor, proton pump inhibitors, oral steroids, and anti-osteoporotic medicines; and subjects with missing BMD values (**Fig. 1**). Consequently, 4,905 postmenopausal women were included in this study.

Study procedures

Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared. Height and weight were measured with the Inbody[®] scale (BSM-330; Biospace[®], Seoul, Korea). Laboratory tests such as serum creatinine, ALT, aspartate transaminase (AST), and fasting blood glucose were performed on the blood sample. Cigarette smoking habits and calcium supplementation were assessed with a survey questionnaire. BMD, bone mineral content (BMC), and T-score at the lumbar spine and proximal femur were measured by DXA scan (Lunar iDXA; General Electric[®], Boston, MA, USA) performed in standard mode. Spine and hip scans were analyzed using enCORE (2007,

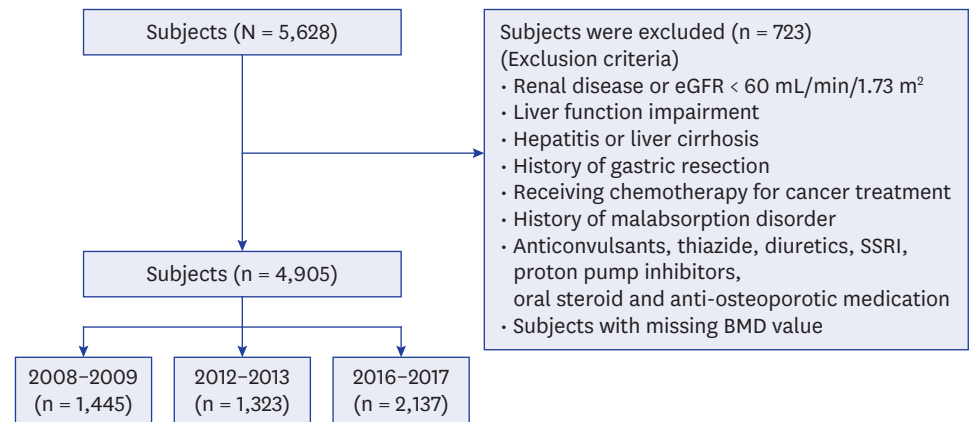


Fig. 1. Sample extraction.

eGFR = estimated glomerular filtration rate, SSRI = selective serotonin reuptake inhibitor, BMD = bone mineral density.

Version 11.4; General Electric Company, Madison, WI, USA) in 2008–2009, and enCORE (Version 15.0) in 2012–2013 and 2016–2017. Quality control for calibration of DXA scan was conducted once a week using the aluminum spine phantom model.

Data analysis

Statistical analyses were performed by using R Statistical Software (version 4.0.2; R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were presented as means \pm standard deviation. We examined whether the change in secular BMD trend remained significant after adjusting for multiple BMD-associated factors such as BMI, serum creatinine, AST, ALT, fasting blood sugar, smoking habit, and calcium supplementation. Thus, the least-square means, which were adjusted for means of the aforementioned factors in the multiple regression model, and their 95% confidence intervals were calculated to plot our figures. Categorical variables were transformed into dummy variables so that they could be analyzed by multiple linear regression analysis. *P* values were obtained after Bonferroni adjustment, which are significant when < 0.05 .

Ethics statement

All participants included in the current study have signed an informed consent. This study was approved by the Institutional Review Board of Ajou University Hospital (AJIRB-MED-MDB-18-049) and all procedures were carried out in accordance with relevant guidelines and regulations.

RESULTS

General characteristics

General characteristics of the subjects in each period are demonstrated in **Table 1**. The mean ages of the subjects and the mean serum creatinine values declined during the survey period, while the values of mean body weight, mean AST, mean ALT, and calcium supplementation rate increased. The proportion of subjects aged 50–59 years was higher in 2016–2017 (73.59%) compared with those in other periods, while the proportion of subjects aged 70 years or more was highest in 2008–2009.

Table 1. Demographic and clinical characteristics of the study group

Variables	2008–2009 (n = 1,445)	2012–2013 (n = 1,323)	2016–2017 (n = 2,137)	P value
Age ^a	60.27 ± 7.53	59.33 ± 7.28	57.05 ± 6.54	< 0.001
Height ^a	156.67 ± 5.27	156.32 ± 5.24	156.88 ± 5.26	0.005
Weight ^a	57.02 ± 7.62	57.24 ± 8.22	57.82 ± 7.88	0.003
BMI ^a	23.23 ± 2.93	23.42 ± 3.14	23.5 ± 3.03	0.065
Creatinine ^a	0.78 ± 0.09	0.84 ± 0.07	0.69 ± 0.1	< 0.001
Fasting blood glucose ^a	95.88 ± 19.12	96.02 ± 19.28	96.16 ± 19.56	0.828
AST ^a	22.09 ± 7.35	25.11 ± 9.27	23.24 ± 8.61	< 0.001
ALT ^a	19.96 ± 11.12	20.69 ± 11.74	20.78 ± 11.86	0.036
Calcium supplement status ^b				< 0.001
Yes	219 (15.16)	290 (21.92)	403 (18.86)	
No	1,226 (84.84)	1,033 (78.08)	1,734 (81.14)	
Smoking habits ^b				0.595
Never	1,386 (95.92)	1,282 (96.9)	2,053 (96.07)	
Former	19 (1.31)	14 (1.06)	32 (1.5)	
Current	40 (2.77)	27 (2.04)	52 (2.43)	

Data are presented as mean ± standard deviation and number (%) for the categorical variables.

Kruskal-Wallis rank-sum test was used for continuous variables and χ^2 test was used for categorical variables, as appropriate.

BMI = body mass index, AST = aspartate transaminase, ALT = alanine transaminase.

^aEvaluated by Kruskal-Wallis test; ^bEvaluated by χ^2 test.

Trend of BMD, BMC and T-score across whole population

The BMD, BMC and T-score of the lumbar spine demonstrated a declining trend over the survey period. The BMD and T-score of the femur neck and femur total also showed a declining trend over the survey period. These declining trends became more apparent both for the lumbar spine and the femur after adjusting for age (Table 2, Fig. 2).

Trend of BMD, BMC and T-score in different age groups

Subjects were divided into different age groups (50–59 years, 60–69 years, 70 years and more), and the outcomes of bone density analysis of the lumbar spine and the femur for each of the

Table 2. Lumbar spine and femur bone density during the survey periods (before division into age groups)

Osteoporosis epidemiology	2008–2009 (n = 1,445)	2012–2013 (n = 1,323)	2016–2017 (n = 2,137)	P value (linear)	P value (quadratic)
L1–L4 BMD					
Unadjusted	1.09 ± 0	1.06 ± 0	1.06 ± 0	< 0.001	0.028
Adjusted by age	1.1 ± 0	1.07 ± 0	1.05 ± 0	< 0.001	0.301
L1–L4 BMC					
Unadjusted	58.52 ± 0.3	58.66 ± 0.31	56.88 ± 0.25	< 0.001	0.005
Adjusted by age	59.55 ± 0.28	57.11 ± 0.29	55.9 ± 0.23	< 0.001	0.065
L1–L4 T-score					
Unadjusted	-0.53 ± 0.04	-0.73 ± 0.04	-0.72 ± 0.03	< 0.001	0.028
Adjusted by age	-0.39 ± 0.03	-0.66 ± 0.04	-0.86 ± 0.03	< 0.001	0.302
Femur neck BMD					
Unadjusted	0.87 ± 0	0.85 ± 0	0.84 ± 0	< 0.001	0.312
Adjusted by age	0.88 ± 0	0.86 ± 0	0.83 ± 0	< 0.001	0.796
Femur neck T-score					
Unadjusted	-0.62 ± 0.03	-0.77 ± 0.03	-0.85 ± 0.02	< 0.001	0.312
Adjusted by age	-0.52 ± 0.02	-0.72 ± 0.02	-0.94 ± 0.02	< 0.001	0.796
Total femur BMD					
Unadjusted	0.94 ± 0	0.91 ± 0	0.9 ± 0	< 0.001	0.084
Adjusted by age	0.95 ± 0	0.92 ± 0	0.89 ± 0	< 0.001	0.519
Total femur T-score					
Unadjusted	-0.31 ± 0.03	-0.5 ± 0.03	-0.58 ± 0.02	< 0.001	0.083
Adjusted by age	-0.21 ± 0.03	-0.46 ± 0.03	-0.67 ± 0.02	< 0.001	0.516

Data are presented as mean ± standard deviation.

P values are obtained by using Kruskal-Wallis rank sum test.

BMD = bone mineral density, BMC = bone mineral content.

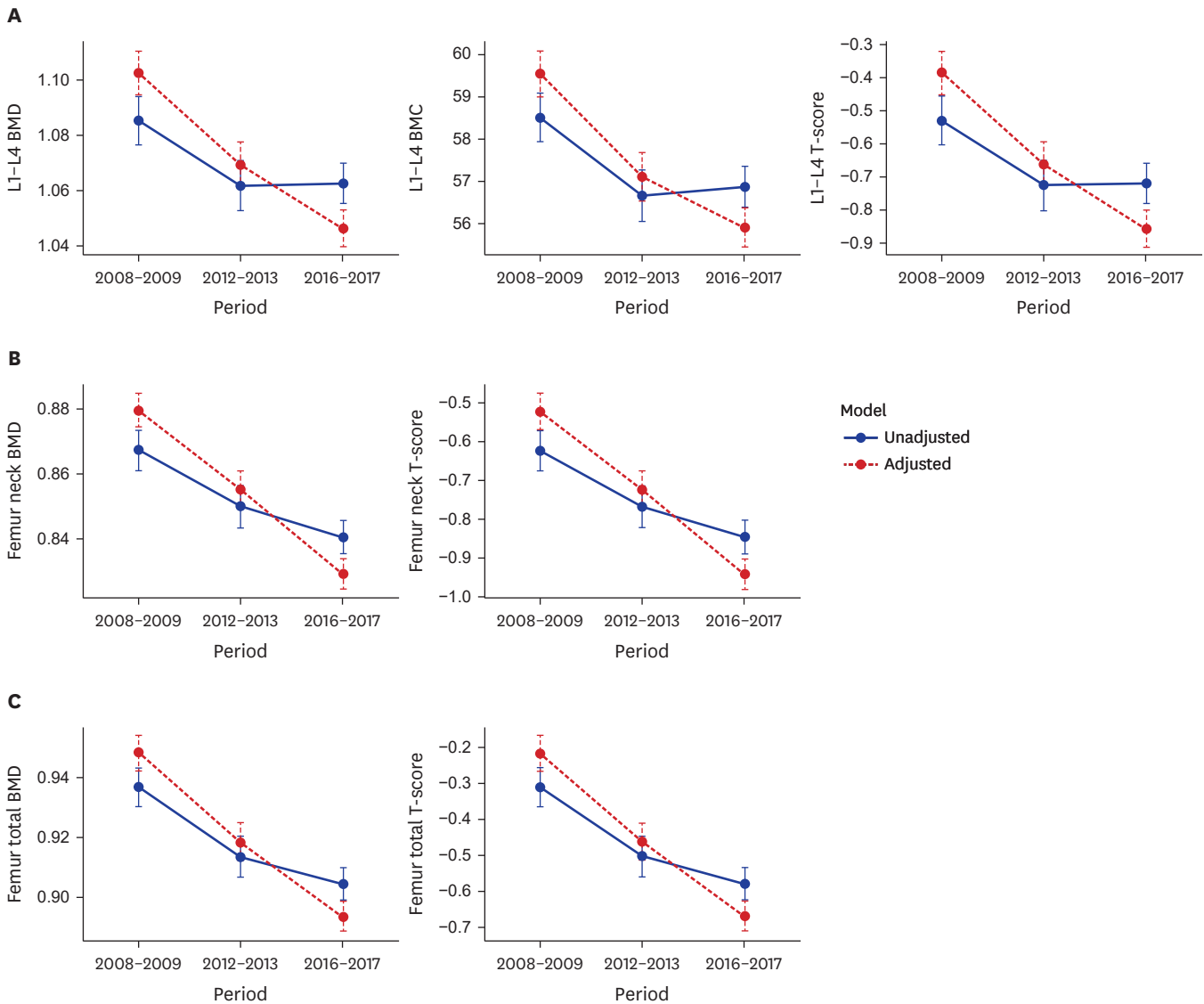


Fig. 2. Secular trend of lumbar spine and femur bone density (calculated before division into age groups). BMD = bone mineral density, BMC = bone mineral content.

groups were calculated as demonstrated in Table 3. We found a declining linear trend of BMD, BMC, and T-scores in the 50–59 years age group and a quadratic declining trend in the 60–69 years age group during the survey periods. These declining trends of BMD, BMC and T-score in the 50–59 years and the 60–69 years age groups remained statistically significant even after adjusting for BMI, renal function, liver function, fasting blood glucose, cigarette smoking, and calcium supplementation. On the contrary, BMD and T-score of the lumbar spine demonstrated linear increasing trends during the survey periods in the 70 years or more age group. These linear increasing trends of BMD and T-scores changed to quadratic trends after applying the same adjustments but remained statistically significant (Table 3, Fig. 3A).

For the femoral neck and the total femur bone, we identified declining linear trends during the survey periods in the 50–59 years and the 60–69 years age group. The declining trends of BMD and T-score were persistently statistically significant even after adjusting for BMI, renal function,

Table 3. Lumbar spine and femur bone density during the survey periods and for each age group

Osteoporosis epidemiology	2008–2009	2012–2013	2017–2018	P value (linear) ^b	P value (quadratic) ^b
Lumbar spine (L1–L4) BMD					
50–59 yr (n = 3,173)					
Unadjusted	1.16 ± 0.01	1.12 ± 0.01	1.09 ± 0	< 0.001	> 0.999
Adjusted ^a	1.14 ± 0.01	1.1 ± 0.01	1.09 ± 0.01	< 0.001	0.097
60–69 yr (n = 1,226)					
Unadjusted	1.03 ± 0.01	0.98 ± 0.01	0.99 ± 0.01	< 0.001	< 0.001
Adjusted ^a	1.04 ± 0.02	0.97 ± 0.02	1.01 ± 0.02	0.039	< 0.001
70 yr or more (n = 506)					
Unadjusted	0.92 ± 0.01	0.93 ± 0.01	0.96 ± 0.01	0.127	> 0.999
Adjusted ^a	0.95 ± 0.03	0.94 ± 0.03	1.01 ± 0.03	0.002	0.066
Lumbar spine (L1–L4) BMC					
50–59 yr (n = 3,173)					
Unadjusted	62.84 ± 0.38	60.36 ± 0.37	58.65 ± 0.27	< 0.001	> 0.999
Adjusted ^a	62.09 ± 0.75	58.75 ± 0.76	59.04 ± 0.69	< 0.001	< 0.001
60–69 yr (n = 1,226)					
Unadjusted	55.21 ± 0.48	51.49 ± 0.53	52.55 ± 0.50	< 0.001	< 0.001
Adjusted ^a	56.11 ± 1.20	51.67 ± 1.27	54.55 ± 1.28	0.112	< 0.001
70 yr or more (n = 506)					
Unadjusted	49.07 ± 0.76	49.15 ± 0.88	50.3 ± 0.87	0.856	> 0.999
Adjusted ^a	51.41 ± 2.11	50.77 ± 2.16	53.97 ± 2.22	0.088	0.278
Lumbar spine (L1–L4) T-score					
50–59 yr (n = 3,173)					
Unadjusted	0.06 ± 0.05	-0.21 ± 0.05	-0.48 ± 0.03	< 0.001	> 0.999
Adjusted ^a	-0.06 ± 0.09	-0.41 ± 0.09	-0.5 ± 0.08	< 0.001	0.097
60–69 yr (n = 1,226)					
Unadjusted	-0.97 ± 0.06	-1.44 ± 0.07	-1.33 ± 0.06	< 0.001	< 0.001
Adjusted ^a	-0.93 ± 0.15	-1.48 ± 0.16	-1.16 ± 0.16	0.040	< 0.001
70 yr or more (n = 506)					
Unadjusted	-1.87 ± 0.09	-1.8 ± 0.11	-1.58 ± 0.11	0.127	> 0.999
Adjusted ^a	-1.64 ± 0.26	-1.72 ± 0.26	-1.15 ± 0.27	0.002	0.066
Femur neck BMD					
50–59 yr (n = 3,173)					
Unadjusted	0.91 ± 0	0.89 ± 0	0.86 ± 0	< 0.001	0.780
Adjusted ^a	0.91 ± 0.01	0.88 ± 0.01	0.86 ± 0.01	< 0.001	> 0.999
60–69 yr (n = 1,226)					
Unadjusted	0.84 ± 0	0.8 ± 0.01	0.79 ± 0.01	< 0.001	0.273
Adjusted ^a	0.83 ± 0.01	0.78 ± 0.01	0.78 ± 0.01	< 0.001	0.021
70 yr or more (n = 506)					
Unadjusted	0.76 ± 0.01	0.74 ± 0.01	0.75 ± 0.01	> 0.999	0.212
Adjusted ^a	0.73 ± 0.01	0.7 ± 0.01	0.74 ± 0.01	> 0.999	0.007
Femur neck T-score					
50–59 yr (n = 3,173)					
Unadjusted	-0.27 ± 0.03	-0.42 ± 0.03	-0.66 ± 0.02	< 0.001	0.780
Adjusted ^a	-0.28 ± 0.07	-0.49 ± 0.07	-0.66 ± 0.06	< 0.001	> 0.999
60–69 yr (n = 1,226)					
Unadjusted	-0.84 ± 0.04	-1.15 ± 0.05	-1.28 ± 0.04	< 0.001	0.272
Adjusted ^a	-0.96 ± 0.10	-1.32 ± 0.11	-1.33 ± 0.11	< 0.001	0.021
70 yr or more (n = 506)					
Unadjusted	-1.52 ± 0.06	-1.71 ± 0.07	-1.61 ± 0.07	> 0.999	0.212
Adjusted ^a	-1.75 ± 0.17	-2.01 ± 0.18	-1.7 ± 0.18	> 0.999	0.007
Total femur BMD					
50–59 yr (n = 3,173)					
Unadjusted	0.98 ± 0	0.95 ± 0	0.93 ± 0	< 0.001	> 0.999
Adjusted ^a	0.97 ± 0.01	0.94 ± 0.01	0.92 ± 0.01	< 0.001	0.552
60–69 yr (n = 1,226)					
Unadjusted	0.91 ± 0.01	0.87 ± 0.01	0.86 ± 0.01	< 0.001	0.137
Adjusted ^a	0.9 ± 0.01	0.85 ± 0.01	0.85 ± 0.01	< 0.001	0.009
70 yr or more (n = 506)					
Unadjusted	0.83 ± 0.01	0.8 ± 0.01	0.81 ± 0.01	0.115	0.238
Adjusted ^a	0.81 ± 0.02	0.77 ± 0.02	0.79 ± 0.02	0.909	0.042

(continued to the next page)

Secular Trends of Bone Mineral Density in Korean Postmenopausal Women

Table 3. (Continued) Lumbar spine and femur bone density during the survey periods and for each age group

Osteoporosis epidemiology	2008–2009	2012–2013	2017–2018	P value (linear) ^b	P value (quadratic) ^b
Total femur T-score					
50–59 yr (n = 3,173)					
Unadjusted	0.01 ± 0.04	-0.18 ± 0.04	-0.4 ± 0.03	< 0.001	> 0.999
Adjusted ^a	-0.01 ± 0.07	-0.28 ± 0.07	-0.44 ± 0.06	< 0.001	0.552
60–69 yr (n = 1,226)					
Unadjusted	-0.5 ± 0.04	-0.85 ± 0.05	-0.97 ± 0.05	< 0.001	0.135
Adjusted ^a	-0.62 ± 0.11	-1.02 ± 0.11	-1.02 ± 0.11	< 0.001	0.008
70 yr or more (n = 506)					
Unadjusted	-1.16 ± 0.06	-1.42 ± 0.07	-1.36 ± 0.07	0.115	0.238
Adjusted ^a	-1.4 ± 0.18	-1.69 ± 0.18	-1.5 ± 0.19	0.909	0.042

Data are presented as mean ± standard deviation.

BMD = bone mineral density, BMC = bone mineral content.

^aAdjusted for BMI, serum creatinine, AST, ALT, fasting blood glucose, smoking habit, calcium supplementation status.

^bP values were obtained after Bonferroni adjustment, which are significant when < 0.05.

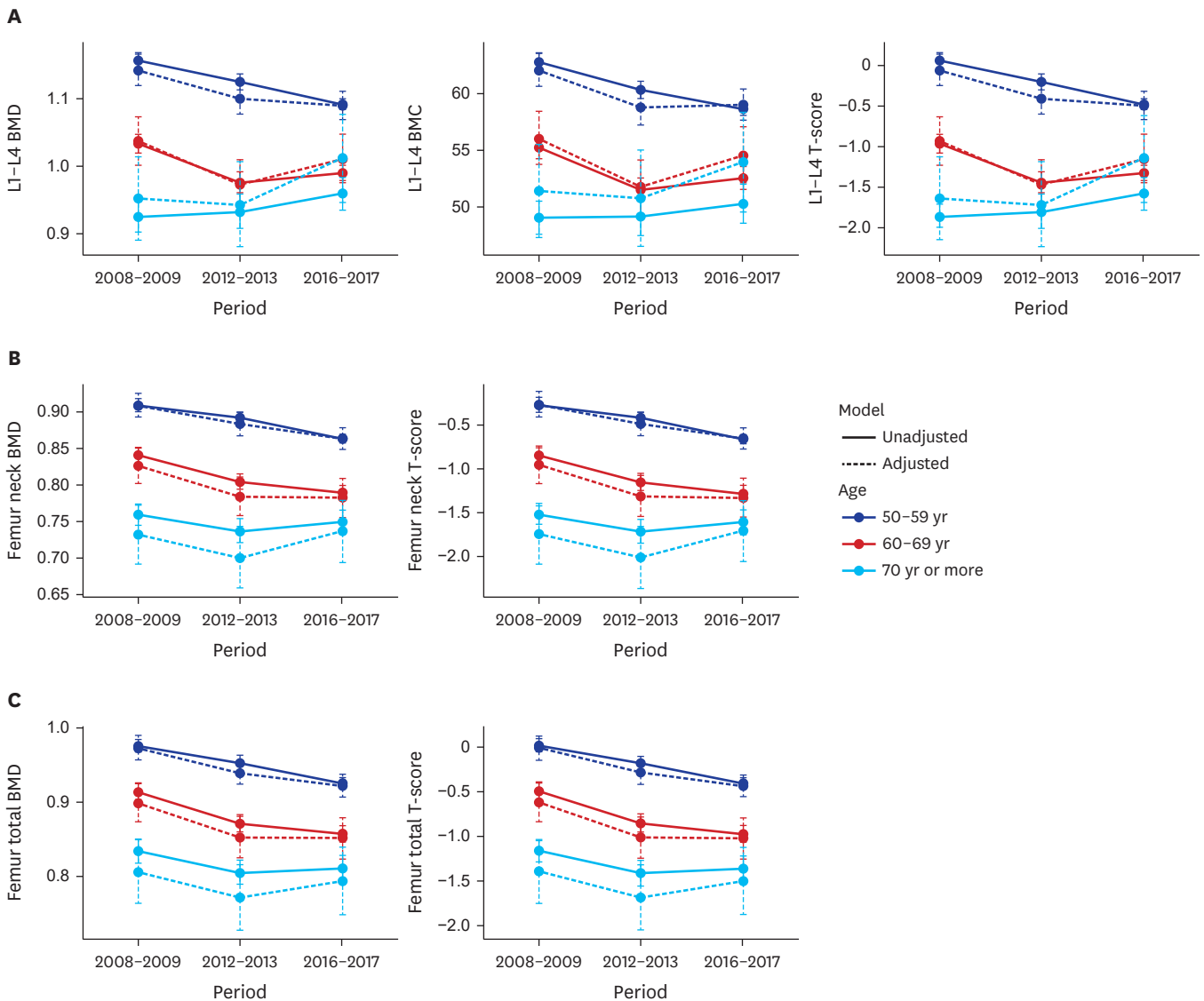


Fig. 3. Secular trend of lumbar spine and femur bone density of each age group. BMD = bone mineral density, BMC = bone mineral content.

liver function, fasting blood glucose, cigarette smoking, and calcium supplementation in each age group. In women aged 70 years or more, U shape trends in BMD and T-score were seen but those trends were not statistically significant before or after the adjustment (Table 3, Fig. 3B and C).

DISCUSSION

In this study, we demonstrated that the BMD values of the lumbar spine and proximal femur in postmenopausal women have been decreasing from 2008 to 2017. However, the analysis conducted in different age groups revealed a discrepancy in the secular trend of BMD. The decrease in BMD values over the survey periods was more apparent in younger postmenopausal women, whereas women aged over 70 years showed increasing values of BMD at the lumbar spine and unchanged values for the proximal femur during the survey period.

Previous studies have reported that hip fracture incidence has decreased in developed countries.⁴⁻⁹ This declining trend of fragility fracture was also observed among Asian countries,^{11,12} including Korea.¹³ However, a recent study regarding the BMD trend in the United States reported an unexpected finding for hip fracture incidence. The prevalence of osteoporosis in the United States defined by the femur neck BMD and T score under -2.5 increased from 2007–2008 to 2013–2014 based on data from NHANES,¹⁰ and it also detailed a declining quadratic trend of femoral neck BMD during the same period.¹⁴ This finding is consistent with the present study. However, the background of the discordance between trends of BMD and fracture incidence reported in NHANES has not been clearly elucidated yet. The attempt to analyze BMD trends by dividing the study group into different age groups may shed light on the variations in BMD trends following age and may discover transition of BMD trends between those age groups as our analysis did.

Age is the most powerful and independent risk factor for osteoporotic fractures.^{15,16} Fragility fracture, especially hip fracture, is more common in elderly postmenopausal women than that in young postmenopausal women with the same BMD.^{17,18} The BMD trend in the younger ages may have a lesser impact on the incidence of osteoporotic fractures compared to that in the elderly. According to the National Osteoporosis Risk Assessment (NORA) study, the overall fracture incidence increases about 8 per 1,000 person-years as T-score changes from -1.0 – -2.0 to less than -2.0 in ages of 50–69 years while it increases 13 per 1,000 person-years in ages of 70–79 years and even 15 per 1,000 person-year in ages over 80 years with the same T-score change.¹⁹ Accounting for the NORA study and our observation, the discordance between decreased fracture incidence and increasing BMD trend may have originated from the discrepancy of BMD trends across different age groups.

To figure out plausible causes for the observed differences in BMD trends among different age groups, we explored the changes in BMD-related factors such as BMI, renal function, liver function, fasting blood glucose, smoking habit, and calcium supplementation.²⁰⁻²² Surprisingly, these factors had shown a favorable change for BMD in the younger age group during the survey periods (Supplementary Table 1). However, a previous study revealed that changes in BMD-related factors may cause very little effect on the actual BMD change. Looker et al stated that adjustments for BMI and smoking habit failed to make a meaningful difference on BMD.¹⁰

This discordance in BMD trends may have originated from physical inactivity in younger women relative to the elderly.²³ The sedentary lifestyle has become more pervasive in Korea

lately, physical activity of adults has decreased by 13.1% as reported in Korea NHANES 2008 to 2014.²⁴ And similarly, a study based on data from the 2020 National Health and Nutrition Survey, published in 2022, found that physical activity in the age group under 19–64 was significantly lower than those over 64.²⁵ The level of physical activity is an important factor to maintain adequate bone mass. Especially, increased exercise or physical activity can reduce accelerated bone loss during the early menopausal period.^{26,27} Another possible explanation is that in Korea, not like other countries, vitamin D deficiency is more prominent among young people. As is well known, vitamin D deficiency is significantly associated with decreased bone density.²⁸

The increasing secular trend of BMD of the lumbar spine in the over 70 years age group shown in this study may contribute to the declining trend in vertebral compression fracture.²⁹ In a study that reports the incidence of vertebral fracture in different age groups in Korea from 2012 to 2016, a substantial decline in vertebral fracture trend from 2013 to 2016 was observed only in the 70–74 age group. In other age groups, the incidence of vertebral fracture showed increasing trends, which supports our findings.

The strength of this study is that a substantial number of participants were included to probe the secular trends of BMD. The average number of subjects for each time period to find the secular trend of BMD in the United States was about 2,000 and 3,500 participants, respectively.^{10,14} The population of the US is approximately 6 times larger than that of Korea, so an average of 1635 subjects for each time period in our study is relatively substantial, to analyze secular BMD trends. Moreover, the large number of subjects enabled us to perform an age-based analysis of participants, which revealed the discrepancy in BMD trends between younger and older postmenopausal women.

This study should be viewed in the light of its limitations. This research was conducted in a single institution in a single ethnic group. Due to the nature of these samples, some bias may occur in the sampling of participants between periods. In addition, since this study is a cross-sectional study and was not conducted on the same patients, there is a limitation that causality may not be evident. Another limitation is that the software version of the bone density measurement equipment used in this study is different between the data for 2008–2009 and the data for 2012–2013 and 2016–2017. Although this is a very subtle difference, it cannot be ruled out that it may have influenced the results of the study. And, this study was unable to completely address the causes of varying trends of BMD among the age groups due to lack of additional information such as serum vitamin D values.

In conclusion, our study indicated that BMD in postmenopausal women has declined significantly from 2008 to 2017 despite the increasing trends in elderly women. Our findings explain the recent discovery of the discrepancy between trends of BMD and fragility fracture. This data may help predict the trajectory of osteoporotic fractures in the future.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Demographic and clinical characteristics for 50 to 59 years age group

[Click here to view](#)

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