Original Article

Relationship between bone mineral density and alcohol consumption in Korean men: the Fourth Korea National Health and Nutrition Examination Survey (KNHANES), 2008-2009

Jung Hyeon Hyeon MD[1], Jong Seop Gwak MD[1], Sung Woo Hong MD[1], Hyuktae Kwon PhD[2], Seung-Won Oh PhD[2], Cheol Min Lee PhD[2]

[1]*Department of Family Medicine, Seoul National University Hospital, Seoul, Korea*
[2]*Department of Family Medicine, Healthcare System Gangnam Center of Seoul National University Hospital, Seoul, Korea*

Background and Objectives: Drinking is a risk factor of osteoporosis, but controversy surrounds the relationship between alcohol consumption and bone mineral density (BMD). We performed an analysis of the association between alcohol consumption and BMD. **Methods and Study Design:** A cross-sectional study was performed including 2421 men, aged 40-93 years, who participated in the fourth Korea National Health and Nutrition Examination Survey in 2008-2009. Alcohol intake was determined by self-administered questionnaires, and BMD was measured by dual energy x-ray absorptiometry. ANOVA was used to determine the relationship between alcohol intake and BMD, and ANCOVA was performed after adjusting for age, body mass index, education, household income, smoking status, calcium intake, physical activity, and serum 25-hydroxyvitamin D levels. **Results:** BMD increased significantly in the lumbar spine, total femur, and femoral neck with increased alcohol intake (p for trend=0.028, <0.001, <0.001, respectively). However, after adjusting for age, the relation was no longer statistically significant in any of 3 bone sites (lumbar, p for trend=0.606; total femur, p for trend=0.342; femoral neck, p for trend=0.549). Additionally, after adjusting for all other confounders, no significant relationships were reported in the 3 bone sites (lumbar, p for trend=0.451; total femur, p for trend=0.150; femoral neck, p for trend=0.343). In the stratified analysis, there were no significant correlations according to age, smoking status, physical activity or obesity. **Conclusions:** After adjusting for age and other confounders, no significant relationship was found between alcohol intake and BMD.

Key Words: osteoporosis, alcohol, bone mineral density, KNHANES, Korean men

INTRODUCTION

According to the World Health Organization (WHO), osteoporosis, a disease of the skeletal system, is characterised by decreased bone mass and a micro-architectural disorder and is defined as a condition in which bones become weaker and more prone to fracture.[1] Osteoporosis is primarily of interest in studies of postmenopausal women, but its incidence among men has also increased along with a recent explosion in the aging population. One study reported that the annual mortality rate after a hip fracture was 31% in men, a value much higher than that of 17% in women.[2] The prevalence rate of osteoporosis in men was 13.6%, according to a study of men aged 40-79 years,[3] but another study reported that the disease is treated in only 23.3% of diagnosed male patients.[4]

Most cases of osteoporosis in men, unlike those in women, are regarded as secondary osteoporosis and may be caused by binge drinking and smoking, hypogonadism, steroid use or hyperparathyroidism, among others.[5] Of these, drinking and male gender are closely related in modern society. In Korea, the monthly drinking rate of men over the age of 19 years was 77.8% with a steady increase evident in 2010. Additionally, the proportion of high-risk drinkers (i.e., average alcohol consumption per occasion >7 drinks and drinking more than twice per week) has been reported to be 24.9% and seems to be increasing.[6] This is a high prevalence albeit less than the American monthly drinking rate of 59.2%.[7]

Drinking has long been recognised as a risk factor of osteoporosis, and excessive alcohol intake reportedly reduces the bone mineral density (BMD).[8-11] Yet some studies have reported that drinking increases the BMD,[12, 13] with recent studies to show that moderate drinking

Corresponding Author: Prof Cheol Min Lee, Department of Family Medicine, Healthcare System Gangnam Center of Seoul National University Hospital, 152, Teheran-ro, Gangnam-gu, Seoul, Korea, 135-984.
Tel: +82-2-2112-5668; Fax: +82-2-2112-5636
Email: bigbangx.snuh@gmail.com; hyeonjh@hotmail.com
Manuscript received 19 August 2014. Initial review completed 14 December 2014. Revision accepted 12 April 2015.
doi: 10.6133/apjcn.2016.25.2.17

increases BMD, leading to much controversy.[14-16]

This study focused on the relation between alcohol intake and BMD in adult Korean men who participated in the Korea National Health and Nutrition Examination Survey (KNHANES), a large and highly reliable survey that represents the Korean population.

MATERIALS AND METHODS

Study population

In this study, we used data from the Health Interview Survey and Health Examination Survey, administered during the second and third years of the fourth season of the KNHANES. KNHANES has been conducted since 1998 and is enforced for compiling statistics on citizens' health levels, health consciousness and behaviours, and the actual conditions of food intake and nutrition. A total of 13,800 households have been extracted from 600 enumeration districts that comprise every family; individuals older than 1 year who live in the Republic of Korea were targeted from selected households.[6] Those participants who did not respond to the survey or physical examination were considered missing; from a total 4275 men older than 40 years (from 20,277 total participants), 1333 men who did not undergo surveys, physical examinations, or body density measurements were excluded. A total of 2421 subjects were targeted for the analysis, excluding 490 who did not provide nutrition surveys or blood samples, and 31 who were under osteoporosis medication that might have affected the BMD status or were affected by chronic renal failure or endocrine diseases such as thyroid disease. (Figure 1) In this study, ethical approval was not required as the KNHANES IV survey data are publically available. All the participants signed an informed consent form.

Data collection and analysis

The Health Interview Survey and Health Examination Survey were conducted through mobile examination centres, while the health nutrition survey was administered by visiting target households. All topics associated with education and economic activity, previous disease status, medical uses, and the nutrition survey were investigated in interviews, and information about health behaviours such as smoking or drinking was self-provided in writing. The Health Examination was performed to direct the measurements, inspections, and sample analyses, among other parameters.[6] Alcohol intake was determined from self-administered questionnaires about the average

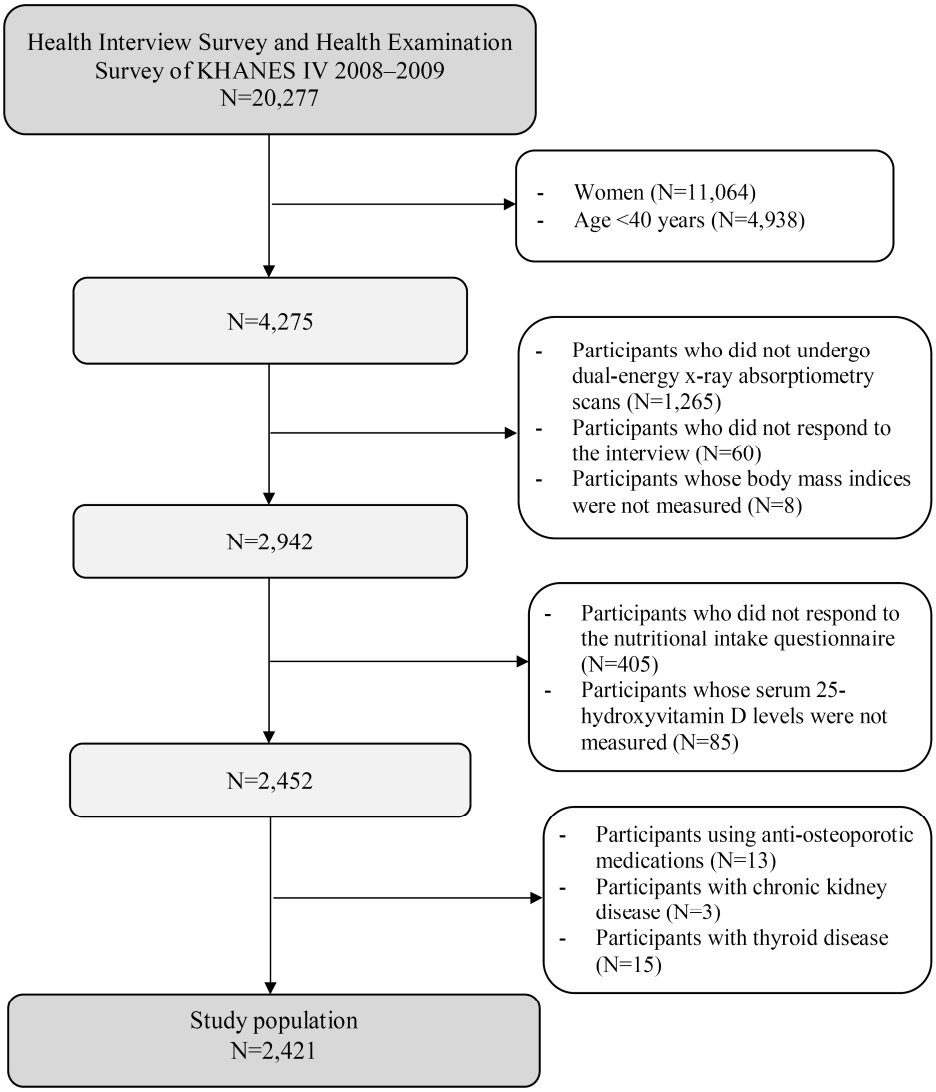

Figure 1. Flow diagram of study participant inclusion or exclusion. KNHANES IV: Fourth Korea National Health and Nutrition Examination Survey.

amount of drinking and drinking frequency over the past 12 months. A standard drink was defined as a single glass of liquor, wine, or the Korean traditional drink So-ju (Korean distilled liquor). One bottle of beer (355 mL) was counted as 1.6 standard drinks. According to the WHO osteoporosis assessment, we considered the amount of alcohol per 1 standard drink as 10 g, and the average amounts of daily alcohol intake were calculated and classified into 3 groups: 0 g/day, <30 g/day, and ≥30 g/day.[17] Smoking habits were categorised as never smoked, ex-smoker, and smoker. The household income levels were divided into 3 groups as <1 million won, 1 to <3 million won, and >3 million won, and the personal education levels were divided into 4 groups: elementary school, middle school, high school, and beyond college. Calcium intake was measured and determined through visiting interviews from recalled events over the preceding 24 hours. This value was calibrated according to the residual method because its value depends on the individual total caloric intake.[18] Physical examinations measured the body mass index (BMI, kg/m^2), using only weight and height that were measured while the participants wore light clothes. Blood 25-hydroxyvitamin D (25(OH) Vit D, ng/mL) concentrations were calibrated by radioimmunoassay with a Biosource reagent (Life Technologies Corp., Carlsbad, CA, USA) after collecting venous blood samples.[6] The Korean-translated version of the International Physical Activity Questionnaire (IPAQ) was used to measure physical activity, and physical activity was calculated as the Metabolic Equivalent Task (MET)-minute/week.[19] Alcohol use behaviour was evaluated using the Alcohol Use Disorder Identification Test-Korea (AUDIT-K), a Korean-translated version of AUDIT developed by the WHO. BMD of the lumbar spine, total femur, and femoral neck was measured by Dual Energy X-ray Absorptiometry (DXA) with a DISCOVERY-W machine (Hologic, Inc., Bedford, MA, USA).[6] According to the measured BMD and WHO criteria, the group with T scores <-1.0 and >-2.5 was defined as osteopenic, and the group with T scores <-2.5 was defined as osteoporotic.[17]

Statistical analysis

The participants were divided into 3 groups according to daily alcohol intake, and a univariate analysis was performed for each variable, including age, height, weight, BMI, smoking status, physical activity levels, calcium intake, blood 25(OH) Vit D concentration, education level, income level, and BMD (lumbar spine, total femur, femoral neck). To determine statistical differences in the average BMD according to each alcohol intake group, an analysis of variance (ANOVA) was used for each lumbar spine, total femur, and femoral neck. We also used an analysis of covariance (ANCOVA) that was adjusted in repeat tests for age, BMI, education levels, income levels, smoking status, physical activity levels, calcium intake based on calorie intake, and blood 25(OH) Vit D concentrations. To ensure the relevance of drinking and BMD in certain groups, stratified analyses were performed for the following variables: age, smoking status, exercise status, and obesity. Finally, an additional analysis was performed for more specific factors such as the AUDIT scores. All statistical data analyses were completed with the STATA software package (version 12.0; StataCorp LP, College Station, TX, USA). A p-value <0.05 was considered significant.

RESULTS

General characteristics

This study included a total of 2421 participants, and each variable according to alcohol intake is featured in Table 1. According to alcohol consumption, there were significant trends in age, height, weight, smoking status, physical activity, calcium intake, serum 25(OH) Vit D level, education, house income. The osteoporosis prevalence, according to the femoral neck BMD, was lower (p<0.001) in the group that consumed >30 g of alcohol (1.2%) than in the group that abstained (4.8%), and similar results were observed (p<0.001) for the osteoporosis prevalence according to the total femur BMD (0.2% and 0.8%, respectively). However, there was no statistical difference between the groups with regard to osteoporosis prevalence according to the lumbar BMD (p=0.084).

Correlations between BMD and each variable

A correlation analysis was conducted to investigate the relationships between BMD and several variables that affected the BMD. As shown in table 2, the positively correlated values included BMI, physical activity, calcium intake, and alcohol intake. BMI correlated significantly with all 3 BMD measurements. Alcohol intake correlated with the total femur and femoral neck BMD, but not the lumbar spine BMD. On the other hand, a negative correlation was observed between age and BMD.

Association of alcohol intake with BMD

Estimated marginal mean of the lumbar spine, total femur, and femoral neck BMD with alcohol intake both before and after adjusting for variables such as age are shown in Table 3. Before adjusting for variables, the BMD in the total femur and femoral neck differed significantly among the alcohol intake groups, and the BMD in the lumbar spine, total femur, and femoral neck tended to increase significantly. However, after adjusting for age, the relation was no longer statistically significant in any of the 3 bones assessed. This remained so after adjusting for each variable, including BMI, smoking status, physical activity, calcium intake, blood 25(OH) Vit D concentration, education level, and income level. BMD increased with increased alcohol intake, so there was no inflection point for the correlation between alcohol intake and BMD. For a detailed evaluation of the association between alcohol consumption and BMD, we performed analysis by more subdividing groups. For quartiles based on alcohol intake, no significant differences was observed (lumbar spine, p for trend=0.510; total femur, p for trend=0.053; femoral neck, p for trend=0.445). Even with smaller intervals of alcohol intake, namely 0 g, 0-15 g, 15-30 g, and >30 g, the results were the same (lumbar spine, p for trend=0.462; total femur, p for trend=0.150; femoral neck, p for trend=0.375). Additionally, the questionnaire, based on the number of drinks per occasion, i.e., 0 drinks, 1-2 drinks, 3-6 drinks, and >7 drinks, did not demonstrate any significance (lumbar spine, p for trend=0.356; total femur,

p for trend=0.190; femoral neck, *p* for trend=0.696). Finally, division into 3 groups according to the AUDIT-K scores (0-7, 8-15, and 16-40 points) did not reveal significance for the lumbar spine or femoral neck; only the total femur had a borderline *p*-value (lumbar spine, *p* for trend=0.238, femoral neck, *p* for trend=0.393; total femur, *p* for trend=0.051).

Relationship between alcohol intake and BMD in particular groups

The results of the stratified analysis according to groups by age, smoking status, physical activity status, and obesity, related to alcohol intake and femoral neck BMD, are shown in Table 4. The age groups of <50 years, 50-64 years or ≥65 years did not showed any statistical significance (*p* for trend=0.900, 0.528, and 0.487, respectively).

Table 1. Characteristics of study participants according to alcohol intake (n=2,421)[†]

Variables	Alcohol intake			*p*-value[‡]
	0 g/day n=523	<30 g/day n=1,481	≥30 g/day n=417	
Age, yr	63.0±11.8	57.3±11.3	55.4±10.6	<0.001
Height, cm	166±6.4	168±6.0	168±6.0	<0.001
Weight, kg	65.6±10.5	67.2±9.8	68.7±10.8	<0.001
BMI, kg/m^2	23.7±3.2	23.9±2.9	24.2±3.2	0.065
Smoking (%)				<0.001
Non-smoker	149 (28.5)	220 (14.9)	40 (9.6)	
Ex-smoker	245 (46.9)	687 (46.4)	162 (38.9)	
Current-smoker	129 (24.7)	574 (38.8)	215 (51.6)	
Physical activity[§], MET-min/wk	2760±4977	3053±4859	3910±6940	0.003
Calorie adjusted calcium intake, mg/day	554±389	537±297	472±317	<0.001
25-hydroxyvitamin D, ng/mL	21.5±7.4	22.2±7.2	23.1±7.7	0.004
Education level (%)				<0.001
Elementary school or below	214 (40.9)	386 (26.1)	125 (30.0)	
Middle school	88 (16.8)	277 (18.7)	87 (20.9)	
High school	117 (22.4)	445 (30.1)	135 (32.4)	
College or higher	104 (19.9)	373 (25.2)	70 (16.8)	
Monthly house income, won (%)				<0.001
≤1,000,000	236 (45.1)	403 (27.2)	120 (28.8)	
1,010,000~3,000,000	175 (33.5)	601 (40.6)	158 (37.9)	
>3,000,000	112 (21.4)	477 (32.2)	139 (33.3)	
Lumbar BMD, g/cm^2	0.937±0.160	0.951±0.146	0.958±0.144	0.079
Femoral neck BMD, g/cm^2	0.743±0.131	0.772±0.124	0.784±0.126	<0.001
Total femur BMD, g/cm^2	0.921±0.134	0.954±0.129	0.963±0.127	<0.001
Lumbar spine (%)				0.084
Normal	303 (57.9)	924 (62.4)	264 (63.3)	
Osteopenia	184 (35.2)	486 (32.8)	139 (33.3)	
Osteoporosis	36 (6.9)	71 (4.8)	14 (3.4)	
Femoral neck (%)				<0.001
Normal	289 (55.3)	952 (64.3)	282 (67.6)	
Osteopenia	209 (40.0)	498 (33.7)	130 (31.2)	
Osteoporosis	25 (4.8)	31 (2.1)	5 (1.2)	
Total femur (%)				<0.001[*]
Normal	424 (81.1)	1,325 (89.5)	374 (89.7)	
Osteopenia	95 (18.2)	150 (10.1)	42 (10.1)	
Osteoporosis	4 (0.8)	6 (0.4)	1 (0.2)	

BMD: bone mineral density; BMI: body mass index; MET: metabolic equivalent task.
[†]Data are presented as the means and standard deviation (SD) or percentages and standard error (SE).
[‡]*p* value from ANOVA for continuous variables or chi-squared test for categorical variables.
[§]Physical activity was defined by the IPAQ scoring protocol.
[*]*p* value from Fisher's exact test because of the small number of each cell.

Table 2. Correlations between bone mineral density and variables

Variable	Lumbar BMD (*r*)	*p* value	Total femur BMD (*r*)	*p* value	Femoral neck BMD (*r*)	*p* value
Age	-0.164	<0.001	-0.365	<0.001	-0.422	<0.001
BMI	0.354	<0.001	0.454	<0.001	0.408	<0.001
Physical activity	0.032	0.112	0.083	<0.001	0.067	0.001
Calcium intake	0.052	0.010	0.076	<0.001	0.094	<0.001
Serum 25-hydroxyvitamin D	-0.005	0.804	0.036	0.076	0.019	0.358
Alcohol intake	0.036	0.074	0.071	<0.001	0.074	<0.001

r: Pearson correlation coefficient; BMI: body mass index (kg/m^2); lumbar BMD: lumbar spine bone mineral density (g/cm^2); total femur BMD: total femur bone mineral density (g/cm^2); femoral neck BMD: femoral neck bone mineral density (g/cm^2).

Table 3. Bone mineral density by alcohol intake category[†]

	Alcohol intake			*p* value	*p* for
	0 g/day	<30 g/day	≥30 g/day	(ANCOVA)	trend
F-neck BMD only	0.743 (0.732, 0.754)	0.772 (0.765, 0.778)	0.784 (0.772, 0.796)	<0.001	<0.001
Age-adjusted	0.764 (0.754, 0.774)	0.768 (0.762, 0.774)	0.771 (0.760, 0.782)	0.693	0.549
Fully-adjusted	0.765 (0.755, 0.774)	0.767 (0.762, 0.773)	0.772 (0.761, 0.782)	0.630	0.343
F-total BMD only	0.921 (0.910, 0.933)	0.954 (0.947, 0.961)	0.963 (0.951, 0.975)	<0.001	<0.001
Age-adjusted	0.941 (0.930, 0.951)	0.950 (0.944, 0.957)	0.951 (0.940, 0.963)	0.269	0.342
Fully-adjusted	0.941 (0.931, 0.951)	0.950 (0.945, 0.956)	0.951 (0.941, 0.962)	0.235	0.150
Lumbar BMD only	0.937 (0.924, 0.950)	0.951 (0.943, 0.958)	0.958 (0.944, 0.972)	0.079	0.028
Age-adjusted	0.947 (0.934, 0.960)	0.949 (0.942, 0.957)	0.952 (0.938, 0.966)	0.873	0.606
Fully-adjusted	0.946 (0.934, 0.958)	0.949 (0.942, 0.956)	0.953 (0.940, 0.967)	0.744	0.451

BMI: body mass index (kg/m^2); lumbar BMD: lumbar spine bone mineral density (g/cm^2); F-total BMD: total femur bone mineral density (g/cm^2); F-neck BMD: femoral neck bone mineral density (g/cm^2).
[†]All values are estimated marginal means (95% confidence intervals). Confounders include age, BMI, education, household income, serum 25-hydroxyvitamin D level, total calorie adjusted calcium intake, smoking status, and physical activity.

Table 4. Femoral neck bone mineral density by alcohol intake category and each status[†]

Adjusted F-neck BMD	Alcohol intake			*p* value	*p* for
	0 g/day	<30 g/day	≥30 g/day	(ANCOVA)	trend
Age					
<50	0.839 (0.815, 0.864)	0.817 (0.807, 0.828)	0.830 (0.812, 0.848)	0.182	0.900
50-64	0.776 (0.760, 0.792)	0.785 (0.777, 0.794)	0.785 (0.769, 0.801)	0.594	0.528
≥65	0.694 (0.682, 0.707)	0.703 (0.693, 0.713)	0.699 (0.678, 0.720)	0.573	0.487
Smoking status					
Non-smoker	0.770 (0.754, 0.787)	0.767 (0.754, 0.781)	0.792 (0.760, 0.824)	0.369	0.479
Ex-smoker	0.762 (0.749, 0.776)	0.765 (0.757, 0.773)	0.765 (0.749, 0.782)	0.952	0.772
Current smoker	0.766 (0.746, 0.785)	0.771 (0.762, 0.780)	0.772 (0.757, 0.786)	0.868	0.659
Physical activity[‡]					
Physically non-active	0.737 (0.724, 0.750)	0.741 (0.732, 0.749)	0.752 (0.735, 0.769)	0.358	0.186
Physically active	0.785 (0.772, 0.798)	0.785 (0.779, 0.792)	0.785 (0.772, 0.798)	0.997	0.992
Obesity[§]					
Not obese	0.740 (0.729, 0.751)	0.739 (0.732, 0.745)	0.746 (0.733, 0.759)	0.605	0.549
Obese	0.808 (0.790, 0.825)	0.820 (0.810, 0.830)	0.821 (0.803, 0.838)	0.487	0.332

MET: metabolic equivalent task; BMI: body mass index (kg/m^2); F-neck BMD: femoral neck bone mineral density (g/cm^2).
[†]All values are estimated marginal means (95% confidence intervals). Confounders include age, BMI, education, household income, serum 25-hydroxyvitamin D level, total calorie adjusted calcium intake, smoking status, and physical activity.
[‡]Physically non-active group is defined by a MET-min/week of zero.
[§]Obesity is defined as a BMI ≥ 25 kg/m^2.

Similarly, no differences were found between the never smoked, ex-smokers, and smokers groups (*p* for trend=0.479, 0.772, and 0.659, respectively), nor between the groups of different physical activity levels or obesity (non-active, *p* for trend=0.186 and activity, *p* for trend=0.992; non-obese, *p* for trend=0.549 and obese, *p* for trend=0.332). There were also no statistically significant differences in the BMD analyses of the total femur and lumbar spine (data not shown).

DISCUSSION

In this study, the correlation between alcohol intake in healthy adult men and BMD in the lumbar spine, total femur, and femoral neck seemed to increase significantly with alcohol intake, but all relevant statistical significance disappeared after adjusting for age. This was also true for the other variable-adjusted analyses that enabled an analysis of the effects of variables such as BMI, education level, income level, physical activity, calcium intake, blood 25(OH) Vit D concentration, and smoking status, on BMD. To determine relevance in specific groups, stratified analyses were conducted according to age, smoking status, physical activity, and obesity, and the results remained insignificant.

Previous research findings regarding the correlation between alcohol intake and BMD are controversial. Alcohol intake was previously defined as the cause of osteoporosis, and the actual osteoporosis risk was reported to be 2.4-fold higher (*p*=0.002) than normal, with excessive alcohol intake.[8] Even a cross-sectional study from South Korea showed that 14 drinks per week increases the risk in those who belong to the lower tertile groups and that increased alcohol intake tended to lead to decreasing BMD.[20]

However, subsequent research has shown that moderate drinking promotes an increase in BMD. In the Cardiovascular Health Study cohort, the femoral neck and hip joint BMD increased by approximately 5% (95% confidence interval, 1-9%) in the group that ingested 14 drinks per week, compared to the group that abstained.[21] Additionally, the Framingham Heart Cohort Study reported that the average BMD increased by 3.9% in the group that drank >14 oz. of alcohol.[22] A number of studies that support these findings have been recently reported,[14-16] but the most recent systematic review and meta-analysis proved that osteoporotic fractures increased by 28% in

the group that consumed >10 drinks per week; hence, this is a controversial issue.[23]

As a result of the present study, many studies reported a lack of correlation between alcohol intake and BMD. According to a study of 283 healthy adult men aged 40-69 years, alcohol intake had no association with BMD,[24] and among other studies that conducted surveys of postmenopausal women in particular, as well as men, a study reported that neither lifetime alcohol intake nor recent alcohol intake were independent risk factors of BMD.[25] Interestingly, a recent study assessing the correlation between BMD and alcoholic beverages, which were divided into beer, wine, and liquor subgroups, found that after adjusting for lifestyle, only beer had a protective effect (p=0.005) on BMD.[14] Similarly, in this study, significant results might not be obtained in Korea, where the drinks include So-ju (Korean distilled liquor) and Makgeolli (raw rice-wine), as well as beer.

In contrast with recent studies, there was no significant relationship between alcohol intake and BMD in the present study most likely attributable to the relationship between age and BMD apparently being very strong. In our study, BMD was shown to be very strongly negatively correlated with age, whereas BMD was shown to be only weakly associated with alcohol intake. As shown in table 1, subjects with higher alcohol intake tended to be younger and younger subjects tended to have higher BMD. Although BMD was shown to be correlated with alcohol intake, this relationship lacked statistical power, possibly due to its strong association with age. The fact that smoking is also a known risk factor for low BMD,[5] possibly explains why subjects with higher alcohol intake also tended to be current smokers, and why the association between low BMD and smoking was shown to lack statistical power. There have been many controversies regarding the correlation between alcohol intake and BMD, and several hypotheses have been presented about the mechanism that affects BMD. According to the traditional consensus, alcohol directly interacts with osteoblasts to generally reduce the BMD,[26] and a secondary nutrition deficiency or reduction in physical activity could also reduce BMD.[10]

However, since controversy has arisen over the relevance of alcohol intake to BMD, various hypotheses have been presented. Despite a report showing that alcohol intake enabled transmutation of the parathyroid hormone or calcitonin, which could affect bone metabolism and thus increase BMD,[27] no impact of alcohol intake was found in a follow-up study of the report.[28] There also were reports showing that alcohol intake could affect serum oestrogen levels[29] or that phenolic compounds, present in beer or wine, could also act on oestrogen receptors in osteoblasts or osteoclasts to increase BMD;[30] however, thus far, no exact mechanism has been proven, and an additional larger clinical study is necessary. A recent study was conducted to determine whether silicon, contained in beer, could increase BMD; however, further research would be necessary to confirm the results.[29]

Our study has a number of limitations. First, the interactions between alcohol intake and BMD could not be explained because this was a cross-sectional study. Second, because the alcohol intake survey replaced self-administered recall over a year, the questionnaire might not accurately reflect the exact alcohol intake, and the answers might have been underestimated with regard to the actual amount consumed. Third, other factors such as bone markers were not considered, and BMD alone is not enough to properly assess the impact of alcohol. However, despite these limitations, this study confirms the previously reported research because it referred to KNHANES, the largest representative database of adults in Korea, and the findings are meaningful because we adjusted for all well-known variables that could affect BMD.

In conclusion, this study assessing the relationship between alcohol intake and BMD seemed to show an increase in BMD before adjusting for variables such as age and other confounding factors, but no such significant correlations were observed after the adjustments. Most recent studies of the relationship between alcohol intake and BMD have reported positive trends with regard to increasing BMD;[14-16] however, protective effects of alcohol intake on BMD in Korean adult men cannot be asserted on current evidence. Abroad interpretation requires consideration of the social effects of drinking in Korea which may entail, as elsewhere, the risk of falls and fracture irrespective of alcohol's association with BMD. A prospective cohort study, an interventional study, and other social and metabolic studies which reflect global risks for fracture and utilise bone markers as well as BMD will be necessary to resolve satisfactorily the alcohol-bone health nexus.

AUTHOR DISCLOSURES

The author has no conflict of interest to disclose.

REFERENCES

1. Kanis JA. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: synopsis of a WHO report. Osteoporos Int. 1994;4:368-81. doi: 10.1007/bf01622200.
2. Gruntmanis U. Male osteoporosis: deadly, but ignored. Am J Med Sci. 2007;333:85-92. doi: 10.1097/00000441-200702000-00004.
3. Shin CS, Choi HJ, Kim MJ, Kim JT, Yu SH, Koo BK et al. Prevalence and risk factors of osteoporosis in Korea: a community-based cohort study with lumbar spine and hip bone mineral density. Bone. 2010;47:378-87. doi: 10.1016/j.bone.2010.03.017.
4. No YS, Kwak TH, Chang SH. A study of treatment realities and recognition of male osteoporosis. J Korean Acad Fam Med. 2004;7:527-33.
5. Ebeling PR. Clinical practice. Osteoporosis in men. N Engl J Med. 2008;358:1474-82. doi: 10.1056/NEJMcp0707217.
6. Korea Centers for Disease Control and Prevention. Korea Health Statistics 2010: Korea National Health and Nutrition Examination Survey (KNHANES V-1). Osong, Chungcheong Buk-Do, Republic of Korea: Minstry of Health & Welfare; 2011.
7. National Center for Health Statistics. Summary health statistics for the U.S. adult: National Health Interview Survey 2010. Vital Health Stat. 2012;252:1-207.
8. Seeman E, Melton Iii LJ, O'Fallon WM, Riggs BL. Risk factors for spinal osteoporosis in men. Am J Med. 1983;75:977-83. doi: 10.1016/0002-9343(83)90878-1.
9. Gordon GG, Altman K, Southren AL, Rubin E, Lieber CS. Effect of alcohol (ethanol) administration on sex-hormone metabolism in normal men. N Engl J Med. 1976;295:793-7.

doi: 10.1056/NEJM197610072951501.
10. Kim MJ, Shim MS, Kim MK, Lee Y, Shin YG, Chung CH, Kwon SO. Effect of chronic alcohol ingestion on bone mineral density in males without liver cirrhosis. Korean J Intern Med. 2003;18:174-80.
11. Joo NS, Kong MH, Kim BT, Park SB, Lee TY, Kim KM. Impact of smoking and alcohol intake on bone Mineral density in men. J Korean Acad Fam Med. 2006;11:911-16. (In Korean)
12. May H, Murphy S, Khaw KT. Alcohol consumption and bone mineral density in older men. Gerontology. 1995;41: 152-8. doi: 10.1159/000213676.
13. Holbrook TL, Barrett-Connor E. A prospective study of alcohol consumption and bone mineral density. BMJ. 1993; 306:1506-9. doi: 10.1136/bmj.306.6891.1506.
14. McLernon DJ, Powell JJ, Jugdaohsingh R, Macdonald HM. Do lifestyle choices explain the effect of alcohol on bone mineral density in women around menopause? Am J Clin Nutr. 2012;95:1261-9. doi: 10.3945/ajcn.111.021600.
15. Lavado-Garcia J, Moran J, Lopez-Arza LG, Costa-Fernandez C, Guerrero-Bonmatty R, Lopez-Arza MG. Effect of alcohol consumption on bone mineral density in healthy elderly Spanish males. Endocrine Abstracts. 2012;29:162.
16. Marrone JA, Maddalozzo GF, Branscum AJ, Hardin K, Cialdella-Kam L, Philbrick KA et al. Moderate alcohol intake lowers biochemical markers of bone turnover in postmenopausal women. Menopause. 2012;19:974-9. doi: 10.1097/gme.0b013e31824ac071.
17. Kanis JA. Assessment of osteoporosis at the primary health care level. Technical Report. University of Sheffield Medical School, UK: WHO Collaborating Centre for Metabolic Bone Diseases; 2008
18. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol. 1986;1:17-27.
19. Oh JY, Yang YJ, Kim BS, Kang JH. Validity and reliability of Korean version of International Physical Activity Questionnaire (IPAQ) short form. Journal of the Korean Academy of Family Medicine. 2007;7:532-41. (In Korean)
20. Kim EH, Joh HK, Kim EY, Cho DY, Kweon HJ, Choi JK, Lym YL, Do HJ, Oh SW. Biochemical markers and health behavior related with bone mineral density in adult men. Korean J Fam Med. 2009;30:359-68. (In Korean)
21. Mukamal KJ, Robbins JA, Cauley JA, Kern LM, Siscovick DS. Alcohol consumption, bone density, and hip fracture among older adults: the cardiovascular health study. Osteoporos Int. 2007;18:593-602. doi: 10.1007/s00198-006-0287-7.
22. Felson DT, Zhang Y, Hannan MT, Kannel WB, Kiel DP. Alcohol intake and bone mineral density in elderly men and women. Am J Epidemiol. 1995;5:485-92.
23. Drake MT, Murad MH, Mauck KF, Lane MA, Undavalli C, Elraiyah T et al. Risk factors for low bone mass-related fractures in men: a systematic review and meta-analysis. J Clin Endocrinol Metab. 2012;97:1861-70. doi: 10.1210/jc. 2011-3058.
24. Medras M, Jankowska EA, Rogucka E. The effect of smoking tobacco and drinking of alcohol and coffee on bone mineral density of healthy men 40 years of age. Pol Arch Med Wewn. 2000;103:187-93. (In Polish)
25. Grainge MJ, Coupland CA, Cliffe SJ, Chilvers CE, Hosking DJ. Cigarette smoking, alcohol and caffeine consumption, and bone mineral density in postmenopausal women. The Nottingham EPIC Study Group. Osteoporos Int. 1998;8:355-63.
26. Laitinen K, Välimäki M. Alcohol and bone. Calcalif Tissue Int. 1991;49(S1):S70-3. doi: 10.1007/bf02555094.
27. Rapuri PB, Gallagher JC, Balhorn KE, Ryschon KL. Alcohol intake and bone metabolism in elderly women. Am J Clin Nutr. 2000;5:1206-13.
28. Sripanyakorn S, Jugdaohsingh R, Mander A, Davidson SL, Thompson RP, Powell JJ. Moderate ingestion of alcohol is associated with acute ethanol-induced suppression of circulating CTX in a PTH-independent fashion. J Bone Miner Res. 2009;24:1380-8. doi: 10.1359/jbmr.090222.
29. Jugdaohsingh R, O'Connell MA, Sripanyakorn S, Powell JJ. Moderate alcohol consumption and increased bone mineral density: potential ethanol and non-ethanol mechanisms. Proc Nutr Soc. 2006;65:291-310.
30. Madhan B, Subramanian V, Rao JR, Nair BU, Ramasami T. Stabilization of collagen using plant polyphenol: role of catechin. Int J Biol Macromol. 2005;37:47-53. doi: 10. 1016/j.ijbiomac.2005.08.005.

Original Article

Relationship between bone mineral density and alcohol consumption in Korean men: the Fourth Korea National Health and Nutrition Examination Survey (KNHANES), 2008-2009

Jung Hyeon Hyeon MD[1], Jong Seop Gwak MD[1], Sung Woo Hong MD[1], Hyuktae Kwon PhD[2], Seung-Won Oh PhD[2], Cheol Min Lee PhD[2]

[1] Department of Family Medicine, Seoul National University Hospital, Seoul, Korea
[2]Department of Family Medicine, Healthcare System Gangnam Center of Seoul National University Hospital, Seoul, Korea

韩国男性骨密度与饮酒的关系：2008-2009 年第四届韩国全国健康与营养调查（KNHANES）

背景与目的：饮酒是骨质疏松的一个危险因素，但关于饮酒和骨密度（BMD）之间的关系却存在争议。我们对饮酒和 BMD 之间的关系进行了分析。**方法与研究设计**：在 2008-2009 年参加韩国第四次全国健康与营养调查的 2421 名年龄在 40-93 岁的男性中进行横断面研究。酒精摄入量由自填问卷确定，BMD 的测量采用双能 X 射线吸收法测量。采用方差分析确定饮酒和 BMD 的关系，采用协方差分析校正年龄、体质指数、教育、家庭收入、吸烟、钙的摄入量、体力活动和血清 25-羟基维生素 D 的浓度。**结果**：随着酒精摄入量的增加，腰椎、全股骨和股骨颈的 BMD 显著增加（$p_{\text{-趋势}}$分别为 0.028、＜0.001 和＜0.001）。然而，校正年龄之后，这三个部位与饮酒的关系不再有统计学意义（腰椎、全股骨和股骨颈的 $p_{\text{-趋势}}$分别为 0.606、0.342 和 0.549）。此外，在校正了其他所有的混杂因素之后，这三个部位与饮酒之间也没有显著关系（腰椎、全股骨和股骨颈的 $p_{\text{-趋势}}$分别为 0.451、0.150 和 0.343）。根据年龄、吸烟、体力活动或肥胖分层分析，也没有发现饮酒与 BMD 之间有显著关系。**结论**：校正年龄和其它混杂因素之后，饮酒与 BMD 之间没有显著的关系。

关键词：骨质疏松、酒精、骨密度、KNHANES、韩国男性