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Total and specific fruit and vegetable consumption and risk of stroke: A prospective study

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ABSTRACT

Background: Fruit and vegetables is a heterogeneous food group with different content of dietary fiber, vitamins, minerals, carotenoids, and bioactive phytochemicals. Our objective was to examine the relation between specific consumption of fruit and vegetable subgroups and stroke risk in a cohort of Swedish women and men.

Methods and results: We prospectively followed 74,961 participants (34,670 women and 40,291 men) who had completed a food frequency questionnaire in the autumn of 1997 and were free from stroke, coronary heart disease, and cancer at baseline. Diagnoses of stroke in the cohort during follow-up were ascertained from the Swedish Hospital Discharge Registry. A total of 4089 stroke cases, including 3159 cerebral infarctions, 435 intracerebral hemorrhages, 148 subarachnoid hemorrhages, and 347 unspecified strokes, were ascertained during 10.2 years of follow-up. The multivariable relative risk (RR) of total stroke for the highest vs. lowest category of total fruit and vegetable consumption was 0.87 (95% confidence interval [CI] 0.78–0.97; P for trend = 0.01). The association was confined to individuals without hypertension (corresponding RR, 0.81; 95% CI, 0.71–0.93; P for trend = 0.01). Among individual fruits and vegetable subgroups, inverse associations with total stroke were observed for apples/pears (RR, 0.89; 95% CI, 0.80–0.98; P for trend = 0.02) and green leafy vegetables (RR, 0.92; 95% CI, 0.81–1.04; P for trend = 0.03).

Conclusion: This study shows an inverse association of fruit and vegetable consumption with stroke risk. Particularly consumption of apples and pears and green leafy vegetables was inversely associated with stroke.

1. Introduction

High consumption of fruit and vegetables has been associated with lower risk of stroke [1]. Fruit and vegetables is a heterogeneous food group with different content of dietary fiber, vitamins, minerals, carotenoids, and other bioactive phytochemicals. It remains unclear which fruit and vegetable subgroups that are most protective against stroke. Consumption of specific fruit and vegetable subgroups, such as apples and pears [2–4], citrus fruits [3,5,6], berries [7,8], cruciferous vegetables [5,6,9], leafy vegetables [5,9], and root vegetables [6,9] has been inconsistently associated with risk of stroke in previous studies. Moreover, studies on fruit and vegetable consumption in relation to risk of hemorrhagic stroke are limited [7,10].

To further examine the association between consumption of total fruits and vegetables, specific fruits, and vegetable subgroups and risk of total stroke and stroke types, we used data from two large prospective cohorts of Swedish women and men.

2. Methods

2.1. Study population

We used data from two prospective population-based cohorts of Swedish women and men, namely the Swedish Mammography Cohort (SMC) and the Cohort of Swedish Men (COSM). In the autumn of 1997, 39 227 women (SMC) and 48 850 men (COSM) who lived in central Sweden (Uppsala, Västmanland, and Örebro counties) completed a 350-item questionnaire that sought information on diet, lifestyle factors, and other factors that could affect the risk of chronic diseases. For the present analyses, we excluded women and men with an erroneous or a missing National

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Registration Number and those with implausible values for total energy intake (i.e., 3 SDs from the $\log_e$-transformed mean energy intake). We further excluded those with a previous stroke, coronary heart disease, or cancer at baseline. After these exclusions, 74 961 participants (34 670 women and 40 291 men), 45–83 years of age, remained for the analyses. The Regional Ethical Review Board at Karolinska Institutet in Stockholm, Sweden, approved this study.

2.2. Baseline data collection

Information about education, weight, height, smoking, physical activity, aspirin use, history of hypertension and diabetes, family history of myocardial infarction before 60 years, alcohol consumption (type of alcoholic beverage and frequency of consumption), and diet was obtained through a self-administered questionnaire. We classified participants into three groups based on their highest reported education/school (elementary school, secondary school/vocational school, and university). Participants were classified as having diabetes if they self-reported diabetes on the questionnaire or had a diagnosis of diabetes recorded in Swedish National Inpatient Register or the Swedish National Diabetes Register. History of hypertension was based on self-report only. We calculated pack-years of smoking history by multiplying the number of packs of cigarettes smoked per day by the number of years of smoking. Body mass index was calculated as the weight in kilograms divided by the square of height in meters. Participants reported their level of activity at work, home/housework, walking/bicycling, and exercise as well as inactivity (watching TV/reading) and hours per day of sitting/lying down and sleeping. The time per day reported by the subject to have engaged in each activity was multiplied by the activity's typical energy expenditure requirement expressed in metabolic equivalents. The metabolic equivalent-hours for all individual activities (including inactivity) reported by the subject were added together to create a metabolic equivalent-hours per day (24-h) score [11]. Spearman correlation coefficient between total activity score estimated from the questionnaire and two 7-day activity records, performed 6 months apart, was 0.56 [11].

2.3. Dietary assessment

Fruit and vegetable consumption was assessed with a food-frequency questionnaire (FFQ) on which participants indicated their average consumption of 96 foods and beverages over the previous year. Participants could choose from 8 predefined frequency categories, ranging from never to 3 or more times per day. The FFQ included the following fruit and vegetable items: apples and pears; bananas; orange and other citrus fruits; other fruits; berries; spinach; lettuce and green salad; cabbages (cabbage and red cabbage); cauliflower; broccoli and Brussels sprouts; carrots; beetroots; tomatoes and tomato juice; sweet pepper; onion and leek; garlic; green peas; and mixed vegetables. For the present study, the exposures of interest were consumption of total fruit and vegetables, total fruit, total vegetables, specific fruits and vegetables, and vegetable subgroups. We combined specific vegetables into the following subgroups: green leafy vegetables (including spinach, lettuce, and green salad), cruciferous vegetables (white cabbage and red cabbage, cauliflower, broccoli, and Brussels sprouts), and root vegetables (carrots and beetroots). The remaining vegetable items on the FFQ were examined separately, as were the fruit items. We defined the reported times eaten per day as the number of servings. For example, consumption of apples one time per day was defined as one serving of apples per day. In a validation study in a subsample of 129 women from the SMC using a similar FFQ (including 60 foods), the Pearson correlation coefficients between the FFQ and four 1-week diet records (completed 3–4 months apart) ranged from 0.4 to 0.5 for fruit items and from 0.4 to 0.6 for vegetable items (A. Wolk, unpublished data).

2.4. Case ascertainment

Cases of first stroke that occurred in the cohort were ascertained by linkage to the Swedish Hospital Discharge Registry. The strokes were classified as cerebral infarction (International Classification of Diseases 10th Revision code I63), hemorrhagic stroke (I61 and I60), and unspecified stroke (I64). Information on dates of death for deceased participants was obtained from the Swedish Death Register.

2.5. Statistical analysis

Participants contributed follow-up time from January 1, 1998 until the date of diagnosis of stroke, death, or end of follow-up (December 2008), whichever occurred first. We categorized participants into five frequency categories of consumption of total fruit and vegetables (1st to 99th percentile: 0.5–13.0 servings/d), total fruit (0.1–5.5 servings/d), and total vegetables (0.1–9.3 servings/d). Because of the narrow range of consumption of specific fruits and vegetables and the uneven distribution of individuals across frequency categories, the number of individuals (and person-years) in each category varied. Cox proportional hazards regression models were used to estimate relative risks (RR) with 95% confidence intervals (CI) of total stroke, cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage. Separate analyses of women and men showed similar associations. Therefore, we report results for women and men combined, adjusting for sex as a stratum variable in the Cox model. We also adjusted all models for age (in months) as a stratum variable. In the multivariable models, we additionally adjusted for known risk factors for stroke, including smoking status and pack-years of smoking (never; past < 20, 20–39, or ≥ 40 pack-years; or current < 20, 20–39, or ≥ 40 pack-years), education (less than high school, high school, or university), body mass index (<20, 20–24.9, 25–29.9, or ≥ 30 kg/m^2), physical activity (metabolic equivalent-hours/day, quintiles), aspirin use (never, 1–6 tablets/week, ≥ 7 tablets/week), history of hypertension (yes or no), history of diabetes (yes or nor), family history of myocardial infarction before 60 years of age (yes or no). All multivariable models were also adjusted for total energy intake (kcal/day, continuous variable) (to account for over- or underreporting in the FFQ) as well as dietary factors that are associated with risk of stroke in these cohorts and previous studies, including consumption of alcohol, coffee, fresh red meat, processed meat, and total fish (all in quintiles). Further adjustment for intakes of low-fat dairy foods, poultry, whole grains, nuts, legumes, chocolate, sugar, dietary fat, fiber, and sodium did not change the results materially. Therefore, those variables were not included in the multivariable model. Total fruit and total vegetable consumption was mutually adjusted by including both variables in the same multivariable model. Likewise, in the multivariable analyses of specific fruits and vegetable subgroups, the individual fruit items and vegetable subgroups were included in the same model and adjusted for each other.

Tests for trends were conducted by assigning the median value for each category and modeling this variable as a continuous variable. We conducted analyses stratified by history of hypertension to assess potential interaction with this variable. Test for interaction was performed by using the likelihood ratio test. We also performed a sensitivity analysis confined to individuals without diabetes at baseline because diabetics may have changed their fruit and vegetable consumption after their diabetes diagnosis and they are at higher risk for stroke. All analyses were conducted with SAS Version 9.2 (SAS Institute, Cary, NC). All statistical tests were