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Original article

Coffee drink consumption pattern and its contribution of calcium and caffeine intake related to bone status in college students in Korea

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Abstract. *Background and aim:* Coffee consumption is steadily increasing especially among young adults in Korea. This study aimed to investigate the coffee drink consumption and its association with calcium and caffeine intake related to bone in young adults. *Methods:* A total of 145 male and 156 female college students aged 19–29 years participated in the study. Anthropometric measurements and a questionnaire survey were conducted. Bone mineral density (BMD) of the calcaneus was measured using quantitative ultrasound. The study participants were divided into three groups according to their coffee consumption status: high–coffee group (HC≥median of daily intake), low coffee group (LC<median of daily intake), and non-coffee group. *Results:* The average daily intake of any type of coffee was 2.72 servings for men and 1.72 servings for women in the HC, and 0.59 servings for men and 0.43 servings for women in the LC. The average calcium intake from coffee drinks was 147.54 mg/day for men and 85.31 mg/day for women in the HC, and 59.83 mg/day for men and 41.30 mg/day for women in the LC. The average caffeine intake from coffee was 301.02 mg/day for men and 190.15 mg/day for women in the HC, and 64.42 mg/day for men and 42.84 mg/day for women in the LC. The type of coffee contributing the most to calcium intake was café-made latte. Café-made black coffee contributed the most to caffeine intake. After adjusting for age, BMI, smoking, exercise, and drinking, there were no significant differences in BMD of the calcaneus among the three groups. *Conclusions:* The intake levels of calcium and caffeine varied greatly in the college students. Although coffee consumption amount and pattern may affect bone metabolism in the long term, significant differences in BMD were not found in this study.

Key words: coffee, calcium, caffeine, bone, college students

Introduction

Coffee is among the most popular beverages worldwide, and Korea is in line with this trend (1). Coffee consumption in Korea was dominated by an instant coffee mix, which was 3 in 1 coffee containing sugar and nondairy creamer together (2). However, in recent years, espresso-based coffee drinks such as Americanos, lattes, etc., which are directly made at many global or local brand cafes, have been widely consumed, especially among the young adults in Korea. In addition, the Ready-to-Drink (RTD) coffee beverages that can be easily bought at retail stores or supermarkets are also highly consumed (3, 4). As the most preferred beverage among Koreans in their 20s, take-out coffee took third place with 13.1%, and other coffee, which includes instant and canned/bottled coffee and brewed coffee, took fourth place with 12.1%. When these two types of coffees were combined, the coffee consumption was higher than carbonated

drinks, which took first place at a rate of 14.5% (4). As such, Korean young adults have a high preference for coffee, and the type of coffee they consume is changing. Accordingly, it is necessary to pay attention to coffee consumption and its effect on the health of young adults.

It has been reported that coffee consumption has protective effects on the occurrence of some diseases such as cirrhosis (5), type 2 diabetes mellitus (6), cardiovascular disease (7), metabolic syndrome (8), obesity (9), and fatty liver disease (10). The association between coffee or caffeine intake and bone mineral density is inconsistent among studies by differences in sample size, method of data collection, and amount of coffee consumed, race, age, gender, nutritional status and so on (11-14). Caffeine is known to promote calcium excretion through the kidneys and intestines, and it was reported that 112 mg of caffeine intake increases calcium loss by about~10 mg in postmenopausal women (15). According to Heaney (16), however, there was no evidence that caffeine had any detrimental effect on bone status or on the calcium economy in individuals consuming the currently recommended daily allowances of calcium. In a previous study, the content of calcium in coffee drinks was much higher in milk-containing coffee like, latte than in Americano, and in both café-made latte and Americano than in RTD coffee (17). In terms of content and cost-effectiveness, the milk-containing coffee also had higher potassium and magnesium content in addition to calcium (17).

Calcium has continually been noted to be an insufficient nutrient in the average Korean diet. The mean calcium intake among Korean adults falls below the Recommended Intake (RI) levels, with only 30.3% of Korean adults aged over 19 years meeting the mean daily requirement (18). The mean calcium intake level was reported to be 536.8 mg/day (69.0% of RI) for adult men aged over 19 years, and 450.0 mg/day (61.7% of RI) for adult women aged over 19 years (18). Calcium consumption of Korean young adults aged 19–29 years, who were in the period of achieving peak bone mass, was the lowest among the adult groups aged under 65 years (18). Bone mass increases primarily during the growth period and peak bone mass is completed by 18–30 years of age. The peak bone mass is one of the most important determinants of osteoporosis (19, 20). As it has been reported that a 10% increase in peak bone mass in early adulthood reduces fracture risk by 50% in old age (21), the formation of peak bone density at a young age is very important for skeletal health after adulthood. Therefore, a study is needed to investigate the status of coffee intake and its association with bone status in Korean young adults.

Thus, this study surveyed the consumption status of coffee drinks of male and female college students in their young adulthood and classified the study participants into high coffee consumption group, low coffee consumption group, and non–coffee group according to the coffee consumption level. This study was aimed to investigate the relationship between coffee intake status, calcium intake, and bone density by comparing the intake conditions for each type of coffee and the intake of calcium and caffeine among college students, who account for a large portion of young adults.

Method

Syudy participant

Poster and announcement notices were used to recruit 145 male and 156 female college students aged 19–29 years at Kongju National University (Chungnam, South Korea). Study participants excluded those who had thyroid disease, kidney disease, high blood pressure, or diabetes mellitus, which are metabolic diseases that affect bone density, or who had undergone female hormone therapy or hysterectomy. The survey was conducted from September 2020 to June 2021. All study participants completed a questionnaire survey, and anthropometrical measurements and calcaneal bone density measurements were performed. The study was approved by the Kongju National University institutional review board.

Among the male and female participants, the participants who did not consume coffee were divided into the non-coffee group (n=82). In the case of those who consumed coffee, those who drank in excess of the median value (men=1.12 serving/day, women=0.76 serving/day) of the sum of the average daily intake

of coffee by type were classified into the high-coffee group (*n*=104) while those who drank below the median were classified into the low–coffee group (*n*=115).

Anthropometrical measurements

Height was measured to the nearest 0.1 cm using an automatic measuring scale (DS-102, Dongsahn Jenix Co., Seoul, South Korea), and weight and percent body fat were measured using a body composition analyzer (Inbody DX-505, Bodyhealthcare Co., Seoul, South Korea). Measurements were made after removing metals to prevent the subjects's current error. Weight, BMI, and percent, body fat were used as analysis values. According to the criteria presented by the Korean Society for the study of Obesity, BMI of less than 18.5 kg/m^2 was classified as underweight, 18.5–22.9 as healthy weight, 23–24.9 as overweight, and ≥25 as obesity (22).

Questionnaire survey

A self-reported questionnaire survey was conducted. The questionnaire included the participant's gender, age, smoking status, frequency of drinking, experience of bone fracture, frequency of each type of listed coffee drink, and the 21 checklist items to evaluate overall dietary quality, which were developed and validated for Korean adults (23). Checklist items were composed of four factors: nutrition balance (intake frequency of fruits, eggs, bean and bean products, milk and dairy products, nuts, fish and shellfishes, and breakfast), food diversity (knowledge of vegetable dishes at each meal, intake frequency of water, and refusal of specific food items), moderation for the amount of food intake (intake frequency of fast food, ramyeon, night snacks, eating out or delivery food, sweet and greasy baked products, and processed beverages), and dietary behavior (checking nutrition label, efforts to have healthy eating habits, perception level for one's health, frequency of exercise over 30 minutes, and washing hands before meal). The nutrition quotient (NQ) score and the score for each area were calculated out of 100 points after multiplying the score calculated for each evaluation item by the weight and adding them all together (23).

The frequency of coffee consumption was investigated for each type of coffee (café-made black coffee, café-made latte, RTD black coffee, RTD latte, and instant coffee mix) per serving. This was converted into the average number of servings per day ('3 or more times a day'=3, '2 times a day'=2, 'once a day'=1, '5–6 times a week'=0.79, '2-4 times a week'=0.43, 'once a week'=0.14, '2-3 times a month '=0.08, 'less than once a month'=0.03, 'didn't consume coffee'=0). Calcium and caffeine intake through coffee were calculated by referring to the previous study results (cafe-made black coffee calcium=6.83 mg/serving, caffeine=146.0 mg/serving; cafe-made latte calcium=311.8 mg/serving, caffeine=102.5 mg/serving; RTD black coffee calcium=1.11 mg/serving, caffeine=99.3 mg/serving; RTD latte calcium=114.77 mg/serving, caffeine=104.1 mg/serving) presented by Lee et al. (17). In the case of instant coffee mix, calcium intake (14 mg/serving) was calculated by referring to the National Standard Food Composition table (24), and caffeine (6.366 mg/serving) content was calculated by referring to the data from the Ministry of Food and Drug Safety (25).

Measurement of bone mineral density (BMD)

Bone mineral density of the study participants was measured by trained investigator using ultrasonic equipment (SONOST 3000, Osteosys Co., Seoul, South Korea) to measure the calcaneal bone density of the left foot. The equipment was claibrated daily. At the time of measurement, socks or stockings were removed, an ultrasound measuring gel was applied to the ankle, and the ankle was placed in close contact with the sensor of the device to prevent movement in the correct posture. The measurement values obtained included bone quality index (BQI), T-score, sound of speed (SOS), and broadband ultrasound attenuation (BUA). Osteoporosis was defined as a T-score ≤ 2.5, osteopenia as T-score between -1.0 and –2.5, and normal as T-score ≥ -1.0 according to the WHO (World Health Organization) criteria (26).

Statistical analysis

The data were given numerically as means with standard deviations. The three coffee intake subgroups

underwent ANOVA analysis (One-Way Analysis of Variance) and Duncan's multiple range tests to determine any significant differences. Chi-square tests were performed to determine any significant association of the noncontiguous variables within the groups. Analysis of covariance (ANCOVA) was also used to compare least squares means (LSM) of the QUS and bone metabolism markers among the three coffee subgroups. The LSM represents the mean value adjusted for the average value of the covariates (age, BMI, smoking status, and frequency of exercise and drinking) among the three groups. Data analysis was conducted using the statistical software package for Windows (SAS version 9.4, SAS institute, USA). The significance level for all analyses was set to $p<0.05$.

Results

General characteristics

The general characteristics of the study participants are shown in Table 1. The mean age of the study participants was 22.30 years for men and 20.47 years for women, with a significant difference among the three coffee consumption groups of the male participants, showing the highest mean age in the HC ($p<0.01$) but not in the female participants. There were significant differences in body weight ($p<0.01$), BMI ($p<0.05$), and percent body fat ($p<0.05$) among the three coffee consumption subgroups in the females. But, in the males, there were no significant differences in the anthropometric measurements among the three coffee consumption groups except for body weight ($p<0.05$). The status of physical exercise and having experience of fracture were not significantly different among the three coffee consumption subgroups in both males and females. The frequency of alcohol drinking was significantly lower in the NC groups of males ($p<0.05$) and females ($p<0.01$). In men, the proportion of current smokers was the highest in the order of the HC, LC, and NC ($p<0.01$).

Diet quality

The dietary quality scores of the study participants, evaluated by the NQ for Korean adults, are shown in Table 2. The mean score of the NQ was not significantly different among the three coffee consumption subgroups in both males and females. In the males, the score of the moderation area was significantly lower in the HC than in the NC group ($p<0.05$). In all other areas, no significant difference was found between the groups according to coffee consumption in both men and women.

Consumption status of coffee drinks

The average daily intake of any type of coffee drink consumed by the study participants was 2.72 servings for men (ranging from 1.16 to 6.15) and 1.72 servings for women (ranging from 0.77 to 5.15) in the HC group; and 0.59 servings for men (ranging from 0.21 to 1.12) and 0.43 servings for women (ranging from 0.21 to 0.74) in the LC group (Table 3). The type of coffee that contributed the most to the total coffee consumption in the HC (46.43% for men, 47.57% for women) and LC (32.56% for men, 28.83% for women) was café-made black coffee, with a significant difference in the contribution rate ($p<0.01$ for men, $p<0.001$ for women). For men, the type of coffee that contributed second to the total coffee consumption in the HC was RTD black (18.71%), but café-made latte in the LC (26.30%). For women, the type of coffee that contributed second to total coffee consumption in both the HC (14.58%) and LC (24.88%) was café-made latte. The coffee type that contributed the least to total coffee consumption was RTD latte in the male (9.05%) and female (8.87%) HC groups, instant coffee mix (10.24%) in the male LC group, and RTD black coffee (9.77%) in the female LC group (Figure 1).

Intakes of calcium and caffeine from coffee drinks

The average daily calcium intake from coffee drinks was 147.54 mg for men, ranging from 32.29 mg to 906.77 mg, and 85.31 mg in women, ranging from 28.99 mg to 376.15 mg in the HC group; and 59.83 mg for men, ranging from 26.25 mg to 268.96 mg, and 41.30 mg for women, ranging from 26.25 mg to 151.67 mg in the LC group (Table 4). The average daily caffeine intake from coffee was 301.02 mg for men, ranging from 48.55 mg to 748.49 mg, and 190.15 mg

Table 1. Characteristics of the study participants aged 19–29 years.

		Male					Female				
		Total (n=145)	**HC (n=53)**	**LC (n=64)**	**NC (n=28)**	***p-value***	**Total (n=156)**	**HC (n=51)**	**LC (n=51)**	**NC (n=54)**	***p-value***
Age (years)		22.30±2.08	23.06±2.19[a]	22.03±1.89[b]	21.46±1.90[b]	0.0015	20.47±1.59	20.67±1.56	20.35±1.82	20.41±1.39	0.5696
Height (cm)		174.80±5.71	174.28±5.35	175.98±5.99	173.10±5.35	0.0579	160.86±5.68	161.13±5.76	161.50±5.68	160.00±5.60	0.3736
Weight (kg)		75.81±12.42	77.27±13.34[a]	77.06±12.11[a]	70.18±9.84[b]	0.0271	58.52±11.07	58.32±12.16[ab]	62.02±11.11[a]	55.41±8.99[b]	0.0084
BMI (kg/m^2)		24.77±3.61	25.36±3.72	24.88±3.69	23.40±2.89	0.0628	22.60±4.05	22.43±4.35[ab]	23.79±4.22[a]	21.64±3.30[b]	0.0216
Percent Body Fat (%)		22.36±6.07	22.64±6.60	22.60±6.05	21.25±5.05	0.5631	32.36±5.42	31.55±5.93[b]	34.04±5.22[a]	31.53±4.78[b]	0.0248
Exercising for at least 30 minutes	Less than twice a week	85(58.62)	28(52.83)	37(57.81)	20(71.42)	0.5877	132(84.62)	44(86.28)	44(86.28)	44(81.48)	0.5893
	3–4 times a week	34(23.45)	14(26.42)	16(25.00)	4(14.29)		15(9.61)	4(7.84)	6(11.76)	5(9.26)	
	over 5 times a week	26(17.93)	11(20.75)	11(17.19)	4(14.29)		9(5.77)	3(5.88)	1(1.96)	5(9.26)	
Experience of fracture		49(33.79)	24(45.28)	17(26.56)	8(28.57)	0.0836	21(13.46)	5(9.80)	10(19.61)	6(11.11)	0.2871
Drinking alcohol	Less than once a month	32(22.07)	9(16.98)	10(15.63)	13(46.43)	0.0128	51(32.69)	7(13.73)	18(35.30)	26(48.15)	0.0017
	2–3 times a month	40(27.59)	17(32.08)	17(26.56)	6(21.43)		49(31.41)	17(33.33)	19(37.25)	13(24.07)	
	Over once a week	73(50.34)	27(50.94)	37(57.81)	9(32.14)		56(35.90)	27(52.94)	14(27.45)	15(27.78)	
Current smoker		57(39.31)	29(54.72)	23(35.94)	5(17.86)	0.0041	12(7.69)	6(11.76)	2(3.92)	4(7.41)	0.3387

Note: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); NC: Non-coffee group. Values are mean±SD or n(%). Significant differences were determined by ANOVA test or Chi-squire test. Values followed by the different superscript letters in the same row are significantly different ($p < 0.05$) by the Duncan test.

Table 2. The nutrition quotient (NQ) score of the study participants aged 19–29 years.

	Male					Female				
	Total (n=145)	**HC (n=53)**	**LC (n=64)**	**NC (n=28)**	***p-value***	**Total (n=156)**	**HC (n=51)**	**LC (n=51)**	**NC (n=54)**	***p-value***
NQ	50.98±9.915	50.70±10.79	51.32±9.42	50.77±9.62	0.9380	47.00±8.61	46.38±8.63	47.17±8.80	47.41±8.53	0.8171
Balance	25.47±12.52	26.43±13.04	25.50±12.74	23.58±11.14	0.6239	22.85±12.97	22.34±13.37	22.21±13.09	23.93±12.64	0.7531
Diversity	58.29±17.56	60.48±19.81	57.29±16.40	56.45±15.70	0.5156	50.27±16.38	51.05±19.46	49.47±14.39	50.28±12.18	0.8892
Moderation	66.59±14.04	62.50±15.43^{b}	68.02±11.43^{ab}	71.04±15.17^{a}	0.0176	67.46±12.56	64.50±12.47	68.46±11.02	68.38±13.67	0.1095
Dietary behavior	50.03±16.73	50.83±15.49	50.76±17.58	46.87±17.22	0.5411	42.00±8.61	43.01±12.97	41.68±13.83	41.35±14.13	0.8072

Note: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); NC: Non-coffee group; NQ: Nutrition Quotient. Values are mean±SD. Significant differences were determined by ANOVA. Values followed by the different superscript letters in the same row are significantly different ($p < 0.05$) by the Duncan test.

Table 3. Coffee consumption status by type of coffee drink of the study participants aged 19–29 years.

	Male				Female			
	Total (n=117)	**HC (n=53)**	**LC (n=64)**	***p-value***	**Total (n=102)**	**HC (n=51)**	**LC (n=51)**	***p-value***
Café-made coffee (serving/day)	0.92±0.93 (0.09-5.14)	1.60±1.01 (0.20-5.14)	0.37±0.26 (0.09-0.96)	<0.0001	0.65±0.72 (0.09-3.46)	1.07±0.82 (0.14-3.46)	0.24±0.15 (0.09-0.49)	<0.0001
Café-made black coffee (serving/day)	0.68±0.82 (0.03-3.00)	1.24±0.92 (0.03-3.00)	0.22±0.24 (0.03-0.79)	<0.0001	0.51±0.71 (0.03-3.00)	0.87±0.85 (0.03-3.00)	0.14±0.15 (0.03-0.43)	<0.0001
Café-made latte (serving/day)	0.24±0.46 (0.06-3.03)	0.35±0.64 (0.06-3.03)	0.15±0.17 (0.06-0.82)	0.0273	0.15±0.17 (0.06-1.03)	0.20±0.22 (0.06-1.03)	0.10±0.07 (0.06-0.46)	0.0038
RTD coffee (serving/day)	0.46±0.68 (0.09-3.16)	0.81±0.89 (0.09-3.16)	0.17±0.14 (0.09-0.85)	<0.0001	0.26±0.46 (0.09-3.06)	0.41±0.61 (0.09-3.06)	0.12±0.05 (0.09-0.24)	0.0015
RTD black coffee (serving/day)	0.31±0.66 (0.03-3.00)	0.60±0.88 (0.03-3.00)	0.07±0.13 (0.03-0.79)	<0.0001	0.16±0.43 (0.03-3.00)	0.28±0.58 (0.03-3.00)	0.04±0.02 (0.03-0.14)	0.0047
RTD latte (serving/day)	0.14±0.24 (0.06-2.08)	0.20±0.35 (0.06-2.08)	0.09±0.06 (0.06-0.46)	0.0237	0.10±0.12 (0.06-1.08)	0.13±0.17 (0.06-1.08)	0.08±0.04 (0.06-0.17)	0.0465
Instant coffee mix (serving/day)	0.17±0.42 (0.03-3.00)	0.31±0.59 (0.03-3.00)	0.05±0.06 (0.03-0.43)	0.0022	0.16±0.30 (0.03-2.00)	0.24±0.39 (0.03-2.00)	0.07±0.11 (0.03-0.43)	0.0047
Total coffee (serving/day)	1.55±1.46 (0.21-6.15)	2.72±1.45 (1.16-6.15)	0.59±0.27 (0.21-1.12)	<0.0001	1.07±0.98 (0.21-5.15)	1.72±1.02 (0.77-5.15)	0.43±0.18 (0.21-0.74)	<0.0001

Note: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); Values are mean±SD. Significant differences were determined by student t-test. Values given in parentheses are the minimum and maximum values.

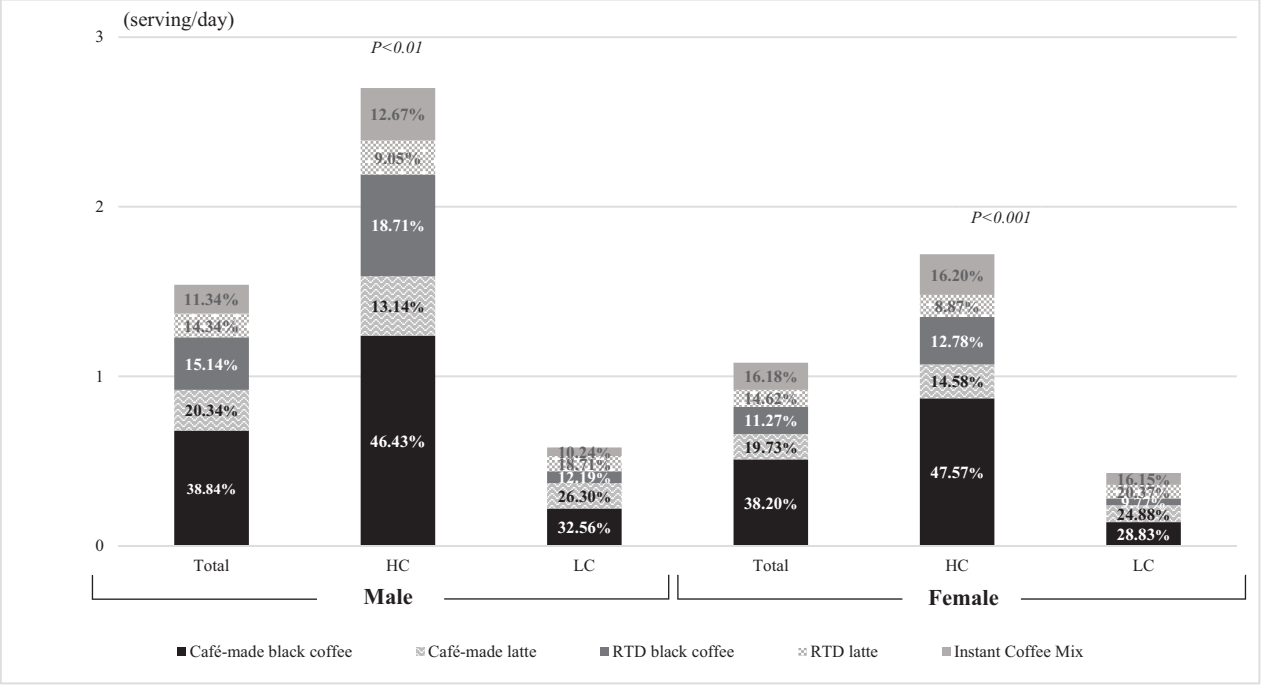

Figure 1. Daily coffee consumption and contribution rate from different types of coffee drinks among the study participants aged 19–29 years. Abbreviations: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women). Significant differences were determined by Chi-square test.

Table 4. Calcium intake from different types of the coffee drinks of the study participants aged 19–29 years.

	Male				Female			
	Total (n=117)	**HC (n=53)**	**LC (n=64)**	***p-value***	**Total (n=102)**	**HC (n=51)**	**LC (n=51)**	***p-value***
Café-made coffee (mg/day)	80.40±142.39 (18.91-947.69)	119.03±197.57 (19.66-947.69)	48.40±53.09 (18.91-256.63)	0.0142	49.23±53.72 (18.91-324.09)	67.17±68.56 (19.25-324.09)	31.28±21.69 (18.91-143.63)	0.0007
Café-made black coffee (mg/day)	4.66±5.61 (0.20-20.49)	8.49±6.30 (0.20-20.49)	1.49±1.61 (0.20-5.40)	<0.0001	3.46±4.86 (0.20-20.49)	6.00±5.82 (0.20-20.49)	0.96±1.02 (0.20-2.94)	<0.0001
Café-made latte (mg/day)	75.74±142.39 (18.71-944.75)	110.54±198.77 (18.71-944.75)	46.92±53.45 (18.71-255.68)	0.0273	45.76±53.79 (18.70-321.15)	61.20±69.85 (18.71-321.15)	30.32±21.93 (18.71-143.43)	0.0038
RTD coffee (mg/day)	16.75±27.81 (6.92-238.75)	24.10±39.47 (6.92-238.75)	10.66±7.44 (6.92-52.83)	0.0178	11.88±13.99 (6.92-125.06)	14.78±19.00 (6.92-125.06)	8.98±4.17 (6.92-19.54)	0.0376
RTD black coffee (mg/day)	0.35±0.73 (0.03-3.33)	0.67±0.98 (0.03-3.33)	0.08±0.14 (0.03-0.88)	<0.0001	0.18±0.47 (0.03-3.33)	0.31±0.65 (0.03-3.33)	0.04±0.03 (0.03-0.16)	0.0047
RTD latte (mg/day)	16.40±27.86 (6.89-238.72)	23.43±39.65 (6.89-238-72)	10.58±7.45 (6.89-52.79)	0.0237	11.70±13.94 (6.89-123.95)	14.47±18.95 (6.89-123.95)	8.93±4.17 (6.89-19.51)	0.0465
Instant coffee mix (mg/day)	2.41±5.81 (0.42-42.00)	4.41±8.19 (0.42-42.00)	0.76±0.83 (0.42-6.02)	0.0022	2.20±4.14 (0.42-28.00)	3.37±5.44 (0.42-28.00)	1.04±1.51 (0.42-6.02)	0.0047
Total coffee (mg/day)	99.56±153.98 (26.25-960.77)	147.54±212.26 (32.29-960.77)	59.83±54.10 (26.25-268.96)	0.0048	63.31±60.06 (26.25-376.15)	85.31±75.74 (28.99-376.15)	41.30±23.70 (26.25-151.67)	0.0002

Note: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women). Values are mean±SD. Significant differences were determined by student t-test. Values given in parentheses are the minimum and maximum values.

for women, ranging from 29.91 mg to 649.19 mg in the HC group; and 64.42 mg for men, ranging from 19.95 mg to 136.03 mg, and 42.84 mg for women, ranging from 19.95 mg to 89.27 mg in the LC group (Table 5).

The type of coffee that contributed the most to calcium intake in the HC (56.37% for men, 63.22% for women) and LC (71.36% for men, 70.78% for women) was café-made latte, with a significant difference in the contribution rate (p<0.001 for men, p<0.01 for women) (Fig. 2). The type of coffee that contributed the most to caffeine intake in the HC (58.68% for men, 58.45% for women) and LC (41.32% for men, 39.48% for women) was café-made black coffee, with a significant difference in the contribution rate (p<0.01 respectively) (Figure 2).

Bone status of the calcaneus

After adjusting for age, BMI, smoking status, and frequency of exercise and drinking, there were no significant differences in QUS parameters (BQI, SOS, and BUA) and T-score of the calcaneus among the three groups (Table 6).

Discussion

This study analyzed and compared calcium and caffeine intake from coffee drinks, and the BMD according to daily coffee intake status in young adults. A significant amount of calcium and caffeine was consumed by the High Coffee-consuming collegians; however, the daily coffee intake at levels presently consumed by Korean college students was not significantly associated with the bone mineral status of the calcaneus in both men and women.

Previous studies on the association between coffee intake and BMD have shown varied results (13, 27, 28). This discrepancy may be due to differences in the study targets, the evaluating methods of coffee or caffeine intake, the levels of coffee or caffeine exposure, and the analyzing methods of BMD. In our study, the coffee consumption status was investigated by developing a frequency questionnaire composed of subdivided types of coffee drinks to reflect the diversification of coffee drink types consumed by young adults in Korea. The intake amount of the coffee drinks was calculated as the average number of servings per day by multiplying the average value of the typical serving size of the same type of coffee drinks by the frequency of consumption reflecting the market research results of previous studies (17). The average amount of coffee drinks per serving applied in this study was 360.8 ml for the café-made Americano and café-made latte, 275.7 ml for RTD Americano, and 275.6 ml for RTD latte (17). In the case of instant-mixed coffee, one serving was applied as one serving stick. The calcium intake from coffee drinks was estimated based on analytic data using inductively coupled plasma optical emission spectroscopy (ICP-OES) except for instant-mixed coffee, which was applied data from the standard food composition table. In Korea, processed beverage products are required to be labeled regarding nutrition facts, but calcium is not a mandatory labeling scheme (29). In the case of cafe-made coffee, nutrition labeling is not mandatory. Therefore, the recent study on the calcium content evaluation of coffee beverages commonly consumed by Koreans made it possible to evaluate the calcium intake more accurately from coffee drinks currently consumed by young Korean adults (17).

The average daily intake of coffee drinks consumed in the HC group was 2.72 servings for men, 1.72 servings for women; and for those in the LC group, 0.59 servings for men, and 0.43 servings for women. In both men and women, the consumption rate of black coffee in the total coffee intake was significantly higher in the HC group than in the LC group, and the consumption rate of lattes was significantly lower in the HC group. This showed that the consumption of black coffee is higher than that of lattes containing milk in the high coffee consumption group. In the case of the LC group, although their absolute intake amount of coffee drinks was lower than that of the HC group, the consumption of lattes containing milk was preferred compared to the HC group.

The average daily calcium intake from coffee drinks in the HC group was 147.54 mg for men, 85.31 mg for women; and that in the LC group was 59.83 mg for men and 41.30 mg for women. These are significant amounts considering the reported average calcium consumption of Korean young adults

Table 5. Caffeine intake from different types of the coffee drinks of the study participants aged 19–29 years.

	Male				Female			
	Total (n=117)	**HC (n=53)**	**LC (n=64)**	***p-value***	**Total (n=102)**	**HC (n=51)**	**LC (n=51)**	***p-value***
Café-made coffee (mg/day)	124.48±127.86 (10.53-657.35)	217.74±137.08 (26.59-657.35)	47.25±34.84 (10.53-126.62)	<0.0001	89.09±104.30 (10.53-485.15)	147.71±120.49 (15.66-485.15)	30.47±21.11 (10.53-68.93)	<0.0001
Café-made black coffee (mg/day)	99.58±119.88 (4.38-438.00)	181.40±134.71 (4.38-438.00)	31.82±34.46 (4.38-115.34)	<0.0001	74.04±103.88 (4.38-438.00)	127.59±124.40 (4.38-438.00)	20.50±21.78 (4.38-62.78)	<0.0001
Café-made latte (mg/day)	24.90±46.81 (6.15-310.58)	36.34±65.34 (6.15-310.58)	15.42±17.57 (6.15-84.05)	0.0273	15.04±17.68 (6.15-105.58)	20.12±22.96 (6.15-105.58)	9.97±7.21 (6.15-47.15)	0.0038
RTD coffee (mg/day)	46.02±68.07 (9.23-314.56)	81.28±88.24 (9.23-314.56)	16.83±13.87 (9.23-84.69)	<0.0001	26.40±45.55 (9.23±304.15)	40.91±61.15 (9.23-304.15)	11.90±4.73 (9.23-24.60)	0.0014
RTD black coffee (mg/day)	31.15±65.13 (2.98-297.90)	60.03±87.86 (2.98-297.90)	7.23±12.50 (2.98-78.45)	<0.0001	15.79±42.43 (2.98-297.90)	27.78±57.77 (2.98-297.90)	3.80±2.46 (2.98-13.90)	0.0047
RTD latte (mg/day)	14.88±25.27 (6.25-216.53)	21.25±35.96 (6.25-216.53)	9.60±6.76 (6.25-47.89)	0.0237	10.61±12.64 (6.25-112.43)	13.12±17.19 (6.25-112.43)	8.10±3.78 (6.25-17.70)	0.0465
Instant coffee mix (mg/day)	1.10±2.64 (0.19-19.10)	2.00±3.73 (0.19-19.10)	0.35±0.38 (0.19-2.74)	0.0022	1.00±1.88 (0.19-12.73)	1.53±2.47 (0.19-12.73)	0.47±0.69 (0.19-2.74)	0.0047
Total coffee (mg/day)	171.60±170.65 (19.95-748.49)	301.02±179.58 (48.55-748.49)	64.42±35.24 (19.95-136.03)	<0.0001	116.49±121.03 (19.94-649.19)	190.15±134.24 (29.91-649.19)	42.84±22.40 (19.95-89.27)	<0.0001

Abbreviations: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women). Values are mean±SD. Significant differences were determined by student t-test. Values given in parentheses are the minimum and maximum values.

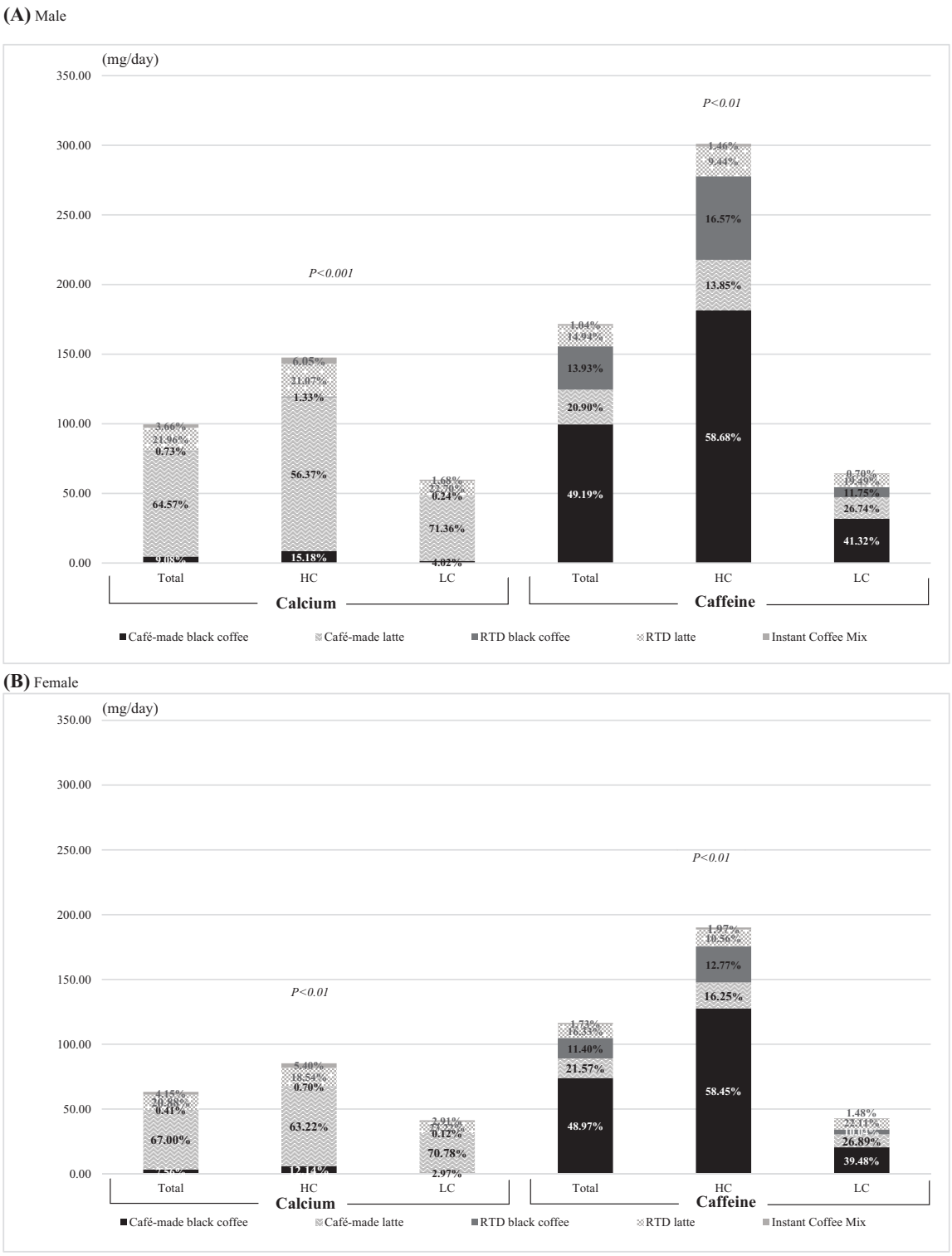

Figure 2. Contribution rate of calcium and caffeine from different types of coffee drinks in the male (A) and female (B) participants. Abbreviations: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women). Significant differences were determined by Chi-square test.

Table 6. Bone status of the study participants after adjusting for age, BMI, smoking status, and frequency of exercise and drinking.

	Male					Female				
	Total (n=145)	**HC (n=53)**	**LC (n=64)**	**NC (n=28)**	***p-value***	**Total (n=156)**	**HC (n=51)**	**LC (n=51)**	**NC (n=54)**	***p-value***
T-score	-0.70±0.86	-0.59±0.13	-0.61±0.12	-0.97±0.19	0.1969	-1.90±7.34	-1.37±0.15	-1.27±0.15	-1.30±0.14	0.7840
BQI[5]	90.90±16.10	92.96±2.48	92.67±2.32	85.82±3.55	0.1967	82.10±14.30	78.42±2.73	80.36±2.80	79.72±2.57	0.7879
SOS[6] (m/s)	1517.88±16.24	1519.36±2.48	1519.86±2.32	1511.84±3.54	0.1247	1512.16±14.46	1508.45±2.81	1511.36±2.88	1508.56±2.64	0.5282
BUA[7] (dB/MHz)	104.95±15.95	107.36±2.53	105.76±2.37	103.15±3.62	0.6398	93.54±15.19	91.06±2.87	90.73±2.95	94.03±2.70	0.4718

Abbreviations: HC: High coffee group > Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); LC: High coffee group ≤ Median of daily total coffee intake (1.12 serving/day for men, 0.76 serving/day for women); NC: Non-coffee group; BQI: Bone quality index; SOS: Sound of speed; BUA: Broadband Ultrasound Sound Attention. Values are least square mean±SE. Significant differences were determined by ANCOVA adjusting for age, BMI, smoking status, and frequency of exercise and drinking.

aged 19-29 years, 533.4 mg for men and 439.1 mg for women. This corresponds to about 10%–30% of the average daily intake, and about 5%–20% of the recommended intake for Korean adults (30).

Accurate assessment of the caffeine intake is difficult because the range of caffeine content in coffee is broad depending on the type of coffee and its production method. In our study, caffeine intake from the coffee drinks was assessed based on previously reported data using informed labels (17). It is thought that this made it possible to partially reflect the types and production methods of coffee drinks in the evaluation of caffeine intake through coffee drinks. The average daily caffeine intake from coffee in the HC group was 301.02 mg for men, 190.15 mg for women, and that in the LC group was 64.42 mg for men and 42.84 mg for women. According to Hasling et al. (15), 112 mg of caffeine intake increases calcium loss by about 10 mg; however, Heaney (16) reported that the negative effect of caffeine on calcium absorption was small enough to be fully offset by as little as 1–2 tablespoons of milk. In our study, the average calcium intake from coffee drinks widely ranged from 29.94 mg to 960.40 mg, showing 144.66 mg on average in the male HC group, and their mean caffeine intake also widely ranged from 48.44 mg to 748.49 mg (average 301.02 mg). The female HC group and the male and female LC groups showed a narrower range than the male HC group. When looking at the average of calcium and caffeine, as Heaney mentioned, it seems that calcium is supplied from the coffee drinks is sufficient to compensate for the calcium loss caused by the caffeine contained in coffee drinks. However, due to the low calcium and high caffeine of black coffee, it should not be overlooked that excessive consumption of black coffee is within the range that can cause calcium loss.

Conlisk and Galuska (28) reported that the average caffeine intake from coffee, tea, caffeinated soft drink, and chocolate in young adult women was 99.9 mg/day and the caffeine intake level was not significantly related to BMD. In a previous study of young adult males in Korea (13), who mainly consumed instant coffee mix, the study participants were divided into two groups based on calcium intake status (calcium intake ≥ 75% RI or < 75% RI) and each group was then further divided into the following three subgroups: no-coffee, less than one serving per day, and one or more servings per day. There were no significant differences in QUS parameters and serum bone metabolism indicators among either the two calcium-intake groups or the three coffee consumption subgroups. The daily caffeine intake of the study participants was calculated under 20 mg for the <one-coffee group and about 100 mg for the ≥one-coffee group. Hallström et al. (31) reported that subjects with high coffee consumption, over 4 cups a day, had 4% lower BMD at the proximal femur compared with low or non-consumers of coffee in elderly men, but not in women. However, other studies targeting men showed no association between coffee consumption and BMD (32, 33).

Our study has some limitations. First, even after some adjustments were made, potential confounding factors may have remained such as intake levels of calcium and vitamin D, as this study did not evaluate the quantitative dietary intake using 24-hour recalls or food frequency questionnaires that made it possible to investigate overall nutrient intake. Second, BMD, the main dependent variable, was measured by quantitative ultrasound of the calcaneus instead of the major sites of the femoral neck and lumbar spine using DXA measurements, so interpretation of the relevance of coffee intake to BMD may be restricted. Third, this study did not analyze bone metabolism-related biomarkers, which could reflect current bone metabolism status more than BMD. Lastly, the study had a small sample size and was recruited from a single institution, thus a larger population is needed in future studies. Despite these limitations, this study has strength in its originality and significant findings on the association between the coffee consumption status, and intake of calcium and caffeine and bone density of young people whose consumption of coffee drinks has been changing.

Conclusion

This study analyzed and compared the calcium and caffeine intake levels and BMD according to coffee drink consumption status in Korean young adults aged 19-29 years. The intake levels of calcium and caffeine significantly differed according to the intake

levels of coffee drinks. Although the coffee consumption amount and pattern may affect bone metabolism in the long term, no significant associations were found between daily coffee intake at levels presently consumed by Korean young males and females. Although coffee consumption has increased and production forms have been diversified, continuous research on coffee consumption and bone health is needed given that the problem of insufficient dietary calcium intake has yet to be resolved.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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