Tea and Coffee Consumption and Cardiovascular Morbidity and Mortality

J. Margot de Koning Gans, Cuno S.P.M. Uiterwaal, Yvonne T. van der Schouw, Jolanda M.A. Boer, Diederick E. Grobbee, W.M. Monique Verschuren, Joline W.J. Beulens

Objective—To examine the associations of coffee and tea consumption with risk of morbidity and mortality of stroke and coronary heart disease (CHD) and with all-cause mortality.

Methods and Results—Coffee and tea consumption were assessed with a validated food-frequency questionnaire, and 37 514 participants were observed for 13 years for the occurrence of cardiovascular morbidity and mortality. A U-shaped association between coffee and CHD was found, with the lowest hazard ratio (HR [95% CI]) for 2.1 to 3.0 cups per day (0.79 [0.65 to 0.96]; P_{trend}=0.01). Tea was inversely associated with CHD, with the lowest HR (95% CI) for more than 6.0 cups per day (0.64 [0.46 to 0.90]; P_{trend}=0.02). No associations between tea or coffee and stroke were found (P_{trend}=0.63 and P_{trend}=0.32, respectively). Although not significant, coffee slightly reduced the risk for CHD mortality (HR, 0.64; 95% CI, 0.37 to 1.11; P_{trend}=0.12) for 3.1 to 6.0 cups per day. A U-shaped association between tea and CHD mortality was observed, with an HR of 0.55 (95% CI, 0.31 to 0.97; P_{trend}=0.03) for 3.1 to 6.0 cups per day. Neither coffee nor tea was associated with stroke (P_{trend}=0.22 and P_{trend}=0.74, respectively) and all-cause mortality (P_{trend}=0.33 and P_{trend}=0.43, respectively).

Conclusion—High tea consumption is associated with a reduced risk of CHD mortality. Our results suggest a slight risk reduction for CHD mortality with moderate coffee consumption and strengthen the evidence on the lower risk of CHD with coffee and tea consumption. **(*Arterioscler Thromb Vasc Biol*. 2010;30:00-00.)**

Key Words: coronary heart disease ■ stroke ■ mortality ■ coffee ■ tea

Coffee and tea are 2 of the most widely consumed beverages in the world. Therefore, many studies have examined the association between coffee or tea consumption and health, especially cardiovascular morbidity.

Coffee consumption is thought to have both beneficial and detrimental effects on cardiovascular risk, probably as the result of the different biologically active substances in coffee.[1,2] However, the association between coffee and cardiovascular diseases (CVD) still remains controversial. In several prospective cohort studies, no clear relation between coffee consumption and CVD has been observed.[3] However, a recent meta-analysis[4] concluded that habitual coffee drinking was associated with a lower risk of coronary heart disease (CHD). The association of coffee with other CVDs, such as stroke, is not clear. One recent study[5] suggested a modestly reduced risk of stroke with coffee consumption among women, whereas others[6–8] observed no relation or even increased risks. Two other studies[9,10] suggested that coffee consumption could specifically reduce the risk of cardiovascular and all-cause mortality.

In general, tea consumption is thought to reduce the risk of CVDs. Most studies[11,12] on the association of tea with CVD focused on CHD. In a meta-analysis[12] on tea consumption, results for CHD and stroke were inconclusive; however, in the European region, a protective effect was observed for myocardial infarction. The relation of tea consumption with stroke or CHD mortality is unclear. A recent study[13] on green tea observed an inverse association for CVD mortality. However, a few studies[14–18] on black tea were performed, mostly in specific subpopulations or focused on components from tealike flavonoids. Therefore, this study investigated the relation between coffee and tea consumption, mainly black tea, and CVD in the large Dutch cohort of healthy men and women in the European Prospective Investigation into Cancer and Nutrition (EPIC-NL), specifically focusing on relations with stroke and cardiovascular and all-cause mortality.

Methods

Study Population

The EPIC-NL cohort is the Dutch contribution to the EPIC and consists of the Prospect-EPIC cohort and the MORGEN cohort.[19] The Prospect cohort includes 17 357 women aged 50 to 69 years who participated in a breast cancer screening program. The MORGEN cohort includes 22 654 men and women aged 20 to 65 years who

Received on: December 19, 2009; final version accepted on: April 26, 2010.

From the Julius Center for Health Sciences and Primary Care (J.M.d.K.G., C.S.P.M.U., Y.T.v.d.S., D.E.G., and J.W.J.B.), University Medical Center Utrecht, Utrecht, the Netherlands; and the National Institute for Public Health and the Environment (J.M.A.B. and W.M.M.V.), Bilthoven, the Netherlands.

Correspondence to Joline W.J. Beulens, PhD, Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, P. O. Box 85500, 3508GA Utrecht, the Netherlands. E-mail J.Beulens@umcutrecht.nl

Arterioscler Thromb Vasc Biol **is available at http://atvb.ahajournals.org** **DOI: 10.1161/ATVBAHA.109.201939**

were recruited through random population sampling. Participants were recruited into both studies from 1993 to 1997.

Signed informed consent was obtained from all participants before study inclusion. Both cohorts comply with the Declaration of Helsinki. Prospect was approved by the institutional review board of the University Medical Centre Utrecht, and the MORGEN cohort was approved by the Medical Ethics Committee of the Netherlands Organization for Applied Scientific Research. The full details of both cohorts and the EPIC-NL study have been described elsewhere.[19]

After excluding participants with prevalent CVD (n=1157), with missing information about coffee or tea consumption (n=233), without follow-up information or permission for follow-up (n=1003), and with extreme energy intakes (<600 or >5000 kcal/d [n=104]), we included 37 514 participants.

General Assessments

At baseline, study participants completed a general questionnaire on demographic characteristics, presence of chronic diseases and related potential risk factors, and medical and lifestyle histories. Trained medical staff measured weight, height, waist and hip circumferences, and blood pressure. Hypertension was defined as present based on self-report of a physician diagnosis, measured hypertension (>140 mm Hg systolic or >90 mm Hg diastolic), or the use of hypertensive medication. The presence of diabetes mellitus and hypercholesterolemia was identified through self-report using the general baseline questionnaire.[19] Duration and types of physical activity were assessed. According to the validated Cambridge Physical Activity Index, participants were divided into 4 physical activity categories.[20]

Assessment of Coffee and Tea Consumption

At baseline, a food-frequency questionnaire was completed by the participants, including questions on average daily consumption frequency of 79 main food groups during the year preceding enrollment. This questionnaire allows the estimation of the mean daily consumption of 178 foods. In the food-frequency questionnaire, the subjects were asked to indicate how many cups of coffee or tea they regularly drank during the past year. They could indicate the number of cups consumed per day, week, month, or year. In addition, they were asked about the frequency of the different types of coffee (regular [instant], decaffeinated, or other) using 4 categories (ie, always/mostly, often, sometimes, and seldom/never). To convert these frequencies into absolute percentages, the categories were defined as 90%, 65%, 35%, and 10% of the time, respectively. These percentages were prespecified in the questionnaire for participants to make informed and consistent decisions. For decaffeinated coffee, these percentages were multiplied by the total amount of coffee. The food-frequency questionnaire was validated against twelve 24-hour recalls and biomarkers.[21] The Spearman correlation coefficients were 0.74 for coffee consumption and 0.87 for tea consumption, suggesting sufficient validity.

For the analyses on cardiovascular morbidity, the amount of coffee and tea consumption was divided into 6 categories: less than 1.0, 1.0 to 2.0, 2.1 to 3.0, 3.1 to 4.0, 4.1 to 6.0, and more than 6.0 cups per day. For the analyses of cardiovascular mortality, we divided coffee and tea consumption into 4 groups because of fewer events: less than 1.0, 1.0 to 3.0, 3.1 to 6.0, and more than 6.0 cups per day.

Assessment of Cardiovascular Morbidity and Mortality

The vital status of all EPIC-NL participants was obtained through linkage with the municipal population registries. Subsequently, causes of death for the deceased persons were obtained through linkage with Statistics Netherlands. Data on morbidity were obtained from the National Medical Registry, which holds a standardized computerized register of hospital discharge diagnoses. In the National Medical Registry, all diagnoses are coded according to the *International Classification of Diseases, Ninth Revision, Clinical Modification*. The National Medical Registry collects and checks these data in the Hospital Discharge Diagnosis Database. The database is linked to the cohort based on information on the date of birth, sex, postal code, and general practitioner with a validated probabilistic method.[22] Our primary end points are events and deaths from CHD (*International Classification of Diseases, Ninth Revision, Clinical Modification* codes 410 to 414, including subcodes 427.5, 798.1, 798.2, and 798.9; and *International Statistical Classification of Diseases, 10th Revision (ICD-10)* codes I20 and I23 up to 125 inclusive, including all subcodes) and stroke (*International Classification of Diseases, Ninth Revision, Clinical Modification* codes 430 to 438 and *International Statistical Classification of Diseases, 10th Revision (ICD-10)* codes G45, I60 up to 167 inclusive, and I69, including all subcodes). Furthermore, we also analyze the combined end points of morbidity and mortality for stroke and CHD. Another end point is all-cause mortality.

Data Analysis

We calculated person-years of follow-up for each participant from the date of return of the baseline questionnaire to the date of the first cardiovascular event or death from any cause, loss to follow-up, or January 1, 2006, whichever came first.

We used Cox proportional hazards models to estimate hazard ratios (HRs) and 95% CIs for the association between coffee or tea consumption and all end points, using the lowest category as the reference.

A crude model adjusted for age (continuous) and sex. The multivariable model adjusted for educational level (3 categories), physical activity (4 categories), waist circumference (continuous), smoking status (3 categories), hormone replacement therapy and menopausal status (5 categories), alcohol intake (continuous), tea or coffee intake (continuous), total energy intake, and energy-adjusted intake of saturated fat, fiber, and vitamin C (all continuous). We also adjusted for total fluid intake because it could confound the results. An additional analysis further adjusted for potential biological mediators, including hypertension, hypercholesterolemia, and diabetes (all present or absent). All analyses were stratified for cohort (Prospect or MORGEN). To test for linear trends across categories, we modeled consumption of coffee and tea by including the median value of each category as a continuous variable. The square of this term was included to test if a nonlinear association was present. To assess the possible effect modification, we included interaction terms of coffee or tea consumption with age, sex, and cardiovascular risk factors (ie, hypertension, hypercholesterolemia, type 2 diabetes, and smoking). Finally, we excluded cases obtained in the first 4 years of follow-up to check for possible reverse causation. A 2-tailed $P<0.05$ was considered statistically significant. All statistical analyses were performed using SPSS for Windows, version 15.0 (SPSS Inc, Chicago, Illinois).

Results

During a mean follow-up of 13 years, 1950 incident cases of cardiovascular morbidity were documented: 563 from stroke and 1387 from CHD. In total, 1405 cases of all-cause mortality were registered, of which 70 were caused by stroke and 123 were caused by CHD.

High coffee consumption was associated with a lower educational level, the prevalence of diabetes and smoking, a higher waist circumference, hypercholesterolemia, and a less healthy diet (Table 1). High tea consumption was associated with a higher educational level, higher physical activity, a healthier diet, lower waist circumference, and a lower prevalence of smoking, hypercholesterolemia, and diabetes.

In age- and sex-adjusted analyses, we observed a U-shaped association of coffee consumption with CHD morbidity (Table 2). After multivariable adjustment, we found the lowest HR for 2.1 to 3.0 cups per day (0.79 [95% CI, 0.65 to 0.96]; $P_{\text{quadratic trend}}=0.01$). The inclusion of potential intermediates did not appreciably alter the results. Changing the reference group to fewer than 2.0 cups per day slightly altered the

Table 1. Baseline Characteristics by Coffee and Tea Consumption Categories in 37 514 Participants*

	Liquid Consumption, Cups/d					
Characteristic	<1.0	1.0–2.0	2.1–3.0	3.1–4.0	4.1–6.0	>6.0
Coffee						
No. of participants	7452	5023	5063	6477	8906	4593
Male sex†	21.0	19.0	20.8	19.7	29.6	44.2
Age, y	46.3 (14.1)	49.5 (12.5)	49.8 (11.9)	51.7 (11.0)	49.6 (10.5)	47.1 (9.9)
Low educational level†	53.7	51.5	52.2	62.1	60.7	59.4
Low physical activity level†	10.4	9.1	8.6	7.1	8.6	11.8
Waist circumference, cm	83.9 (11.7)	83.8 (11.2)	84.2 (11.2)	84.9 (11.0)	86.2 (11.3)	87.6 (11.9)
Hypertension†	34.9	37.2	38.7	39.4	36.3	33.4
Hypercholesterolemia†	7.0	6.7	7.6	6.7	8.8	9.9
Diabetes mellitus†	1.6	1.7	1.4	1.4	1.6	1.1
Postmenopausal HRT†	6.2	7.8	7.8	7.8	6.6	4.9
Current smoker†	22.3	23.1	25.3	25.1	36.6	53.7
Alcohol consumption, g/wk	52.7 (88.0)	73.9 (113.2)	77.8 (99.7)	75.3 (103.2)	88.5 (112.5)	99.7 (126.4)
Tea consumption, cups/d	3.6 (3.0)	2.9 (2.4)	2.4 (2.0)	2.4 (2.0)	1.7 (1.8)	1.0 (1.6)
Nonalcohol fluid intake, mL/d	1148 (586)	1061 (543)	1003 (499)	938 (492)	925 (510)	902 (515)
Total energy intake, kcal/d	1971 (622)	1987 (574)	2009 (570)	2013 (574)	2105 (617)	2287 (717)
Saturated fat, g/d	31.4 (6.0)	32.1 (5.8)	32.4 (5.6)	33.0 (5.7)	33.1 (5.7)	33.5 (6.1)
Fiber, g/d	23.2 (5.2)	23.3 (4.9)	23.3 (4.7)	23.6 (4.6)	23.4 (4.7)	23.3 (4.9)
Vitamin C, mg/d	115 (48)	116 (47)	113 (45)	111 (43)	106 (44)	96 (42)
Tea						
No. of participants	11 653	11 425	4159	4410	4028	1839
Male sex†	38.1	25.2	17.9	14.6	14.1	13.0
Age, y	46.3 (11.6)	49.2 (11.7)	50.4 (11.9)	52.4 (11.5)	51.3 (12.1)	49.2 (12.2)
Low educational level†	58.9	60.5	55.6	57.0	49.5	43.0
Low physical activity level†	12.0	8.7	7.5	6.4	7.6	7.4
Waist circumference, cm	86.7 (12.1)	85.5 (11.4)	83.9 (10.9)	84.0 (10.6)	83.0 (10.6)	81.9 (10.6)
Hypertension†	34.7	37.4	37.0	39.4	37.1	35.7
Hypercholesterolemia†	8.9	8.0	7.0	7.2	6.2	5.9
Diabetes mellitus†	1.5	1.8	1.4	1.5	1.3	0.8
Postmenopausal HRT†	5.7	7.1	7.6	7.1	7.8	8.1
Current smoker†	44.0	29.8	22.4	19.5	18.1	20.3
Alcohol consumption, g/wk	94.2 (126.0)	74.2 (101.7)	68.9 (92.0)	64.1 (92.3)	65.8 (93.3)	60.2 (100.5)
Coffee consumption, cups/d	4.5 (2.8)	3.5 (2.2)	2.8 (2.0)	2.8 (1.9)	2.2 (1.9)	1.6 (1.9)
Nonalcohol fluid intake, mL/d	1020 (559)	995 (515)	992 (526)	975 (499)	990 (533)	952 (588)
Total energy intake, kcal/d	2150 (678)	2052 (610)	1994 (567)	1980 (545)	1984 (579)	1970 (604)
Saturated fat, g/d	32.8 (6.0)	32.7 (5.8)	32.5 (5.7)	32.5 (5.7)	32.0 (5.7)	32.0 (6.2)
Fiber, g/d	22.5 (4.9)	23.2 (4.6)	23.7 (4.6)	24.3 (4.6)	24.3 (4.7)	24.7 (5.3)
Vitamin C, mg/d	99 (44)	108 (43)	115 (44)	119 (45)	122 (46)	127 (53)

HRT indicates hormone replacement therapy.

*Data (continuous variables) are given as mean (SD) unless otherwise indicated. All *P* values for trend are ≤0.01, except for diabetes mellitus (coffee: $P=0.30$).

†Data are given as percentage of participants in each liquid consumption group.

results; however, we still observed a U-shaped association of coffee with CHD (data not shown). No association between decaffeinated coffee and risk of CHD was found, with an HR of 1.11 (95% CI, 0.97 to 1.28; $P_{trend}=0.10$) for more than 1.0 cup per day.

A positive linear association was found in the age- and sex-adjusted analyses for coffee and the risk of stroke, with the highest and statistically significant HR for more than 6.0 cups per day (1.41 [95% CI, 1.03 to 1.91]; $P_{trend}=0.03$). However, the association attenuated to nonsignificant after multivariable adjustment ($P_{trend}=0.32$).

In age- and sex-adjusted analyses for tea consumption, a linear and inverse association with CHD was observed. After multivariable adjustment, the association between tea and CHD still remained, with the lowest HR for more than 6.0 cups per day (0.64; 95% CI, 0.46 to 0.90; $P_{trend}=0.02$).

Table 2. Data for CHD and Stroke Morbidity According to Coffee and Tea Consumption

Variable	Liquid Consumption, Cups/d						Linear *P* Value*
	<1.0	1.0–2.0	2.1–3.0	3.1–4.0	4.1–6.0	>6.0	
Coffee							
CHD							
No. of cases	261	163	161	236	359	207	NA
Person-years	74 631	50 374	51 339	65 691	90 565	46 545	NA
Sex and age adjusted†	1.00	0.82 (0.67–0.99)	0.78 (0.64–0.95)	0.83 (0.70–0.99)	0.97 (0.82–1.13)	1.14 (0.95–1.38)	<0.01‡
Multivariate adjusted†§	1.00	0.85 (0.70–1.04)	0.79 (0.65–0.96)	0.82 (0.68–0.98)	0.86 (0.73–1.02)	0.91 (0.74–1.11)	0.01‡
Stroke							
No. of cases	90	71	78	105	141	78	NA
Person-years	75 445	50 896	51 687	66 336	91 701	47 283	NA
Sex and age adjusted†	1.00	1.04 (0.76–1.41)	1.11 (0.82–1.51)	1.08 (0.82–1.44)	1.16 (0.89–1.51)	1.41 (1.03–1.91)	0.03
Multivariate adjusted†§	1.00	1.08 (0.79–1.47)	1.15 (0.85–1.57)	1.10 (0.82–1.46)	1.11 (0.84–1.46)	1.22 (0.88–1.70)	0.32
Tea							
CHD							
No. of cases	475	440	138	158	137	39	NA
Person-years	117 476	115 716	42 156	44 564	40 702	18 531	NA
Sex and age adjusted†	1.00	0.86 (0.76–0.99)	0.74 (0.61–0.90)	0.73 (0.61–0.88)	0.73 (0.60–0.89)	0.53 (0.38–0.73)	<0.01
Multivariate adjusted†§	1.00	0.93 (0.81–1.06)	0.87 (0.72–1.06)	0.88 (0.72–1.06)	0.91 (0.74–1.11)	0.64 (0.46–0.90)	0.02
Stroke							
No. of cases	175	173	59	76	52	28	NA
Person-years	118 989	117 103	42 579	44 978	41 060	18 640	NA
Sex and age adjusted†	1.00	0.88 (0.71–1.09)	0.79 (0.59–1.07)	0.87 (0.66–1.15)	0.69 (0.50–0.95)	0.92 (0.61–1.38)	0.07
Multivariate adjusted†§	1.00	0.99 (0.80–1.23)	0.98 (0.72–1.34)	1.11 (0.83–1.49)	0.92 (0.66–1.28)	1.24 (0.82–1.89)	0.63

CHD indicates coronary heart disease; NA, not applicable.

*For trend.

†Data are given as the hazard ratio (95% CI).

‡$P_{\text{quadratic trend}}<0.05$.

§Adjusted for sex; age; cohort (strata); educational level; physical activity; smoking status; waist circumference; menopausal status; alcohol, tea, and coffee consumption; total energy; and saturated fat, fiber, and vitamin C level.

Adjustment for potential intermediates did not influence this association. Tea consumption tended to be associated ($P_{\text{trend}}=0.07$) with a reduced risk of stroke in an age- and sex-adjusted model, with the lowest HR for 4.1 to 6.0 cups per day (0.69; 95% CI, 0.50 to 0.95). This relation attenuated to nonsignificant after multivariate adjustment (HR, 0.92; 95% CI, 0.66 to 1.28; $P_{\text{trend}}=0.63$).

Coffee consumption was not associated with CHD, stroke, and all-cause mortality ($P_{\text{trend}}=0.12$, $P_{\text{trend}}=0.22$, and $P_{\text{trend}}=0.33$, respectively) (Table 3). Although not significant, coffee slightly reduced the risk for CHD mortality (HR, 0.64; 95% CI, 0.37 to 1.11) for 3.1 to 6.0 cups per day; for all-cause mortality, we observed a similar trend (HR, 0.89; 95% CI, 0.77 to 1.04).

A U-shaped relation between tea and CHD mortality was found, both in a crude and multivariate model, with the lowest HRs for 1.0 to 3.0 cups per day (0.65; 95% CI, 0.43 to 0.99; $P_{\text{trend}}=0.03$) and 3.1 to 6.0 cups per day (0.55; 95% CI, 0.31 to 0.97; $P_{\text{trend}}=0.03$). In age- and sex-adjusted analyses for tea, a similar U-shaped association was observed with risk of all-cause mortality; however, this finding attenuated after multivariate adjustment ($P_{\text{trend}}=0.43$). No association between tea consumption and risk of stroke mortality was observed ($P_{\text{trend}}=0.74$).

Combining the morbidity and mortality for CHD and stroke, similar results were observed compared with CHD and stroke morbidity only (supplemental Table; available online at http://atvb.ahajournals.org). The same U-shaped association for coffee and CHD was found ($P_{\text{trend}}=0.01$). For tea and CHD, we observed the lowest HR for more than 6.0 cups per day (0.65; 95% CI, 0.49 to 0.92; $P_{\text{trend}}=0.01$).

We also estimated the HRs for ischemic and hemorrhagic stroke separately. We could not detect an association of coffee and tea consumption with ischemic stroke ($P_{\text{trend}}=0.57$ and $P_{\text{trend}}=0.87$, respectively) or hemorrhagic stroke ($P_{\text{trend}}=0.56$ and $P_{\text{trend}}=0.98$, respectively). Replacing smoking status for pack-years (stratification for current smokers versus nonsmokers), adjustment for fluid intake, or exclusion of the first 4 years of follow-up did not alter the results (data not shown). Similar results were found by adjusting for alcohol as a categorical variable (ie, for 2.1 to 3.0 cups per day: HR, 0.78; 95% CI, 0.64 to 0.96). Finally, no interactions for CHD were found between coffee or tea consumption and hypertension, diabetes, hypercholesterolemia, and smoking, with the lowest $P_{\text{interaction}}$ for coffee and smoking ($P=0.14$).

Table 3. Data for CHD, Stroke, and Overall Mortality According to Coffee and Tea Consumption

Variable	Liquid Consumption, Cups/d				Linear *P* Value*
	<1.0	1.0–3.0	3.1–6.0	>6.0	
Coffee					
CHD					
No. of cases	21	36	45	21	NA
Person-years	75 809	103 179	158 932	47 550	NA
Sex and age adjusted†	1.00	1.10 (0.64–1.89)	0.82 (0.49–1.38)	1.37 (0.74–2.54)	0.82
Multivariate adjusted†‡	1.00	1.06 (0.61–1.84)	0.64 (0.37–1.11)	0.73 (0.37–1.42)	0.12
Stroke					
No. of cases	11	16	35	8	NA
Person-years	75 809	103 179	158 932	47 550	NA
Sex and age adjusted†	1.00	0.89 (0.41–1.92)	1.38 (0.70–2.72)	1.87 (0.74–4.73)	0.08
Multivariate adjusted†‡	1.00	0.86 (0.39–1.87)	1.20 (0.59–2.47)	1.34 (0.49–3.64)	0.22
All causes					
No. of cases	259	375	597	174	NA
Person-years	75 809	103 179	158 932	47 550	NA
Sex and age adjusted†	1.00	0.92 (0.78–1.08)	0.94 (0.81–1.09)	1.16 (0.96–1.42)	0.05§
Multivariate adjusted†‡	1.00	0.93 (0.79–1.09)	0.89 (0.77–1.04)	0.93 (0.76–1.15)	0.33
Tea					
CHD					
No. of cases	54	44	19	6	NA
Person-years	119 623	160 588	86 554	18 704	NA
Sex and age adjusted†	1.00	0.56 (0.37–0.84)	0.41 (0.24–0.71)	0.76 (0.32–1.78)	<0.01§
Multivariate adjusted†‡	1.00	0.65 (0.43–0.99)	0.55 (0.31–0.97)	0.93 (0.39–2.25)	0.01§
Stroke					
No. of cases	22	29	15	4	NA
Person-years	119 623	160 588	86 554	18 704	NA
Sex and age adjusted†	1.00	0.63 (0.36–1.10)	0.45 (0.23–0.88)	0.72 (0.25–2.11)	0.12
Multivariate adjusted†‡	1.00	0.79 (0.44–1.42)	0.67 (0.33–1.38)	1.16 (0.38–3.56)	0.74
All causes					
No. of cases	417	573	346	69	NA
Person-years	119 623	160 588	86 554	18 704	NA
Sex and age adjusted†	1.00	0.83 (0.73–0.94)	0.80 (0.69–0.92)	0.89 (0.69–1.15)	<0.01§
Multivariate adjusted†‡	1.00	0.95 (0.83–1.09)	1.00 (0.86–1.18)	1.13 (0.87–1.48)	0.43

CHD indicates coronary heart disease; NA, not applicable.

*P value for trend.

†Data are given as the hazard ratio (95% CI).

‡Adjusted for sex; age; cohort (strata); educational level; physical activity; smoking status; waist circumference; menopausal status; alcohol, tea, and coffee consumption; total energy; and saturated fat, fiber, and vitamin C level.

§$P_{\text{quadratic trend}}<0.05$.

Discussion

In this large prospective cohort, the consumption of both coffee and tea (mainly black tea) was associated with a lower incidence of CHD morbidity. For coffee, this relation was U shaped, whereas a linear and inverse association for tea was found. Although not significant, coffee slightly reduced the risk for CHD mortality with moderate consumption. We showed that consuming 3.0 to 6.0 cups of tea per day was associated with a reduced risk of CHD mortality. Neither coffee nor tea consumption was associated with stroke or all-cause mortality.

To appreciate these findings, certain limitations need to be addressed. First, relatively few patients died of CHD (n=123) or stroke (n=70). Therefore, we had limited power to detect associations for these end points. Second, we relied on self-reported data on coffee and tea consumption. However, we validated the assessment of coffee and tea consumption against twelve 24-hour recalls, showing sufficient validity, with correlations of 0.74 and 0.87, respectively. Furthermore, we only had data on coffee and tea consumption from the baseline questionnaire. Participants could have changed their consumption as the result of health status, which could have

influenced our results. However, excluding the first 4 years of follow-up to account for such possible reverse causation did not alter the associations. Third, we did not have specific information on the type of tea that participants consumed. However, 78% of the total amount of tea consumed in the Netherlands is black tea, whereas only 4.6% is green tea.[23] Therefore, it is reasonable to assume that our results are mainly based on black tea. Fourth, we cannot draw firm conclusions on decaffeinated coffee because of the somewhat crude method of quantifying decaffeinated coffee. Last, coffee and tea drinkers have different and almost opposite health behaviors. Coffee drinkers tend to smoke more and have a less healthy diet, whereas tea consumption is associated with a healthier lifestyle. Especially for tea consumption, confounding by health behavior could result in the observed inverse relation; for coffee consumption, this could explain the increased risks in the higher intake categories. Although we have adjusted for several lifestyle and dietary factors, we cannot exclude residual confounding.

Our findings of a relation between coffee and CHD morbidity are in line with previous studies. A recent meta-analysis by Wu et al[4] concluded that habitual moderate (3.1 to 4.0 cups per day) coffee consumption was associated with a lower risk of CHD morbidity, with a relative risk of 0.87 (95% CI, 0.80 to 0.86; $P_{trend}=0.001$). Our findings were almost similar to these results, with an HR of 0.82 for 3.1 to 4.0 cups per day. In our data, no association was found between coffee and stroke, inconsistent with the results of a recent study by Lopez-Garcia et al,[5] who suggested a modestly reduced risk. If anything, our data suggest a modestly increased risk of stroke among coffee consumers. This risk reduction was only observed at the lower levels of coffee intake. The higher amounts of coffee consumption in our population could possibly explain these differences. The larger sample size of the Nurses' Health Study could also be involved.[5]

Regarding coffee consumption and cardiovascular and all-cause mortality, Jazbec et al[24] could not detect an association with cardiovascular mortality; these researchers found a positive association for overall mortality in women. However, Andersen et al[9] found a protective effect of coffee on cardiovascular mortality. They observed a U-shaped trend, with the lowest HR for 1.0 to 3.0 cups per day (0.76; 95% CI, 0.64 to 0.94; $P_{trend}=0.005$). Similar results were reported by Kleemola et al[25] and Lopez-Garcia et al,[10] suggesting a modest benefit of coffee on overall and cardiovascular mortality. Although not significant, our results also show a slightly reduced risk, with the lowest HR of 0.64 for 3.1 to 6.0 cups per day; however, no association for overall mortality was found. Altogether, these studies may suggest a modest risk reduction of cardiovascular mortality with moderate coffee consumption.

Only a few prospective studies investigated the relation between black tea consumption and cardiovascular morbidity. A meta-analysis by Peters et al[12] concluded that these studies for CHD (n=7) and stroke (n=5) were too heterogeneous. Only the studies in continental Europe suggest a decrease in the rate of CHD with increasing tea consumption. A review by Gardner et al[11] showed a modest inverse association between tea and CHD, with the lowest risk for 3.0 cups per day or more. However, a more recent large study by Lopez-Garcia et al[26] showed no association for tea and CHD. We found a linear and inverse association with CHD, with the lowest ratio for more than 6.0 cups per day.

A recent study by Larsson et al[8] suggests that high tea consumption may reduce the risk of stroke among male smokers, independent of known cardiovascular risk factors. However, our study only showed an inverse relation in crude analyses, which attenuated after multivariate adjustment. Apart from alcohol, coffee, and tea intake, no other dietary component was used for adjustment by Larsson et al.[8]

A recent study[13] investigated the relation between green tea consumption and total or cardiovascular mortality and observed a reduced risk with increasing tea consumption. For black tea consumption and CHD mortality, most previous studies[14–18] were performed in specific subgroups, such as hypertensive or postmenopausal patients, or focused only on components from tealike flavonoids. In general, the evidence from the studies on tea and CHD is weak and, if anything, only suggests an inverse association. We show that high tea consumption is associated with a reduced risk of CHD mortality in a mainly black tea–drinking population. Therefore, both green and black tea appear to be associated with a reduced risk of CHD mortality.

Coffee contains several biologically active substances, such as caffeine and diterpene alcohols, which could increase cardiovascular risk by increasing serum cholesterol and decreasing insulin sensitivity.[1,2] Conversely, coffee contains compounds, such as chlorogenic acid, with antioxidant properties that could reduce the risk of cardiovascular morbidity and mortality.[1,2] The cardiovascular benefit of tea consumption could be explained by antioxidants. Flavonoids in tea are thought to contribute to the reduced risk, but the underlying mechanism is still not entirely clear. In vitro flavonoids inhibit low-density lipoprotein oxidation and reduce platelet aggregation; however, in vivo, the effect on blood pressure and cholesterol remains inconsistent.[27] In our study, adjustment for potential intermediates did not alter the associations. However, this could also be the result of the crude measures for the presence of diabetes, hypertension, or hypercholesterolemia that were used.

In conclusion, with this large prospective cohort study, we showed that tea consumption (mainly black tea) was associated with a reduced risk of CHD mortality. Our results suggest only a modest risk reduction for CHD mortality with moderate coffee consumption. We strengthen the evidence on the lower risk of CHD associated with coffee and tea consumption; however, neither coffee nor tea was associated with the risk of stroke or all-cause mortality.

Sources of Funding

The EPIC-NL study was supported by the "Europe Against Cancer" Programme of the European Commission; the Dutch Ministry of Public Health, Welfare and Sports (formerly the Ministry of Welfare, Public Health and Culture); the Dutch Cancer Society; ZonMW the Netherlands Organisation for Health Research and Development; and the World Cancer Research Fund.

Disclosures

None.

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Arteriosclerosis, Thrombosis, and Vascular Biology

JOURNAL OF THE AMERICAN HEART ASSOCIATION

Tea and Coffee Consumption and Cardiovascular Morbidity and Mortality

J. Margot de Koning Gans, Cuno S.P.M. Uiterwaal, Yvonne T. van der Schouw, Jolanda M.A. Boer, Diederick E. Grobbee, W. M. Monique Verschuren and Joline W.J. Beulens

Arterioscler Thromb Vasc Biol. published online June 18, 2010;
Arteriosclerosis, Thrombosis, and Vascular Biology is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 1079-5642. Online ISSN: 1524-4636

Supplemental table I

Table 4. HRs (95%-CI) for CHD and stroke (morbidity & mortality) according to coffee and tea consumption

	Coffee consumption, cups/day						
	<1.0	**1.0-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-6.0**	**>6.0**	Linear*
CHD							
Cases, n	277	175	174	249	377	222	
Sex and age-adjustment	1.0	0.83 (0.68-1.00)	0.80 (0.66-0.96)	0.83 (0.70-0.98)	0.95 (0.82-1.11)	1.16 (0.97-1.39)	<0.01†
Multivariate adjustment‡	1.0	0.86 (0.71-1.04)	0.80 (0.66-0.97)	0.81 (0.68-0.96)	0.84 (0.71-0.99)	0.89 (0.74-1.08)	0.01†
Stroke							
Cases, n	94	79	83	108	154	80	
Sex and age-adjusted	1.0	1.10 (0.81-1.48)	1.13 (0.84-1.52)	1.06 (0.80-1.40)	1.22 (0.94-1.58)	1.42 (1.05-1.92)	0.02
Multivariate adjustment‡	1.0	1.13 (0.84-1.53)	1.16 (0.86-1.57)	1.06 (0.80-1.41)	1.15 (0.88-1.50)	1.21 (0.87-1.67)	0.32
	Tea consumption, cups/day						
	<1.0	**1.0-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-6.0**	**>6.0**	Linear*
CHD							
Cases, n	514	460	145	167	144	44	

Sex and age-adjusted	1.0	0.83 (0.73-0.95)	0.72 (0.60-0.87)	0.71 (0.59-0.85)	0.71 (0.59-0.86)	0.55 (0.40-0.74)	<0.01
Multivariate adjustment‡	1.0	0.90 (0.79-1.02)	0.85 (0.70-1.03)	0.85 (0.71-1.03)	0.88 (0.72-1.08)	0.67 (0.49-0.92)	0.01
Stroke							
Cases, n	185	185	62	79	59	28	
Sex and age-adjustment	1.0	0.88 (0.71-1.08)	0.77 (0.57-1.03)	0.82 (0.63-1.08)	0.71 (0.53-0.96)	0.85 (0.57-1.26)	0.04
Multivariate adjustment‡	1.0	0.98 (0.79-1.21)	0.95 (0.70-1.28)	1.05 (0.79-1.39)	0.95 (0.69-1.30)	1.14 (0.75-1.72)	0.81

*p-value for trend

†$p_{quadratic\ trend}$=<0.05

‡Adjusted for sex, age, cohort (strata), education, physical activity, smoking status, waist circumference, menopausal status, alcohol, tea resp. coffee consumption, total energy, saturated fat, fibres and vitaminC