

## Green tea consumption in everyday life and mental health

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### Abstract

**Objective:** Green tea has been widely acknowledged in Japan to induce a pleasurable mental feeling. Recent laboratory studies have suggested positive psychological effects as a result of consuming green tea. The present study examined whether green tea consumption in everyday life in Japan is associated with positive mental health.

**Design:** A cross-sectional study was performed in February–March 2002.

**Setting and subjects:** The subjects of the study consisted of a general population of 600 Japanese aged 20–69 years. Responses of 380 subjects, obtained by home-visit interview, were analysed. The questionnaire inquired about consumption of brewed green tea and other beverages, perceived mental health status, lifestyle and others. The 12-item General Health Questionnaire (GHQ 12) was used for the assessment of mental ill-health (GHQ score  $\geq 4$ ).

**Results:** After adjustments for age, area, perceived mental stress, lifestyle and daily caffeine intake, the consumption of brewed green tea was not statistically associated with any decrease in risk of mental ill-health among either males or females (odds ratio (OR) = 0.78, 95% confidence interval (CI) = 0.47–1.29 for males; OR = 0.77, 95% CI = 0.51–1.14 for females). Daily caffeine intake (100 mg) inclusive of green tea, black tea, coffee and other caffeine-containing beverages was associated with a higher risk of mental ill-health among females (OR = 1.26, 95% CI = 1.01–1.56).

**Conclusions:** The results provide population-based evidence on the consumption of brewed green tea in everyday life and mental health, together with information on consumption patterns of various beverages and lifestyles.

**Keywords**  
Green tea  
Mental health  
Caffeine  
Stress

Green tea, a drink brewed from the dried leaves of the plant *Camellia sinensis*, is a frequently consumed beverage in Asian countries and is one of the most popular beverages in Japan. Most interest in the effects of green tea has been stimulated by emerging evidence linking green tea consumption with positive health outcomes. Epidemiological evidence has suggested that green tea consumption may be associated with a reduction in blood cholesterol levels<sup>1,2</sup>, cardiovascular disease and cancer<sup>3–5</sup>.

It has long been said that green tea induces a pleasurable mental feeling and recently green tea has received much scientific attention because of its positive psychological effects, thought to be caused by the novel amino acid theanine ( $\gamma$ -glutamylethylamide)<sup>6–8</sup>. Brewed properly, green tea produces a taste of umami. It is generally accepted that the amino acid theanine is associated with this taste<sup>9</sup>. Several new products – including medically designed foods containing theanine aimed at relaxation and reduction of stress – have become available on the Japanese market in recent years,

but actual consumption of such foods among the general public is still relatively minor. Among human volunteers an oral intake of theanine was reported to induce feelings of relaxation<sup>6</sup>. Some studies supported a causal relationship between theanine and positive mental health by using theanine in its isolated form. However, no studies have yet been conducted examining this relationship by quantifying the consumption of green tea, which is still the major source of theanine in everyday life.

Epidemiological studies have identified an association between mental health and stress, lifestyle and caffeine intake<sup>10–27</sup>. Therefore, it is necessary to make adjustments for these confounding factors to examine any independent relationships between brewed green tea consumption and mental health using a population-based study.

The objectives of the present study were to examine the independent relationship between brewed green tea consumption and positive mental health in the course of general daily consumption after controlling for caffeine, perceived mental stress and lifestyle.

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## Materials and methods

### Study population

A cross-sectional study was performed in February–March 2002. First, two areas were selected. One was from an urban area in Tokyo; the other was a green tea-producing area in Shizuoka Prefecture, situated approximately 200 km west of Tokyo and 100 km east of Japan's third largest city, Nagoya. Shizuoka Prefecture's average annual amount of green tea purchased per household is the highest in Japan<sup>28</sup>. In 2000, the total population for the urban and green tea-producing areas was 619 953 and 59 835, respectively, with a population density of 12 459 and 747 per km<sup>2</sup>, respectively. The total percentage of the population employed in agriculture, forestry and fisheries industries was 0.29 and 7.38%, respectively<sup>29</sup>.

Next, males and females ( $n = 600$ ) aged 20–69 years were randomly selected by using the Basic Resident Registration list in each area. Three sub-areas were selected in each area, and then individuals aged 20–69 years were selected by using a sampling rate of 1:15. Sampling was continued until a total of 150 males and females were selected from each area. The study received approval from the local governments in each area and informed consent was obtained from all participating subjects.

Of the 600 subjects, the response rate was 64.5% ( $n = 387$ ) and the number of completed questionnaires was 380 (63.3%). The distribution of respondents aged 20–29, 30–39, 40–49, 50–59 and 60–69 years was 13.9, 20.5, 21.8, 23.9 and 19.7%, respectively.

### Measurements

Trained interviewers conducted 387 interviews. The interviews were performed using a standardised questionnaire. It consisted of the following categories of questions: consumption of brewed or instant green tea, coffee, black tea and oolong tea; thoughts about drinking green tea; mental health status; demographics; health status and lifestyle.

The frequency of brewed tea consumption was established according to four categories (less than 1 cup per day, 1–2 cups per day, 3–4 cups per day, and more than 5 cups per day). The total daily caffeine intake was calculated based on the amount of tea (green tea, black tea and oolong tea) and coffee consumed, both brewed and instant. Estimated caffeine content in one cup (150 ml) is as follows: green tea and oolong tea, 30 mg; black tea, 45 mg; and coffee, 90 mg<sup>30</sup>.

Mental health status was assessed using a Japanese version of the 12-item General Health Questionnaire (GHQ 12)<sup>31</sup>. The GHQ 12 is often used in general practice as a screening tool for assessing mental ill-health<sup>32</sup>. Responses to each item were coded on 0–0–1–1. A GHQ score is obtained by summing up all items, which results in an integer from 0 to 12. Mental ill-health was defined when GHQ score was equal to or greater than 4.

The number of stressors was calculated as the sum of seven items (work, family, interpersonal relationships, future, financial situation, environmental pollution including noise and self-image), and the number of things done for health was calculated as the sum of eight items (well-regulated lifestyle, nutritional diet, moderate salt intake, avoidance of overeating, regular exercise, adequate sleep, avoidance of smoking and moderate alcohol consumption).

### Statistical analysis

Statistical analysis was performed using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, USA). A  $P$ -value of  $<0.05$  was considered statistically significant. Analyses were conducted for area and gender separately.

Regional differences with respect to age, gender, brewed green tea consumption, daily caffeine intake, mental health status and perceived mental stress were examined by Student's  $t$ -test, the Mann–Whitney  $U$ -test or the chi-square test according to the distribution of variables. The Cochran–Armitage trend test was used to examine the relationship between brewed green tea consumption and thoughts about drinking green tea. One-way analysis of variance was used to compare the amount of daily caffeine intake from green tea, coffee and other caffeine-containing beverages among each of four levels of perceived mental stress, and a *post hoc* test (Dunnett's T3) was performed if the overall difference was significant.

Bivariate association of brewed green tea consumption with mental health-related indicators was tested using Spearman correlation.

The independent contributions of brewed green tea consumption to the absence ( $= 0$ ) or presence ( $= 1$ ) of mental ill-health were estimated by multivariate logistic regression. To explore the potential influence, adjustment for confounding factors was developed in a stepwise manner. Age and area were first controlled for, and confounders selected by previous bivariate analyses were then added. Daily caffeine intake was finally entered to clarify the independent effects of theanine from daily consumption of brewed green tea. Odd ratios (OR) and 95% confidence interval (CI) were used to indicate the protective or risk effects on mental ill-health.

## Results

### Brewed green tea consumption and mental health status

The mean age of subjects in the urban and green tea-producing areas was 44.7 years ( $n = 190$ ) and 47.3 years ( $n = 190$ ), respectively. The percentage of males among subjects in the urban and green tea-producing areas was 45.8% ( $n = 87$ ) and 48.9% ( $n = 93$ ), respectively. There were no significant differences in age and gender distribution between the two areas.

Table 1 shows that subjects in the green tea-producing area reported a significantly higher consumption of brewed

green tea compared with those in the urban area ( $P < 0.01$ ). Consumption of green tea in quantity greater than 5 cups per day in the urban and the green tea-producing areas was 30.5% and 53.2%, respectively. The prevalence of mental ill-health, calculated by the GHQ, showed no significant difference between the two areas. Total daily caffeine intake in the two areas was similar, with the median being 231.7 and 231.6 mg in the urban and green tea-producing area, respectively.

There were no significant differences in the distribution of brewed green tea consumption between genders. The consumption ratio of more than 5 cups per day between males and females was 40.6% and 43.0%, respectively. Regardless of the amount of brewed green tea consumed, 70.6% of males and 82.0% of females felt that drinking green tea relaxes the mind.

#### **Associations of brewed green tea consumption and demographics, health status and lifestyle indicators**

Table 2 shows that consumption of brewed green tea increased with age but decreased with education in both genders. There was a negative relationship between brewed green tea consumption and perceived mental stress. In general, healthy lifestyle practice was associated with increased consumption of brewed green tea.

#### **Independent contributions of brewed green tea consumption to mental health status**

Table 3 shows the OR (95% CI) between brewed green tea consumption and the risk of mental ill-health estimated by stepwise logistic regression analysis by gender separately. Elevated brewed green tea consumption decreased the risk of mental ill-health when age, area, perceived mental stress and lifestyle were adjusted for. However, the statistical associations were not significant among either males or females (OR = 0.70, 95% CI = 0.43–1.13,

$P = 0.15$  for males; OR = 0.74, 95% CI = 0.50–1.10,  $P = 0.13$  for females).

Daily caffeine intake showed a significant influence on mental ill-health status among females after adjustments for age, area, perceived mental stress, lifestyle and brewed green tea consumption were made (OR = 1.26, 95% CI = 1.01–1.56,  $P = 0.04$ ). However, this association was not found among males (OR = 0.74, 95% CI = 0.53–1.05,  $P = 0.09$ ). Caffeine intake reduced mental ill-health among males but increased mental ill-health among females.

#### **Patterns of caffeine intake from green tea, coffee and other caffeine-containing beverages in relation to perceived mental stress**

Table 4 and Fig. 1 show the mean (standard error of mean) total daily caffeine intake and caffeine intake from green tea, coffee and other caffeine-containing beverages according to level of perceived mental stress. The mean daily caffeine intake was not significantly different by gender, being 253.0 and 271.1 mg for males and females, respectively. Male subjects who reported high levels of stress ingested on average 331.3 mg of total caffeine per day. This was significantly higher than for male subjects who reported no stress, with a daily caffeine intake of 212.0 mg ( $P < 0.05$ ). The pattern of caffeine intake from green tea, coffee and other caffeine-containing beverages in relation to perceived mental stress was similar between males and females. Both male and female subjects who reported no perceived stress obtained most of their daily caffeine from the consumption of green tea. No overall difference in caffeine intake from green tea or coffee could be found among the four stress levels in both genders.

#### **Discussion**

We conducted a population-based study in Japan to examine whether consumption of brewed green tea in

**Table 1** Comparisons of brewed green tea consumption, mental health status and perceived mental stress between sub-samples in an urban area and a green tea-producing area from a community-based survey among Japanese adults aged 20–69 years in 2002

	Urban area ( $n = 190$ ) (%)	Green tea-producing area ( $n = 190$ ) (%)	<i>P</i> -value
Brewed green tea consumption			
Less than 1 cup/day	26.3	1.1	
1–2 cups/day	20.5	18.4	
3–4 cups/day	22.6	27.4	<0.01†
5 cups/day or more	30.5	53.2	
Mental health status			
Health (GHQ score < 4)	80.0	81.1	
Ill-health (GHQ score $\geq 4$ )	20.0	18.9	0.80‡
Perceived mental stress			
None	20.0	10.5	
Low	44.7	50.5	
Medium	20.5	23.7	0.12†
High	14.7	15.3	

GHQ – General Health Questionnaire.

† Test of significance performed using the Mann–Whitney *U*-test.

‡ Test of significance performed using the chi-square test.

**Table 2** Bivariate association (Spearman's correlation coefficients) of brewed green tea consumption with demographic, health status and lifestyle indicators in sub-samples of males and females from a community-based survey among Japanese adults aged 20–69 years in 2002

	Value (label)	Brewed green tea consumption 1 (< 1 cup/day)–4 (≥ 5 cups/day)	
		Males (n = 180)	Females (n = 200)
<b>Demographics</b>			
Age	20–60 (years)	0.36**	0.52**
Family unit	1 (single)–5 (four generations)	0.26**	0.04
Education	1 (< high school)–4 (≥ college)	–0.24**	–0.18*
<b>Health status</b>			
Subjective health	1 (poor)–5 (excellent)	0.01	0.10
Perceived physical fatigue	1 (none)–4 (high)	–0.09	–0.14
Perceived mental stress	1 (none)–4 (high)	–0.12	–0.19**
Perceived number of stressors	0–7	–0.13	–0.14
<b>Lifestyle</b>			
Well-regulated lifestyle	0 (no), 1 (yes)	0.20**	0.28**
Nutritional diet	0 (no), 1 (yes)	0.08	0.20**
Moderate salt intake	0 (no), 1 (yes)	0.06	0.29**
Avoidance of overeating	0 (no), 1 (yes)	0.19*	0.26**
Regular exercise	0 (no), 1 (yes)	0.15*	0.15*
Adequate sleep	0 (no), 1 (yes)	0.10	0.20**
Avoidance of smoking	0 (no), 1 (yes)	0.01	0.15*
Moderate alcohol consumption	0 (no), 1 (yes)	0.001	0.11
Number of things done for health	0–8	0.17*	0.34**

\**P* < 0.05; \*\**P* < 0.01.

everyday life is associated with positive mental health. The results indicated a lack of statistically significant associations between brewed green tea consumption in everyday life and mental health among males and females. Daily caffeine intake, inclusive of green tea, black tea, coffee and other caffeine-containing beverages, was associated with a higher risk of mental ill-health among females.

The present study indicates an interesting association between brewed green tea consumption in everyday life and mental health. Factors that have a known effect on mental health, such as age, area and lifestyle, were adjusted for. Reported perceived mental stress was also adjusted for, as several studies have reported that mental stress has a significant influence on mental disorders and depression<sup>10–15</sup>. Although no independent relationship was found between brewed green tea consumption and a decrease in the risk of mental ill-health in everyday life, an independent association was found between

perceived mental stress and an increase in the risk of mental ill-health.

The results of this study raise a new suggestion as to the effects of theanine, a major component of brewed green tea, on mental health. The effects of theanine on positive mood among human volunteers have previously been observed under artificial, stress-free conditions and using high doses<sup>6</sup>. The concentrations of theanine differ greatly between the experimental doses used previously and the amount found occurring naturally in brewed green tea. The oral intake of theanine that was reported to have induced feelings of relaxation was approximately 22 times higher than the concentration found in a regular cup (150 ml) of brewed green tea. This result is based on 430 ml of water boiled to 90°C with 10 g of a popular Japanese green tea leaf (*sencha*) added and allowed to brew for 60 min<sup>33</sup>. This would indicate that perhaps the concentrations of theanine found in brewed green tea are

**Table 3** Effect of brewed green tea consumption on the presence (= 1) or absence (= 0) of mental ill-health estimated by multivariate logistic regression models, from a community-based survey among Japanese adults aged 20–69 years in 2002

	Brewed green tea consumption 1 (< 1 cup/day)–4 (≥ 5 cups/day)	Perceived mental stress 1 (none)–4 (high)	Number of things done for health, 0–8	Daily caffeine intake (100 mg)
<b>Males</b>				
OR (95% CI) – multiple adjusted †	0.70 (0.43–1.13)	2.29 (1.26–4.17)**	0.81 (0.64–1.03)	
OR (95% CI) – multiple adjusted ‡	0.78 (0.47–1.29)	2.51 (1.34–4.69)**	0.80 (0.63–1.01)	0.74 (0.53–1.05)
<b>Females</b>				
OR (95% CI) – multiple adjusted †	0.74 (0.50–1.10)	3.00 (1.79–4.88)**	0.92 (0.78–1.08)	
OR (95% CI) – multiple adjusted ‡	0.77 (0.51–1.14)	2.95 (1.78–4.90)**	0.92 (0.78–1.09)	1.26 (1.01–1.56)*

OR – odds ratio; CI – confidence interval.

\**P* < 0.05; \*\**P* < 0.01.

† Age, area, perceived mental stress and number of things done for health were adjusted for.

‡ Age, area, daily caffeine intake (100 mg), perceived mental stress and number of things done for health were adjusted for.

**Table 4** Total daily caffeine intake (mean  $\pm$  standard error of the mean) from green tea, coffee and other caffeine-containing beverages according to level of perceived mental stress in males ( $n = 180$ ) and females ( $n = 200$ ) from a community-based survey on brewed green tea consumption and mental health among Japanese adults aged 20–69 years in 2002

	Perceived mental stress level			
	None	Low	Medium	High
<b>Males</b>				
<i>n</i>	28	43	85	24
Intake (mg)	212.0 $\pm$ 18.8 <sup>a</sup>	257.9 $\pm$ 23.9 <sup>ab</sup>	241.9 $\pm$ 14.0 <sup>ab</sup>	331.3 $\pm$ 34.9 <sup>b</sup>
<b>Females</b>				
<i>n</i>	29	41	96	34
Intake (mg)	249.9 $\pm$ 24.1	264.1 $\pm$ 23.0	272.5 $\pm$ 16.5	293.6 $\pm$ 26.0

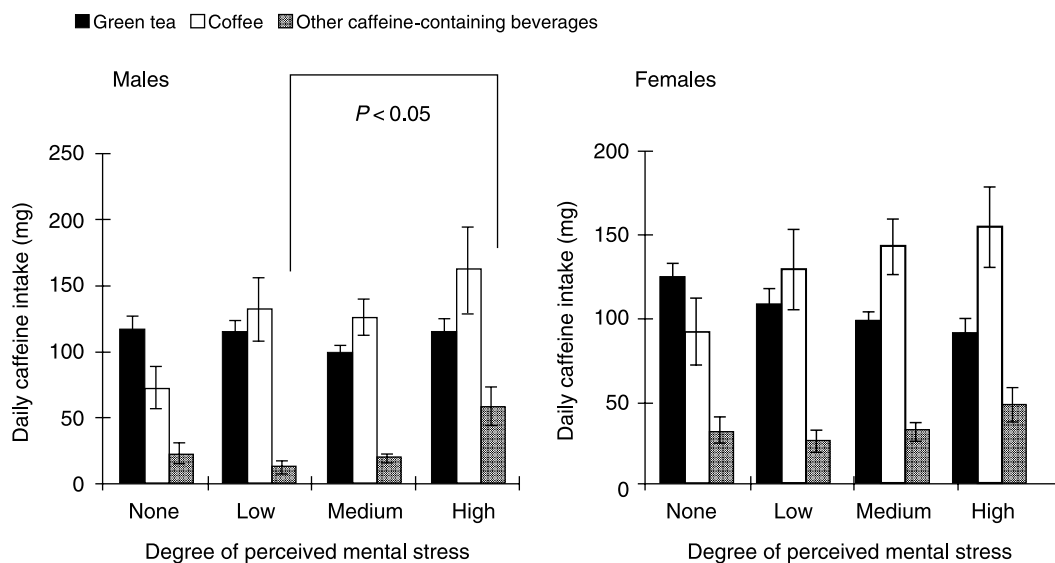
Values with different superscript letters are significantly different by Dunnett's T3 test ( $P < 0.05$ ).

not sufficient to induce any measurable positive mental health status in everyday life. Therefore, the results from the previous laboratory study<sup>6</sup>, which suggested that green tea components relate to positive mental health, may not be applicable to everyday life. This being the case, a theanine supplement would be required to induce the same feelings of relaxation previously reported.

It is interesting to note that, regardless of the quantity of green tea consumed, 70.6% of males and 82.0% of females felt drinking green tea relaxes the mind. This is likely to reflect their feeling just after their consumption of green tea. Caffeine, a major component found in green tea, is known for its psychoactive effects at low doses<sup>24,34–36</sup>. A laboratory study reported that the administration of decaffeinated green tea in the drinking water of mice exposed to psychosocial stress resulted in significantly reduced physiological stress markers and behavioural responses<sup>37</sup>. Our results indicated an independent association between perceived mental stress and an increase in the risk of mental ill-health. Greater consumption of brewed green tea by those who perceived mental stress might have

reduced mental ill-health, however, both male and female subjects who reported high stress levels generally consumed lower quantities of brewed green tea. The timing in consumption of brewed green tea should be considered, with encouragement to consume brewed green tea particularly in situations invoking some psychological stress.

In everyday life, caffeine is ingested in multiple small quantities in a variety of forms like green tea, coffee and other caffeine-containing beverages. This is different from a single large dose of caffeine given in a specific laboratory setting. Much research has been conducted indicating that a single large dose of caffeine has a negative effect on mood<sup>24–27</sup>. It is important to illustrate the difference in effects on mental health between a single large experimental dose and the actual quantity of caffeine consumed in everyday life. Our results showed a significant association between daily caffeine intake and higher risk of mental ill-health among females but not among males. Reasons to explain this difference by gender could be pharmacodynamic in relation to general differences in



**Fig. 1** Daily caffeine intake (mean  $\pm$  standard error) from green tea, coffee and other caffeine-containing beverages according to level of perceived mental stress in males ( $n = 180$ ) and females ( $n = 200$ ) from a community-based survey on brewed green tea consumption and mental health among Japanese adults aged 20–69 years in 2002



body weight and smoking among males and females<sup>38</sup>. Therefore, it is necessary to consider gender differences when examining caffeine-related effects.

Further studies using a cohort design or an intervention trial would determine the causal association between theanine, caffeine and mental health. It is also important to consider that the consumption patterns of green tea in various regions and their influence on mental health may vary according to cultural and population characteristics.

In conclusion, our results have provided population-based evidence on the consumption of brewed green tea in everyday life and mental health. The association between brewed green tea consumption and mental health was insignificant, under current conditions of ordinary everyday life in Japan.

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