



Original article

Association of green tea consumption with mortality due to all causes and major causes of death in a Japanese population: the Japan Public Health Center-based Prospective Study (JPHC Study)



Eiko Saito PhD^{a,b}, Manami Inoue MD, PhD^{a,b,*}, Norie Sawada MD, PhD^a, Taichi Shimazu MD, PhD^a, Taiki Yamaji MD, PhD^a, Motoki Iwasaki MD, PhD^a, Shizuka Sasazuki MD, PhD^a, Mitsuhiro Noda MD, PhD^c, Hiroyasu Iso MD, PhD^d, Shoichiro Tsugane MD, DMSc^{a,1} for the JPHC Study Group²

^a Epidemiology and Prevention Group, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, Japan

^b Graduate School of Medicine, The University of Tokyo, Tokyo, Japan

^c Department of Diabetes Research, Diabetes Research Center, National Center for Global Health and Medicine, Tokyo, Japan

^d Public Health, Department of Social and Environmental Medicine, Osaka University Graduate School of Medicine, Suita, Osaka-fu, Japan

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ABSTRACT

Purpose: We examined the association between green tea consumption and mortality due to all causes, cancer, heart disease, cerebrovascular disease, respiratory disease, injuries, and other causes of death in a large-scale population-based cohort study in Japan.

Methods: We studied 90,914 Japanese (aged between 40 and 69 years) recruited between 1990 and 1994. After 18.7 years of follow-up, 12,874 deaths were reported. The association between green tea consumption and risk of all causes and major causes of mortality was assessed using the Cox proportional hazards regression model with adjustment for potential confounders.

Results: Hazard ratios for all-cause mortality among men who consumed green tea compared with those who drank less than 1 cup/day were 0.96 (0.89–1.03) for 1–2 cups/day, 0.88 (0.82–0.95) for 3–4 cups/day, and 0.87 (0.81–0.94) for more than 5 cups/day (P for trend $<.001$). Corresponding hazard ratios for women were 0.90 (0.81–1.00), 0.87 (0.79–0.96), and 0.83 (0.75–0.91; P for trend $<.001$). Green tea was inversely associated with mortality from heart disease in both men and women and mortality from cerebrovascular disease and respiratory disease in men. No association was found between green tea and total cancer mortality.

Conclusions: This prospective study suggests that the consumption of green tea may reduce the risk of all-cause mortality and the three leading causes of death in Japan.

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* Corresponding author. Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. Tel.: +81-3-5841-3617; fax: +81-3-5841-3637.

E-mail address: mnminoue@m.u-tokyo.ac.jp (M. Inoue).

¹ Address reprint requests. Research Centre for Cancer Prevention and Screening, National Cancer Centre, 5-1-1 Tsukiji, Chuo-ku, Tokyo 104-0045, Japan.

² Study group members are listed in the Acknowledgment.

Introduction

Tea is one of the most popular beverages consumed globally and in Japan. Among different kinds of tea, 53% of Japanese adults drink green tea every day [1]. Green tea contains many compounds that are beneficial for health, including caffeine and polyphenol catechins [2]. Because green tea is regularly consumed throughout life, the health effects of these compounds may accumulate to make a large effect on the longevity of the general population.

Epidemiologic studies of the associations between green tea and mortality events have been reported, but most of them are limited to all-cause, stroke, or cardiovascular disease mortality [3,4]. Only one large-scale cohort study has shown an inverse association between

green tea and deaths due to pneumonia [5], and for total cancer mortality, past studies have shown conflicting results [3,4,6]. In contrast, no prospective cohort studies reported the effect of green tea on injury-related deaths, although total injury deaths including accidents and suicide account for 5.9% of mortality and rank the fifth of the major causes of death in Japan [7]. It means that no study has comprehensively assessed the effect of green tea consumption on five leading causes of death, which may contribute to explain the prolonged life expectancy in Japan. We aim to investigate the potential benefits of the most commonly consumed beverage on five leading causes of death in Japan, thereby suggesting health promotion strategies that can be implemented with minimal costs to the national health systems.

Methods

Study population

The details of the Japan Public Health Center-based Prospective Study have been reported elsewhere [8–10]. The study commenced in 1990 for cohort I and in 1993 for cohort II, covering a total of 140,420 individuals (68,722 men and 71,698 women) in 11 public health center areas. Cohort I included individuals aged between 40 and 59 years, whereas cohort II identified individuals aged between 40 and 69 years. Participants with non-Japanese nationality ($n = 51$), incorrect birth date ($n = 7$), and duplicate registration ($n = 4$), or those who emigrated before commencement of the starting point ($n = 206$) were excluded. We also excluded the late report of migration that occurred before the start of the follow-up period ($n = 6371$), leaving 133,758 individuals eligible for the study. Of all the eligible subjects, 113,323 individuals (53,314 men and 60,009 women) completed the self-administered questionnaire on demographics, height and weight, smoking, alcohol intake, physical exercise, and dietary habits. We excluded participants with a past history of cancer, stroke, or myocardial infarction ($n = 4164$). We also excluded those with missing information on consumption of green tea, coffee, Chinese tea, black tea, and soda or juice; total energy intake; consumption of fruits, vegetables, meat, fish, dairy products, rice, and miso soup; job status at baseline; smoking status; alcohol intake; history of diabetes, hypertension, or ulcer; and physical activity ($n = 18,245$). Finally, 90,914 participants were included in the analysis (42,836 men and 48,078 women). This study was approved by the Institutional Review Board of the National Cancer Center in Tokyo and The University of Tokyo, Japan.

Follow-up

Participants were followed from the baseline survey (1990–1994) until the date of death or to the end date of follow-up (December 31, 2011), whichever occurred first. Participants who died or moved to other areas were traced annually through the residential registry. Of those who returned the baseline questionnaires, 89 (0.1%) emigrated outside of Japan and 1052 (0.9%) were lost to follow-up during the study period. Cause of death was confirmed using death certificates, with permission of the Ministry of Health, Labor and Welfare [9]. Analysis of cause-specific mortality followed the *International Classification of Diseases and Related Health Problems, Tenth Revision* (ICD-10) [11]. We used the five leading causes of deaths in Japan [7], namely cancer (C00–C97); heart disease (I20–I52); cerebrovascular disease (I60–I69); respiratory disease (J10–J18 and J40–J47), including pneumonia, influenza, chronic obstructive pulmonary disease and associated conditions; injuries and accidents (V01–X59, X60–X84, X85–Y09, and Y85–Y86); as well as other remaining causes.

Assessment of exposure

The baseline questionnaire asked about the average consumption of beverage items with regard to frequency and quantity, including green tea, coffee, Chinese tea, and black tea [12]. Green tea intake was originally classified into six groups: almost never, 1–2 times/week, 3–4 times/week, 1–2 cups/day, 3–4 cups/day, and 5 cups/day or more. Because only a small fraction of participants never drank green tea (16.6% for cohort I and 8.0% for cohort II) or only occasionally drank it (18.2% for cohort I and 10.7% for cohort II), never and occasional drinkers were collapsed into a group having less than 1 cup/day. Furthermore, we examined the independent effects of caffeine, one of the major substances in green tea, to understand the mechanism by which green tea improves mortality in general populations. Total caffeine intake was calculated from the sum of caffeine contained in green tea, coffee, Chinese tea, and black tea that the person consumed per day [13] and the amount of caffeine per cup derived from the *Standard Tables of Food Composition in Japan, Fifth Revised Edition* [14]. Cup size was estimated from the validation study separately for men and women, including cups for green tea (men: 140 ml/cup, women: 130 ml/cup), coffee (men: 150 ml/cup, women: 120 ml/cup), Chinese tea (men and women: 120 ml/cup), and black tea (men and women: 150 ml/cup) [15]. Classifications for consumption of these beverages were consistent in the questionnaires used for cohort I and cohort II.

Validity of the questionnaire in measuring green tea consumption was assessed with 201 participants using dietary records for 28 days (1-week dietary record repeated at 3-month intervals) or 14 days [15]. Spearman rank correlation coefficients between the questionnaire and the dietary record were 0.57 for males and 0.63 for females in cohort I [15] and 0.37 for males and 0.43 for females for green tea consumption in cohort II [16].

Statistical analysis

Associations between beverage intake and the risk of all-cause and cause-specific mortality were estimated from hazard ratios (HRs) and 95% confidence intervals (CIs) measured using a Cox proportional hazards regression model. *P*-values for linear trend were calculated by assigning scores for categories of beverage intake, starting from 1 for the lowest consumption status of green tea to 4 for the highest, being used as a continuous variable. The model was adjusted for potential confounders, including age at baseline (continuous), public health center, smoking status (never, former, <20 cigarettes/day, and ≥20 cigarettes/day), alcohol consumption (never or former, <1 times/week, and regular [<23 , 23 to <46, 46 to <69, 69 to <92, and ≥92 g/d]), body mass index (<18.5, 18.5 to <25, 25 to <30, and ≥30), history of hypertension (no and yes), history of diabetes (no and yes), history of ulcer (no and yes), leisure-time sports or physical exercise (almost never, 1–3 times/month, 1–2 times/week, 3–4 times/week, and almost daily) which was collapsed into two categories (<almost daily and almost daily), job status at baseline (employed and unemployed), intake of coffee, Chinese tea, and black tea, soda or juice excluding 100% fruit juice or vegetable juice (almost never, ≥1 cup/week, and ≥1 cup/day), total energy intake per day (continuous), and the daily intake of fruits, vegetables, meat, fish, and dairy products (continuous) that were log transformed and adjusted for total energy intake using the residual model, rice (<3, 3–4, and >4 bowls/day) and miso soup (not everyday and everyday). We modeled the risk factors separately for men and women. To avoid potential bias from ongoing but sub-clinical illnesses, we conducted the same analyses after excluding deaths within 5 years after baseline, and further conducted a subgroup analysis by smoking status to assess effect modification. *P* values for interactions were estimated by likelihood ratio tests

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