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ORIGINAL RESEARCH

Coffee and Green Tea Consumption and Cardiovascular Disease Mortality Among People With and Without Hypertension

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BACKGROUND: This study was conducted to examine the impacts of coffee and green tea consumption on cardiovascular disease (CVD) mortality among people with severe hypertension.

METHODS AND RESULTS: In the JACC (Japan Collaborative Cohort Study for Evaluation of Cancer Risk), 18 609 participants (6574 men and 12 035 women) aged 40 to 79 years at baseline who completed a lifestyle, diet, and medical history questionnaire, and health examinations, were followed up until 2009. We classified the participants into four blood pressure (BP) categories: optimal and normal BP, high-normal BP, grade 1 hypertension, and grade 2–3 hypertension. A Cox proportional hazard model was used to calculate the multivariable hazard ratios with 95% CIs of CVD mortality. During the 18.9 years of median follow-up, a total of 842 CVD deaths were documented. Coffee consumption was associated with an increased risk of CVD mortality among people with grade 2–3 hypertension; the multivariable hazard ratios (95% CI) of CVD mortality were 0.98 (0.67–1.43) for <1 cup/day, 0.74 (0.37–1.46) for 1 cup/day, and 2.05 (1.17–3.59) for ≥2 cups/day, compared with non–coffee drinkers. Such associations were not found among people with optimal and normal, high-normal BP, and grade 1 hypertension. Green tea consumption was not associated with an increased risk of CVD across any BP categories.

CONCLUSIONS: Heavy coffee consumption was associated with an increased risk of CVD mortality among people with severe hypertension, but not people without hypertension and with grade 1 hypertension. In contrast, green tea consumption was not associated with an increased risk of CVD mortality across all categories of BP.

Key Words: coffee ■ cohort study ■ diet ■ green tea ■ hypertension

Coffee consumption can reduce the risk of incident hypertension[1] and mortality among the general population,[2–4] while it can lead to a short-term increase in blood pressure (BP) among people with hypertension.[5] In an experimental study, Hartley et al compared the acute effects of the oral administration of caffeine on arterial BP among 182 men divided into 5 hypertension risk groups.[6] The most substantial acute response of BP elevation to caffeine ingestion was observed among diagnosed hypertensive groups, followed by stage 1 (systolic blood pressure [SBP] 140–159 mm Hg or diastolic blood pressure [DBP] 90–99 mm Hg) and high-normal (SBP 130–139 mm Hg or DBP 85–89 mm Hg) groups and then by normal (SBP 120–129 mm Hg or DBP 80–85 mm Hg) and optimal (SBP <120 mm Hg and DBP <80 mm Hg) groups. As an acute increase in BP can increase an individual's risk of cardiovascular disease (CVD),[7] these results can suggest that the preventive effect of caffeinated coffee consumption depends on the drinkers' BP level and applies only to people without severe hypertension.

Caffeinated green tea consumption has been shown to lower BP among people with prehypertension and stage 1 hypertension[8] and reduce the risk of mortality

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CLINICAL PERSPECTIVE

What Is New?

- Heavy coffee consumption was associated with an increased risk of cardiovascular disease mortality among people with severe hypertension but not in those without hypertension or with grade 1 hypertension.
- In contrast, green tea consumption was not associated with an increased risk of cardiovascular disease mortality across all blood pressure categories.

What Are the Clinical Implications?

- Heavy coffee consumption can increase the risk of cardiovascular disease mortality among people with severe hypertension, while green tea consumption does not increase the risk of cardiovascular disease mortality.
- The present study may support the assertion that heavy coffee consumption should be avoided among people with severe hypertension.

Nonstandard Abbreviations and Acronyms

DBP	diastolic blood pressure
JACC	Japan Collaborative Cohort Study for Evaluation of Cancer Risk
SBP	systolic blood pressure

from all causes and CVD among those with CVD[9] and the general population.[10] We recently reported that ≥7 cups of green tea consumed per day was associated with a reduced risk of all-cause mortality among people with a history of stroke or myocardial infarction by 62% and 53%, respectively, compared with nondrinkers.[9] Approximately 50% of the stroke and myocardial infarction survivors in that study had a history of hypertension, suggesting that green tea consumption may also reduce the risk of mortality among people with hypertension.

To the best of our knowledge, only 1 study of a small number of participants examined the associations between habitual coffee consumption and the risk of CVD mortality or incidence among people with hypertension across multiple BP categories.[11] In particular, little is known about whether the protective effect of coffee consumption exists for people with severe hypertension. Moreover, no study has examined whether the association between green tea consumption and the risk of CVD mortality varies across the BP categories. Therefore, this study aimed to examine and compare the effect of green tea or coffee consumption on the risk of CVD mortality across multiple BP categories in a large long-term cohort study of Japanese men and women.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Population

The JACC (Japan Collaborative Cohort Study for Evaluation of Cancer Risk) is a large, nationwide, community-based prospective study that was established between 1988 and 1990 and enrolled 110 585 individuals (46 395 men and 64 190 women) aged 40 to 79 years, living in 45 communities across Japan. The methodology of the JACC has been described elsewhere.[12] In brief, a total of 110 585 participants from 45 communities were asked to complete self-administered questionnaires, including demographic characteristics, medical history, lifestyle, and diet.

Among these participants, BP was measured for 29 928 participants (10 884 men and 19 044 women) from 30 communities who underwent health examinations conducted by municipal governments (Figure). We excluded 8267 participants (3160 men and 5107 women) in 6 communities because the questions on the frequency of green tea or coffee consumption or the questions on the number of cups of green tea and coffee consumed per day were not included in the questionnaire. Furthermore, we excluded 2483 participants (918 men and 1565 women) because of missing responses to questions about green tea and coffee consumption; 567 participants (232 men 335 women) who reported a history of stroke, coronary heart disease, or cancer at baseline; and 2 participants with outliers of pulse pressure (≤10 mm Hg). Thus, a total of 18 609 participants (6574 men and 12 035 women) from 24 communities were included in the analyses. Before completing the questionnaire, the participants or community representatives provided informed consent to participate in this epidemiological study according to the guidelines of the Council for International Organizations of Medical Sciences. Informed consent was obtained from each participant in 18 of the 24 communities. In the remaining 6 areas, group consent was obtained from each area leader. The study protocol was approved by the Ethics Committees of Hokkaido University (reference number: 14–044), Nagoya University (reference number: 177 and 227), and Osaka University (reference number: 14285–8), and in compliance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

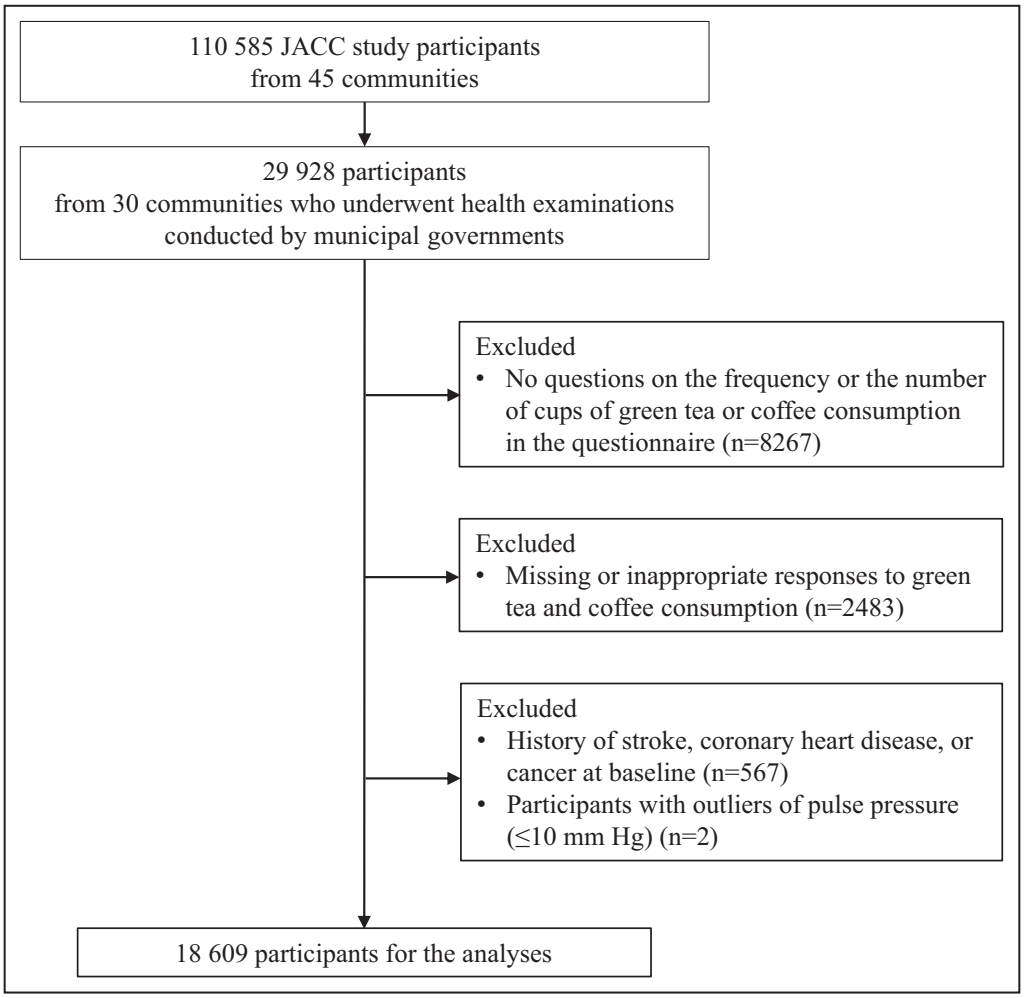

Figure. Flowchart of study population selection.
JACC indicates Japan Collaborative Cohort Study for Evaluation of Cancer Risk.

Assessment of Blood Pressure

Baseline BP was measured by trained staff using a standard mercury sphygmomanometer on the right arm of seated participants after a 5-minute rest. In principle, BP was measured twice and averaged according to the guideline from the Japanese Association for Cerebro-Cardiovascular Disease Control. According to the modified classification of the 2018 European Society of Hypertension–European Society of Cardiology guidelines,[13] we classified the participants into 5 BP categories: optimal and normal BP, high-normal BP, grade 1 hypertension, grade 2 hypertension, and grade 3 hypertension. Optimal and normal BP was defined as SBP <130 mm Hg and DBP <85 mm Hg, high normal BP as SBP 130–139 mm Hg or DBP 85–89 mm Hg, grade 1 hypertension as SBP 140–159 mm Hg or DBP 90–99 mm Hg, grade 2 hypertension as SBP of 160–179 mm Hg or DBP of 100–109 mm Hg, and grade 3 hypertension as SBP ≥180 mm Hg or DBP ≥110 mm Hg. Because of the relatively low percentage of the categories of participants with grade 3 hypertension, the categories of grade 2 and 3 hypertension were combined.

Assessment of Coffee and Green Tea Consumption

We asked participants about their frequency and amount of coffee and green tea consumed using the following choices: "almost every day," "3 to 4 cups per week," "1 to 2 cups per week," "1 to 2 cups per month," and "almost never." For those who answered "almost every day," we asked questions about the number of cups consumed per day. According to their responses to these two questions, we classified their responses into 4 levels for coffee consumption (occasionally or none, <1, 1, and ≥2 cups per day) and into 6 levels for green tea consumption (occasionally or none, <1, 1–2, 3–4, 5–6, and ≥7 cups per day). Coffee type, such as decaffeinated or caffeinated, was not asked because decaffeinated coffee was not common, and

most participants consumed instant or drip brewed coffee during the baseline survey period in Japan. The validation study of the food frequency questionnaire used in this cohort was conducted during the 1-year follow-up period, indicating a relatively higher correlation coefficient of coffee (Spearman's correlation coefficient, 0.86) and green tea (Spearman's correlation coefficient, 0.62).[14]

Assessment of Confounding Variables

Height, weight, and total cholesterol levels were measured during the health examinations. Other demographic, lifestyle, and biological factors were derived from a self-administered questionnaire at baseline: age, sex, history of diabetes, use of antihypertensive medication, smoking and alcohol drinking status, exercise and walking habits, mental status, educational level, occupation, and eating habits. Body mass index was calculated as body weight (kg) divided by height squared (m^2).

Mortality Surveillance

To determine the cause of death, a systematic review of death certificates was conducted for each area. Mortality data were sent centrally to the Ministry of Health and Welfare through the local public health center, and the underlying cause of death was coded for the National Vital Statistics according to the *International Classification of Diseases*, *Tenth Revision* (*ICD-10*). The end point of death in this study was CVD mortality defined as *ICD-10* codes: I01 to I99. The follow-up was finished by the end of 1999 in 2 areas, the end of 2003 in 1 area, the end of 2008 in 2 areas, and the end of 2009 in the rest of the areas. The date of moving from the community was verified using the population registration documents. Participants were censored when they moved from the areas.

Statistical Analysis

Person-years of follow-up were calculated as the duration from the date of the baseline questionnaire to the date of death, emigration from the community, or the end of follow-up, whichever occurred first. Age-adjusted mean values and proportions of cardiovascular risk factors were calculated using generalized linear models. Hazard ratios with 95% CIs of CVD mortality were calculated for each BP category using Cox proportional hazards regression models according to coffee and green tea consumption. We confirmed no violation for the proportional hazard assumption in all models. We adjusted for age (continuous); sex (women or men); use of antihypertensive medication (yes or no); history of diabetes (yes or no); body mass index (sex-specific quintile); total cholesterol level (mg/dL; sex-specific quintile); smoking status (never, ex-smoker, current smoker of 1–19 cigarettes per day, or current smoker of ≥20 cigarettes per day); alcohol consumption (never drinker, ex-drinker, current drinker of 0.1–45.9 g ethanol per day, or ≥46.0 g ethanol per day); hours of exercise (almost never, 1–4 hours, or ≥5 hours per week); hours of walking (almost never, 0.5 hours, or >0.5 hours per day); perceived mental stress (low, moderate, or high); educational level (≤18 or ≥19 years of age upon completion of education); employment status (unemployed or employed); frequency of consuming vegetables, fish, fruits, and soybean intakes (quintile); and coffee consumption or green tea consumption. The number of missing for each variable was as follows: use of antihypertensive medication (n=795), a history of diabetes (n=935), body mass index (n=35), total cholesterol level (n=1005), smoking (n=1126) and alcohol drinking status (n=1572), exercise (n=893) and walking habits (n=834), mental status (n=1275), educational level (n=883), employment status (n=519), and eating habits (vegetable, n=1995; fish, n=1903; fruit, n=1816; soy; n=1142). The proportion of missing for each variable was at most about 10% of the study participants. To account for missing values for each covariate, dummy variables for missing were created and put into the Cox model. In the sensitivity analysis, we repeated the same analysis by using multiple imputation techniques (10 repetitions) to impute missing covariates. SAS version 9.4 (SAS, Inc., Cary, NC) was used for the statistical analyses.

RESULTS

Table 1 shows the age-adjusted baseline characteristics of the participants by coffee consumption in each BP category. People with more frequent coffee consumption were more likely to be younger, be current smokers, be current drinkers, eat fewer vegetables, and have higher total cholesterol levels and lower SBP regardless of the BP category.

Age-adjusted baseline characteristics of the participants by green tea consumption in each BP category are presented in Table 2. People with more frequent green tea consumption were more likely to be older and less likely to be unemployed, be smokers, or eat fruits regardless of BP categories. Among people with grade 2–3 hypertension, frequent green tea consumption was associated with a lower total cholesterol level.

Risk of Cardiovascular Disease Mortality According to Coffee Consumption

During the 18.9 years of median follow-up, a total of 842 CVD deaths were documented. Among people

Table 1. Age-Adjusted Baseline Characteristics of Participants by Coffee Consumption in Each Blood Pressure Category

	Coffee consumption				
Blood pressure category	None	<1 cup/d	1 cup/d	≥2 cups/d	*P* for trend
Optimal and normal					
No. of participants	2459	3186	1204	1473	
Age, y	56.7	53.8	52.4	50.4	<0.001
Sex, male, %	26.6	32.6	25.2	34.8	<0.001
Systolic blood pressure, mm Hg	115.6	115.4	114.9	114.9	0.009
Diastolic blood pressure, mm Hg	71.0	71.3	70.7	70.9	0.29
Total cholesterol, mg/dL	192.2	192.6	195.6	196.2	<0.001
Body mass index, kg/m^2	22.4	22.6	22.3	22.3	0.06
Antihypertensive medication, %	4.4	3.2	3.2	2.6	0.008
History of diabetes, %	2.6	2.2	1.4	2.3	0.54
Current smoker, %	14.7	18.8	17.1	30.8	<0.001
Current drinker, %	29.0	37.0	29.9	35.8	0.007
High mental stress, %	17.7	17.3	18.4	23.0	<0.001
College or higher education, %	9.7	10.6	9.2	11.7	0.08
Unemployed, %	13.9	11.0	11.6	11.6	0.09
Walking≥30 min/d, %	42.8	44.1	45.0	47.4	0.006
Exercise≥1 h/wk, %	21.5	26.5	25.5	25.1	0.10
Vegetable intake, times/wk	15.8	15.0	14.9	14.4	<0.001
Fish intake, times/wk	7.4	7.0	7.1	6.7	<0.001
Fruits intake, times/wk	6.8	6.7	7.2	6.9	0.21
Soybeans intake, times/wk	5.2	5.0	4.9	4.8	<0.001
High-normal					
No. of participants	1371	1423	521	532	
Age, y	59.4	56.6	55.4	52.4	<0.001
Sex, male, %	34.2	40.8	32.3	42.2	0.02
Systolic blood pressure, mm Hg	132.2	132.5	132.0	131.8	0.02
Diastolic blood pressure, mm Hg	78.5	78.8	79.1	78.7	0.68
Total cholesterol, mg/dL	196.5	198.8	201.7	201.4	0.01
Body mass index, kg/m^2	23.1	23.1	23.2	23.1	0.89
Antihypertensive medication, %	10.7	7.3	10.5	10.1	0.71
History of diabetes, %	3.4	3.6	2.2	3.3	0.74
Current smoker, %	17.4	21.3	18.9	33.6	<0.001
Current drinker, %	36.5	40.3	37.7	40.6	0.25
High mental stress, %	14.2	13.6	13.0	19.7	0.002
College or higher education, %	7.1	11.4	9.9	11.5	0.03
Unemployed, %	18.5	14.7	14.9	16.9	0.68
Walking ≥30 min/d, %	40.2	42.6	48.4	46.3	0.02
Exercise ≥1 h/wk, %	23.7	27.4	26.5	26.0	0.55
Vegetable intake, times/wk	16.1	15.3	14.9	14.0	<0.001
Fish intake, times/wk	7.0	7.3	6.8	6.9	0.38
Fruits intake, times/wk	6.7	7.0	7.0	6.6	0.46
Soybeans intake, times/wk	5.1	5.3	5.2	4.8	0.03
Grade 1 hypertension					
No. of participants	1776	1709	577	570	
Age, y	60.5	57.9	57.1	55.0	<0.001
Sex, male, %	39.8	41.3	34.8	43.0	0.36

(*Continued*)

Table 1. Continued

Blood pressure category	Coffee consumption				*P* for trend
	None	<1 cup/d	1 cup/d	≥2 cups/d	
Systolic blood pressure, mm Hg	144.4	143.8	144.8	143.6	0.10
Diastolic blood pressure, mm Hg	85.4	85.3	85.3	85.8	0.26
Total cholesterol, mg/dL	199.0	199.4	206.0	202.4	0.02
Body mass index, kg/m^2	23.7	23.6	23.8	23.5	0.25
Antihypertensive medication, %	22.4	20.9	16.1	16.9	0.00
History of diabetes, %	5.0	3.6	1.8	3.1	0.06
Current smoker, %	20.7	21.5	20.7	29.2	<0.001
Current drinker, %	40.4	43.4	38.9	44.2	0.27
High mental stress, %	14.4	15.9	13.8	20.3	0.003
College or higher education, %	6.9	8.2	13.3	9.7	0.02
Unemployed, %	19.6	17.6	17.1	17.3	0.26
Walking≥30 min/d, %	45.3	45.3	45.4	46.7	0.56
Exercise≥1 h/wk, %	24.6	28.9	23.8	25.9	0.94
Vegetable intake, times/wk	15.4	15.3	15.5	14.9	0.25
Fish intake, times/wk	7.1	7.2	7.1	6.5	0.003
Fruits intake, times/wk	6.4	6.7	7.2	6.7	0.23
Soybeans intake, times/wk	5.0	5.2	5.2	5.0	0.53
Grade 2–3 hypertension					
No. of participants	753	633	222	200	
Age, y	61.8	59.7	58.6	56.9	<0.001
Sex, male, %	44.4	43.2	33.9	40.2	0.21
Systolic blood pressure, mm Hg	167.2	165.7	167.5	164.0	0.01
Diastolic blood pressure, mm Hg	94.6	94.6	94.3	96.8	0.007
Total cholesterol, mg/dL	202.1	202.6	203.9	212.3	0.001
Body mass index, kg/m^2	24.2	24.1	24.2	24.2	0.93
Antihypertensive medication, %	38.2	33.7	32.8	31.7	0.14
History of diabetes, %	5.9	4.4	5.9	2.4	0.09
Current smoker, %	22.1	21.4	19.7	27.6	0.10
Current drinker, %	44.4	42.2	37.7	42.2	0.58
High mental stress, %	16.0	17.1	14.3	14.3	0.44
College or higher education, %	5.2	8.6	6.2	11.7	0.009
Unemployed, %	21.0	18.7	20.1	18.1	0.46
Walking≥30 min/d, %	48.5	47.4	56.9	54.9	0.05
Exercise≥1 h/wk, %	27.0	35.9	28.5	25.4	0.22
Vegetable intake, times/wk	15.4	14.6	15.5	13.4	0.01
Fish intake, times/wk	6.7	6.9	6.8	6.4	0.38
Fruits intake, times/wk	6.9	7.1	7.1	6.5	0.26
Soybeans intake, times/wk	5.0	4.9	5.1	4.9	0.83

Data are mean for continuous variables and percentages for categorical variables.

with grade 2 to 3 hypertension, coffee consumption of ≥2 cups/day was associated with an increased risk of CVD mortality, compared with non-drinkers (Table 3). Further adjustment for potential confounding factors did not materially change the association. The multivariable hazard ratios of CVD mortality among grade 2 to 3 hypertension were 0.98 (95% CI, 0.67–1.43) for <1 cup/day, 0.74 (95% CI, 0.37–1.46) for 1 cup/day, and 2.05 (95% CI, 1.17–3.59) for ≥2 cups/day compared with non-drinkers (*P* for trend=0.09). No significant association between coffee consumption and CVD mortality was found among people with optimal and normal BP, high-normal BP, or grade 1 hypertension. In the sensitivity analysis, multiple imputation to account for missing values did not change the associations materially (Table S1).

Table 2. Age-Adjusted Baseline Characteristics of Participants by Green Tea Consumption in Each Blood Pressure Category

	Green tea consumption						
Blood pressure category	None	<1 cup/d	1–2 cups/d	3–4 cups/d	5–6 cups/d	≥7 cups/d	*P* for trend
Optimal and normal							
No. of participants	679	994	1020	2024	2245	1360	
Age, y	53.9	52.5	52.4	53.8	54.2	55.2	<0.001
Sex, male, %	25.6	28.8	33.5	27.1	30.5	34.9	<0.001
Systolic blood pressure, mm Hg	114.7	115.1	115.2	115.0	115.4	115.9	0.002
Diastolic blood pressure, mm Hg	71.0	71.1	71.1	70.8	71.1	71.3	0.51
Total cholesterol, mg/dL	196.5	192.4	193.3	193.8	194.4	191.2	0.08
Body mass index, kg/m^2	22.7	22.7	22.3	22.3	22.4	22.4	0.03
Antihypertensive medication, %	3.5	5.1	2.6	4.2	2.7	3.0	0.07
History of diabetes, %	2.5	1.5	2.1	2.2	2.2	2.6	0.41
Current smoker, %	16.0	18.3	22.8	16.2	19.4	24.5	<0.001
Current drinker, %	25.0	37.9	37.3	30.9	33.0	35.6	0.12
High mental stress, %	21.0	16.6	21.4	17.8	18.6	17.9	0.21
College or higher education, %	8.8	10.0	10.7	10.9	10.2	10.4	0.38
Unemployed, %	14.6	14.8	11.7	11.7	11.8	10.1	<0.001
Walking≥30 min/d, %	41.2	42.9	44.5	46.2	46.5	41.1	0.51
Exercise≥1 h/wk, %	22.0	23.6	26.0	25.6	24.9	23.6	0.49
Vegetable intake, times/wk	15.7	14.5	14.9	15.2	14.8	15.8	0.14
Fish intake, times/wk	7.2	6.8	7.1	7.0	7.1	7.5	0.03
Fruits intake, times/wk	6.6	5.8	6.7	7.1	7.0	7.2	<0.001
Soybeans intake, times/wk	5.0	4.8	5.0	4.9	5.1	5.2	0.04
High-normal							
No. of participants	283	443	442	907	1106	666	
Age, y	56.3	54.8	55.4	56.6	57.8	58.3	<0.001
Sex, male, %	28.4	36.9	39.6	34.1	38.0	44.2	<0.001
Systolic blood pressure, mm Hg	131.9	132.1	131.9	132.2	132.4	132.6	0.003
Diastolic blood pressure, mm Hg	78.7	79.2	78.9	78.5	78.7	78.6	0.25
Total cholesterol, mg/dL	198.6	199.2	198.3	199.4	199.5	196.8	0.62
Body mass index, kg/m^2	23.3	23.3	23.2	22.9	23.1	23.2	0.28
Antihypertensive medication, %	10.8	11.8	9.6	8.7	7.9	10.3	0.18
History of diabetes, %	2.8	4.2	4.2	3.0	2.4	4.1	0.81
Current smoker, %	16.1	21.1	23.8	18.3	22.0	24.9	0.03
Current drinker, %	30.6	43.8	44.0	37.3	37.0	39.7	0.87
High mental stress, %	15.4	13.8	12.8	14.9	15.5	13.9	0.86
College or higher education, %	7.5	9.1	11.7	8.2	10.3	10.5	0.28
Unemployed, %	22.4	22.1	15.4	16.6	12.9	16.4	<0.001
Walking ≥30 min/d, %	39.2	38.3	49.2	43.2	44.2	41.7	0.42
Exercise ≥1 h/wk, %	19.4	28.4	28.6	24.0	26.9	25.2	0.54
Vegetable intake, times/wk	14.8	14.6	15.1	15.2	15.6	15.8	0.01
Fish intake, times/wk	7.2	6.8	7.1	6.9	7.1	7.3	0.40

(*Continued*)

Table 2. Continued

	Green tea consumption						
Blood pressure category	**None**	**<1 cup/d**	**1–2 cups/d**	**3–4 cups/d**	**5–6 cups/d**	**≥7 cups/d**	***P* for trend**
Fruits intake, times/wk	6.0	5.3	7.2	6.9	7.3	7.0	<0.001
Soybeans intake, times/wk	5.2	4.9	5.2	5.1	5.3	5.2	0.39
Grade 1 hypertension							
No. of participants	347	512	550	1044	1397	782	
Age, y	57.7	56.7	57.5	58.7	58.7	59.7	<0.001
Sex, male, %	34.3	37.4	42.6	36.6	40.3	47.1	<0.001
Systolic blood pressure, mm Hg	143.5	143.5	144.6	144.5	144.2	144.0	0.17
Diastolic blood pressure, mm Hg	85.4	86.1	85.7	85.3	85.1	85.3	0.08
Total cholesterol, mg/dL	198.4	204.9	200.1	200.7	200.8	197.9	0.16
Body mass index, kg/m^2	23.8	24.0	23.6	23.7	23.5	23.5	0.02
Antihypertensive medication, %	24.8	23.0	18.2	20.8	19.1	19.9	0.04
History of diabetes, %	3.2	4.0	2.6	3.7	4.2	4.5	0.17
Current smoker, %	18.1	22.1	21.8	19.1	21.6	28.3	0.002
Current drinker, %	37.4	47.5	39.3	41.4	40.1	45.4	0.36
High mental stress, %	15.7	14.4	17.7	16.7	15.0	14.5	0.54
College or higher education, %	8.6	6.3	9.7	9.4	7.1	10.5	0.27
Unemployed, %	20.8	22.1	18.6	17.3	17.0	18.2	0.02
Walking ≥30 min/d, %	41.0	43.7	48.1	47.8	47.0	41.0	0.93
Exercise ≥1 h/wk, %	23.2	23.6	28.1	28.4	27.3	23.4	0.66
Vegetable intake, times/wk	14.9	15.3	14.6	15.2	15.2	16.3	0.005
Fish intake, times/wk	6.5	7.2	6.9	7.0	7.1	7.3	0.04
Fruits intake, times/wk	5.5	5.5	6.8	6.8	6.9	7.0	<0.001
Soybeans intake, times/wk	4.6	5.2	5.0	5.0	5.2	5.3	0.01
Grade 2–3 hypertension							
No. of participants	115	157	214	431	601	290	
Age, y	59.3	57.3	60.3	60.1	60.6	61.0	<0.001
Sex, male, %	32.3	43.0	49.0	39.9	40.2	48.2	0.11
Systolic blood pressure, mm Hg	166.3	163.1	165.1	167.0	167.4	166.1	0.05
Diastolic blood pressure, mm Hg	95.8	94.1	94.7	95.0	94.9	94.3	0.55
Total cholesterol, mg/dL	212.2	204.4	200.0	204.5	204.2	200.5	0.06
Body mass index, kg/m^2	24.4	24.2	24.0	24.0	24.2	24.1	0.68
Antihypertensive medication, %	42.4	32.4	35.2	32.8	36.1	36.1	0.65
History of diabetes, %	5.8	7.2	3.9	5.2	5.5	3.1	0.21
Current smoker, %	13.6	19.9	19.5	21.7	21.3	31.1	<0.001
Current drinker, %	38.4	51.2	47.1	39.0	41.7	43.2	0.46
High mental stress, %	19.1	11.8	17.6	14.7	17.2	15.2	0.90
College or higher education, %	6.4	4.7	8.2	9.0	6.8	6.7	0.69
Unemployed, %	24.3	25.9	17.0	23.6	17.5	16.0	0.009
Walking ≥30 min/d, %	50.3	42.9	54.1	51.9	49.6	47.6	0.96
Exercise ≥1 h/wk, %	24.2	26.6	34.1	32.8	29.8	28.2	0.51
Vegetable intake, times/wk	16.0	13.0	14.3	14.6	15.5	15.2	0.20

(*Continued*)

Table 2. Continued

	Green tea consumption						
Blood pressure category	None	<1 cup/d	1–2 cups/d	3–4 cups/d	5–6 cups/d	≥7 cups/d	*P* for trend
Fish intake, times/wk	6.9	6.5	6.8	6.6	6.9	6.7	0.97
Fruits intake, times/wk	6.1	5.3	6.6	6.9	7.5	7.2	<0.001
Soybeans intake, times/wk	4.7	4.4	5.4	4.7	5.1	5.0	0.17

Data are mean for continuous variables and percentages for categorical variables.

Risk of Cardiovascular Disease Mortality According to Green Tea Consumption

Green tea consumption was not associated with an increased risk of CVD mortality among grade 1 to 3 hypertension (Table 4). The 5 to 6 cups/day of green tea consumption among people with a high-normal BP and 1 to 2 cups/day of green tea consumption among people with optimal or normal BP were associated with a borderline reduced risk of CVD mortality in age- and sex-adjusted analyses. After the additional adjustment, the association was attenuated and no longer statistically significant. Similar associations were observed using multiple imputation to account for missing values (Table S2).

DISCUSSION

In a large prospective observational study of Japanese men and women aged 40 to 79 years with a median follow-up of 18.9 years, heavy coffee drinking (≥2 cups/day) was associated with twice the CVD mortality of no coffee drinking among those with grade 2 to 3 hypertension (SBP ≥160 or DBP ≥100), while such an association was not observed for other BP categories.

Table 3. HRs (95% CIs) of Cardiovascular Disease Mortality by Coffee Consumption in Each Blood Pressure Category

	Coffee consumption				
	None	<1 cup/d	1 cup/d	≥2 cups/d	*P* for trend
Optimal and normal					
Person-years	42 128	55 006	20 312	23 825	
No. of cases	99	78	21	30	
Mortality rate (per 1000 person-years)	2.4	1.4	1.0	1.3	
Age- and sex-adjusted HR (95% CI)	Ref	0.82 (0.61–1.10)	0.76 (0.48–1.23)	1.26 (0.83–1.90)	0.51
Multivariable HR (95% CI)	Ref	0.83 (0.61–1.12)	0.78 (0.48–1.28)	1.19 (0.77–1.85)	0.62
High-normal					
Person-years	22 953	24 297	8346	8389	
No. of cases	86	57	17	13	
Mortality rate (per 1000 person-years)	3.7	2.3	2.0	1.5	
Age- and sex-adjusted HR (95% CI)	Ref	0.73 (0.52–1.03)	0.80 (0.47–1.35)	0.84 (0.46–1.51)	0.41
Multivariable HR (95% CI)	Ref	0.75 (0.52–1.07)	0.84 (0.49–1.45)	0.75 (0.40–1.40)	0.33
Grade 1 hypertension					
Person-years	28 693	28 337	9133	8644	
No. of cases	140	89	32	25	
Mortality rate (per 1000 person-years)	4.9	3.1	3.5	2.9	
Age- and sex-adjusted HR (95% CI)	Ref	0.82 (0.63–1.07)	1.02 (0.69–1.49)	1.05 (0.68–1.62)	0.77
Multivariable HR (95% CI)	Ref	0.90 (0.68–1.19)	1.16 (0.78–1.74)	1.06 (0.68–1.66)	0.57
Grade 2–3 hypertension					
Person-years	11 602	9673	3047	2688	
No. of cases	77	49	10	19	
Mortality rate (per 1000 person-years)	6.6	5.1	3.3	7.1	
Age- and sex-adjusted HR (95% CI)	Ref	0.86 (0.60–1.23)	0.71 (0.36–1.37)	1.78 (1.07–2.97)	0.16
Multivariable HR (95% CI)	Ref	0.98 (0.67–1.43)	0.74 (0.37–1.46)	2.05 (1.17–3.59)	0.09

Multivariable HR: adjusted for age, sex, green tea consumption, use of antihypertensive medication, total cholesterol levels, history of diabetes, body mass index, smoking status, alcohol consumption, hours of exercise, hours of walking, perceived mental stress, educational level, regular employment, and dietary intakes of vegetable, fish, fruits and soybeans. HR indicates hazard ratio.

Table 4. HRs (95% CIs) of Cardiovascular Disease Mortality by Green Tea Consumption in Each Blood Pressure Category

	Green tea consumption						
	None	<1 cup/d	1–2 cups/d	3–4 cups/d	5–6 cups/d	≥7 cups/d	*P* for trend
Optimal and normal							
Person-years	11 844	17 595	17 077	33 611	37 803	23 341	
No. of cases	28	22	17	54	69	38	
Mortality rate (per 1000 person-years)	2.4	1.3	1.0	1.6	1.8	1.6	
Age- and sex-adjusted HR (95% CI)	Ref	0.67 (0.38–1.17)	0.53 (0.29–0.97)	0.75 (0.47–1.18)	0.89 (0.57–1.38)	0.65 (0.40–1.07)	0.97
Multivariable HR (95% CI)	Ref	0.69 (0.39–1.22)	0.56 (0.30–1.04)	0.81 (0.51–1.30)	0.91 (0.58–1.43)	0.67 (0.40–1.10)	0.96
High-normal							
Person-years	4841	7809	7069	14 938	18 147	11 181	
No. of cases	18	22	18	41	41	33	
Mortality rate (per 1000 person-years)	3.7	2.8	2.5	2.7	2.3	3.0	
Age- and sex-adjusted HR (95% CI)	Ref	0.85 (0.46–1.59)	0.82 (0.42–1.57)	0.80 (0.46–1.40)	0.56 (0.32–0.98)	0.65 (0.37–1.16)	0.04
Multivariable HR (95% CI)	Ref	0.88 (0.46–1.69)	0.92 (0.46–1.83)	0.94 (0.53–1.68)	0.62 (0.34–1.10)	0.69 (0.38–1.27)	0.06
Grade 1 hypertension							
Person-years	5819	8768	8617	16 541	22 233	12 828	
No. of cases	23	35	32	64	70	62	
Mortality rate (per 1000 person-years)	4.0	4.0	3.7	3.9	3.1	4.8	
Age- and sex-adjusted HR (95% CI)	Ref	1.06 (0.63–1.80)	0.92 (0.54–1.57)	0.89 (0.55–1.44)	0.71 (0.45–1.14)	0.95 (0.59–1.53)	0.24
Multivariable HR (95% CI)	Ref	0.94 (0.55–1.60)	0.94 (0.54–1.63)	0.90 (0.55–1.47)	0.71 (0.43–1.15)	0.99 (0.60–1.63)	0.47
Grade 2–3 hypertension							
Person-years	1738	2619	3098	5997	8985	4573	
No. of cases	11	11	14	42	50	27	
Mortality rate (per 1000 person-years)	6.3	4.2	4.5	7.0	5.6	5.9	
Age- and sex-adjusted HR (95% CI)	Ref	0.56 (0.24–1.30)	0.53 (0.24–1.17)	0.97 (0.50–1.88)	0.68 (0.36–1.32)	0.65 (0.32–1.33)	0.83
Multivariable HR (95% CI)	Ref	0.49 (0.20–1.19)	0.62 (0.26–1.43)	1.03 (0.50–2.10)	0.75 (0.37–1.54)	0.65 (0.30–1.39)	1.00

Multivariable HR: adjusted for age, sex, coffee consumption, use of antihypertensive medication, total cholesterol levels, history of diabetes, body mass index, smoking status, alcohol consumption, hours of exercise, hours of walking, perceived mental stress, educational level, regular employment, and dietary intakes of vegetable, fish, fruits and soybeans. HR indicates hazard ratio.

In contrast, green tea consumption was not associated with an increased risk of CVD mortality across any BP category. Our results suggest that heavy coffee consumption can increase the risk of CVD mortality among people with severe hypertension, while green tea consumption does not increase the risk of CVD mortality.

To the best of our knowledge, this is the first study to find a positive association between heavy coffee consumption and CVD mortality among people with severe hypertension. In the Framingham study of 1354 participants aged ≥65 years with 10.1 years of follow-up, habitual caffeinated coffee consumption (≥1.0 versus 0 cups per day) was associated with a reduced risk of coronary heart disease mortality among persons with a BP less than stage 2 hypertension (SBP <160 mm Hg and diastolic BP <100 mm Hg) but not among those with stage 2 hypertension (SBP ≥160 mm Hg and DBP ≥100 mm Hg); the multivariable hazard ratio was 0.57 (95% CI, 0.36–0.91) and 0.87 (95% CI, 0.44–1.72), respectively.[11] In the Nurses' Health Study of 83 076 women with 24 years of follow-up, no association between habitual coffee consumption and the risk of incident stroke was observed among participants with hypertension; the relative risks of stroke across the categories of coffee consumption (<1 cup per month, 1 per month to 4 per week, 5–7 per week, 2–3 per day, and ≥4 per day) were 1.0, 0.97 (95% CI, 0.76–1.24), 0.90 (95% CI, 0.72–1.11), 0.98 (95% CI, 0.77–1.24), and 1.10 (95% CI, 0.76–1.58).[15] That study is the largest observational study to date with comprehensive adjustment for confounders, but the risks among people with severe hypertension were not investigated.

Caffeinated coffee, which contains ingredients such as chlorogenic acid and other phenolic compounds, magnesium, and trigonelline, has been shown to lower serum cholesterol levels, improve endothelial function, and reduce inflammation in women with diabetes.[16,17] Habitual coffee drinkers can also develop caffeine tolerance, which may reduce the adverse effects of caffeine on CVD outcomes.[18] The harmful cardiovascular effects of caffeine (ie, transient BP elevation) would be offset by the beneficial effects of these other components and tolerance to caffeine in the general population. However, because people with hypertension are more susceptible to the effects of caffeine,[6] caffeine's harmful effects may outweigh its protective effects and increase the risk of mortality in people with severe hypertension.

In contrast, the mechanism underlying the beneficial effects of green tea may be explained by the effect of (–)-epigallocatechin3-gallate, the most abundant polyphenol in green tea. Previous animal studies have suggested that (–)-epigallocatechin3-gallate can significantly reduce BP levels and enhance endothelial function in hypertensive rats.[19–21] (–)-epigallocatechin3-gallate can also reduce oxidative stress,[22] attenuate inflammation,[23,24] and improve the plasma lipid profile.[25] These beneficial effects of green tea catechins may partially explain why only coffee consumption was associated with an increased risk of mortality in people with severe hypertension despite both green tea and coffee containing caffeine.

The strength of the present study is its prospective design that minimizes recall bias of the exposure assessment and the sufficient number of CVD deaths among people with severe hypertension to enable the assessment of the impact of coffee and green tea consumption. Furthermore, we were able to examine the risk of a high consumption of green tea compared with studies in Western countries. However, this study also has several limitations. First, because the consumption of coffee or green tea was self-reported, false reporting could be a potential problem. Second, since there was only a single baseline assessment of BP and coffee and green tea consumption, we did not take into account for BP and the consumption changes during the follow-up. Nondifferential misclassification could result in underestimation of the association between coffee or green tea consumption and mortality outcomes across BP categories. However, a relatively high correlation coefficient of coffee (Spearman's correlation coefficient, 0.86) and green tea (Spearman's correlation coefficient, 0.62) consumption was observed at 1 year apart in the validation study.[14] Third, we cannot rule out confounding attributable to unmeasured factors or residual confounding despite our efforts to adjust for many potential confounding factors. Finally, the causality of coffee consumption in relation to CVD risk among people with hypertension cannot be determined because of the observational nature of this study.

Heavy coffee consumption was associated with an increased risk of CVD mortality among people with severe hypertension but not in those without hypertension or with grade 1 hypertension. In contrast, green tea consumption was not associated with an increased risk of CVD mortality across all BP categories. The present study may support the assertion that heavy coffee consumption should be avoided among people with severe hypertension. More research is needed to confirm the effects of coffee and green tea consumption among people with hypertension.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Multivariable hazard ratios (95% confidence intervals) of cardiovascular disease mortality according to coffee consumption after missing values were imputed using multiple imputation.

	Coffee consumption				*P* for trend
	None	1-6 Cups/Week	1 Cup/d	≥2 Cups/d	
Optimal and Normal					
Multivariable HR (95%CI)	Ref	0.86 (0.63-1.17)	0.80 (0.49-1.31)	1.21 (0.79-1.87)	0.58
High normal					
Multivariable HR (95%CI)	Ref	0.77 (0.54-1.10)	0.80 (0.47-1.39)	0.77 (0.42-1.43)	0.33
Grade 1 hypertension					
Multivariable HR (95%CI)	Ref	0.89 (0.67-1.17)	1.15 (0.77-1.72)	1.05 (0.67-1.64)	0.61
Grade 2-3 hypertension					
Multivariable HR (95%CI)	Ref	0.93 (0.64-1.36)	0.73 (0.37-1.46)	2.05 (1.17-3.57)	0.09

HR, hazard ratio; CI, confidence interval.

Multivariable HR: adjusted for age, sex, green tea consumption, use of antihypertensive medication, total cholesterol levels, history of diabetes, body mass index, smoking status, alcohol consumption, hours of exercise, hours of walking, perceived mental stress, educational level, regular employment, and dietary intakes of vegetable, fish, fruits and soybeans.

Table S2. Multivariable hazard ratios (95% confidence intervals) of cardiovascular disease mortality according to green tea consumption after missing values were imputed using multiple imputation.

	Green tea consumption						*P* for trend
	None	1-6 Cups/Week	1-2 Cups/d	3-4 Cups/d	5-6 Cups/d	≥7 Cups/d	
Optimal and Normal							
Multivariable HR (95%CI)	Ref	0.72 (0.40-1.27)	0.58 (0.32-1.08)	0.81 (0.51-1.30)	0.92 (0.59-1.45)	0.68 (0.41-1.12)	0.93
High Normal							
Multivariable HR (95%CI)	Ref	0.98 (0.48-1.86)	0.94 (0.48-1.87)	0.97 (0.54-1.73)	0.64 (0.36-1.15)	0.70 (0.38-1.28)	0.05
Grade 1 hypertension							
Multivariable HR (95%CI)	Ref	1.00 (0.58-1.72)	0.96 (0.56-1.66)	0.92 (0.57-1.51)	0.72 (0.44-1.17)	1.00 (0.61-1.65)	0.39
Grade 2-3 hypertension							
Multivariable HR (95%CI)	Ref	0.53 (0.22-1.27)	0.63 (0.28-1.45)	1.04 (0.51-2.09)	0.77 (0.38-1.54)	0.70 (0.33-1.48)	0.94

HR, hazard ratio; CI, confidence interval.

Multivariable HR: adjusted for age, sex, coffee consumption, use of antihypertensive medication, total cholesterol levels, history of diabetes, body mass index, smoking status, alcohol consumption, hours of exercise, hours of walking, perceived mental stress, educational level, regular employment, and dietary intakes of vegetable, fish, fruits and soybeans.