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Green tea consumption is associated with lower psychological distress in a general population: the Ohsaki Cohort 2006 Study[1–3]

Atsushi Hozawa, Shinichi Kuriyama, Naoki Nakaya, Kaori Ohmori-Matsuda, Masako Kakizaki, Toshimasa Sone, Masato Nagai, Yumi Sugawara, Akemi Nitta, Yasutake Tomata, Kaijun Niu, and Ichiro Tsuji

ABSTRACT

Background: Although green tea or its constituents might reduce psychological stress, the relation between green tea consumption and psychological distress has not been investigated in a large-scale study.

Objective: Our aim was to clarify whether green tea consumption is associated with lower psychological distress.

Design: We analyzed cross-sectional data for 42,093 Japanese individuals aged ≥40 y from the general population. Information on daily green tea consumption, psychological distress as assessed by the Kessler 6-item psychological distress scale, and other lifestyle factors was collected by using a questionnaire. We used multiple logistic regression analyses adjusted for age, sex, history of disease, body mass index, cigarette smoking, alcohol consumption, time spent walking, dietary factors, social support, and participation in community activities to investigate the relation between green tea consumption and psychological distress.

Results: We classified 2774 (6.6%) of the respondents as having psychological distress (Kessler 6-item psychological distress scale ≥13/24). There was an inverse association between green tea consumption and psychological distress in a model adjusted for age and sex. Although the relation was largely attenuated when possible confounding factors were adjusted for, a statistically significant inverse association remained. The odds ratio (with 95% CI) of developing psychological distress among respondents who consumed ≥5 cups of green tea/d was 0.80 (0.70, 0.91) compared with those who consumed <1 cup/d. These relations persisted when respondents were stratified by social support subgroups or by activities in communities.

Conclusion: Green tea consumption was inversely associated with psychological distress even after adjustment for possible confounding factors. *Am J Clin Nutr* 2009;90:1390–6.

INTRODUCTION

Mental health is an important component of overall well-being (1). Thus, to determine risk factors for impaired mental health or psychological distress is an important task.

Kessler et al (2) recently compared the projected lifetime risk of any mental disorder as assessed by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) in 17 countries. The risk was the lowest in metropolitan areas in China (18.0%), Nigeria (19.5%), and Japan (24.4%). These values were lower than other countries, such as the United States (55.3%), France (47.2%), and Germany (33.0%). This suggests that some cultural or lifestyle-related features of Japan, such as dietary habit, personality, or social capital, might have a positive effect on mental disorders.

Among these features, green tea consumption is a traditional part of the Japanese lifestyle (3–5), and it has long been considered that drinking green tea is associated with stress relief (6). Actually, recent trials suggest that tea consumption (6) or supplementation with L-theanine (7), which is a constituent of green tea, reduces responses to acute psychological stress when assessed as post-task cortisol (6), heart rate, and salivary immunoglobulin-A (7). Therefore, green tea consumption might be able to reduce psychological distress. However, large-scale studies have not investigated the relation between green tea and psychological distress in the general population. One reason for this might be the difficulties with assessing psychological distress in a general population. However, Kessler et al (8, 9) have developed a short form of screening scales to monitor the prevalence of psychological distress in populations [the Kessler 6-item psychological distress scale (K6)], which we applied in the present study to investigate whether green tea consumption is associated with a lower psychological distress.

SUBJECTS AND METHODS

Study design, setting, and participants

The design of the Ohsaki Cohort 2006 Study has been described in detail (10). In brief, the source population for the

[1] From the Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan (AH, SK, NN, KO-M, MK, TS, MN, YS, AN, YT, and IT), and the Department of Medicine and Science in Sports and Exercise, Tohoku University Graduate School of Medicine, Sendai, Japan (KN).

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[3] Address correspondence to A Hozawa, Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine 2-1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan. E-mail: hozawa-thk@umin.ac.jp.

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baseline survey comprised all men and women aged ≥40 y living in Ohsaki City, northeastern Japan, on 1 December 2006.

The baseline survey was conducted between 1 December and 15 December 2006. A questionnaire was distributed by the heads of individual administrative districts to individual households and collected by mail. Of the eligible 77,235 respondents, the 49,855 (26,512 men and 23,343 women; 64.5%) who provided valid responses formed the study cohort. Of the 49,855 respondents, 43,716 (87.7%) completed the K6. We excluded 1623 persons who did not complete the questionnaire regarding green tea consumption. Thus, 42,093 responses were analyzed in this study.

Measurement of psychological distress

The K6 was used as an indicator of psychological distress (8, 9). Respondents were asked about their mental status over the last month by using 6 questions to which they responded by choosing "all of the time" (4 points), "most of the time" (3 points), "some of the time" (2 points), "a little of the time" (1 point), and "none of the time" (0 points). Total point scores ranged from 0 to 24. The questions were as follows: "Over the last month, how often have you felt the following? *1*) nervous, *2*) hopeless, *3*) restless or fidgety, *4*) so sad that nothing could cheer you up, *5*) that everything was an effort, and *6*) worthless. The K6 is based on modern psychometric theory and has already outperformed some existing scales (8, 9). The Japanese version of the K6 was recently developed by using the standard back-translation method and has been validated (11). As suggested by Kessler et al (9), we classified individuals with scores of ≥13/24 as having psychological distress (10). Furukawa et al (12) investigated whether K6 was able to predict 30-d disorders of the DSM-IV as assessed by the World Health Organization Composite International Diagnostic Interview in the Australian National Survey. They showed that K6 was able to detect Composite International Diagnostic Interview/DSM-IV mood and anxiety disorders (area under the receiver operating curve: 0.89; 95% CI: 0.88, 0.90) better than the General Health Questionnaire 12 (AUC: 0.80; 95% CI: 0.78, 0.82).

Measurements of other types of exposure

The survey included questions about the frequency of recent average consumption of green tea, oolong tea, black tea, coffee, and 36 food items, as well as questions regarding alcohol and tobacco consumption, history of disease, body weight, height, and time spent walking per day. The food-frequency questionnaire did not cover a specific period of time but asked about "daily diet." The frequency of green tea consumption was categorized as never, occasionally, or 1–2, 3–4, and >5 cups/d. Within the study region, the volume of a typical cup of green tea is 100 mL.

We conducted a validation study of the food-frequency questionnaire, in which 113 respondents provided four 3-d food records within a period of 1 y and subsequently responded to the questionnaire. The Spearman rank coefficient for the correlation between amounts of consumed green tea according to the questionnaire and amounts consumed according to the food records was 0.71 for men and 0.53 for women; the correlation between consumption measured by the 2 questionnaires administered 1 y apart was 0.63 for men and 0.64 for women (13). Body mass index was calculated as the self-reported body weight (kg) divided by the square of the self-reported body height (m).

The degree of social support available to each individual was assessed by asking the following (14): Do you have someone *1*) whom you can talk to when you are in trouble? *2*) whom you can consult when you do not feel well? *3*) who can help you with your daily housework? *4*) who can take you to a hospital when you feel ill? and *5*) who can take care of you if you become bedridden? This social support questionnaire consisted of 5 questions, each requiring a "yes" or "no" answer. This questionnaire was available only in Japanese. The validity and reliability of the questionnaire were not evaluated.

We also assessed participation in community activities. We asked about how often the respondent participates in the following activities: *1*) neighborhood associations; *2*) sports, exercise, or a hobby; *3*) volunteering for nonprofit organizations; and *4*) participation in other social gatherings. The frequency of these activities was assessed as never, a few times each year, monthly, 2–3 times/month, 1 time/wk, 2–3 times/wk, and ≥4 d/wk.

Ethical issues

We considered the return of completed questionnaires to imply the consent to participate in the study involving a cross-sectional analysis of the baseline survey data and subsequent follow-up of mortality and emigration. The Ethics Committee of Tohoku University Graduate School of Medicine reviewed and approved the study protocol.

Statistical analysis

Baseline characteristics were evaluated by using the analysis of variance for continuous variables and the chi-square test for categorical variables. We also used age-sex-adjusted logistic regression analyses to clarify the age-sex-adjusted relation between green tea consumption and history of diseases. We used multivariate logistic regression analysis to calculate the odds ratios (ORs) and 95% CIs for having psychological distress (a K6 total score of ≥13/24) according to categories of green tea consumption. We established respondents who consumed <1 cup/d green tea as the reference category and examined the relation between green tea consumption and psychological distress by using the following models. Model 1 was age-sex adjusted. Model 2 was adjusted for the following physical risk factors: sex; age (40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and ≥85 y); history of hypertension ("yes," "no"), diabetes mellitus ("yes," "no"), stroke ("yes," "no"), myocardial infarction ("yes," "no"), and cancer ("yes," "no"); smoking status ("never," "former," "current," "missing"); alcohol consumption ("never," "former," "current," "missing"); body mass index (in kg/m^2: <18.5, 18.5–24.9, ≥25.0, missing); and time spent walking (<30 min/d, 30 min to 1 h/d, ≥1 h/d, missing). Model 3 was further adjusted for dietary factors, namely volume of rice intake and frequency of consumption of miso soup, red meat, chicken, fish, green or yellow vegetable, soy products, fruit, coffee, black tea, and oolong tea. Model 4 was fully adjusted and included the answers to the questions about social support ("yes," "no support," "missing") and participation in community activities ("yes," "never," "missing").

TABLE 1
Relation between green tea consumption and the characteristics of the participants of the Ohsaki Cohort 2006 Study[1]

	Green tea consumption (cups/d)				
	<1 (n = 10,770)	1–2 (n = 12,007)	3–4 (n = 10,364)	>5 (n = 8952)	P
Age (y)	58.5 ± 12.5[2]	59.9 ± 12.5	64.6 ± 12.0	67.5 ± 10.8	<0.01
Women [n (%)]	5090 (47)	6093 (51)	5954 (57)	5742 (64)	<0.01
Smoking [n (%)]					
Current	3249 (30)	2829 (24)	1787 (17)	1323 (15)	<0.01
Former	2319 (22)	2589 (22)	2126 (21)	1633 (18)	
Never	4749 (44)	5991 (50)	5721 (55)	5202 (58)	
Alcohol drinking [n (%)]					
Current	5797 (54)	6415 (53)	4573 (44)	3266 (36)	<0.01
Former	1020 (9)	886 (7)	802 (8)	749 (8)	
Never	3603 (33)	4244 (35)	4404 (42)	4311 (48)	
BMI [n (%)]					
18.5 kg/m^2	506 (5)	455 (4)	405 (4)	375 (4)	<0.01
18.5–24.9 kg/m^2	6517 (61)	7454 (62)	6322 (61)	5376 (60)	
≥25 kg/m^2	3077 (29)	3420 (28)	2875 (28)	2466 (28)	
Time spent walking >1 h [n (%)]	3074 (29)	3209 (27)	2717 (26)	2539 (28)	<0.01
History of diseases [n (%)]					
Hypertension	2610 (24)	3191 (27)	3296 (32)	3139 (35)	<0.01
Diabetes mellitus	850 (8)	966 (8)	981 (9)	867 (10)	<0.01
Stroke	278 (3)	269 (2)	233 (2)	183 (2)	<0.01
Myocardial infarction	243 (2)	261 (2)	307 (3)	267 (3)	<0.01
Cancer	483 (4)	571 (5)	656 (6)	643 (7)	<0.01
Volume of rice intake [n (%)]					
>3 bowls/d	1107 (10)	1135 (9)	882 (9)	687 (8)	<0.01
Consumed miso soup almost every day [n (%)]	7790 (72)	9585 (80)	8756 (84)	7715 (86)	<0.01
Frequency of food intake [n (%)]					
Red meat (at least once/wk)	8910 (83)	10225 (85)	8901 (86)	7579 (85)	<0.01
Chicken (at least once/wk)	6163 (57)	7266 (61)	6387 (62)	5432 (61)	<0.01
Fish (almost every day)	1867 (17)	2470 (21)	2814 (27)	3211 (36)	<0.01
Green yellow vegetable (almost every day)	3097 (29)	4176 (35)	4526 (44)	4795 (54)	<0.01
Soy products (almost every day)	4314 (40)	5750 (48)	5971 (58)	5859 (65)	<0.01
Fruit (almost every day)	2509 (17)	3673 (31)	4210 (41)	4626 (52)	<0.01
Frequency of beverage intake [n (%)]					
Coffee ≥1 cup/d	7749 (72)	8843 (74)	6586 (64)	4796 (54)	<0.01
Black tea ≥1 cup/d	937 (9)	2173 (18)	1875 (18)	1677 (19)	<0.01
Oolong tea ≥1 cup/d	1507 (14)	2304 (19)	1845 (18)	1714 (19)	<0.01
Social support [n (%)]					
To consult when you are in trouble (no)	1690 (16)	1567 (13)	1061 (10)	764 (9)	<0.01
To consult when you are in bad physical condition (no)	1335 (12)	1214 (10)	812 (8)	594 (7)	<0.01
To help with your daily housework (no)	1903 (18)	1834 (15)	1476 (14)	1163 (13)	<0.01
To take you to a hospital (no)	1188 (11)	1057 (9)	782 (8)	637 (7)	<0.01
To take care of you (no)	1498 (14)	1460 (12)	1259 (12)	1096 (12)	<0.01
Participation in community activities [n (%)]					
Activities in neighborhood association (any yes)	4659 (43)	5681 (47)	5120 (49)	4352 (49)	<0.01
Sports or exercise (any yes)	4140 (38)	5283 (44)	4707 (45)	4005 (45)	<0.01
Volunteers (any yes)	2854 (27)	3588 (30)	3189 (31)	2736 (22)	<0.01
Social gathering (any yes)	4061 (38)	5271 (44)	4698 (45)	4081 (46)	<0.01

[1] For smoking, alcohol drinking, and BMI, the sum of the number of participants did not match all numbers of participants due to missing information.
[2] Mean ± SD (all such values).

We used several dummy variables to adjust for the aforementioned factors.

Because we considered that social support or community activities might modify the relation between green tea and psychological distress, we further stratified the responses by social support (support in all 5 social support categories and perception of not being supported in ≥1 of 5 social support categories) and community activity (participation in at least one community activity or none) to confirm the relation between green tea consumption and psychological distress. Those who did not answer any questions about social support or participation in community activities were excluded when stratified by social support and participation in communities, respectively. In an analysis of social support and participation in community activities, neither of these was used as the respective covariate. When we calculated the interaction of green tea with social support and participation in community activities, we used cross-product terms of green tea and social support or participation in community activities.

We also analyzed the relation between black tea consumption and psychological distress by using a fully adjusted model (model 4). All data were statistically analyzed by using SAS version 9.1 (SAS Inc, Cary, NC). All statistical tests described here were 2-sided, and $P < 0.05$ was accepted as statistically significant.

RESULTS

The association between green tea consumption and other lifestyle factors is shown in **Table 1**. The mean age, the proportion of women, the proportion of those who had never smoked or never consumed alcohol, as well as the frequency of a history of hypertension and cancer were higher among those who more frequently consumed green tea. This group also consumed more fish, soy products, green and yellow vegetables, and fruit and participated more often in community activities. Conversely, fewer respondents who consumed more green tea felt a lack of social support. Because the relation between green tea consumption and a history of diseases might be strongly confounded by age, we conducted age-sex-adjusted logistic regression analyses. The relation of green tea consumption to hypertension, diabetes, and myocardial infarction was no longer statistically significant when adjusted for age and sex (P for trends ≥ 0.13). However, the inverse association between green tea consumption and history of stroke ($P < 0.001$) and the positive relation between green tea consumption and history of cancer ($P = 0.007$) remained statistically significant.

Overall, 2774 (6.6%) respondents were considered to have psychological distress (K6 $\geq$ 13). The prevalence was the highest (8.4%) and lowest (5.1%) among those who consumed <1 and $\geq$5 cups green tea/d, respectively (*see* **Table 2**). The age-sex-adjusted model (model 1) revealed a close inverse relation between green tea consumption and having psychological distress. In comparison with individuals who consumed <1 cup/d, the ORs (95% CI) of having psychological distress for those who consumed 1–2, 3–4, and $\geq$5 cups/d were 0.79 (0.71, 0.87), 0.68 (0.61, 0.76), and 0.59 (0.52, 0.67), respectively. Although these associations were attenuated when adjusted for other lifestyle factors or a history of disease (model 2), the significant inverse association persisted (P for trend < 0.001). Although adjustment for dietary factors (model 3) and for social support or participation in community activities (model 4) also attenuated the relation, the inverse association between green tea consumption and psychological distress persisted (both P's for trend were <0.001). The adjusted ORs (95% CI) for psychological distress in subjects who consumed 1–2, 3–4, and $\geq$5 cups of green tea/d were 0.95 (0.86, 1.06), 0.89 (0.79, 1.00), and 0.80 (0.70, 0.91), respectively, in model 4, compared with the reference group.

To confirm whether the relation between green tea consumption and psychological distress persisted irrespective of social support or participation in community activities, we also investigated the association stratified in a subgroup by these 2 factors (**Table 3**). Neither an interaction between green tea consumption and social support for psychological distress ($P = 0.91$) nor an interaction between green tea consumption and participation in community activities for psychological distress ($P = 0.08$) was statistically significant.

We also analyzed the relation between the consumption of black tea and psychological distress. Compared with participants who consumed <1 cup black tea/d (n = 35,431), the ORs (95% CI) for those who consumed 1–2 cups black tea/d (n = 2161), and $\geq$3 cups black tea/d (n = 516) were 1.14 (0.95, 1.36) and 1.11 (0.78, 1.58), respectively.

TABLE 2
Relation between green tea consumption and psychological distress, as assessed by the Kessler 6-item psychological distress scale (K6), in the Ohsaki Cohort 2006 Study[1]

	Green tea consumption (cups/d)				
	<1 (n = 10,770)	1–2 (n = 12,007)	3–4 (n = 10,364)	>5 (n = 8952)	P for trend
No. of participants with psychological distress (K6 $\geq$13)	902	808	604	460	—
Prevalence of psychological distress (%)	8.4	6.7	5.8	5.1	—
Model 1[2]	Ref	0.79 (0.71, 0.87)[3]	0.68 (0.61, 0.76)	0.59 (0.52, 0.67)	<0.001
Model 2[4]	Ref	0.83 (0.75, 0.92)	0.73 (0.65, 0.81)	0.64 (0.57, 0.72)	<0.001
Model 3[5]	Ref	0.91 (0.82, 1.01)	0.83 (0.74, 0.93)	0.73 (0.64, 0.83)	<0.001
Model 4[6]	Ref	0.95 (0.86, 1.06)	0.89 (0.79, 1.00)	0.80 (0.70, 0.91)	<0.001

[1] Ref, referent.

[2] Adjusted for age categories (40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and $\geq$85 y) and for sex.

[3] Odds ratio; 95% CI in parentheses (all such values).

[4] Same as model 1 + history of hypertension (yes, no), history of diabetes mellitus (yes, no), history of stroke (yes, no), history of myocardial infarction (yes, no), history of cancer (yes, no), smoking status (never, former, current, missing), alcohol consumption (never, former, current, missing), BMI (in kg/m^2; <18.5, 18.5–24.9, $\geq$25.0, missing), and time spent walking (<30 min/d, 30 min–1 h/d, $\geq$1 h/d, missing).

[5] Same as model 2 + volume of rice intake, frequency of consumption of miso soup, red meat, chicken, fish, green and yellow vegetable, soy product, fruit, coffee, black tea, and oolong tea.

[6] Same as model 3 + social support [ie, *1*) Do you have someone with whom you can consult when you are in trouble? (yes, no, missing), *2*) Do you have someone with whom you can consult when your physical condition is not good? (yes, no, missing), *3*) Do you have someone who can help you with your daily housework? (yes, no, missing), *4*) Do you have someone who can take you to a hospital when you do not feel well? (yes, no, missing), and *5*) Do you have someone who can take care of you when you are ill in bed? (yes, no, missing)] and participation in community activities [ie, How often do you participate in the following activities? *1*) activities in neighborhood association (any yes, never, missing), *2*) sports, exercise, or hobby (any yes, never, missing), *3*) volunteer for a nonprofit organization (any yes, never, missing), and *4*) other social gatherings (any yes, never, missing)].

TABLE 3
Relation between green tea consumption and psychological distress, as assessed by the Kessler 6-item psychological distress scale (K6), stratified by social support and community activity subgroup in the Ohsaki Cohort 2006 Study[1]

	Green tea consumption (cups/d)				
	<1	1–2	3–4	>5	*P* for trend
Social support[2]					
No lack					
No. of participants	7466	8723	7799	6839	
No. of participants with psychological distress (K6 ≥ 13)	414	422	312	259	
Prevalence of psychological distress (%)	5.5	4.8	4.0	3.8	
Multiple adjusted OR (95% CI)[3]	Ref	0.99 (0.86, 1.15)	0.86 (0.73, 1.01)	0.81 (0.68, 0.96)	0.005
Any lack					
No. of participants	3283	3255	2544	2098	
No. of participants with psychological distress (K6 ≥ 13)	484	383	291	201	
Prevalence of psychological distress (%)	14.7	11.8	11.4	9.6	
Multiple adjusted OR (95% CI)[3]	Ref	0.89 (0.77, 1.04)	0.94 (0.80, 1.11)	0.77 (0.64, 0.94)	0.02
Participation in community activities[2]					
Participated					
No. of participants	6830	8281	7285	6246	
No. of participants with psychological distress (K6 ≥ 13)	370	383	288	197	
Prevalence of psychological distress (%)	5.4	4.6	4.0	3.2	
Multiple adjusted OR (95% CI)[3]	Ref	0.99 (0.85, 1.15)	0.98 (0.83, 1.16)	0.82 (0.67, 0.998)	0.08
Did not participate					
No. of participants	3759	3499	2876	2491	
No. of participants with psychological distress (K6 ≥ 13)	500	387	297	245	
Prevalence of psychological distress (%)	13.3	11.1	10.3	9.8	
Multiple adjusted OR (95% CI)[3]	Ref	0.93 (0.80, 1.08)	0.87 (0.73, 1.02)	0.82 (0.69, 0.98)	0.02

[1] OR, odds ratio; Ref, referent; "No lack," participants who perceived that they were supported for all 5 social support categories; "Any lack," participants who perceived that they were not supported for at least one social support category; "Participated," participants who participated in at least one community activity; "Did not participate," participants who did not participate in any community activities.

[2] Social support and participation in community activities were not used as covariates in analyses. *P* values for interaction for social support and participation in community activities were 0.91 and 0.08, respectively.

[3] Model 4 in Table 2 was used for adjustment.

DISCUSSION

We identified an inverse relation between green tea consumption and psychological distress as assessed by K6 in a large-sample cross-sectional study of a Japanese population. We considered that green tea consumption might contribute, at least in part, to a low lifetime risk of any mental disorder in Japan (2).

The main strength of our study is that we investigated a large sample of the general population, which allowed the consideration of many confounding factors, including social support and participation in community activities. Another strength is that we used a practical and tested questionnaire to assess psychological distress (8, 9). Of the 49,855 respondents, 88% completed the K6 [the 6-item scale developed by Kessler et al (8, 9)], which enabled an assessment of risk factors for psychological distress in a general population.

To understand whether green tea was inversely and independently related to psychological distress, we attempted several approaches to control confounding. First, we tested the effects of comorbidities or lifestyle factors on the relation. Both green tea consumption and psychological distress are inversely related with a history of cardiovascular diseases (CVDs) (10) and risk factors for CVD (10, 15, 16). Furthermore, we already reported that green tea consumption is inversely related with CVD mortality (4). Thus, CVD or risk factors for CVD can be confounding factors of the relation between green tea and psychological distress. However, the association persisted although adjustment for these factors attenuated the inverse relation between green tea consumption and psychological distress. Therefore, we considered that the relation was independent of CVD or these risk factors.

We also considered confounding by other dietary factors. Adjustments for other foods were required because the consumption of green tea might be associated with that of other Japanese foods, such as fish or soy products (5). Furthermore, the effect of other beverages on psychological distress also should be adjusted. However, adjustment for dietary factors and beverages did not fully explain the inverse relation between green tea and psychological distress. Therefore, we considered that the relation was independent of other dietary factors or beverages.

Third, we considered the effect of social support or community activities. Because green tea is the most likely beverage to be served during social activities in Japan, its consumption might be merely a marker of social support or community activity (3). In fact, our cross-sectional analyses have already shown a close inverse relation between psychological distress and social support or activities in the community (10). Thus, consideration of these factors is also important to understanding the relation between green tea consumption and psychological distress. However, we show that the inverse association between green tea consumption and psychological distress persisted even after further adjustment for social support and participation in community activities, irrespective of social support subgroup or

subgroup of community activities. Therefore, although other residual confounding factors might exist, we considered that green tea consumption was inversely and independently related to psychological distress.

Only one study has described a relation between green tea consumption and mental illness (17). Shimbo et al (17) investigated 380 Japanese individuals aged 20–69 y and assessed the relation between green tea consumption and a Japanese version of the General Health Questionnaire 12. Although they show that brewed green tea consumption was inversely associated with mental illness (OR: 0.78 for males and 0.77 for females), the relation was not statistically significant. Because the point estimate was large, Shimbo et al (17) might have detected a significant association if a sufficiently large sample had been investigated. Thus, although the assessment methods were different, we considered that our results agreed with their findings.

Some clinical trials have examined the effect of tea (6), L-theanine (7), or high doses of ascorbic acid (18) on responses to psychological stress. Both L-theanine and ascorbic acid are constituents of green tea (16). An investigation of the influence of black tea compared with a caffeine-matched placebo on both acute biological responses and the rate of poststress recovery by using double-blind methodology (6) discovered that 6 wk of tea consumption leads to lower poststress cortisol and greater subjective relaxation. Kimura et al (7) examined whether L-theanine influences the physiologic response under stress by using a mental arithmetic task as an acute stressor. They show that L-theanine intake resulted in a reduction in heart rate and salivary immunoglobulin A responses to an acute stress task relative to a placebo control. Brody et al (18) reported that high-dose ascorbic acid palliates blood pressure, cortisol, and subjective responses to acute psychological stress. These studies consistently show that the acute response to psychological stress was reduced in a group provided with tea or tea constituents. Because reducing physiologic stress might result in reduced psychological distress, these data could be considered as evidence that supports our findings.

These results from clinical trials also suggested that not only green tea but also black tea might have a beneficial effect on psychological distress because the constituents of the 2 types of tea are similar (16). In fact, Hintikka et al (19) have reported an inverse relation between the daily consumption of black tea and the risk of depression, as assessed by a postal questionnaire and the Beck Depression Inventory in a relatively large general Finnish population sample. In our study, however, we did not find any relation between consumption of black tea and psychological distress. We considered that the lack of such an association was due to the less-frequent consumption of black tea in Japan. Any relation between black tea and psychological distress might be masked by frequent consumption of green tea.

This study has some limitations. The first was the cross-sectional design. We could not conclude whether green tea reduces psychological distress or whether individuals without psychological distress are more likely to consume green tea. However, because we clarified an inverse relation between green tea consumption and psychological distress irrespective of social support and participation in community activities, we considered that green tea has a beneficial effect on psychological distress. A prospective study or a clinical trial is required to confirm this notion. Second, the correlation between the amounts of green tea consumed according to the questionnaire and the amounts consumed according to the 3-d food records was not very high (men: 0.71; women: 0.53), especially in women. Because green tea consumption varied day by day, we considered that a certain difference could be acceptable for green tea consumption. However, in any case, questionnaire surveys have some misclassifications regarding green tea consumption. Due to this limitation, we might have underestimated the inverse relation between green tea consumption and psychological distress in this study. Third, although we claimed that social support is an important confounding factor and we stratified according to this variable, the variable is not validated. However, the questionnaire comprised simple questions, and therefore we considered that it could be used for the assessment of social support. In conclusion, we showed that green tea consumption was inversely associated with psychological distress in a cross-sectional study of a large Japanese population.

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Green tea consumption is associated with depressive symptoms in the elderly[1–3]

Kaijun Niu, Atsushi Hozawa, Shinichi Kuriyama, Satoru Ebihara, Hui Guo, Naoki Nakaya, Kaori Ohmori-Matsuda, Hideko Takahashi, Yayoi Masamune, Masanori Asada, Satoshi Sasaki, Hiroyuki Arai, Shuichi Awata, Ryoichi Nagatomi, and Ichiro Tsuji

ABSTRACT

Background: Green tea is reported to have various beneficial effects (eg, anti–stress response and antiinflammatory effects) on human health. Although these functions might be associated with the development and progression of depressive symptoms, no studies have investigated the relation between green tea consumption and depressive symptoms in a community-dwelling population.

Objective: The aim of this study was to investigate the relations between green tea consumption and depressive symptoms in elderly Japanese subjects who widely consumed green tea.

Design: We conducted a cross-sectional study in 1058 community-dwelling elderly Japanese individuals aged ≥70 y. Green tea consumption was assessed by using a self-administered questionnaire, and depressive symptoms were evaluated by using the 30-item Geriatric Depression Scale with 2 cutoffs: 11 (mild and severe depressive symptoms) and 14 (severe depressive symptoms). If a participant was consuming antidepressants, he or she was considered to have depressive symptoms.

Results: The prevalence of mild and severe and severe depressive symptoms was 34.1% and 20.2%, respectively. After adjustment for confounding factors, the odds ratios (95% CI) for mild and severe depressive symptoms when higher green tea consumption was compared with green tea consumption of ≤1 cup/d were as follows: 2–3 cups green tea/d (0.96; 95% CI: 0.66, 1.42) and ≥4 cups green tea/d (0.56; 95% CI: 0.39, 0.81) (*P* for trend: 0.001). Similar relations were also observed in the case of severe depressive symptoms.

Conclusion: A more frequent consumption of green tea was associated with a lower prevalence of depressive symptoms in the community-dwelling older population. *Am J Clin Nutr* 2009; 90:1615–22.

INTRODUCTION

Depression in late life is a recognized public health problem. Depression can increase the risk of medical illnesses, worsen the outcome of other medical illnesses, and even increase mortality (1, 2).

Many risk factors are recognized as contributors to the occurrence of depressive symptoms. Stress is particularly well established as a factor that can cause depressive symptoms or contribute to the severity of depression (3). Inflammation also is of key importance for central and peripheral hormonal secretion; it also interacts with neurotransmitters and is related to pathophysiologic processes such as neurodegeneration (4). Epidemiologic studies of patients and community dwellers have shown that inflammatory proteins are associated with depressive symptoms (5).

In Asia, green tea, a widely consumed beverage, has been regarded for centuries to possess significant health-promoting effects (6). Many animal studies have suggested that theanine, one of the major amino acids contained in green tea, has a tranquilizing effect on the brain (7). A laboratory study on acute stress showed that the oral intake of theanine lowered the stress response in human participants (8). Several experimental and animal studies have also shown that green tea is an antiinflammatory agent and that it ameliorates the overproduction of proinflammatory cytokines and mediators (9–11). These effects have been attributed largely to the most prevalent polyphenol contained in green tea, catechin, or flavanol (−) epigallocatechin-3-gallate (12).

Thus, we hypothesized that green tea might have a beneficial effect in the primary and secondary prevention of depressive symptoms or psychological distress due to its antagonistic effects on the stress response and inflammation. However, to the best of our knowledge, only a few studies have reported relations between green tea consumption and mental health (13, 14), and a relation concerning depressive symptoms does not appear to have been investigated. Thus, the relation between green tea

[1] From the Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate School of Biomedical Engineering, Sendai, Japan (KN, HG, and RN); the Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan (AH, SK, NN, KO-M, HT, and IT); the Department of Geriatrics and Gerontology Division of Brain Sciences, Institute of Development, Aging and Cancer, Tohoku University, Sendai, Japan (SE, MA, and HA); the Division of Psychiatry, Kodama Hospital, Sendai, Japan (YM); the Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, Tokyo, Japan (SS); and the Division of Neuropsychiatry and Center for Dementia, Sendai City Hospital, Sendai, Japan (SA).

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[3] Address correspondence to K Niu, Division of Biomedical Engineering for Health and Welfare, Tohoku University Graduate School of Biomedical Engineering, 2-1 Seiryo-machi, Aoba-ku, Sendai 980-8575, Japan. E-mail: ggg@mail.tains.tohoku.ac.jp.

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consumption and depressive symptoms in community-dwelling elderly adults, in whom this condition is highly prevalent, remains unclear. In the present study, we investigated the relation between green tea consumption and depressive symptoms in elderly Japanese subjects who consume green tea.

SUBJECTS AND METHODS

Study participants

Our study population comprised subjects aged ≥70 y who resided in the Tsurugaya area of Sendai city, one of the major cities in the Tohoku area of Japan (15, 16). At the time of the study in 2002, there were 2730 individuals aged ≥70 y living in Tsurugaya. All of them were invited to participate in a comprehensive geriatric assessment, which included physical function, cognitive function, and dental status. Of those invited, 1198 participated in the survey and 1178 provided their informed consent for data analysis. The protocol of this study was approved by the Institutional Review Board of the Tohoku University Graduate School of Medicine.

In this study, the depressive symptoms were assessed by using the Geriatric Depression Scale (GDS). Of the 1178 subjects, 1169 completed the GDS (**Figure 1**). Those who did not have any information on diet were excluded (n = 94). Furthermore, subjects who reported cognitive dysfunction (Mini-Mental State Examination score: <18; n = 17) (17) were also excluded. As a result of these exclusions, the final study population comprised 1058 subjects (mean ± SD age: 75.9 ± 4.7 y; men: 42.6%).

Assessment of depressive symptoms

Depressive symptoms were assessed according to the Japanese version (18) of the 30-item GDS. The score ranged from 0 to 30, with greater values indicating increased severity. In this study, 2 cutoffs were used to define different levels of depressive symptoms. The first cutoff was a GDS score ≥11 and/or the use of antidepressants, which indicated relatively mild and severe depressive symptoms. The second cutoff was a GDS score ≥14 and/or the use of antidepressants, indicating relatively severe depressive symptoms.

Assessment of dietary intake

The participants were instructed to fill out a brief self-administered diet-history questionnaire that included 75 food items with specified serving sizes described by natural portions or standard weight and volume measures of the servings commonly

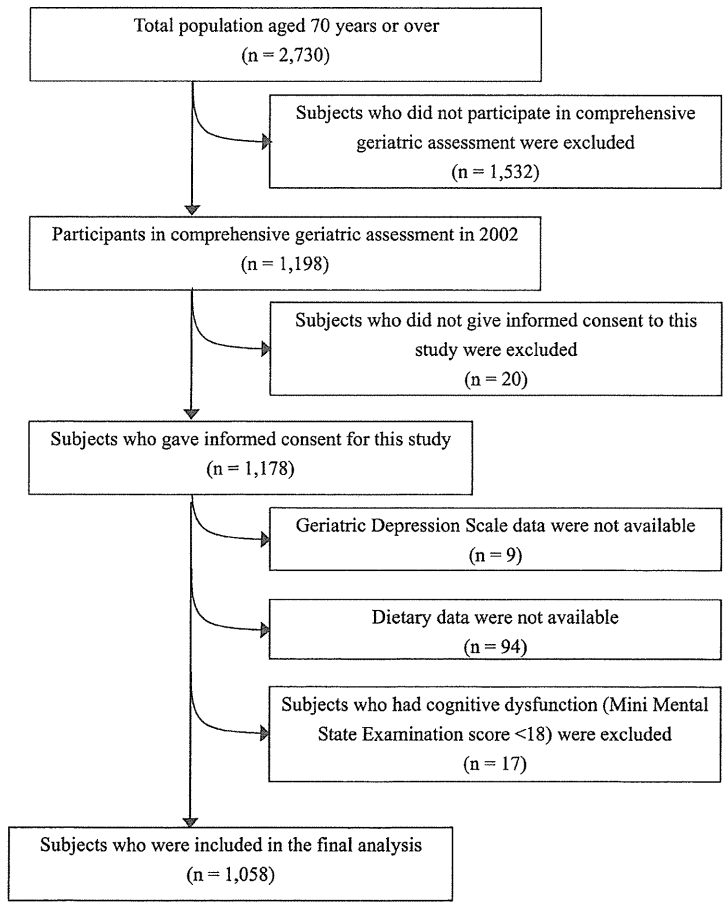

FIGURE 1. Flow chart of the sample selection.

consumed in the study population. The mean daily intake of nutrients was calculated by using an ad hoc computer program developed to analyze the questionnaire. The Japanese food composition tables (19) and others (20) were used as the nutrient database. The reproducibility and validity of the brief self-administered diet-history questionnaire have already been described in detail elsewhere (21).

Participants indicated the mean frequency of consumption of green tea, black or oolong tea, and coffee over the previous 1 mo in terms of the specified serving size by selecting 1 of the 8 frequency categories: almost never, <1 cup/wk, 1 cup/wk, 2–3 cups/wk, 4–6 cups/wk, 1 cup/d, 2–3 cups/d, and ≥4 cups/d. In the study region, the volume of a typical cup of green tea is 100 mL. We summarized these categories in tertile in the following way: green tea (≤1 cup/d, 2–3 cups/d, and ≥4 cups/d), black or oolong tea (almost never, <1 cup/d, and ≥1 cups/d), and coffee (almost never, <1 cup/d, and ≥1 cups/d).

Assessment of other variables

Blood pressure (BP) was measured at home with an HEM747IC device (Omron Life Science Co Ltd, Tokyo, Japan), which uses the cuff oscillometric method to generate a digital display of systolic and diastolic BPs. The mean (±SD) of 15.6 ± 10.4 BP measurements was used as the BP value. Participants who did not measure BP at home on ≥3 d were treated as having missing information on hypertension. Hypertension was defined as a home systolic BP ≥135 mm Hg or a home diastolic BP ≥85 mm Hg or the use of antihypertensive agents (22).

Blood samples were drawn from the antecubital vein, with minimal tourniquet use, while subjects were seated. Specimens were collected in siliconized vacuum glass tubes containing sodium fluoride for blood glucose and no additives for C-reactive protein (CRP) analyses. Blood glucose concentration was measured by using enzymatic methods (Shino-Test, Tokyo, Japan). Diabetes was defined as a casual blood glucose concentration of ≥200 mg/dL or the current use of antidiabetic medication. Highly sensitive CRP concentrations were determined by an immunotechnique that uses a Behring BN II analyzer (Dade Behring, Tokyo, Japan). The BN II assay utilizes a monoclonal antibody coated on polystyrene particles and fixed-time kinetic nephelometric measurements. The detection limit of this assay is 0.02 mg/L. We categorized the study participants on the basis of proposed cutoffs for CRP as low (<1.0 mg/L) or high (at least 1.0 mg/L) (23). The drug information was confirmed by a well-trained pharmacist.

The anthropometric variables (height and body weight) were recorded by using a standard protocol. Body mass index was calculated as weight in kilograms divided by height in meters squared. The sociodemographic variables, which include sex, age, educational level, marital status, cohabitants, perceived social support, and visiting friends, were also assessed. The educational level was assessed by determining the age at completion of schooling and was divided into 2 categories: ≤12 or >12 y (24). Marital status was categorized as follows: married, divorced or widowed, or single. The subjects were also classified as living alone or living with others. Perceived social support (PSS) was evaluated on the basis of the responses (yes or no) to the following 5 questions: "Do you have someone to talk to when you are in trouble?" (PSS1); "Do you have someone to talk to when your physical condition is not good?" (PSS2); "Do you have someone to help you with daily housework?" (PSS3); "Do you have someone to take you to the hospital when you are not feeling well?" (PSS4); and "Do you have someone to take care of you when you are ill and in bed?" (PSS5). These questions were extracted from a previous study on social support and depression among elderly individuals in a rural community (25). A single score was calculated by adding the scores of PSS1–5. The lack of PSS was defined as a PSS score of 0. "Visiting friends" was evaluated on the basis of the responses (yes or no) to the following question: "Do you visit your friends?"

The health-related variables included history of physical illness, pain, cognitive function, instrumental activities of daily living (IADLs), and current medication use. History of physical illness was evaluated on the basis of the responses (yes or no) to questions concerning the history of stroke, ischemic heart disease, cancer, and arthritis. Pain within the previous 4 wk was assessed on the basis of the question, "Have you had any pain recently? If so, how intense was it?" The possible answers were "no pain," "very mild pain," "mild pain," "moderate pain," and "severe pain." Subjects who reported "mild" to "severe" pain were considered to have pain. Cognitive function was assessed with the Mini-Mental State Examination, and scores were classified as belonging to 1 of 3 categories: 18–23, 24–27, and ≥28. The IADL scores were assessed by using the Rouken-Shiki scale (26), and a cutoff of 10/11 was used to determine impairment in IADLs (27).

Information on the smoking ("never," "former," and "current smoking") and drinking ("never," "former," and "current drinking") status of the participants was obtained from a questionnaire survey. Physical activity (PA) was first assessed by a self-reported single question on whether the participant had any PA in the past year. If "yes," further questions were asked about the frequency and duration of walking, brisk walking, and sports. PA was then classified into 3 categories on the basis of the frequency and duration of participation: *1*) "high" (PA ≥3–4 times/wk for ≥30 min each time), *2*) "low" (reporting some PA in the past year, but not enough), and *3*) "none" (no PA). Furthermore, PA was classified into 6 levels on the basis of the above 3 categories and the nature of the physical activity, such as walking, brisk walking, and sports: *1*) level 1 (no walking, brisk walking, or sports), *2*) level 2 (low walking, no brisk walking, no sports), *3*) level 3 (high walking, no brisk walking, no sports), *4*) level 4 (any walking, low brisk walking, no sports), *5*) level 5 (any walking, high brisk walking, no sports), and *6*) level 6 (any walking, any brisk walking, low or high sports). Detailed information has been provided in previous reports (28).

Statistical analysis

The descriptive data have been presented as the mean (with 95% CIs) or as percentages. Depressive symptoms were used as dependent variables, and green tea consumption categories in tertile were used as independent variables. The differences of variables among the green tea consumption categories were examined by analysis of variance for continuous variables or by logistic regression analysis for variables of proportion. For model 1, multiple logistic regression analysis was used to examine relations between green tea consumption and depressive symptoms with adjustment for age; sex; body mass index;

hypertension; diabetes; history of cardiovascular diseases, cancer, or arthritis; high C-reactive protein (≥1.0 mg/L); history of smoking and drinking habits; physical activity (all 6 levels as a categorical variable); cognitive status; impaired IADLs; self-reported body pain; educational level; living alone; and marital status (model 1). For model 2, all of the above variables were used, in addition to serum albumin concentration, total energy intake, intakes per 2000 kcal of energy intake as protein and folate, and consumption frequencies of black or oolong tea (almost never, <1 cup/d, and ≥1 cups/d) and coffee (almost never, <1 cup/d, and ≥1 cups/d). For model 3, all variables in models 1 and 2 in addition to lack of PSS and visiting friends were included. The final multivariate logistic analysis was performed with the forced entry of all factors considered to be potential covariates. Bonferroni-corrected *P* values were used for comparisons between groups differing in green tea consumption. All *P* values for linear trends were calculated by using the categories of green tea consumption (≤1 cup/d: 1; 2–3 cups/d: 2; ≥4 cups/d: 3). The interactions between green tea consumption and all confounders for having depressive symptoms were tested through the addition of the cross-product terms to the regression model. A difference was defined to be significant when $P < 0.05$. All statistical analyses were performed by using the Statistical Analysis System 9.1 edition for Windows (SAS Institute Inc, Cary, NC).

RESULTS

On the basis of the data obtained from 1058 subjects, 34.1% (361/1058) [27.3% (123/451) of men and 39.2% (238/607) of women] were classified as having mild and severe depressive symptoms and 20.2% (214/1058) [14.9% (67/451) of men and 24.2% (147/607) of women] were classified as having severe depressive symptoms.

The participant characteristics according to their green tea consumption status are presented in **Table 1**. The proportion of women, those with a history of cancer, nonsmokers, visiting friends, and widowed (or divorced) status were significantly higher across the green tea consumption tertiles (*P* for trend: <0.0001, 0.04, <0.0001, 0.0001, and 0.02, respectively). The proportion of subjects with a history of cardiovascular disease, who were current smokers or ex-smokers, who were married, and who had impaired IADLs, self-reported body pain, and lack of perceived social support was significantly lower across the categories of green tea consumption (*P* for trend: <0.01, 0.02, <0.0001, <0.01, 0.01, 0.03, and 0.04, respectively). Although the difference was not statistically significant, the proportion of nondrinkers was highest in categories with the lowest green tea consumption. The mean folate consumption ($\mu g \cdot d^{-1} \cdot 2000$ kcal) was significantly higher across categories of green tea consumption (*P* for trend < 0.0001). The mean GDS score was significantly lower across the categories of green tea consumption (*P* for trend < 0.0001). There were no apparent associations between high CRP and green tea consumption. Otherwise, no significant difference was observed between categories of green tea consumption.

The adjusted association between categories of green tea consumption and mild and severe or severe depressive symptoms is shown in **Table 2**. The ORs of the depressive symptoms decreased across categories of green tea consumption. In the final multivariate logistic models, the adjusted ORs for mild and severe depressive symptoms across categories of green tea consumption were 1.00 (reference) for ≤1 cup/d, 0.96 (95% CI: 0.66, 1.42) for 2–3 cups/d, and 0.56 (95% CI: 0.39, 0.81) for ≥4 cups/d (*P* for trend < 0.001). The prevalence of depressive symptoms was 44% lower for participants who consumed ≥4 cups green tea/d tea than for those who consumed ≤1 cup/d (Bonferroni-corrected *P* value <0.01). The ORs of mild and severe depressive symptoms for CRP were 1.00 (reference) for low CRP (<1 mg/L) and 1.08 (95% CI: 0.79, 1.48) for high CRP (≥1.0 mg/L). Similar relations were observed even when we used GDS ≥14 and the use of antidepressants as a definition of depressive symptoms. When we analyzed the relation between the consumption of other beverages and depressive symptoms, a weak or null relation was observed between the consumption of black or oolong tea or coffee and prevalence of depressive symptoms. The multivariate ORs for mild and severe depressive symptoms according to the frequencies of black or oolong tea consumption were 1.00 (reference) for almost never, 0.82 (95% CI: 0.56, 1.20) for <1 cup/d, and 0.71 (95% CI: 0.49, 1.02) for ≥1 cups/d (*P* for trend: 0.06), whereas those for coffee were 1.00 (reference) for almost never, 1.01 (95% CI: 0.73, 1.39) for <1 cup/d, and 0.82 (95% CI: 0.53, 1.27) for ≥1 cups/d (*P* for trend: 0.49). Similar results were also observed when the cutoff ≥14 or the use of antidepressants was used to indicate severe depressive symptoms. Eighteen participants consumed antidepressants in this study. Because individuals who were taking monoamine oxidase inhibitors may have been instructed to avoid the intake of green tea, our findings may have been affected. Therefore, we also analyzed the relations between green tea consumption and depressive symptoms in participants not consuming antidepressants. However, this exclusion did not alter our findings. ORs (95% CI) for mild and severe and for severe depressive symptoms across the green tea consumption tertiles were 1.00, 0.96 (95% CI: 0.67, 1.45), and 0.59 (95% CI: 0.40, 0.87) (*P* for trend < 0.01) and 1.00, 0.97 (95% CI: 0.61, 1.54), and 0.51 (95% CI: 0.32, 0.81) (*P* for trend < 0.01), respectively. We observed a similar relation between green tea consumption and depressive symptoms when men and women were separately analyzed. In model 3, the adjusted ORs (95% CI) for mild and severe and for severe depressive symptoms across the categories of green tea consumption were as follows: for men, the values were 1.00, 0.78 (95% CI: 0.41, 1.48), and 0.45 (95% CI: 0.22, 0.91) (*P* for trend: 0.03) and 1.00, 0.96 (95% CI: 0.44, 2.12), and 0.35 (95% CI: 0.14, 0.87) (*P* for trend: 0.02), respectively; for women, the values were 1.00, 1.09 (95% CI: 0.64, 1.86), and 0.65 (95% CI: 0.40, 1.05) (*P* for trend: 0.04) and 1.00, 0.83 (95% CI: 0.46, 1.49), and 0.50 (95% CI: 0.29, 0.87) (*P* for trend: <0.01), respectively. We did not observe significant interaction between green tea consumption and sex either for mild and severe or for severe depressive symptoms (*P* for interaction: 0.29 for mild and severe and 0.80 for severe). The tests for interaction between the consumption of green tea and other confounders in the final models were also not statistically significant.

DISCUSSION

The present study examined the relation between green tea consumption and depressive symptoms among a community-

TABLE 1
Subject characteristics according to categories of green tea intake[1]

	Categories of green tea intake			
	≤1 cup/d	2–3 cups/d	≥4 cups/d	*P* for trend[2]
n	286	284	488	
Age (y)	75.5 (75.0, 76.1)[3]	76.4 (75.8, 76.9)	75.9 (75.5, 76.3)	0.10
Female sex (%)	48.3	52.8	65.4	<0.0001
BMI (kg/m^2)	23.8 (23.4, 24.2)	23.8 (23.4, 24.2)	24 (23.7, 24.3)	0.80
Serum albumin (g/dL)	4.33 (4.29, 4.36)	4.33 (4.30, 4.36)	4.34 (4.31, 4.36)	0.82
Hypertension (%)	69.6	64.4	70.5	0.61
Diabetes (%)	9.4	8.8	8.8	0.78
History of CVD (%)	19.9	15.9	12.9	<0.01
History of cancer (%)	5.2	4.9	8.8	0.04
History of arthritis (%)	18.5	18.3	17.8	0.80
High CRP (%)[4]	33.9	32.4	31.4	0.46
Smoking status (%)				
Current smoker	16.4	12.7	10.7	0.02
Ex-smoker	39.2	31.0	23.6	<0.0001
Nonsmoker	42.7	55.3	62.9	<0.0001
Drinking status (%)				
Current drinker	41.6	41.2	38.7	0.40
Ex-drinker	14.7	12.0	10.0	0.055
Nondrinker	39.2	44.0	46.3	0.057
PA > level 3 (%)	37.4	41.9	35.3	0.40
Impaired cognitive function (%)				
18 ≤ MMSE < 24	8.4	6.7	7.2	0.58
24 ≤ MMSE < 28	38.5	34.5	34.4	0.29
Impaired IADLs (%)	14.0	15.1	8.4	<0.01
Visiting friends: "yes" (%)	69.6	72.9	81.5	0.0001
Body pain: "yes" (%)	28.0	21.8	20.1	0.01
Lack of perceived social support: total score = 0 (%)	15.7	16.6	10.7	0.03
Educational level ≤12 y (%)	68.2	68.0	71.7	0.26
Living alone: "yes" (%)	22.7	23.9	25.4	0.39
Marital status (%)				
Married	67.1	60.2	59.4	0.04
Widowed or divorced	29.4	34.2	37.5	0.02
Single	3.5	5.6	3.1	0.59
Nutrient intake				
Total energy intake (kcal/d)	1959.9 (1901.3, 2018.5)	2023.9 (1965.2, 2082.7)	1959.6 (1914.8, 2004.4)	0.19
Total protein (g · d^{-1} · 2000 kcal)	82.8 (81.2, 81.2)	81.7 (80.1, 80.1)	83.2 (81.9, 81.9)	0.34
Folate (μg · d^{-1} · 2000 kcal)	336.2 (324.6, 347.8)	372.4 (360.7, 384.1)	404.0 (395.1, 412.9)	<0.0001
GDS scores	9.9 (9.3, 10.5)	9.8 (9.1, 10.4)	8.3 (7.8, 8.8)	<0.0001

[1] CVD, cardiovascular disease; CRP, C-reactive protein; PA, physical activity; MMSE, Mini-Mental State Examination score; IADLs, instrumental activities of daily living; GDS, Geriatric Depression Scale.
[2] Obtained by using ANOVA for continuous variables and logistic regression analysis for variables of proportion.
[3] Mean; 95% CI in parentheses (all such values).
[4] Serum CRP concentrations ≥1.0 mg/L.

dwelling elderly population aged ≥70 y. Our results suggested that high consumption of green tea was significantly related to a lower prevalence of depressive symptoms.

In this large community-based population study, we adjusted for a considerable number of confounding factors. First, we considered that older age, chronic disease, inflammatory status, body mass index, cognitive impairment, disability, lifestyle factors, and psychological problems were potential confounders. However, adjustments for these confounding factors did not change the significant inverse relation between green tea consumption and depressive symptoms. That is, the inverse relation between the frequency of green tea consumption and depressive symptoms was independent of these factors. Second, the effect of the consumption of folate (29) and other beverages such as black or oolong tea or coffee on depressive symptoms was adjusted. Moreover, depressive symptoms can affect hunger and thirst and thus affect nutritional intake (30, 31). Accordingly, we made adjustments for total energy intake, protein consumption, and serum albumin concentration. However, the adjustment for the consumption of these factors also did not change the significant inverse relation between green tea consumption and depressive symptoms. Third, green tea consumption is a unique form of social activity among the Japanese and this, in itself, may influence the depression status. However, the adjustment for perceived social support and visiting friends did not change the significant inverse relation between green tea consumption and depressive symptoms. The association between green tea consumption and the 2 grades (mild and severe and severe) of

TABLE 2
Adjusted relations between consumption of green tea and mild and severe or severe depressive symptoms[1]

	Categories of green tea consumption			
	≤1 cup/d	2–3 cups/d	≥4 cups/d	*P* for trend[2]
n	286	284	488	
No. of mild and severe depressive symptoms, defined as GDS ≥11 or use of antidepressants	114	111	136	—
Model 1[3]	1.00	0.95 (0.66, 1.36)[4]	0.56 (0.40, 0.78)[5]	<0.001
Model 2[6]	1.00	0.96 (0.66, 1.40)	0.54 (0.37, 0.78)[5]	<0.001
Model 3[7]	1.00	0.96 (0.66, 1.42)	0.56 (0.39, 0.81)[5]	0.001
No. of severe depressive symptoms, defined as GDS ≥14 or use of antidepressants	75	67	72	—
Model 1[3]	1.00	0.91 (0.60, 1.37)	0.48 (0.33, 0.71)[5]	<0.001
Model 2[6]	1.00	0.92 (0.59, 1.42)	0.46 (0.30, 0.72)[5]	<0.001
Model 3[7]	1.00	0.92 (0.59, 1.44)	0.48 (0.31, 0.75)[5]	<0.001

[1] GDS, Geriatric Depression Scale.
[2] Obtained by using multiple logistic regression analysis.
[3] Adjusted for age; sex; BMI; hypertension; diabetes; history of cardiovascular diseases, cancer, or arthritis; high C-reactive protein (≥1.0 mg/L); history of smoking and drinking habits; physical activity (all 6 levels as a categorical variable); cognitive status; impaired instrumental activities of daily living; self-reported body pain; educational level; living alone; and marital status.
[4] Adjusted odds ratio; 95% CI in parentheses (all such values).
[5] Significantly different from green tea consumption of ≤1 cup/d, $P < 0.01$ (Bonferroni-corrected).
[6] Additionally adjusted for serum albumin concentration, total energy intake, intakes per 2000 kcal of energy intake as protein and folate, black or oolong tea consumption, and coffee consumption.
[7] Additionally adjusted for lack of perceived social support and visiting friends.

depressive symptoms was tested in this study. Similar relations were observed consistently in the case of both cutoffs. We also conducted a stratified analysis for sex, and similar relations were also observed when men and women were analyzed separately.

In this study, our primary hypothesis was that green tea may have a potentially beneficial effect on the prevention of depressive symptoms due to its anti–stress response and antiinflammatory effects. However, the antiinflammatory mechanisms were less likely to explain our findings. We did not observe any relations between green tea consumption and CRP. CRP also was not associated with depressive symptoms in this elderly population. Thus, CRP did not explain the inverse relation between green tea consumption and depressive symptoms.

We considered that the other mechanism (ie, the anti–stress response effect) of green tea might explain our findings. Theanine might be a candidate for explaining the observed inverse association between green tea consumption and depressive symptoms. Theanine is one of the major amino acid components in green tea and can pass through the blood-brain barrier (32). Dopamine and serotonin dysfunction is a credible etiological candidate for depressive symptoms (33), and animal neurochemistry studies have suggested that theanine increases the brain serotonin and dopamine concentrations (7). Moreover, theanine is also contained in other kinds of tea, such as black or oolong tea (34). In fact, in the current study, a weak, although not statistically significant, relation was also observed between the consumption of black or oolong tea and the prevalence of depressive symptoms (*P* for trend: 0.06). Thus, these data prove a useful hypothesis that higher consumption of green tea is related to a lower prevalence of depressive symptoms, possibly because it leads to a decrease in the stress response. A further study is required to clarify whether green tea or theanine have a beneficial effect on the prevention and treatment of depressive symptoms.

Our recent findings are also consistent with the present findings. Hozawa et al (13) investigated the relation between the frequency of green tea consumption and psychological distress. The study analyzed 42,093 Japanese individuals aged ≥40 y from the general population residing in the rural area of Japan. The study also showed an inverse relation between the frequency of green tea consumption and psychological distress as assessed by K6 (35). The OR and 95% CI of having psychological distress in subjects who consumed ≥5 cups green tea/d was 0.80 (95% CI: 0.70, 0.91) as compared with the subjects who consumed <1 cup green tea/d after adjustment for the possible confounding factors. The inverse association between green tea consumption and mental ill health was consistently observed whether the population was older (the present study) or middle aged (13), whether urban (the present study) or rural (13), whether being assessed by GDS (the present study) or by K6 (13). We considered that these 2 sets of findings corroborate our conclusion that green tea consumption is associated with mental well-being.

This study has several limitations. First, because the assessments were performed in a public facility, the participants were more active and healthy than those who did not undergo the assessment. Therefore, our results might not represent an elderly general population. Second, the GDS is designed for measuring the intensity of depressive symptoms and not for making a clinical diagnosis of depressive episodes. Therefore, a larger population study that uses a standardized comprehensive structured diagnostic interview should be undertaken to confirm the effect of green tea consumption on depressive symptoms. Third, because this study was a cross-sectional study, we could not conclude whether lower green tea consumption increased the

occurrence of depressive symptoms or whether depressive symptoms lead to a decline in green tea consumption. Therefore, a prospective study or trial should be undertaken to confirm the relation between green tea consumption and depressive symptoms. Fourth, we could not make adjustments for a history of depressive disorders, other psychological variables, and associated medications/supplements because data for these were not obtained. However, because all assessments of this study were carried out in a public facility and participation in the study was voluntary, we considered the prevalence of these factors as likely to have been very low, and therefore we believe that not directly accounting for them in our analyses had little effect on the findings. Moreover, although we adjusted for a considerable number of confounding factors, we cannot exclude the possibility that depressive symptoms are affected by the other dietary habits that correlate with the habitual consumption of green tea. Therefore, an intervention study is necessary for establishing a causal relation between green tea consumption and depressive symptoms.

In the present study, higher green tea consumption (as measured by self-administered questionnaires) was significantly associated with a lower prevalence of depressive symptoms in community-dwelling elderly individuals. This finding suggested that the consumption of green tea may have a potentially beneficial effect on the prevention of depressive symptoms. A prospective study or randomized trials are required to clarify the causality.

The authors' responsibilities were as follows—KN and AH: study concept and design; KN, AH, SK, SE, NN, KO-M, HT, YM, HA, SA, RN, and IT: acquisition of subjects and data; KN, AH, SK, SE, HG, NN, KO-M, HT, YM, MA, SS, HA, SA, and RN: analysis and interpretation of data; KN, AH, HG, and MA: preparation of manuscript; SS, HA, SA, RN, and IT: supervision; and IT: obtaining funding. None of the authors had a conflict of interest.

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本欄は、石田重森福岡大学名誉学長、堀勝洋上智大学教授、椋野美智子大分大学教授、大道久日本大学教授、増田雅暢上智大学教授、清家篤慶應義塾大学商学部長、若杉敬明東京経済大学教授、辻一郎東北大学教授、江口隆裕筑波大学ビジネス科学研究科教授の順にご執筆いただいています。

時事評論

介護予防の効果と効率

東北大学大学院社会医学系教授　辻　一郎

本年3月26日に厚生労働省介護予防継続的評価分析等検討会が開催され、2年余の検討結果が取りまとめられた。その概要は本誌4月6日号でも報じられたが、筆者が検討会座長を務めさせていただいた関係で、若干の解説を申し述べたい。

平成17年に介護保険法が改正された際、その附則に介護予防サービスの「費用に対する効果の程度等の観点から検討」を行うべしとの規定が盛り込まれた。そこで全国83か所の地域包括支援センターのご協力により、介護予防サービス利用者約1万人を対象に、サービス利用の実態や心身機能・生活機能等の推移などに関する詳細な情報が収集された。

これにより、第一に介護予防の効果、第二にその費用対効果、第三に個人の属性や利用サービスと介護予防に係る各種指標の推移との関連が検討された。

介護予防の効果

要介護の発生と重度化を防止することが介護予防の目的である以上、特定高齢者から介護保険認定への悪化率、要支援1・2者における要介護度の悪化率が効果の主要指標となる。

効果を評価するには適切な比較対照が不可欠である。理想的には、介護予防サービスを実施する市町村と実施しない市町村とに無作為に分けて、両群の間で悪化率を比較するランダム化比較試験が望ましい。しかし全市町村での実施が法律で規定されている以上、実施しない市町村の設定は不可能である。そこで次善の策として、制度改正の前後で比較するしかない。

前記の83市町村を対象に制度改正の前後で悪化率（1000人1年あたりで要介護度が悪化した者の数）を比べると、要支援1では389から234へ40%減少、要支援2では250から67へと73%減少し、ともに統計学的に有意な差が認められた。一方、特定高齢者では悪化率（1000人1年あたりで介護保険認定を受けるに至った者の数）は56から49へと13%減少したが、その差は有意でなかった。

介護予防の費用対効果

介護保険給付費は要介護認定度とともに上昇するので、介護予防により重度化を食い止めることができれば、給付費が減少することは必然であろう。

実際、制度導入前と比べて、1人1年あたりの費用は、要支援1で約10万7千円、要支援2で約43万9千円、特定高齢者で約2万円、それぞれ減少することが明らかとなった。

この1人あたり費用減少額を平成19年度の全国の給付者数に当てはめると、約1878億円の費用減少が見込まれ、それは介護保険給付費総額の約3%に相当する。

データ解釈の注意点

すでに述べたように、今回の分析は介護予防の導入前1年間と導入後1年間とで、要介護度の悪化率や費用を比較したものである。その比較が適切かどうかは、導入前と後の2つの集団の特徴（重症度・予後関連因子の分布）が似通っているかどうかに依存する。

その点で、要支援1に関する比較では何ら問題がないだろう。制度導入の前も後も、認定基準は基本的に変わっていないからである。したがって、ここにおける「悪化率40%減」という値は信頼に足る。

しかし要支援2と特定高齢者では注意を要する。制度改正前の要介護1のうち「介護予防効果が期待される者」だけが要支援2に移行した以上、旧制度の要介護1と新制度の要支援2とでは、後者の方が予後は良好であろう。したがって要支援2の「悪化率73%減」という値が（どの程度かは不明だが）過大評価であることは間違いない。

制度改正前に「特定高齢者」は存在しなかった。だから予後も分からない。当時のデータを探しても「特定高齢者の基準を満たす者」数千名を対象に1年後の悪化率を調査したものが1件あるのみであった。しかも制度改正後の観察では、「特定高齢者の基準を満たす者」と実際にサービスを利用した「特定高齢者」とを比べると、悪化率は後者で2倍以上も高かった。したがって特定高齢者の「悪化率13%減」という値が（どの程度かは不明だが）過小評価であることは間違いない。

制度発足後に効果を検証することの難しさが、ここにある。とは言え、過小評価であっても悪化率が減少に転じた以上、今回の制度改正は、効果の点でも費用対効果の点でも優れたものと結論付けることは妥当なことと思われる。

生活機能等の推移に関連する要因

第三の検討は、個人の属性や利用サービスと介護予防に係る各種指標の推移との関連を明らかにすることである。言ってみれば「どのような（属性を有する）人に、どのような介護予防サービスを提供すると、（要介護認定度や基本チェックリスト得点、心身機能などに）どのような変化が期待できるか」を検討したのである。

その結果、ふだんの生活で役割がある者、認知機能が高い者、そして認知的活動（テレビを見る、ラジオを聴く、新聞・雑誌・本を読む、ゲームをするなど）の頻度が多い者では、要介護認定度等の維持・改善が多いことが分かった。

さらに運動器の機能向上では、個人特性（既往歴や認知機能など）に応じて、サービス・プログラムの種類を使い分けることの意義が示唆されるなど、興味深い知見が得られた。

閉じこもり、認知症、うつの各予防・支援の基準を満たす者どうしで比べると、運動器の機能向上サービスなどを利用している者は（そうでない者に比べて）改善度が高いことが分かった。実際、（軽度の）抑うつや認知機能低下のある高齢者に運動プログラムやレクリエーションを実施すると症状が改善することが、欧米でのランダム化比較試験により知られている。今回の結果は欧米の研究成果とも共通するものであり、閉じこもり・うつ・認知症の各予防・支援に関する新たなエビデンスとなるであろう。これら3事業の拡充が望まれる。

また、閉じこもり高齢者、うつ高齢者のなかでも、ふだんの生活で役割があったり、ソーシャルサポート（困ったときの相談相手、具合が悪いときに病院に連れて行ってくれる人など）がある人では、改善しやすいことが分かった。人は一人で生きるのではない。公的制度によるサービスだけでなく、家族・親族や友人・知人のインフォーマルなネットワークを通じて相互に支えあうことの価値を再認識したいものである。

行政事業における評価の重要性

本検討会は、改正介護保険法の附則を受けて発足したものである。しかし、国家財政が困難な状況において事業を展開する以上は（附則で規定されなくとも）あらゆる事業で、その効果や費用対効果が常に検証されるべきではなかろうか。

本検討会は、介護予防の発足とほぼ同時に立ち上げられ、その効果と効率をリアルタイムにモニタリングし続けた。これにより、事業実施の具体的な方法を適宜修正するなど、制度運用面での利益も大なるものがあった。現行の保健医療施策のなかで、これほど厳密かつリアルタイムに評価を受けた事業が他にあるだろうか？　きちんとした評価なしに効果は判定できない。今回のモニタリング・評価体制を、あらゆる施策でのスタンダードとすべきである。

本欄は、石田亜森福岡大学名誉学長、堀勝洋上智大学教授、椋野美智子大分大学教授、大道久日本大学教授、増田雅暢上大学教授、清家篤慶應義塾長、若杉敬明東京経済大学教授、辻一郎東北大学教授、江口隆裕筑波大学ビジネス科学研究科教授の順にご執筆いただいています。

時事評論

2025年の地域包括ケア

東北大学教授　辻　一郎

本年5月22日に厚生労働省老健局より「地域包括ケア研究会報告書」が公表された。この研究会は、2025年における地域ケアのあるべき姿を提示し、その実現に向けた検討に当たっての論点を整理するために、田中滋・慶應義塾大学教授を座長として、他8名の委員で構成された。筆者もメンバーの一人であったので、要点の紹介とともに若干の解説を申し述べたい。

2025年未来予想図

本研究会が目標とする2025年には、65歳以上人口が3600万人（全人口の3割）を超える。しかも「団塊の世代」全員が後期高齢者となる。そのときの社会の姿は、現在の延長では済まないであろう。

第一に、介護費用が爆発的に増加する。社会保障国民会議の試算では、現行の給付水準を維持する場合、介護費用は現状の7兆円から2025年には19～24兆円程度になる。財源をどう確保するか、給付水準をどうするかが問われている。

第二に、認知症高齢者が急増する。厚生労働省によると、介護保険の要介護・要支援認定者における認知症高齢者の数は、現状の200万人から2025年には323万人に増える。これにより介護保険サービスのあり方も大きく変わらざるを得ない。さらに、認知症高齢者の権利擁護そして成年後見制度の充実も求められることになる。

第三に、人口高齢化をめぐる地域差がさらに拡大する。国立社会保障・人口問題研究所によれば、2025年までに75歳以上人口は郡部を中心に6%の市町村で減る一方、都市部を中心に約2割の市区町村で2倍以上に増える。地域差がこれほど拡大する以上、地域包括ケアを全国一律に画一的に議論することは現実的でない。地域ごとのニーズや特性に応じて、各地域で個別に構築しなければならない。各市区町村や地域の力量がこれまで以上に試される。

第四に、高齢者像が大きく変わる。これからの高齢社会で中軸となる「団塊の世代」は、現在の高齢世代と比較すれば、多様な価値観とはっきりした権利意識を持ち、戦後の経済成長のなかで豊かな生活を送ってきた人たちである。そして厚生年金受給者の比率も高い。したがって介護サービスなどに対する意識や行動も従来とは異なってくる。一方、社会参加の意識が高いのも、この世代の特徴である。今後、市民の自発的な地域社会への参加が増加するであろう。それが2025年のわが国を支える資源となる。

地域包括ケアとは

本研究会では、地域包括ケアシステムを「ニーズに応じた住宅が提供されることを基本とした上で、生活上の安全・安心・健康を確保するために、医療や介護のみならず、福祉サービスを含めた様々な生活支援サービスが日常生活の場（おおむね30分以内に駆けつけられる圏域）で適切に提供できるような地域での体制」と定義した。

さらに高齢者一人ひとりが抱えるニーズは多様であるため、医療や介護から福祉や権利擁護などに至る様々なサービスのうち、個々人に最も合ったものを適宜コーディネートして、24時間365日を通じて常に提供することが求められる。そのためには、各種制度の横断的な改革、コーディネーターの育成、さらにはコーディネートの主体たる地域包括支援センターの役割拡張をいかに果たしていくかが問われている。

自助・互助・共助・公助の役割分担

「介護の社会化」という介護保険制度の前提は最大限に尊重したうえで、本研究会は「自助・互助と地域包括ケアとの調和のとれた新しい関係」を提案している。これは給付カットや費用削減を意図したものではないことを明言しておきたい。むしろ介護保険という共助のシステムに対して、言わば「魂を入れる」ものと筆者は考えている。

本報告書では「自助は、自らの選択に基づいて自分が自分らしく生きるための最大の前提であり、互助は、家族・親族等、地域の人々、友人たち等との間の助け合いにより行われるものである。したがって、自助や互助は、単に、介護サービス（共助）等を補完するものではなく、むしろ人生と生活の質を豊かにするもの」として、自助・互助に対する期待を表明している。それは、以下のような研究成果に依拠したものである。

たとえば、ソーシャル・サポートのある高齢者では、うつ状態が少ない。地域活動やボランティア活動などを行っている高齢者では、その後の認知症・要介護の発生率が低い。このように、互助をすることもされることも、高齢者には様々な好影響が現れる。さらに、信頼に裏打ちされた社会的つながり（ソーシャル・キャピタル：社会関係資本）の豊かな地域では、住民の健康レベルも高い。互助への期待は、これらのエビデンスに基づくものである。

とは言え、地縁・血縁の結びつきは希薄になっており、互助の基盤は先細りしている。それに対して、筆者自身は、地縁・血縁に代わる新しい結びつきに期待している。たとえば、共通の趣味や習い事、ボランティアや社会活動など、共通の関心事で結ばれる人間関係のことである。最近では、これを「知縁」と呼ぶ者も少なくない。

この新しい結びつきが地域を変えていくことを、筆者は期待している。高齢者どうしの「知縁」は、介護予防や介護にも当然つながるであろう。なぜなら、それが高齢者にとって最大の共通関心事だからである。高齢者の「知縁」が織りなす多様なネットワークが地域包括ケアの原動力となることを望んでいる。

介護報酬の見直し・サービスの評価

介護報酬に関して、本報告書は「住居の形態（介護保険施設等も含む）にかかわらず、地域の中で介護保険サービスを提供するという発想」に立って、居宅・施設という現行の体系を超えた新しい考え方を提案した。

さらに、コストに着目して報酬を支給する現行の体系では「必ずしも、良質なサービスの提供につながらない可能性がある」として、サービスの質に着目して介護報酬を支給する体系を提案した。

質の評価にあたっては、まず「標準化されたケア」を明示したうえで、その観点から適切と判断できるケアがどれくらい行われたか、そしてどのようなアウトカム（生活の場、生活機能、生活の質など）になったかを個々の高齢者について検討することを提案した。

さらにサービス評価の体制では、専門家による評価に加えて住民参加型モニタリングシステムを提案した。これが団塊世代の社会参加とカップリングすれば、地域包括ケアはあるべき姿となるであろうし、「互助」も有効に機能するであろう。

国民全体でさらなる議論を

2025年の地域包括ケアについて、本研究会は特に結論を示していない。それは、国民全体で広く議論をしてもらうための論点整理をすることが本研究会の目的だったからである。

質の評価など、いくつかの領域で斬新な提案をしたが、その具体的方法は示していない。むしろ、その提案を実現するにはどのような検討が必要なのかを指摘するに留めている。

これらについて国民全体で議論を尽くしていただきたい。それこそ、私たち自身がより良く生き、健やかに老い、そして安らかに生を全うするための「互助」の始まりなのだから。

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Association between green tea consumption and tooth loss: Cross-sectional results from the Ohsaki Cohort 2006 Study

Yasushi Koyama [a,*], Shinichi Kuriyama [a], Jun Aida [b], Toshimasa Sone [a], Naoki Nakaya [a], Kaori Ohmori-Matsuda [a], Atsushi Hozawa [a], Ichiro Tsuji [a]

[a] Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan
[b] Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Sendai, Japan

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ABSTRACT

Objective. To examine the association between green tea consumption and tooth loss.

Methods. We analyzed cross-sectional data from the Ohsaki Cohort 2006 Study. Usable self-administered questionnaires about green tea consumption and tooth loss were returned from 25,078 persons (12,019 men and 13,059 women) aged 40 to 64 years in Japan. Multivariate logistic regression analysis was used to calculate odds ratios (ORs) for tooth loss using 3 cut-off points of 10, 20, and 25 teeth relative to each category of green tea consumption.

Results. Consumption of ≥1 cup/day of green tea was significantly associated with decreased odds for tooth loss, and the association appeared to fit a threshold model. In men, the multivariate-adjusted ORs for tooth loss with a cut-off point of <20 teeth associated with different frequencies of green tea consumption were 1.00 (reference) for <1 cup/day, 0.82 (95% CI, 0.74–0.91) for 1–2 cups/day, 0.82 (95% CI, 0.73–0.92) for 3–4 cups/day, and 0.77 (95% CI, 0.66–0.89) for ≥5 cups/day. The corresponding data for women and the results for cut-off points of 10 and 25 teeth were essentially the same.

Conclusions. The present findings indicate an association of green tea consumption with decreased odds for tooth loss.

Introduction

Tooth loss reduces masticatory ability, leading to detrimental changes in food selection. Restricted food selection may increase the risk of certain systemic diseases (Hung et al., 2003; Joshipura et al., 1996; Shimazaki et al., 2002; Willett, 1994). Therefore, prevention of tooth loss is important from the viewpoint of overall human health.

A number of experimental studies have shown that green tea has a profound suppressive effect on the activities of oral bacteria such as *Streptococcus mutans* and *Porphyromonas gingivalis* (Hamilton-Miller, 2001; Hirasawa et al., 2002, 2006; Otake et al., 1991; Sakanaka and Okada, 2004; Smullen et al., 2007; Socransky and Haffajee, 2002). The antibacterial effects of green tea are thought to be due to catechins (Hirasawa et al., 2002; Sakanaka and Okada, 2004; Smullen et al., 2007). Tea catechins inhibit acid production by oral bacteria such as *S. mutans* and exert bactericidal activity against *P. gingivalis* (Hirasawa et al., 2006; Sakanaka and Okada, 2004). These bacteria are strongly implicated in the development of dental caries and periodontal disease (Dietrich et al., 2004; Hamilton-Miller, 2001; Hirasawa et al., 2006; Sakanaka and Okada, 2004; Socransky and Haffajee, 2002), which are the main causes of tooth loss (Aida et al., 2006). Therefore, tea catechins may have potential oral health benefits, reducing the likelihood of tooth loss.

To date, however, there has been only one cross-sectional study of 1002 pregnant women on the association between green tea consumption and tooth loss (Tanaka et al., 2008), and the findings of that study must be verified by epidemiological observation of a large general population. Therefore, we conducted a cross-sectional study in Japan, where consumption of green tea is one of the highest in the world (Kuriyama et al., 2006a,b), to clarify the above association.

Methods

Study sample

We analyzed cross-sectional data from a baseline survey conducted for the Ohsaki Cohort 2006 study. The details of this cohort have been reported elsewhere (Kuriyama et al., 2009). In brief, we delivered a self-administered questionnaire to all 46,407 residents aged 40 to 64 years, who were included in the Residential Registry for Ohsaki City, Miyagi Prefecture, northeastern Japan, as of December 1, 2006. The survey was conducted from December 1 to 15, 2006. The questionnaire consisted of 15 items: history of diseases, family history of diseases, physical health status during the last year, smoking habit, drinking habit, dietary habits, occupation or education, body weight and height, health status during the last month, exercise, psychological distress, social support, participation in community activities, and dental status, plus reproductive history for women. The questionnaire

* Corresponding author.
E-mail address: a5mb1049-thk@umin.ac.jp (Y. Koyama).

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was distributed by the heads of individual administrative districts to individual households and collected by mail. Since 409 subjects were found to have died, moved out of the area, in hospital, or absent for a prolonged period, the questionnaire could not be distributed to them. Among 45,998 eligible individuals, 26,512 responded, giving a response rate of 57.6%. We considered the return of self-administered questionnaires signed by the subjects to imply their consent to participate in the study. The study protocol was approved by the Ethics Committee of Tohoku University Graduate School of Medicine.

Of the 26,512 individuals, we excluded 1434 who did not provide answers to the items on green tea consumption and the number of retained teeth. A final total of 25,078 persons (12,019 men and 13,059 women) were included the present analysis.

Measurement

Dietary intake was assessed using a self-administered food frequency questionnaire (FFQ). In this questionnaire, we asked participants to report their frequency of recent consumption of 40 food and beverage items. The questionnaire provided 5 categories of response to describe the participant's frequency of green tea consumption: never, occasionally, 1–2 cups/day, 3–4 cups/day, and ≥5 cups/day. The volume of a typical cup of green tea was 100 ml in the study region (Kuriyama et al., 2006a). We conducted a validation study of the FFQ, in which 113 participants provided four 3-day dietary records within a period of 1 year and subsequently responded to the questionnaire (Ogawa et al., 2003). The results showed that the Spearman rank coefficient for the correlation between the amounts of green tea consumed according to the questionnaire and the amounts consumed according to the records was 0.71 for men and 0.53 for women; the correlation between consumption measured by the 2 questionnaires administered 1 year apart was 0.63 for men and 0.64 for women. Since only 5.2% of the participants said they never drank green tea, data from participants who never and occasionally drank green tea were collapsed into the single category of <1 cup/day for the purpose of our analysis.

We assessed the number of teeth using the self-administered questionnaire, which was structured with categorical responses: none (zero teeth), few (1–9 teeth), nearly half (10–19 teeth), most (20–24 teeth), almost all (25–27 teeth), or all (28 teeth). We did not take third molars into account. Because there are no specific markers for tooth loss, we used 3 cut-off points to conduct our analyses. The initial cut-off point was <10 teeth, a category including 0–9 teeth, the second was <20 teeth, a category including 0–19 teeth, and the third was <25 teeth, a category including 0–24 teeth.

Statistical analyses

To determine the relationship between green tea consumption and tooth loss, we used logistic regression analyses to derive adjusted odds ratios (ORs). The main independent variables were the levels of green tea consumption. Odds for tooth loss were calculated by dividing the number of persons with a low number of teeth by the number of persons with a high number of teeth. The ORs were computed as the odds among subjects in each green tea consumption category divided by the odds among subjects in the "<1 cup/day" category. The ORs and 95% confidence intervals (CIs) were estimated using SAS Version 9.1 (SAS Institute Inc., 2004). All statistical tests are two-sided. Differences at $P<0.05$ were accepted as statistically significant.

We considered the following variables as potential confounders: age (40–44, 45–49, 50–54, 55–59, or 60–64 years), the number of times teeth were brushed per day (<2, 2, or >2 times/day), years of education (<10, 10–12, or ≥13 years), body mass index calculated with self-reported weight and height (<18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30.0 kg/m^2), time spent walking (<1 or ≥1 h/day), history of stroke, myocardial infarction, diabetes mellitus, cancer (for each disease, yes or no), smoking status (never, former, currently smoking 1–19 cigarettes/day, or currently smoking ≥20 cigarettes/day), alcohol drinking (never, former, or current), weekly consumption of sweets such as *manju* (a steamed bean-jam bun), *yokan* (sweetened and jellied bean paste), or cake (<3 or ≥3 times/week), daily dietary consumption of *miso* (soybean paste) soup, soybean products, milk (for each food, almost everyday or not), oolong tea, black tea, and coffee (for each beverage, <1, 1–2, 3–4, or ≥5 cups/day), daily consumption of total fish, which was categorized into quartile by sex, daily consumption of total calories, which was also categorized into quartiles by sex, and the details were given as follows: the intake of total calories was calculated from daily rice consumption, daily *miso* soup consumption, daily consumption of green tea, oolong tea, black tea, or coffee, alcohol consumption, and FFQ using the *Standard Tables of Food Composition* published by the Science and Technology Agency of Japan. The confounders were selected for their relationship to green tea consumption and tooth loss (Bahekar et al., 2007; Elter et al., 2003; Hanioka et al., 2007; Heitmann and Gamborg, 2008; Klein et al., 2004; Okamoto et al., 2006; Pischon et al., 2007; Pitiphat et al., 2003; Susin et al., 2005; Tu et al., 2007).

We also estimated ORs for tooth loss for other beverages such as oolong tea and coffee for the cut-off point of <20 teeth, since the results for green tea consumption revealed that ORs for tooth loss were similar at each cut-off point. We calculated ORs for tooth loss stratified by coffee consumption with or without sugar or syrup since adding sugar or syrup to coffee is widespread in Japan. In the stratified analyses we excluded participants who never consumed coffee, since they were included in each reference group. We did not estimate ORs for black tea consumption since the number of persons who consumed black tea was extremely small.

Results

Baseline characteristics of the participants are shown in Tables 1 and 2 for men and women, respectively. Men consuming more cups of green tea tended to be older, brush their teeth more often, have a higher calorie intake, and consume more sweets, *miso* soup, and soybean products, but they were less likely to consume coffee. They showed a higher prevalence of chronic diseases such as stroke, myocardial infarction, or cancer. Women consuming green tea more often tended to be older, have a higher calorie intake, and consume more *miso* soup, soybean products, and total fish, but they were less likely to consume coffee. They also showed a higher prevalence of chronic diseases such as myocardial infarction, diabetes mellitus, or cancer. Women who drank no alcohol were less likely to consume a higher number of cups of green tea.

Table 3 shows the ORs of tooth loss with the 95% CIs. We found that consumption of ≥1 cup/day of green tea was significantly associated with decreased odds for tooth loss in both the age-adjusted and multivariate-adjusted ORs. The association appeared to fit a threshold model. In men, the multivariate-adjusted ORs for tooth loss at the <20 teeth cut-off point associated with different frequencies of green tea consumption were 1.00 (reference) for <1 cup/day, 0.82 (95% CI, 0.74–0.91) for 1–2 cups/day, 0.82 (95% CI, 0.73–0.92) for 3–4 cups/day, and 0.77 (95% CI, 0.66–0.89) for ≥5 cups/day (P for trend <0.0001). The corresponding data for women were 1.00, 0.87 (95% CI, 0.78–0.97), 0.87 (95% CI, 0.77–0.98), and 0.89 (95% CI, 0.78–1.01), respectively (P for trend = 0.011). The results for the cut-off points of <10 teeth and <25 teeth were essentially the same as those for the <20 teeth cut-off point. Since we found a threshold association, we conducted additional analysis at the <20 teeth cut-off point, categorizing the green tea consumption level into two groups (<1 cup/day versus ≥1 cup/day). The multivariate-adjusted ORs for men and women were 0.81 (95% CI, 0.74–0.89) and 0.87 (95% CI, 0.79–0.96), respectively.

Table 4 presents the ORs of tooth loss for oolong tea. We found an inverse dose–response relationship, rather than a threshold relationship, for oolong tea consumption with tooth loss.

Table 5 shows the ORs of tooth loss for coffee consumption. We found that higher coffee consumption was significantly associated with increased odds for tooth loss in both age-adjusted and multivariate-adjusted ORs. In women, analyses stratified by addition of sugar or syrup exhibited a pronounced increase of ORs for tooth loss due to sugar or syrup, while ORs for coffee consumption in men were almost unchanged, irrespective of addition of sugar or syrup.

Discussion

Our findings showed that green tea consumption was significantly associated with decreased odds for tooth loss.