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Coffee Consumption is not Associated with Osteoporosis in Adult Estonians

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Abstract

Aim: The aim of this cross-sectional study was to evaluate the associations between coffee consumption and bone mineral density, body composition, and blood levels of vitamin D, calcium, leptin and adiponectin, while considering other factors influencing bone mineral density, such as age and gender.

Methods: In total, 103 subjects (no-coffee consumers, n=39; average coffee consumers (1-4 cups per day), n=40; and excessive coffee consumers (≥5 cups per day), n=24) participated, and the average coffee intake in the last 3 years was considered. Body composition, bone mineral density, and blood levels of vitamin D, calcium, leptin and adiponectin were measured. Information about coffee consumption was collected with questionnaires.

Results: Calcium and vitamin D levels were below the recommended levels in 5.8% and 34% of participants, respectively. The consumption of coffee was not associated with low bone mineral density and blood levels of leptin and adiponectin. According to linear regression analysis, coffee consumption had no connection with blood vitamin D concentration. In this study, calcium and vitamin D concentrations were not associated with bone mineral density.

Conclusion: Coffee consumption is not associated with bone mineral density or blood concentration of calcium, vitamin D, leptin or adiponectin, and therefore, coffee is not an important risk factor for osteoporosis.

Keywords: Adipocytokines; Body composition; Bone mineral density; Calcium; Coffee.

Introduction

Previously, it has been shown that the long-term consumption of coffee, both caffeinated and decaffeinated, but also simply caffeine, is associated with weight loss [1]. This association has been assumed by the fact that coffee can acutely decrease hunger [2], but its real impact on Fat Mass (FM) or Fat-Free Mass (FFM) is not clear. Body weight is one of the most important determinants of Bone Mineral Density (BMD) [3], but obesity is no longer considered to be protective against osteoporosis [4].

Coffee is a widely consumed beverage that includes a large array of components that affect human health [5]. It has been shown that a high intake of coffee could induce loss of bone minerals, as caffeine increases calcium excretion [6] and decreases calcium absorption [7]. A high consumption of coffee could lead to a small reduction in the BMD of elderly women [8] and men [9], but it is suggested that caffeine consumption does not have a detrimental effect on bone health in adults who consume calcium near or above the recommended dietary allowance of 800 mg daily [10,11].

Adiponectin [12] and leptin [13] are cytokine-like hormones that participate in energy homeostasis and contribute to the association between FM and BMD. Leptin is a possible mediator of the positive correlation between fat and bone tissue [14]. A high level of adiponectin is a risk factor for bone fracture at least in elderly men [15]. Adiponectin levels are also higher in lean persons than in overweight individuals; thus, low levels of adiponectin in obesity may confer osteoprotection [16]. Recently, it has been shown that coffee consumption is inversely associated with leptin levels [17-19], and there is a positive association between coffee consumption and adiponectin levels in blood [17, 19-21]. However, there is also several studies that do not show associations between coffee consumption and leptin [21] or adiponectin [22,23] concentrations. Therefore, the data are not conclusive.

Vitamin D has several effects on the human body, including the maintenance of normal bone metabolism [24], but the insufficiency of vitamin D is still widespread worldwide [25]. Recently, it has been suggested that several demographics, environmental, and lifestyle factors (including coffee consumption) are associated with vitamin D (in)sufficiency [26].

The aim of this study was to evaluate the associations between coffee consumption and BMD, body composition, and the blood levels of vitamin D, calcium, leptin and adiponectin, while considering other factors influencing BMD, such as age and gender.

Methods

This prospective cross-sectional study was carried out in Estonia between March 2013 and November 2014. The participants were healthy adult individuals (females before menopause) and they were divided according to survey with open questions: No-Coffee Consumers (NCC), average coffee consumers (ACC; 1-4 cups per day), and excessive coffee consumers (ECC; ≥5 cups per day). The number of cups was assessed by the average amount of caffeine. One cup was considered to contain approximately 200 ml of coffee and 100 mg of caffeine [27,28], and the highest level of healthy coffee consumption is 400-450 mg/day [29].

Venous blood samples (16.5 mL) were drawn in the morning after an overnight fast using an antecubital vein with the participant sitting in the upright position. Haematological analyses

were performed on the same day using the analyser MEK-6400J/K (Nihon Kohden, Tokyo, Japan). Plasma was separated and frozen at -20°C for subsequent analysis. Clinical chemistry analysis was carried out in the laboratory of Tartu Health Care College using analysers BS-120 (Mindray BS 120, China, Nanshan), Cobas® c111 (Roche Diagnostics, Rotkreuz, Switzerland), and Immulite® 2000 (Siemens, Munich, Germany). Adiponectin was determined in duplicate via commercially available Radioimmunoassay (RIA) kits (cat. No. HADP-61HK, Linco Research, St. Charles, MO, USA); the intra- and inter-assay CV values were <7%. Leptin was determined in duplicate by RIA (Mediagnost GmbH, Reutlingen, Germany), this assay has intra- and inter-assay CV values of less than 5%, and the lowest detection limit was 0.01 ng/ml. Vitamin D and calcium levels were measured using the ELISA and CPC methods.

Body height was measured with the use of a Martin metal anthropometer to the nearest 0.1 cm, according to the standard technique. Body mass was measured with minimal clothing to the nearest 0.05 kg with a medical electronic scale (A&D Instruments, Abingdon, UK). BMI was calculated as body mass (kg) divided by body height (m^2). Body composition (body fat %, FM, and FFM), and BMD (g/cm^2) were measured by dual-energy X-ray absorptiometry (DXA, Hologic). Participants were scanned in light clothing while lying flat on their backs with arms on their sides. BMD was determined as Whole Body (WB) BMD, and skeletal sites were determined as lumbar spine (LS; L1-L4) and Femoral Neck (FN). Coefficients of Variation (CVs) for BMD were less than 2%.

On the same day as the blood sample collection, and BMD measures, participants completed a questionnaire. The following information was collected: general characteristics of the study population (age, gender) and coffee consumption habits in last three years.

The software program Sigma Plot for Windows version 11.0 (GmbH Formation, Germany) and R 2.6.2 (A Language and Environment, http://www.r-project.org) were used for statistical analysis. Differences in proportions were compared with chi-square tests or Fisher's exact tests, and differences in values were compared with t-tests or Mann-Whitney U tests (corrected with Bonferroni) as appropriate. To assess the influence of coffee consumption and co-factors on BMD, body composition, and blood levels of vitamin D, calcium, and adipocytokines (adiponectin and leptin), univariate and multiple linear regression analyses, adjusted for gender and age, were performed. Variables that were significant in the univariate linear regression analyses at a p-value of ≤0.05 were entered the multiple regression models.

All surveys were conducted according to the ethical rules, and informed consent was obtained from all participants. The study was approved by Ethics Committee of the University of Tartu, registered at ClinicalTrials.gov with identifier number 219/T11 and adheres to the Strengthening the Reporting of Observational Studies guidelines.

Results

In total, 22 males (33.3 ± 8.7y) and 81 females (30.1 ± 9.5y) were enrolled in the study. The mean (±SD) values of measured characteristics for the study population are presented in Table 1. Participants in the ECC group were older and had higher BMIs than those in the NCC group.

FFM was higher in coffee drinkers than in non-drinkers (see Table 1). There were no differences in FM and body fat % among the study groups, although BM was higher in the ECC group than in the ACC and NCC groups. The results of univariate linear regression

analysis showed the association between coffee consumption and FFM; in comparison to the ACC group, higher FFM levels were shown in the ECC ($p \leq 0.05$) group (see Table 2). In multiple linear regression analysis, when additionally, coffee consumption was adjusted for gender and age, the relationship between coffee and FFM was not significant.

Variables n=	Mean (±SD) 103 (♀=81)	NCC 39 (♀=33)	ACC 40 (♀=33)	ECC 24 (♀=15)
Age (y)	30.80±9.37	**27.62±8.41[a]**	31.80±10.17	**34.29±8.11[a]**
Height (cm)	170.48±7.82	**172.01±8.23[c]**	**168.15±7.70[bc]**	**171.85±6.57[b]**
Body mass (kg)	69.21±16.47	69.03±19.88	**66.24±11.34[d]**	**74.45±16.99[d]**
BMI (kg/m²)	23.75±4.98	**23.20±5.96[e]**	23.45±3.47	**25.15±5.31[e]**
FM (kg)	20.80±8.55	21.22±9.32	19.90±6.45	21.63±10.37
FM %	29.78±7.08	30.37±6.09	29.87±6.87	28.67±8.88
FFM (kg)	45.35±10.40	**44.88±11.71[g]**	**43.61±8.77[f]**	**49.03±10.17[fg]**
Adiponectin	10.37±3.27	10.8±3.36	10.49±3.55	9.43±2.45
Leptin	14.83±16.63	16.44±15.7	12.86±15.54	15.48±19.82
Vitamin-D (mmol/l)	64.46±30.10	69.93±32.32	65.18±32.18	54.52±19.18
Ca^{2+} (nmol/l)	2.16±0.18	2.15±0.21	2.18±0.15	2.15±0.19

BMI - body mass index; FM - fat mass; FFM - fat free mass; BMD - bone mineral density; WB - whole body; FN - femoral neck; NCC – no-coffee consumers; ACC – average coffee consumers; ECC – excessive coffee consumers; a - p=0.001; b - p=0.032; c - p=0.022; d - p=0.043; e - p=0.031; f - p=0.028; g - p=0.048.

Table 1: Mean (±SD) of subject characteristics in study population

Marker	ECC *vs* NCC		ECC *vs* ACC		Female *vs* male		Older *vs* younger	
	Coef	P	Coef	p	Coef	P	Coef	P
A - univariate								
WB BMD	0.096	<0.001	0.102	<0.001	-0.125	<0.001	0.004	<0.001
FN BMD	NS		0.079	0.015	-0.097	0.001	NS	
L1L4 BMD	0.088	0.004	0.104	<0.001	-0.07	0.016	0.004	0.003
FFM	NS		5421	0.044	-20248	<0.001	NS	
B -multiple adjusted for age and gender								
WB BMD	0.056	0.011	0.075	<0.001	-0.103	<0.001	0.003	0.003
FN BMD	NS		0.063	0.049	-0.088	0.004	NS	
L1L4 BMD	NS		0.087	0.004	NS		0.003	0.015
FFM	NS		NS		-19972.6	<0.001	NS	

BMD-bone mineral density; WB-whole body; FN-femoral neck; FFM-fat free mass, NCC- no-coffee consumers; ACC-average coffee consumers; ECC-excessive coffee consumers.

Table 2: Univariate and multiple linear regression analyses (B) adjusted for gender and age

BMD (WB; L1-L4; FN) values according to coffee consumption levels are presented in Figure 1. The ECC group had significantly higher BMD values than the NCC and ACC groups; no differences between the NCC and ACC groups were determined. According to the results of univariate linear analysis, coffee consumption was associated with WB BMD (see Table 2). In comparison with the ACC group, the ECC group had significantly higher WB BMD, L1-L4 BMD, and FN BMD. Also, the ACC group had higher WB BMD and L1-L4 BMD (see Table 2) than did the NCC group. After adjusting the linear regression model for gender and age, the influence of coffee consumption on L1-L4 BMD (ECC *vs* NCC) disappeared, although other associations in the univariate analysis remained.

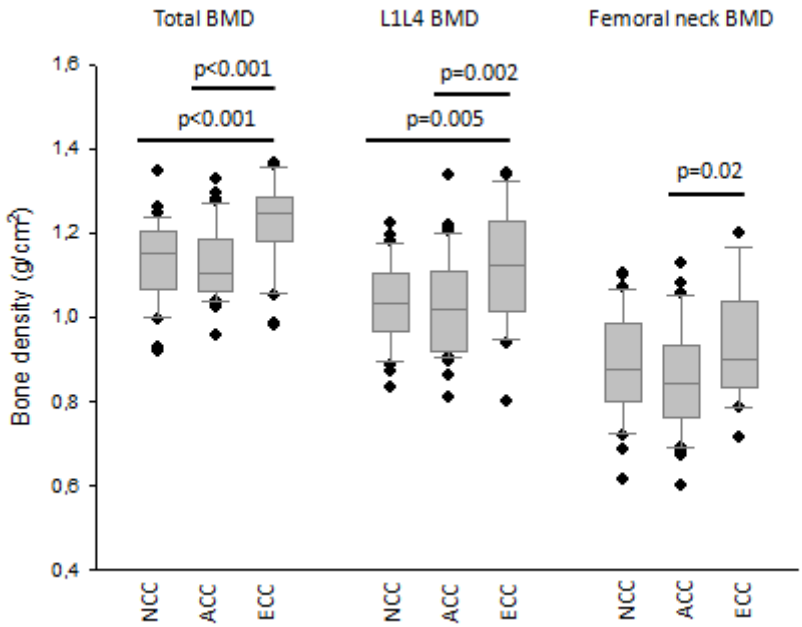

Figure 1: Bone mineral density (BMD) in coffee drinkers and non-drinkers; NCC-no-coffee consumers; ACC-average coffee consumers; ECC-excessive coffee consumers.

Linear regression analysis showed that coffee consumption does not affect participants' blood calcium levels (p=ns). A total of 15.5% of subjects (males 13.6%; females 16.1%) had calcium levels below the suggested (2.02-2.6 mmol/L) levels (NCC 20.5%; ACC 10%; ECC 16.7%). Like calcium levels, vitamin D blood concentration levels also did not differ among the study groups, but 34% of participants had vitamin D levels below the recommended levels (NCC 24.3%; ACC 43.2%; ECC 43.5%). According to linear regression analysis, coffee consumption had no connection with vitamin D blood concentration levels. In this study, calcium and vitamin D concentrations were not associated with BMD. There were also no associations between coffee consumption and the concentration of adipocytokines.

Discussion

Currently, the results that characterise the impact of caffeine on bone health are still contradictory. The results of the current study do not confirm the idea that coffee consumption is a risk factor for osteoporosis, as suggested by others.8 Although the participants in the ECC group were older, they even had significantly higher BMD values compared to those in the ACC and NCC groups. This finding is partly supported by recent studies showing that moderate coffee intake (>3 cups per day) is associated with increased BMD and reduced risk of osteoporosis, at least in Asians [30,31]. This positive association could be attributed to polyphenols in coffee, which possess oestrogenic, antioxidant, and anti-inflammatory properties that are beneficial to bone [32,33]. Previous studies have suggested that the impact of coffee consumption depends on one's genetic factors and lifestyle [34]. Physical activity exerts a strong influence on bone [35], but unfortunately, we did not measure activity levels with objective methods in our study. Nevertheless, it is well known that youngsters are currently quite inactive, and their BMD might also be affected because of their prolonged sedentary time [36].

Although the ECC group had higher body mass and BMI than the ACC and NCC groups in our study, this finding can be explained by higher FFM, which could be the result of higher physical activity levels [37] or a slightly (i.e., not statistically significant) higher proportion of males in the ECC group [38]. In accordance with [39] the lower FFM among females, which was confirmed by the results of the linear regression analysis, the proportion of males in general was relatively low. Therefore, the higher BM and BMI in the ECC group may be primarily the result of a higher proportion of males in this group, but the impact of coffee remains.

Osteoporosis affects both male and females, but it is more common in women [40], especially immediately after menopause and a gradual phase at a later stage of life [41]. The number of lifetime pregnancies [31] and breastfeeding [42] might also cause bone loss and bone health. Our results also show lower BMD in women than in men, but unfortunately, we did not collect data on pregnancies and breastfeeding. There were only 4 women over 50 years old in our study group, so the lower BMD values in women could not have been affected by age. Older subjects had even better BMD than younger participants. BMD is strongly affected by physical activity, especially in childhood [43], and our youngsters are currently increasingly inactive [44]; thus, the supposed higher levels of physical activity in childhood might explain the better BMD in older participants. In any case, our results do not confirm the idea of coffee consumption affecting bone loss [6-9], as those in the ECC group had even stronger bones.

Recent studies have used questionnaires and self-reports to evaluate vitamin D and calcium levels [45-47]. The advantage of these studies is the use of blood analysis, which gives accurate and reliable feedback about real concentration. Coffee consumption is associated with lower calcium [27,48] and vitamin D [26] levels, but there is no evidence that caffeine has any harmful effects on bone with respect to calcium balance in individuals who ingest the recommended daily allowance of calcium [49]. The data about the additional use of calcium or vitamin D supplements were not collected, but without certain indications, the consumption is improbable. The current study does not confirm the negative effect of coffee consumption on blood calcium and vitamin D levels. Participants' vitamin D levels were generally low-55% of men and 31.1% of women had blood vitamin D levels below the suggested level. On the other hand, only 5.8% of participants had calcium levels below the normal value, which is a rather positive result in comparison with that of another similar study [47]. These different results

could be influenced by the specific climate and the season of the year of the current study. Blood was taken in the winter and early spring, and as Estonia is Nordic country, sunny days during this period are quite uncommon. This climate may result in the participants' relatively low blood vitamin D levels [50].

The association between coffee and adipocytokines is still debated because of contradictory results [51,52]. Our results confirm the idea that coffee consumption is not associated with leptin [21] and adiponectin [22,23] levels. This finding might be due to the rather small number of participants in our study. It was also found that adiponectin levels increase significantly after eight cups of coffee per day compared with 0 cups per day [21], but there were no such coffee drinkers in our study. Therefore, the results could differ because of the different amounts of coffee consumption.

Conclusion

In conclusion, coffee consumption was not associated with bone mineral density and blood concentration levels of calcium, vitamin D, leptin or adiponectin; therefore, coffee might not be an important risk factor for osteoporosis.

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Conflict of Interest

The authors declare no conflict of interest.

Authors' contributions

An authorship declaration: ALP and ÜP have the substantial contribution to conception and design, analysis, interpretation of data, and writing the paper, JJ and EL carried out all DXA analysis and analysed the data, AO carried out blood analysis and analysed the data, SD and NŠ interpreted the data and formed the study design, all authors read and approved the final manuscript. All authors declare that the content has not been published elsewhere.

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