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Orignal article

Soft drink, 100% fruit juice, and vegetable juice intakes and risk of diabetes mellitus

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SUMMARY

Background & aims: Japan has experienced a jump in the diabetes prevalence rates. We want to examine whether increased intake of soft drink and juices have contributed to this jump.
Methods: Participants were 27,585 Japanese men and women aged 40–59 years who had no prior history of diabetes. Intakes of soft drink, 100% fruit juice and vegetable juice were measured by a validated food frequency questionnaire. Odds ratios of type 2 diabetes over 5 and 10 years were estimated by using logistic regression.
Results: A total of 484 men and 340 women reported newly diagnosed diabetes during10 years. High soft drink intake was associated with increased risk of type 2 diabetes in women but not men; odds ratio (95% CI) for women with almost daily consumption versus non-consumers was 2.10 (1.23–3.59; *P*-trend = 0.004) and 1.79 (1.11–2.89; *P*-trend = 0.01) at 5 and 10 years, respectively. The association was evident in overweight, highly educated and premenopausal women, and women with blue collar job. Intakes of 100% fruit juice and vegetable juice were not associated with risk of type 2 diabetes for either gender (*P*-trend >0.05).
Conclusions: Soft drink but not pure juices consumption was associated with increased risk of type 2 diabetes in Japanese women.

1. Introduction

Lifestyle related factors; especially eating habits, strongly affect the development of type 2 diabetes.[1] According to community-based studies in Japan, the prevalence of diabetes increased from 2–8% in the 1980s to 6–13% in the 1990s among middle-aged men and from 1–5% in the 1980s to 3–9% in the 1990s among middle-aged women.[2] Changes from traditional to westernized lifestyles accompanied by increased intakes of soft drink and juices have contributed to such jump in the prevalence in Asia.[3] In cross-sectional[4] and longitudinal studies,[5] increased intakes of these beverages were linked to obesity in children and adults. Other studies pointed to the associations of soft drink with metabolic disturbances and type 2 diabetes in Asia[3] and western countries.[6,7] However, no data reported such associations among Japanese population. With the world wide, and especially the Asian increased intake of these beverages,[8] it is important to evaluate the associations of the intakes of these beverages and risk of type 2 diabetes in Japanese ethnic population, which has a low average BMI, and whose soft drink and juices' consumptions are still lower than that of other Asian and Western populations,[9] because the identification of the modifiable risk factors for type 2 diabetes is important to set up public health plans to combat this growing global burden.

We conducted a community-based, prospective cohort study with a large number of middle-aged Japanese men and women with an adequate follow-up period to assess the associations of the intakes of soft drink and juices with risk of incident type 2 diabetes.

2. Subjects and methods

2.1. Study population

The Japan Public Health Center-based prospective study on cancer and cardiovascular disease (JPHC study) Cohort I started in

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1990 in 5 prefectures (Iwate, Akita, Nagano, Okinawa and Tokyo). The study design is described in detail elsewhere[10] and was approved by the Institutional Review Board of the National Cancer Center, Tokyo, Japan.

At baseline, 43,149 participants aged 40–59 years (20,665 men and 22,484 women) completed a questionnaire upon enrollment in 1990. Follow-up questionnaires were sent to each participant after 5 and 10 years. A total of 35,945 participants (16,591 men and 19,354 women) returned the 5-year follow-up questionnaire, and 32,156 participants (14,564 men and 17,592 women) returned both 5- and 10-year follow-up questionnaires (follow-up rate: 74.5% for total participants; 70.4% for men and 78.2% for women). We excluded from the current analysis participants who had any of the following conditions at baseline: diabetes ($n = 1287$), cardiovascular disease ($n = 423$), cancer ($n = 608$), kidney disease ($n = 486$) or chronic liver disease ($n = 250$). Also, we excluded participants who had missing baseline data for any of the exposure parameters; soft drink ($n = 773$), 100% fruit juice ($n = 228$) and vegetable juice intakes ($n = 73$). Finally, participants with implausible total energy intake; <500 kcal/d or >3500 kcal/d, i.e. out of mean ± 3 standard deviations, were also excluded ($n = 443$). The remaining cohort consisted of 27,585 participants (12,137 men and 15,448 women) with data on incident diabetes.

2.2. Data collection

Participants responded to a questionnaire regarding personal, familial and medical histories, lifestyle, and other health related information. At baseline, participants completed a 44-item food frequency questionnaire (FFQ). The FFQ used in the 5- and 10-year follow-up, was expanded to 147 items.

In our study, the inquiry about intakes of soft drink (cola, flavored juices, and non 100% fruit juices), 100% fruit and vegetable juices were made through this question“ How frequent do you consume these beverages: cola and juices, 100% fruit juice, and vegetable juice”. Based on intakes that allowed for logical cut points and provided sufficient participants and cases per category, soft drink and juices categories were presented as follows: “rarely” “1–2 times/week”, “3–4 times/week”, “almost every day”. Pure 100% fruit and vegetable juices were analyzed separately because they provide nutritional value beyond the energy. It is worth noting that we were unable to examine the effects of subcategories of soft drink because they were combined into one question in the FFQ.

The baseline FFQ was validated by using four 7-days weighed dietary records (DR) over one year period as a reference standard. The Spearman rank correlation coefficients for soft drink, 100% fruit juice and vegetable juice intakes between the FFQ and four 7-days DR were 0.29, 0.17 and 0.17 for men, and 0.31, 0.17 and 0.21 for women, and were 0.52, 0.22 and 0.46 for men, and 0.51, 0.33 and 0.23 for women between two FFQ conducted five years apart. The Spearman rank correlation coefficients for soft drink intake between the 5-year FFQ and four 7-days DR were 0.35 for men and 0.41 for women.

2.3. Assessment of covariates

The self-administered questionnaire included questions regarding weight and height, usual pattern of physical activity, smoking habits, alcohol intake, previously diagnosed medical conditions (including diabetes and hypertension), family history of diabetes, and other lifestyle factors. Body mass index (BMI) was calculated from the baseline weight and height as {weight (kg)/[height (m)]^2}. If at least one parent or one sibling had diabetes, participant's family history of diabetes was considered positive. Participants were classified according to their education level into 'less than high school', 'high school', 'university or higher education'. Regarding participants' job, the categories included 'white collar job (professional, self-employed, clerk, sales, or services)', 'blue collar job (agriculture, forestry, fishery, protective service, transportation and communication, labor)', 'unemployed including housewives'. According to smoking habit, participants were classified into 'never smoker', 'former smokers', 'current smoker of 1–19 cigarettes/day', '20–29 cigarettes/day', and '≥30 cigarettes/day'. Total daily alcohol intake was calculated by multiplying the frequency of intake by the alcohol content of each alcoholic beverage. Participants were classified into 'non-drinkers', 'infrequent occasional drinkers', 'drinkers of < 150 ml/day', 'drinkers of 150–299 ml/day', 'drinkers of 300–450 ml/day' and 'drinkers of > 450 ml/day'. If the participant had been informed of a diagnosis of hypertension by a physician, under a prescription for anti-hypertensive drugs or reported systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, a history of hypertension was considered to exist. Participants were asked to report their average hours of sports or exercise per week; ranging from: 'almost no', '1–2 h/week', '3–4 h/week', '≥5 h/week'. Participants were considered physically active if they participated in sports at least 3 h/week; all other participants were considered inactive. As for the frequency intakes of coffee and green tea, participants were classified as 'non-drinkers', 'drinkers less than daily', 'drink daily ≤2 cups', and 'drink ≥3 cups/day'. For other food items in the FFQ, possible responses ranged from “rarely” “1–2 times/week”, “3–4 times/week”, and “almost every day”. The average daily intake of total energy and nutrients; magnesium, calcium, vitamin D, and total dietary fiber were calculated by multiplying the frequency of intakes of each food item in the FFQ with its nutrient content and energy per serving, and summing the nutrient intake for all food items based on the standard food composition tables in Japan.[11] Intakes of Foods and nutrients were energy-adjusted by the residual method.[12]

2.4. Assessment of diabetes mellitus

'Prevalent diabetes mellitus' was defined as a reply of 'yes' to the question on the baseline questionnaire, 'Has a doctor ever told you that you have any of the following diseases? Diabetes (yes/no), etc…'. Individuals without diabetes at baseline, who subsequently answered 'yes' on either or both of the 5- and 10-year follow-up questionnaires, were considered to have developed diabetes mellitus. We classified all incident cases as type 2 diabetes, because the age of onset in this middle-aged cohort was ≥40 years. The validity of self-report of diabetes mellitus in our study population was confirmed previously.[13]

2.5. Statistical analysis

Analyses were performed for men and women separately. Sex-specific mean (standard deviation, SD) values and proportions of diabetes risk factors and participants' characteristics across categories of soft drink, 100% fruit and vegetable juices intakes were calculated, and the differences in those variables across the categories were tested by the analysis of covariance and χ^2-test. Because of the lack of precise dates of diabetes onset, the use of a person-year approach was precluded; instead we used the cumulative incidence of diabetes over the 5- and 10-year period as the outcome, using the 5- and 10-year follow-up questionnaires. Multiple logistic regression analysis was used to assess the contributions of increasing intakes of soft drink and 100% fruit and vegetable juices to the subsequent risk for type 2 diabetes. To obtain odds ratios (OR) and 95% confidence intervals (CI) that were adjusted in the first model for age only, the final model was further