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Habitual coffee but not green tea consumption is inversely associated with metabolic syndrome
An epidemiological study in a general Japanese population

Asuka Hino, Hisashi Adachi *, Mika Enomoto, Kumiko Furuki, Yoshiyuki Shigetoh, Maki Ohtsuka, Shun-Ichi Kumagae, Yuji Hirai, Ali Jalaldin, Akira Satoh, Tsutomu Imaizumi

Department of Internal Medicine, Division of Cardio-Vascular Medicine and Cardiovascular Research Institute, Kurume University School of Medicine, 67 Asahi-machi, Kurume 830-0011, Japan

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Abstract

In Japan, metabolic syndrome used to be rare, and the level of coffee consumption was low. However, the Japanese life style has been changing rapidly, and these changes have been associated with a steady increase in the frequency of metabolic syndrome and with greater consumption of coffee. We examined the relationship between metabolic syndrome and the consumption of coffee or green tea. A total of 1902 Japanese aged over 40 years (785 men and 1117 women) received population-based health check-up in 1999. We measured components of metabolic syndrome (blood pressure, waist circumference, fasting plasma glucose, and lipid profiles). Eating and drinking patterns were evaluated by a food frequency questionnaire. Multivariate analyses were performed to clarify the association between coffee or green tea consumption and the components of metabolic syndrome. All components of metabolic syndrome except for HDL-cholesterol were significantly ($p < 0.01$) and inversely related to coffee but not green tea consumption by multivariate analysis after adjusting for confounding factors. The larger was the number of components of metabolic syndrome, the lower was the level of coffee consumption ($p < 0.0001$). In addition, there was a high frequency of metabolic syndrome in small coffee drinkers. Thus, coffee but not green tea consumption was inversely associated with metabolic syndrome.

Keywords: Coffee; Tea; Diabetes; Metabolic disorder; Epidemiology

1. Introduction

The frequency of obesity is rapidly increasing in western countries [1]. The cluster of risk factors related to obesity is called metabolic syndrome [2,3]. Although the severity of each individual component of metabolic syndrome is mild, the cluster of components is associated with greater cardiovascular morbidity and mortality [4–6]. The development of metabolic syndrome is greatly influenced by life style [7]. Coffee is among the most widely consumed beverages in the world [8,9]. The consumption of coffee decreases the risk of type 2 diabetes [10–14]. In Japan, the frequency of metabolic syndrome is much lower than in western

* Corresponding author. Tel.: +81 942 35 3311x3746; fax: +81 942 33 6509.
E-mail address: hadac@med.kurume-u.ac.jp (H. Adachi).

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countries [15,16]. The favorite beverage of the Japanese is green tea and drinking of coffee has not been very common. Thus, it may be assumed that the habitual consumption of green tea is inversely associated with metabolic syndrome. However, because of westernization, the life style of Japanese has been changing rapidly, and these changes have been associated with a steady increase in metabolic syndrome and with greater consumption of coffee [17,18]. Accordingly, we thought that it might be interesting to examine the relationship between metabolic syndrome and the consumption of coffee or green tea.

2. Methods

2.1. Subjects

In 1999, we performed a health check-up for the residents in a typical farming community, Tanushimaru (a cohort of the Seven Country Studies), located in Kyushu, the southwestern island of Japan. The town had an overall population of 3463. A total of 1920 people over 40 years of age (48.2% men and 62.0% women), received the check-up. Of these, information on dietary habits was obtained from 1902 subjects (785 men and 1117 women) by means of a food frequency questionnaire [17].

2.2. Data collection

We used a version of the ARIC study's food frequency questionnaire that was adapted for use in Japan [19]. It consisted of 105 items, and habitual nutrient intakes were estimated from reports of the frequency and average portion size of foods consumed during the past year.

Kinds of beverages were grouped into the two categories of green tea or coffee. We calculated quantities consumed using the Standard Tables of Food Composition in Japan [20]. The frequency of consumption and frequency weights were classified into the following nine categories: (1) once per day (×1.0); (2) two or three times per day (×2.5); (3) four to six times per day (×5); (4) more than six times per day (×7); (5) once per week (×0.14); (6) two to four times per week (×0.43); (7) five or six times per week (×0.79); (8) one to three times per month (×0.066); (9) never (×0). A trained nutritionist (A. Hino) administered the questionnaire. The dietary data obtained were validated by comparison with data from the National Nutrition Survey in Japan performed in 1999 [21]. Total daily energy intake in this cohort was 1995 kcal (versus 1988 kcal in the National Nutrition Survey in 1999), carbohydrates accounted for 56% (versus 59%) of total daily calories, protein intake was 20% (versus 16%), and fat intake was 24% (versus 24%). Thus, the dietary pattern in this cohort was similar to that of the National Nutrition Survey [21]. Habitual physical activity was evaluated by Baecke Questionnaire [22]. This self-administered questionnaire is commonly used and its reliability has been demonstrated in larger scale epidemiological studies [22,23]. Using this method, information was collected on the level of education, subjective experience of work load, and habitual physical activity.

Blood pressure (BP) was measured in the supine position twice at 3 min intervals using an upright standard sphygmomanometer. Vigorous physical activity and smoking were avoided for at least 30 min before BP measurement. The second BP with the fifth phase diastolic pressure was used for analysis. Medications for hypertension, diabetes, and hyperlipidemia were coded as dummy variables.

We adopted Japanese Criteria of the metabolic syndrome [24–26], which include abdominal obesity (abdominal obesity; given as waist circumference [>85 cm: men; >90 cm: women], triglycerides [≥150 mg/dl (≥1.69 mmol/l)], HDL-cholesterol [<40 mg/dl (<1.03 mmol/l): men; <50 mg/dl (<1.29 mmol/l): women], BP [≥130/≥85 mmHg] and fasting plasma glucose (FPG) [≥110 mg/dl (≥6.11 mmol/l)]). The metabolic syndrome was defined as the presence of at least three of these components.

This study was approved by the Ukiha branch of the Japan Medical Association, by the mayor, and by the welfare section of Tanushimaru district. The Ethics Committee of Kurume University School of Medicine also approved this study. Informed consent was received from all participants.

2.3. Statistical analysis

Results are presented as mean ± S.D. Sex (men = 0 and women = 1), alcohol intake and current smoking (no = 0 and yes = 1) were coded as dummy variables. Multiple linear regression analyses for determinants of coffee and green tea consumption were performed. Demographic backgrounds stratified by the number of components (0, 1, 2, and more than 3) of metabolic syndrome were analyzed by analyses of variance (ANOVA). Consumption of coffee or green tea in proportion to the accumulation of the number of components of metabolic syndrome was evaluated by analyses of covariance (ANCOVA) adjusted for age, sex, total energy intake, alcohol intake, current smoking, and habitual physical activity as covariates. χ^2-tests were used for categorical parameters and for contingency tables to test differences and linearity among groups. Statistical significance was defined as $p < 0.05$. All statistical analyses were performed with the use of the SAS system [27].

3. Results

Demographics of the 1902 subjects were presented in Table 1. Green tea consumption was much greater than coffee consumption. Demographic backgrounds were evaluated with relation to the accumulation of components of metabolic syndrome by the analyses of variance shown in Table 2. Age ($p < 0.05$), sex (<0.001), BMI ($p < 0.001$), waist ($p < 0.001$), SBP

Table 1
Characteristics of the study population

	Men ($n = 785$)		Women ($n = 1117$)		Total ($n = 1902$)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age (years)	63.6	11.0	62.3	11.0	62.7	11.0
Height (cm)	163.2	6.7	150.8	6.5	155.9	8.9
Weight (kg)	61.9	9.9	52.4	8.4	56.4	10.2
BMI (kg/m^2)	23.2	3.0	23.0	3.2	23.1	3.1
Waist (cm)	81.6	8.6	73.8	8.4	77.0	9.3
SBP (mmHg)	136	20	132	21	134	21
DBP (mmHg)	81	12	77	11	79	12
Total cholesterol (mmol/l)	4.88	0.85	5.36	0.87	5.17	0.89
HDL-c (mmol/l)	1.36	0.36	1.51	0.36	1.44	0.36
Triglycerides (mmol/l)	1.43	1.24	1.18	0.63	1.28	0.94
FPG (mmol/l)	5.58	1.32	5.32	0.94	5.43	1.12
Physical activity (U)	7.68	0.89	7.70	0.92	7.69	0.91
Total energy intake (kcal/day)	2139	577	1812	492	1947	522
Coffee consumption (ml/day)	139.0	197.8	145.5	185.2	142.8	190.5
Green tea consumption (ml/day)	657.1	396.0	649.5	342.5	652.6	365.5
Frequency (%)						
Alcohol intake	49.4		3.2		22.3	
Current smoking	39.2		2.0		17.4	

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose. Habitual physical activity was evaluated by Baecke questionnaire.

and DBP ($p < 0.001$), HDL-c (<0.001; inversely), triglycerides ($p < 0.001$), FPG ($p < 0.001$), total energy intake ($p < 0.001$), coffee consumption ($p < 0.0001$), alcohol intake ($p < 0.001$), and current smoking ($p < 0.001$) showed significance as the number of components of metabolic syndrome increased. Total cholesterol, physical activity and green tea consumption did not show such significance.

The relationship between coffee or green tea consumption and the components of metabolic syndrome was evaluated using multiple linear regression analysis adjusted for confounding factors such as age,

Table 2
Demographic backgrounds stratified by the number of the components of the metabolic syndrome

	The number of the components of the metabolic syndrome				*p* for trend
	0	1	2	≥3	
n	485	694	367	189	
Age (years)	58.1	64.9	64.5	62.9	<0.05
Sex (male %)	25.9	34.4	56.1	73.0	<0.001
BMI (kg/m^2)	21.7	22.7	24.3	25.5	<0.001
Waist (cm)	71.5	75.1	82.1	86.4	<0.001
SBP (mmHg)	114.2	139.1	142.2	146.5	<0.001
DBP (mmHg)	69.6	81.4	83.0	85.7	<0.001
Total cholesterol (mmol/l)	5.14	5.19	5.17	5.18	0.799
HDL-c (mmol/l)	1.61	1.50	1.30	1.13	<0.001
Triglycerides (mmol/l)	0.91	1.08	1.54	2.45	<0.001
FPG (mmol/l)	5.05	5.23	5.78	6.42	<0.001
Physical activity (U)	7.76	7.65	7.69	7.70	0.274
Total energy intake (kcal/day)	1939	1897	2014	2069	<0.001
Coffee consumption (ml/day)	183.4	132.8	134.7	98.2	<0.001
Green tea consumption (ml/day)	635.4	673.3	635.7	638.2	0.221
Alcohol intake (yes %)	14.0	19.7	30.5	33.8	<0.001
Current smoking (yes %)	12.3	13.5	20.9	28.0	<0.001

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose. Habitual physical activity was evaluated by Baecke questionnaire.

Table 3
The relationship between (a) coffee consumption and (b) green tea consumption and components of the metabolic syndrome

	β	S.E.	p-Value
(a) Coffee consumption			
Waist (cm)	−1.250	0.538	<0.05
SBP (mmHg)	−0.688	0.227	<0.01
DBP (mmHg)	−0.921	0.389	<0.05
HDL-c (mmol/l)	−0.027	0.333	0.934
Triglycerides (mmol/l)	−0.200	0.056	<0.001
FPG (mmol/l)	−0.763	0.237	<0.001
(b) Green tea consumption			
Waist (cm)	−0.453	0.898	0.614
SBP (mmHg)	0.353	0.403	0.382
DBP (mmHg)	−0.087	0.720	0.904
HDL-c (mmol/l)	−0.807	0.598	0.177
Triglycerides (mmol/l)	−0.244	0.103	<0.05
FPG (mmol/l)	−0.008	0.430	0.986

These relationships were evaluated using multiple linear regression analysis adjusted for age, sex, total energy intake, alcohol intake, current smoking, and habitual physical activity. *Abbreviations*: SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose.

sex, total energy intake, alcohol intake, current smoking, and habitual physical activity (Table 3a and b). All components except for HDL-c were significantly and inversely associated with coffee consumption. But, there were no such associations with green tea consumption, though triglycerides had a marginal significance. Coffee and green tea consumption were stratified in proportion to the number of components of metabolic syndrome, and were evaluated by ANCOVA adjusted for confounding factors such as age, sex, total energy intake, alcohol intake, current smoking, and habitual physical activity. There was a significant ($p < 0.001$) and inverse relationship between the number of components and coffee consumption but no such relationship was observed with green tea (Fig. 1a and b). We analyzed the frequency of metabolic syndrome according to the consumption of coffee or green tea. The frequency of metabolic syndrome decreased as the coffee consumption increased (Table 4a) but there was no such relationship between green tea consumption and frequency of metabolic syndrome (Table 4b).

4. Discussion

Although this study was carried out in a local cohort in Japan, the demographical backgrounds shown in Table 1 are characteristic of a general Japanese population because the dietary data were similar to those of the National Nutrition Survey in Japan [21], and because the data pertaining to body constitution, blood pressure, and blood chemistries were similar to those from the Fifth

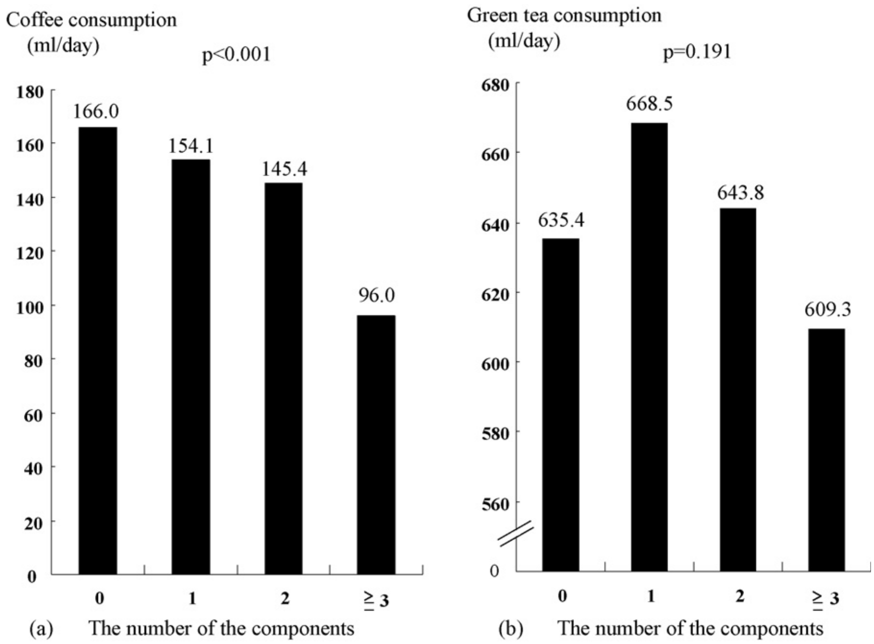

Fig. 1. Mean (a) coffee and (b) green tea consumption stratified by the number of the components of the metabolic syndrome adjusted for age, sex, total energy intake, alcohol intake, current smoking, and habitual physical activity. (a) There was a strong and inverse relationship; (b) there was no relationship.

Table 4
The frequency of the metabolic syndrome according to the (a) coffee consumption and (b) green tea consumption

	(a) Coffee consumption[a]			
	0–9 ml/day	10–99 ml/day	100–199 ml/day	200–1050 ml/day
Number of subjects (*n*)	689	360	433	420
The number of patients with MS (*n*)	83	42	37	26
Frequency (%)	12.0	11.6	8.5	6.2

	(b) Green tea consumption[b]			
	0–399 ml/day	400–699 ml/day	700–999 ml/day	1000–4500 ml/day
Number of subjects (*n*)	564	272	586	480
The number of patients with MS (*n*)	60	24	57	47
Frequency (%)	10.6	8.8	9.7	9.8

MS, metabolic syndrome.
[a] $p = 0.004$.
[b] $p = 0.914$.

National Survey of Cardiovascular Diseases [28]. The frequency of obesity has been increasing in Japan [28]. In this cohort, the prevalence of obesity with BMI $\geq$ 25 kg/m^2 was only 7.6% in 1958, 21.3% in 1977, 25.3% in 1982, 28.4% in 1989, and 34.1% in 1999, but the average BMI was still 23 kg/m^2 [29]. These data indicate that most Japanese are still not very obese. Although it was not the purpose of this study, we thought it would be interesting to analyze whether green tea consumption is associated with obesity. As shown in Table 3, green tea consumption was not related to waist circumference. Thus, there was no such association. In our population, the prevalence of metabolic syndrome (the number of components $\geq$3) was 188/1902 (10.0%). The prevalence was again much lower than the 16–23% reported in western countries [15,16].

Among many beverages consumed in Japan, the most popular ones are green tea and coffee [30,31]. The consumption of black tea or soft drinks like cola is relatively small. Accordingly, we examined the effects of coffee and green tea on metabolic syndrome. Reviewing the literature, it is well accepted that habitual consumptions of coffee and green tea have some favorable effects on cardiovascular risk factors; coffee consumption is associated with lower blood pressure [32,33] and lower blood glucose [10–14] and green tea consumption is associated with lower lipid profiles [30,34,35]. In fact, in this study, coffee consumption was associated with lower blood pressure, triglycerides, and blood glucose. However, there have been no reports on the association between consumption of beverages and this cluster of risk factors (metabolic syndrome). As shown in Fig. 1, coffee consumption was significantly and inversely associated with the number of components of metabolic syndrome, indicating low levels of coffee consumption in the population positive for this cluster of risk factors. As shown in Table 1, the consumption of green tea is much greater (about five-fold) than that of coffee. Thus, big consumption of tea may have obscured our results. However, we analyzed our data by multiple linear regression analysis (Table 3): there was no relationship between tea consumption and components of metabolic syndrome. Furthermore, we analyzed it in more details: we obtained the frequency of metabolic syndrome (Table 4b) in accordance to green tea consumption. There was again no relationship between them. It is possible that obese subjects may consume more alcohol than coffee and in fact, there was an inverse relationship between alcohol intake and coffee consumption shown in Table 2. However, when we performed univariate analysis with coffee consumption as dependent variable, there was no relationship ($p = 0.112$) between them, suggesting that the low incidence of metabolic syndrome in coffee drinkers is independent of alcohol consumption.

Although we could not elucidate the mechanisms for this strong association, several possibilities are considered. Caffeine may explain the favorable effects of coffee on metabolic syndrome, because coffee is a major source of caffeine, which decreases insulin resistance in humans [13,36].

We calculated the caffeine intake of coffee drinkers and green tea drinkers. In our population, mean caffeine intake from coffee and green tea was 0.08 g and 0.03 g, respectively. Thus, the intake of caffeine from green tea was much smaller than that from coffee, which may account for the negative association between metabolic syndrome and green tea consumption. Accordingly, we combined green tea and coffee consumption and stratified caffeine levels by the number of components of metabolic syndrome. Our results showed 0.12 g of caffeine for 0 component, 0.11 g for one component, 0.10 g for two components and 0.08 g for more than three components ($p = 0.015$ by multiple linear regression analysis adjusted for the confounding factors). Thus, the strong association between coffee consumption and metabolic syndrome may well be explained by caffeine intake. Catechins, the minimum unit of condensed tannin, may be a second candidate because it was reported in humans that catechins deceased body fat [37–40]. However, the catechin content of coffee is low [40]. Thus, this possibility is unlikely. Finally, some ingredients contained in coffee but not in green tea may have favorable effects on metabolic syndrome. This issue needs to be investigated further.

4.1. Limitation

The dried powder coffee is more consumed than brewed coffee beans in Japan. We did not examine which type of coffee they consumed in our cohort. Accordingly, our results may not be applicable to western countries where they do not consume much of the dried powder coffee.

In conclusion, this cross-sectional study suggests that coffee intake but not green tea may have a protective effect against metabolic syndrome.

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