Clinical Rheumatology (2019) 38:817–825
https://doi.org/10.1007/s10067-018-4354-1

ORIGINAL ARTICLE

Is knee osteoarthritis related to coffee drinking? A nationwide cross-sectional observational study

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Received: 25 July 2018 / Revised: 16 October 2018 / Accepted: 26 October 2018 / Published online: 5 November 2018

Abstract

Aims Coffee is one of the most consumed beverages globally, and coffee consumption is increasing. Osteoarthritis (OA), the most common musculoskeletal disease in the elderly, is also becoming more prevalent. Coffee is associated with various diseases, but there has not yet been a study of the relationship between coffee and knee OA. Therefore, we investigated this relationship in elderly Koreans.

Methods Data from 2012 to 2013 were collected from the Korea National Health and Nutrition Examination Survey. We included 2302 participants in our study: 897 men and 1405 women. Participants with knee OA were defined as those whose knee joints exhibited radiographic change of Kellgren-Lawrence grade 2 or higher. Daily coffee consumption amounts were categorized as none, < 2 cups, 2–3 cups, 4–6 cups, and ≥ 7 cups based on self-reporting.

Results A multiple logistic regression model, the odds ratios (ORs) of knee OA in the < 2 cup, 2–3 cup, 4–6 cup, and ≥ 7 cup groups compared to the no-coffee group in men were 1.13 (95% CI 0.50–2.55), 1.79 (95% CI 0.81–3.97), 2.21 (95% CI 0.91–5.35), and 3.81 (95% CI 1.46–12.45), respectively. There was no significant association between coffee consumption and knee OA prevalence in women.

Conclusion Daily more than 7 cups of coffee drinking was associated with a prevalence of knee OA in Korean men, and although the ORs did not increase significantly across consumption levels, the prevalence of knee OA tended to increase with increasing coffee consumption.

Keywords Coffee · Knee osteoarthritis · Prevalence

Introduction

Coffee is one of the most consumed beverages in the world, and coffee consumption is increasing. Koreans consume approximately 12 cups of coffee per week, and thus drink more than one cup of coffee per day on average [1]. The health effects of coffee have become of increasing interest and have been the subject of various studies. Coffee is known to have positive effects in preventing cardiovascular disease, liver disease, type 2 diabetes, and digestive system disease (e.g., inflammatory bowel disease) [2, 3]. On the other hand, coffee has been reported to cause tooth damage and to increase the risk of osteoporosis and hip fractures, although these findings have been controversial [3, 4]. The global increase in coffee consumption indicates that it is important to identify the relationships between coffee and specific diseases, considering the increase consumption of coffee.

As the population ages, chronic disease and economic burden increase [5]. The prevalence and economic burden of musculoskeletal disorders causing chronic pain have especially increased, and various factors related to musculoskeletal disorders have been studied [6, 7]. Studies on coffee and musculoskeletal disorders have also been conducted. A meta-analysis of the association between rheumatoid arthritis (RA), a chronic inflammatory arthritis, and coffee drinking

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has shown that coffee increases the risk of RA [8]. Caffeine may increase the risk of RA by antagonizing adenosine receptors [9]; however, a previous study showed that caffeinated coffee was not significantly associated with risk of RA, but decaffeinated coffee increased the incidence of RA [10]. Coffee has been shown to increase excretion of uric acid, reducing the risk of gout [11].

Osteoarthritis (OA) is one of the most common form of arthritis in the elderly. OA starts as a degenerative disease and causes inflammation, resulting in pain and joint damage [12]. In particular, the knee is the most commonly affected large joint by OA which causes pain and physical disability [13]. The prevalence of OA is increasing with the increase in average life expectancy. In addition to age, development of OA is affected by sex, genetic factors, and environmental factors such as diet [14]. Previous studies on the relationship between diet and OA have shown that vitamin D intake and a high-fiber diet reduce the prevalence of OA [15]; however, one study reported that high-fat diet was associated with an increase in OA [16]. Coffee contains more than 800 different ingredients that can affect the human body; thus, it is difficult to determine which are associated with OA. Ingredients of coffee such as caffeine, cafestol, kahweol, and chlorogenic acid have varying effects on the body, depending on the amount consumed [3]. Although cafestol and kahweol have been suggested to reduce the risk of OA due to their antioxidant properties, the most representative component of coffee is caffeine, which has the potential to increase the incidence of OA by antagonizing adenosine and thus promoting inflammatory reactions [17]. Despite the high consumption of coffee, there has been no research on the relationship between coffee consumption and knee OA. Thus, we investigated the relationship between prevalence of knee OA and coffee consumption in an elderly Korean population.

Methods and materials

Study design and setting

This study was a nationwide cross-sectional study conducted with data from 2 years (2012–2013) of the Korea National Health and Nutrition Examination Survey (KNHANES). The KNHANES is a nationwide survey administered by the Korea Centers for Disease Control and Prevention (KCDC), and the institutional review board of the KCDC approved the study (2012-01EXP-01-2C and 2013-07CON-03-4C) [18]. The survey was conducted in accordance with the Helsinki Declaration of 2000. Among the subjects selected through proportional systemic sampling, those who provided informed consent participated in the survey. Households were randomly selected for participation and were sampled by multi-stage stratification based on geographical areas. The informed consent form provided to each participant in the survey can be viewed in the KCDC database (URL https://knhanes.cdc.go.kr/knhanes/sub04/sub04_01.do?classType=1). The requirement for informed consent for this study was exempted because it was a secondary analysis based on the pre-existing KNHANES dataset.

Participants

In the 2012–2013 KNHANES, 6447 participants were older than 50 years; among them, 5990 had undergone knee joint radiography. Of the 5990 participants, 3410 did not complete the health and coffee drinking survey section, and 248 had missing information on the variables in this study. Ultimately, 2302 participants were included in our study: 897 men and 1405 women.

Main variables and covariates

Coffee consumption was surveyed based on participants' self-reports in the questionnaires. Participants were asked how many cups of coffee they drink per day, week, and month. A cup of coffee was defined as the amount of coffee containing 2 teaspoons of coffee grounds. The average caffeine content in a cup of the 10 most frequently consumed coffee brands in Korea was 48.96 ± 7.41 mg. According to coffee consumption, participants were divided into five groups: (1) do not drink coffee, (2) drink < 2 cups of coffee per day, (3) drink 2–3 cups of coffee per day, (4) drink 4–6 cups of coffee per day, and (5) drink ≥ 7 cups of coffee per day.

Knee OA was defined based on radiographic changes of the knee joint. The radiographic criterion was a knee joint Kellgren-Lawrence (KL) grade of ≥ 2. Among the participants who received knee radiologic examination and completed the questionnaires, those who were not defined as OA participants were defined as non-OA participants.

Sex, age, body mass index (BMI), hypertension (HTN), diabetes mellitus (DM), dyslipidemia, alcohol consumption, smoking status, household income, education level, and occupational cluster were considered as potential confounding variables affecting knee OA risk and coffee consumption. The participants were stratified by sex. For obesity classification, in accordance with the guidelines of the KCDC, we defined the underweight group as those with BMI < 18.5 kg/m^2, the normal group as those with BMI between 18.5 and 25 kg/m^2, and the overweight group as those with BMI ≥ 25 kg/m^2. HTN was defined as an average systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or the use of antihypertensive medication, and prehypertension was defined as a blood pressure ≥ 120/80 mmHg. DM was defined as a fasting plasma glucose (FPG) level ≥ 126 mg/dL, diagnosis of DM by a clinician, or use of an oral hypoglycemic agent or injected insulin. Impaired fasting glucose (IFG) was

defined as not having DM and having a FPG level ≥ 100 mg/dL but < 126 mg/dL. Dyslipidemia was defined based on the following: total cholesterol ≥ 200 mg/dL, triglyceride ≥ 150 mg/dL, high-density lipoprotein (HDL) cholesterol < 40 mg/dL in men and < 50 mg/dL in women, or current use of any anti-dyslipidemic drug for the purpose of controlling blood lipid concentrations.

The participants were classified according to alcohol consumption as follows: heavy drinkers who consumed an average of ≥ 7 units of alcohol for men and ≥ 5 units for women ≥2 days per week, moderate drinkers who consumed more than one glass of alcohol per month over the past year, and nondrinkers who never drink or drank less than one unit of alcohol per month over the past year. One unit means one glass, which contains approximately 10 mL of alcohol. The smoking status groups comprised current, former, and nonsmokers. The education level was classified as primary school or lower, middle school, high school, and university or higher [19]. The household income levels were divided into quartiles based on monthly income converted into US dollars (USD): lowest (USD < 918.3), medium-lowest (918.3 ≤ USD < 1836.6), medium-highest (1826.6 ≤ USD < 3213.9), and highest (USD ≥ 3213.9). Occupation was defined as the type of work performed for the longest period by each participant. The occupational type was classified as white-collar for managers and professionals; pink-collar for clerks and service and sales workers; blue-collar for craft/trade workers, machine operators and assemblers, and elementary manual workers; and green-collar for agricultural/fishery workers, based on the International Standard Classification of Occupations [20].

Statistical analysis

We calculated the odds ratios (ORs) and 95% confidence intervals (95% CIs) for knee OA according to coffee consumption with gender stratification. In this study, four different logistic regression models were used to assess the association between coffee consumption and knee OA. Model I was adjusted for age and BMI; model II was adjusted for age, BMI, HTN, DM, and dyslipidemia; model III was adjusted for age, BMI, HTN, DM, dyslipidemia, alcohol consumption, and smoking status; and model IV was adjusted for age, BMI, HTN, DM, dyslipidemia, alcohol consumption, smoking status, and socioeconomic status (household income, education level, and occupational cluster). The *P* values for trends in knee OA according to coffee consumption were calculated with the Cochran-Armitage trend test. SPSS ver. 23.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses, and a *P* value of 0.05 or less was considered to indicate significance.

Results

Baseline characteristics

The prevalence of knee OA among the participants in this study was 17.4% for men, 28.5% for women, and 24.2% overall. For both men and women, participants in the OA group were older and had significantly higher BMIs than those in the non-OA group. In men, the consumption levels of alcohol, tobacco, and coffee were significantly higher in the OA group than in the non-OA group, whereas these measures did not differ significantly between the two groups in women. Table 1 displays the baseline characteristics of the participants with and without knee OA.

Table 2 details the demographic characteristics of the male and female participants according to coffee consumption. In men, as coffee consumption increased, the prevalence of HTN decreased, while the prevalence of dyslipidemia increased. The percentage of smokers also increased as coffee consumption increased. In women, the higher was the consumption of coffee, the lower was the prevalence of obesity but the higher was the prevalence of heavy drinking and current smoking. In addition, the higher was the consumption of coffee, the higher was the education level.

Relationship between coffee consumption and knee OA

In the crude model, the prevalence of knee OA was higher in men drinking ≥ 7 cups of coffee per day (OR 2.57, 95% CI 1.17–7.62) than in those who did not drink coffee at all. In all the other models (I to IV), in which the variables were sequentially adjusted, the prevalence of knee OA remained significantly higher in men drinking ≥ 7 cups of coffee per day than in those who did not drink coffee. In addition, although the ORs did not increase significantly across consumption levels, the prevalence of knee OA in men tended to increase as coffee consumption increased (Table 3; Fig. 1). However, there was no significant association between coffee consumption and the prevalence of knee OA in women.

Discussion

This was the first study of the relationship between coffee consumption and knee OA, showing that consumption of coffee in men was associated with knee OA. There have been many previous studies on coffee intake and various diseases, and the results have varied. A recent meta-analysis of the association of coffee consumption with various diseases revealed that usual levels of coffee intake were not significantly associated with disease, and the authors recommended that pregnant women or women at high risk of fractures should

Table 1 Characteristics of the participants with and without knee OA

	Male ($n = 897$)			Female ($n = 1405$)		
	OA ($n = 156$)	Non-OA ($n = 741$)	*P*	OA ($n = 400$)	Non-OA ($n = 1005$)	*P*
Age (years)	58.40 ± 4.32	56.94 ± 4.28	<0.001*	58.44 ± 4.39	56.04 ± 4.22	< 0.001*
Body mass index			0.001*			< 0.001*
Underweight	1 (0.6)	13 (1.8)		2 (0.5)	17 (1.7)	
Normal	77 (49.4)	458 (61.8)		204 (51.0)	703 (79.9)	
Overweight	78 (50.0)	270 (36.4)		194 (48.5)	285 (28.4)	
Hypertension			0.015*			< 0.001*
Normal	40 (25.7)	205 (27.7)		124 (31.0)	415 (41.3)	
Prehypertension	37 (23.7)	222 (29.9)		94 (23.5)	282 (28.1)	
Hypertension	79 (50.6)	314 (42.4)		182 (45.5)	308 (30.6)	
Diabetes mellitus			0.932			0.002*
Normal	75 (48.1)	338 (45.6)		242 (60.5)	679 (67.6)	
Impaired fasting glucose	47 (30.1)	264 (35.6)		97 (24.3)	227 (22.6)	
Diabetes mellitus	34 (21.8)	139 (18.8)		61 (15.2)	99 (9.8)	
Dyslipidemia			0.053			0.513
None	152 (97.4)	714 (96.4)		388 (97.0)	981 (97.6)	
Yes	4 (2.6)	27 (3.6)		12 (3.0)	24 (2.4)	
Alcohol			0.038*			0.143
Nondrinkers	25 (16.0)	131 (17.7)		189 (47.2)	424 (42.2)	
Moderate drinkers	89 (57.1)	480 (64.8)		202 (50.5)	563 (56.0)	
Heavy drinkers	42 (26.9)	130 (17.5)		9 (2.3)	18 (1.8)	
Smoking			0.021*			0.534
Nonsmokers	23 (14.7)	114 (15.4)		369 (92.2)	942 (93.7)	
Former smokers	72 (46.2)	370 (49.9)		14 (3.5)	24 (2.4)	
Current smokers	61 (39.1)	257 (34.7)		17 (4.3)	39 (3.9)	
Income level			0.042*			< 0.001*
Lowest	27 (17.3)	73 (9.9)		94 (23.5)	130 (12.9)	
Lower middle	36 (23.1)	178 (24.0)		114 (28.5)	275 (27.4)	
Upper middle	42 (36.9)	216 (29.1)		92 (23.0)	266 (26.5)	
Highest	51 (32.7)	274 (37.0)		100 (25.0)	334 (33.2)	
Education level			< 0.001*			< 0.001*
Primary school or lower	45 (28.8)	143 (19.3)		190 (47.5)	330 (32.8)	
Middle school	33 (21.2)	124 (16.7)		85 (21.2)	216 (21.5)	
High school	55 (35.3)	277 (37.4)		98 (24.5)	332 (33.0)	
University or higher	23 (14.7)	197 (26.6)		27 (6.8)	127 (12.7)	
Occupation			0.014*			0.004*
None	42 (26.9)	130 (17.5)		202 (50.5)	455 (45.3)	
White-collar	26 (16.7)	170 (22.9)		16 (4.0)	88 (8.7)	
Pink-collar	14 (9.0)	77 (10.4)		71 (17.7)	210 (20.9)	
Green-collar	18 (11.5)	87 (11.7)		43 (10.8)	77 (7.7)	
Blue-collar	56 (35.9)	277 (37.4)		68 (17.0)	175 (17.4)	
Daily coffee consumption			0.023*			0.471
None	9 (5.8)	55 (7.4)		54 (13.5)	142 (14.1)	
< 2cups	40 (25.6)	246 (33.2)		189 (47.2)	459 (45.7)	
2–3 cups	72 (46.2)	309 (41.7)		137 (34.2)	327 (32.5)	
4–6 cups	27 (17.3)	112 (15.1)		17 (4.3)	65 (6.5)	
≥ 7 cups	8 (5.1)	19 (2.6)		3 (0.8)	12 (1.2)	

Values are presented as mean ± standard deviation or number (%)

OA osteoarthritis

*Significant value

be cautious about drinking coffee [21]. In our study, the prevalence of knee OA was not associated with coffee consumption in women, but was statistically elevated in men drinking ≥ 7 cups of coffee per day. Considering that the average daily coffee consumption in Korea is approximately 1.7 cups [1], coffee consumption at the average daily dose was not related to the prevalence of knee OA. However, it is important to note that the prevalence of knee OA tended to increase as coffee consumption increased in men.

Since the ingredients of coffee include hundreds of different substances [3], it is difficult to determine which constituents affect different diseases. Coffee has generally been reported to have antioxidant and anti-inflammatory activities. Caffeic acid, cafestol, and ferulic acid inhibit the production

Table 2 Demographic characteristics of the study subjects according to coffee consumption, (A) male, (B) female

Male	Coffee consumption ($n = 833$)				No coffee ($n = 64$)	P
	≥ 7 cups ($n = 27$)	4–6cups ($n = 139$)	2–3 cups ($n = 381$)	< 2 cups ($n = 286$)		
A						
Age (years)	57.26 ± 4.81	56.14 ± 4.38	57.32 ± 4.27	57.36 ± 4.33	57.92 ± 4.05	< 0.001*
Body mass index						0.467
Underweight	0 (0.0)	4 (2.9)	3 (0.8)	4 (1.4)	3 (4.7)	
Normal	18 (66.7)	85 (61.1)	224 (58.8)	173 (60.5)	35 (54.7)	
Overweight	9 (33.3)	50 (36.0)	154 (40.4)	109 (38.1)	26 (40.6)	
Hypertension						0.016*
Normal	14 (51.9)	48 (34.5)	100 (26.3)	71 (24.8)	12 (18.8)	
Prehypertension	4 (14.8)	39 (8.1)	114 (29.9)	83 (29.0)	19 (29.7)	
Hypertension	9 (33.3)	52 (37.4)	167 (43.8)	132 (46.2)	33 (51.5)	
Diabetes mellitus						0.278
Normal	16 (59.3)	71 (51.1)	176 (46.2)	123 (43.0)	27 (42.2)	
Impaired fasting glucose	7 (25.9)	48 (34.5)	128 (33.6)	105 (36.7)	23 (35.9)	
Diabetes mellitus	4 (14.8)	20 (14.4)	77 (20.2)	58 (20.3)	14 (21.9)	
Dyslipidemia						0.043*
None	25 (92.6)	132 (95.0)	372 (94.6)	275 (96.2)	62 (96.9)	
Yes	2 (7.4)	7 (5.0)	9 (2.4)	11 (3.8)	2 (3.1)	
Alcohol						0.117
Nondrinkers	10 (37.0)	29 (20.9)	61 (16.0)	40 (14.0)	16 (24.9)	
Moderate drinkers	13 (48.2)	84 (60.4)	246 (64.6)	190 (66.4)	36 (56.3)	
Heavy drinkers	4 (14.8)	26 (18.7)	74 (19.4)	56 (19.6)	12 (18.8)	
Smoking						< 0.001*
Nonsmoker	1 (3.7)	12 (8.6)	47 (12.3)	62 (21.7)	15 (23.4)	
Former smokers	7 (25.9)	55 (39.6)	189 (49.6)	155 (54.2)	36 (56.3)	
Current smokers	19 (70.4)	72 (51.8)	145 (38.1)	69 (24.1)	13 (20.3)	
Income						0.568
Lowest	1 (3.7)	15 (10.8)	42 (11.0)	33 (11.5)	9 (14.1)	
Lower middle	7 (25.9)	31 (22.3)	105 (27.6)	62 (21.7)	9 (14.1)	
Upper middle	12 (44.5)	40 (28.8)	105 (27.6)	85 (29.7)	16 (24.9)	
Highest	7 (25.9)	53 (38.1)	129 (33.8)	106 (37.1)	30 (46.9)	
Education						0.816
Primary school or lower	5 (18.5)	31 (22.3)	86 (22.6)	54 (18.9)	12 (18.8)	
Middle school	6 (22.2)	19 (13.7)	73 (19.2)	47 (16.4)	12 (18.8)	
High school	10 (37.1)	50 (36.0)	129 (33.8)	120 (42.0)	23 (35.9)	
University or higher	6 (22.2)	39 (28.0)	93 (24.4)	65 (22.7)	17 (26.5)	
Occupation						0.050
None	3 (11.1)	26 (18.7)	59 (15.5)	64 (22.4)	20 (31.3)	
White-collar	4 (14.8)	32 (23.0)	80 (21.0)	64 (22.4)	16 (24.9)	
Pink-collar	3 (11.1)	5 (3.6)	41 (10.7)	32 (11.2)	10 (15.6)	
Blue-collar	14 (51.9)	57 (41.0)	158 (41.5)	92 (32.1)	12 (18.8)	
Green-collar	3 (11.1)	19 (13.7)	43 (11.3)	34 (11.9)	6 (9.4)	
Knee osteoarthritis						0.020*
None	19 (70.4)	112 (80.6)	309 (81.1)	246 (86.0)	55 (85.9)	
Yes	8 (29.6)	27 (19.4)	72 (18.9)	40 (14.0)	9 (14.1)	
B						
Female	Coffee consumption ($n = 1209$)				No coffee ($n = 196$)	P
	≥ 7 cups ($n = 15$)	4-6cups ($n = 82$)	2–3 cups ($n = 464$)	< 2cups ($n = 648$)		
Age (years)	54.40 ± 3.64	55.05 ± 4.24	56.02 ± 4.35	57.13 ± 4.36	57.94 ± 4.26	< 0.001*
Body mass index						< 0.001*
Underweight	0 (0.0)	1 (1.2)	9 (1.9)	2 (0.3)	7 (3.6)	
Normal	13 (86.7)	47 (57.3)	279 (60.2)	424 (65.4)	144 (73.4)	
Overweight	2 (13.3)	34 (41.5)	176 (37.9)	222 (34.3)	45 (23.0)	
Hypertension						0.104
Normal	9 (60.0)	35 (42.7)	197 (42.5)	228 (35.2)	70 (35.7)	
Prehypertension	3 (20.0)	24 (29.3)	108 (23.3)	187 (28.8)	54 (27.6)	
Hypertension	3 (20.0)	23 (28.0)	159 (34.2)	233 (36.0)	72 (36.7)	
Diabetes mellitus						0.684
Normal	12 (80.0)	52 (63.4)	295 (63.6)	436 (67.3)	126 (64.3)	
Impaired fasting glucose	2 (13.3)	20 (24.4)	133 (28.6)	127 (19.6)	42 (21.4)	
Diabetes mellitus	1 (6.7)	10 (12.2)	36 (7.8)	85 (13.1)	28 (14.3)	
Dyslipidemia						0.052
None	15 (100)	81 (98.8)	458 (98.7)	629 (97.1)	186 (94.9)	
Yes	0 (0.0)	1 (1.2)	6 (1.3)	19 (2.9)	10 (5.1)	

Table 2 (continued)

Male	Coffee consumption ($n = 833$)				No coffee ($n = 64$)	P
	≥ 7 cups ($n = 27$)	4–6cups ($n = 139$)	2–3 cups ($n = 381$)	< 2 cups ($n = 286$)		
Alcohol						< 0.001*
Nondrinkers	6 (40.0)	32 (39.0)	174 (37.5)	278 (42.9)	123 (62.8)	
Moderate drinkers	8 (53.3)	47 (57.3)	279 (60.1)	360 (55.6)	71 (36.2)	
Heavy drinkers	1 (6.7)	3 (3.7)	11 (2.4)	10 (1.5)	2 (1.0)	
Smoking						< 0.001*
Nonsmokers	12 (80.0)	70 (85.3)	427 (92.0)	612 (94.4)	190 (97.0)	
Former smokers	0 (0.0)	3 (3.7)	14 (3.0)	18 (2.8)	3 (1.5)	
Current smokers	3 (20.0)	9 (11.0)	23 (5.0)	18 (2.8)	3 (1.5)	
Income						0.066
Lowest	1 (6.7)	7 (8.5)	59 (12.7)	119 (18.4)	38 (19.4)	
Lower middle	5 (33.3)	24 (29.3)	133 (28.7)	181 (27.9)	46 (23.5)	
Upper middle	2 (13.3)	21 (25.6)	122 (26.3)	163 (25.2)	50 (25.5)	
Highest	7 (46.7)	30 (36.6)	150 (32.3)	185 (28.5)	62 (31.6)	
Education						< 0.001*
Primary school or lower	4 (26.7)	20 (24.4)	157 (33.8)	253 (39.1)	86 (43.9)	
Middle school	3 (19.9)	10 (12.2)	106 (22.8)	142 (21.9)	40 (20.4)	
High school	4 (26.7)	34 (41.4)	152 (32.8)	186 (28.7)	54 (27.5)	
University or higher	4 (26.7)	18 (22.0)	49 (10.6)	67 (10.3)	16 (8.2)	
Occupation						< 0.001*
None	6 (40.0)	29 (35.4)	189 (40.8)	326 (50.3)	107 (54.6)	
White-collar	1 (6.7)	15 (18.3)	39 (8.4)	40 (6.2)	9 (4.6)	
Pink-collar	4 (26.7)	22 (26.8)	104 (22.4)	123 (19.0)	28 (14.3)	
Blue-collar	2 (13.3)	11 (13.4)	91 (19.6)	105 (16.2)	34 (17.3)	
Green-collar	2 (13.3)	5 (6.1)	41 (8.8)	54 (8.3)	18 (9.2)	
Knee osteoarthritis						0.490
None	12 (80.0)	65 (79.3)	327 (70.5)	459 (70.8)	142 (72.4)	
Yes	3 (20.0)	17 (20.7)	137 (29.5)	189 (29.2)	54 (27.6)	

Values are presented as mean ± standard deviation or number (%)

*Significant value

Table 3 ORs and 95% CIs of knee OA by coffee consumption, (A) male, (B) female

	None	< 2 cups		2–3 cups		4–6 cups		≥ 7 cups	
	OR	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
A									
Crude	1.00	0.99	0.46–2.17	1.42	0.67–3.01	1.47	0.65–3.35	2.57	1.17–7.62
Model I	1.00	1.04	0.47–2.29	1.48	0.69–3.16	1.80	0.78–4.15	2.75	1.18–8.51
Model II	1.00	1.06	0.48–2.34	1.49	0.69–3.20	1.82	0.78–4.23	2.75	1.19–8.52
Model III	1.00	1.06	0.47–2.37	1.51	0.69–3.29	1.87	0.79–4.42	2.85	1.19–9.09
Model IV	1.00	1.13	0.50–2.55	1.79	0.81–3.97	2.21	0.91–5.35	3.81	1.46–12.45
B									
Crude	1.00	1.08	0.76–1.55	1.10	0.76–1.60	0.69	0.37–1.28	0.66	0.18–2.42
Model I	1.00	1.08	0.74–1.57	1.23	0.83–1.83	0.81	0.42–1.56	1.12	0.30–4.27
Model II	1.00	1.09	0.75–1.58	1.25	0.83–1.86	0.83	0.43–1.60	1.14	0.30–4.35
Model III	1.00	1.09	0.75–1.60	1.25	0.84–1.88	0.80	0.41–1.57	1.08	0.28–4.13
Model IV	1.00	1.11	0.76–1.63	1.30	0.87–1.96	0.91	0.46–1.78	1.11	0.28–4.35

Model I: adjusted for age and BMI. Model II: adjusted for age, BMI, HTN, DM, and dyslipidemia. Model II: adjusted for age, BMI, HTN, DM, and dyslipidemia. Model III: adjusted for age, BMI, HTN, DM, dyslipidemia, alcohol consumption, and smoking status. Model IV: adjusted for age, BMI, HTN, DM, dyslipidemia, alcohol consumption, smoking status, and socioeconomic status

OR odds ratio, *CI* confidence interval, *OA* osteoarthritis, *BMI* body mass index, *HTN* hypertension, *DM* diabetes mellitus

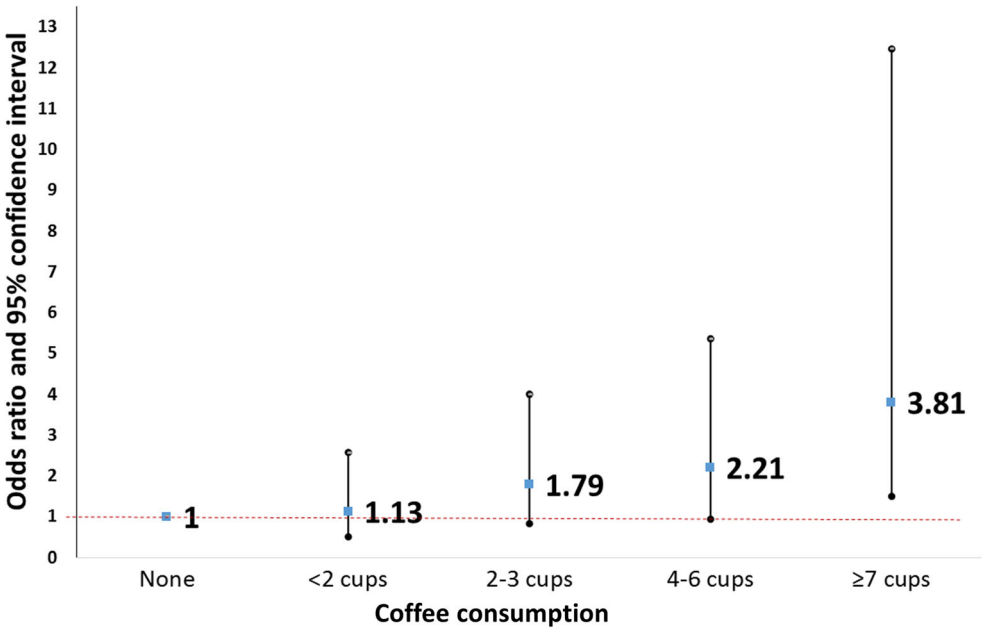

Fig. 1 Knee OA according to coffee consumption in Korean elderly men

of nitric oxide and act as scavengers of reactive oxygen species [17]. In addition, caffeine reportedly inhibits some pro-inflammatory cytokines such as tumor necrosis alpha (TNF-α) and interleukin (IL)-1 [22]. These pro-inflammatory cytokines have crucial effects on the development and progression of OA [23]. Therefore, there seems to be a negative correlation between coffee consumption and prevalence of OA. However, this study showed that coffee consumption in men positively correlated with prevalence of knee OA. The antagonism to adenosine receptors of caffeine, one of the major components of coffee, may be suggested as a cause of the association of coffee with OA [2, 24]. Caffeine also increased osteoclastogenesis, which may be associated with the higher prevalence of OA in coffee drinkers [25]. Thus, further research is needed on the effects of coffee on cartilage and the pathophysiology of OA.

Previous studies have demonstrated that coffee has different effects on various diseases according to gender [26, 27]. The prevalence of many diseases, including OA, varies according to sex. Gender-dependent differences in the effects of coffee may be related to genetic, hormonal, and environmental factors. In particular, women's hormonal factors can affect the influence of coffee on the body [28]. After menopause, the prevalence of OA increases due to changes in hormones, which is related to the presence of estrogen receptors in joint tissue [29]. Estrogen induces the synthesis of glycosaminoglycan and inhibits the expression of cyclooxygenase-2 mRNA, and estrogen deficiency causes cartilage damage. In addition, estrogen deficiency causes loss and remodeling of subchondral bone and affects the synovial lining, periarticular muscles, ligaments, and articular capsule [30]. Considering that the average menopause age of Korean women is approximately 49 years [31], this study included only women aged 50 or older, and the effect of hormone changes on OA may be greater than the effect of coffee on OA. However, coffee affects the metabolism of estrogen [32], and coffee consumption in premenopausal women has been reported to increase luteal estradiol [33]; thus, further studies on the effects of coffee on the development of OA are needed in women. Additionally, coffee consumption in women may be related to eating habits other than coffee intake [27, 34], and other foods may be related to the risk of OA, but our study did not include foods other than coffee and alcohol. Nevertheless, we adjusted our results for chronic diseases such as HTN and DM and for socioeconomic status including occupation and found that prevalence of knee OA was not associated with coffee consumption in women but was higher in men drinking more than 7 cups daily.

In this study, the prevalence of HTN in men decreased as coffee consumption increased, consistent with a previous meta-analysis [35]. In women, education level and occupation were significantly related to coffee consumption, suggesting that women are more influenced by environmental factors than men. In men and women, the higher is the coffee consumption, the greater is the percentage of smokers, suggesting that Koreans usually smoke cigarettes when they drink coffee. However, various factors may affect coffee consumption, and further study is needed.

This study has several strengths. First, using authoritative nationwide data, this study represents the association between coffee consumption and knee OA in Korea. Second, we examine the association between coffee consumption and knee OA according to gender, an important factor affecting both coffee consumption behavior and knee OA risk [36, 37].

Third, radiologic knee OA is closely related to quality of life [38], and all participants in this study received knee X-rays and were defined as having knee OA based on a KL grade ≥ 2. Fourth, our results are sequentially adjusted for various possible confounding factors, including chronic diseases, consumption habits, and socioeconomic status. Finally, this study establishes the relationship between coffee consumption and knee OA for the first time, to the best of our knowledge.

However, this study also had some limitations. Due to the cross-sectional design, the cause-and-effect relationship of the results cannot be determined, so further prospective studies and intervention trials should be performed to establish a causal association. Second, coffee consumption was estimated based on participants' self-reporting. Self-reporting can be erroneous, depending on the memory of the participant. Third, this study did not include other OA such as hand or hip OA and only included knee OA. Finally, there was no investigation of foods other than coffee. However, alcohol intake and smoking habits were included in the survey, and smoking has been shown to be associated with coffee consumption.

In conclusion, the present study demonstrated that daily more than 7 cups of coffee drinking in men was associated with a high prevalence of knee OA. Although the ORs did not increase significantly across consumption levels, the prevalence of knee OA in men tended to increase with increasing coffee intake. However, the prevalence of knee OA was not associated with coffee consumption in women.

Acknowledgements No grants or other support were received for the conduction of this study.

Compliance with ethical standards

The KNHANES is a nationwide survey administered by the Korea Centers for Disease Control and Prevention (KCDC), and the institutional review board of the KCDC approved the study (2012-01EXP-01-2C and 2013-07CON-03-4C)

Disclosures None.

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