White rice-based food consumption and ischemic stroke risk: A case-control study in southern China

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Abstract

White rice-based foods, which are high in refined carbohydrates, are widely consumed in China. A case-control study was conducted to investigate the association between white rice-based food consumption and the ischemic stroke risk among the Southern Chinese population. Information on diet and lifestyle was obtained from 374 incident ischemic stroke patients and 464 hospital-based controls. Logistic regression analyses were performed to assess the effects of rice-based foods on the stroke risk. The mean weekly intakes of rice foods appeared to be significantly higher among cases than control subjects. Increased consumptions of cooked rice, congee and rice noodle were associated with higher risks of ischemic stroke after controlling for confounding factors. The corresponding adjusted odds ratios (95% confidence interval) for the highest versus lowest level of intake were 2.73 (1.31-5.69), 2.93 (1.68-5.13), and 2.03 (1.40-2.94), with significant dose-response relationships observed. The results provided evidence of positive association between habitual rice food consumption and the risk of ischemic stroke for Chinese adults.

INTRODUCTION

Stroke is a leading cause of mortality and morbidity in China (1-3). Ischemic stroke accounts for over 70% of stroke cases in western countries, and about 60% in China (4). A growing body of literature has suggested that high levels of refined carbohydrate intake may increase the risk of hyperlipidemia (5, 6) and diabetes mellitus (7-9). Moreover, a high carbohydrate diet may lead to endothelial and inflammatory responses, which increase the risk of hypertension and atherosclerosis (9). Although hyperlipidemia, diabetes, hypertension and atherosclerosis are known to be risk factors for stroke, the effect of refined carbohydrate intake on stroke and its subtypes remains unclear (10, 11).

China is the largest consumer of rice in the world (12). Refined carbohydrates, consumed mainly from white (polished) rice-based products, provide a major source of energy for the Chinese population (13). Cooked rice, congee (rice porridge) and rice noodle are the three most common white rice-based foods. Similar to cooking rice, congee is prepared by adding extra water, boiled and then simmered until it turns into a soupy form. Rice noodle, a processed white rice product, is usually cooked in boiling water and then served with soup or stir-fried. Our review of the literature has found no report on the relationship between the risk of ischemic stroke and consumption of refined carbohydrate among the Chinese population. Therefore, the purpose of this study was to investigate their possible association by conducting a hospital-based case-control study in Southern China.

MATERIALS AND METHODS

Subjects

Subjects were recruited between July 2007 and July 2008 from three teaching hospitals within Foshan city in the Guangdong Province of Southern China: the First People's Hospital of Shunde, First People's Hospital of Nanhai, and Second People's Hospital of Foshan. Cases

were incident ischemic stroke patients referred from the inpatient wards of the hospital neurology departments. Controls were recruited during the same period from outpatient clinics of the Departments of Gastroenterology, Dermatology, Chinese Medicine, Urology and Otolaryngology. To be eligible, subjects must have resided in Foshan for at least the past five years, and were alive during the interview. Inclusion criteria for cases were sudden onset of a focal neurological event, with symptoms lasting over 24 hours and subsequent confirmation of infarct in the brain by CT or MRI scans, and no previous history of stroke. Therefore, only incident patients with a first-ever ischemic stroke (thrombotic or embolic) were considered. Fatal cases due to stroke were excluded because of ethical constraints.

An eligible control had neither history nor clinical evidence indicating a previous stroke, and whose treatment at the outpatient department was not related to any cardiovascular disease, a malignant tumour, or diabetes. Subjects with a diagnosis of Alzheimer's disease, or who had been on long-term modification of diet for medical reasons, were excluded. Controls were frequency matched to cases within five years of age.

Interview

The hospital neurologists notified the first author within two days of each stroke patient admission. A face-to-face interview was then arranged before being discharged from hospital. Eligible controls were recruited and interviewed by the first author when available. All participants were assured of confidentiality and their right to withdraw from the project at any time without prejudice, before obtaining their formal consent. Each interview took about 45 minutes to complete. When a patient was unable to be interviewed because of the morbidity caused by stroke, the answers were obtained from his or her next-of-kin instead. The validity and reliability of using such proxy information have been established in previous studies (14-

17). Approval of the project protocol was obtained from the Human Research Ethics Committee of the researchers' institution, while access to medical records was granted by the participating hospitals.

Instrument and exposure measurement

A structured questionnaire was administered to obtain demographic and lifestyle characteristics including age, gender, weight (kg), height (m), education level (primary school; secondary school or above), smoking status (non-smoker; current/former smoker) and pack-years, and alcohol drinking status (non-drinker; drinker). Information was also solicited on life-long physical activity exposure, defined as "doing active sports or vigorous exercise long enough to get sweaty, at least twice a week", over the life course. Response options were: never been much involved; previously active but not any more; active just recently; intermittently active; always been involved (18). Self-reported height and weight measurements and comorbidities (presence of hypertension, hyperlipidemia and diabetes) were confirmed with medical records whenever available. These co-morbidities were taken to be positive if the condition was either self-reported or present on the patient's medical record.

Information on habitual food consumption including rice-based food intake was collected using a semi-quantitative food frequency questionnaire developed and tested for the Southern Chinese population (19, 20). This validated instrument included 125 items covering commonly consumed foods in South China and recorded both frequency (per day/week/month) and amount of intake. The reference recall period for dietary variables was set at one year before interview. For rice food products, the quantity of cooked rice and congee was measured by the weight of white rice used in preparation, whereas the quantity of rice noodle was measured by its dry weight.

Energy intake for each food item was calculated by multiplying the consumption frequency, the number of standard size serving at each occasion, weight (in 100 grams) of standard size serving, and the energy data per 100 grams of food from the 2002 Chinese Food Composition Table (21). Total energy intake (kcal per week) was then estimated by summing the energy intake across individual food items.

Statistical analysis

Univariate statistics were used to describe the participant characteristics and to compare the dietary pattern between case and control groups. Unconditional logistic regression analyses were then performed to investigate the effects of white rice-based foods on the ischemic stroke risk. For cooked rice and congee, the 25^{th}, 50^{th} and 75^{th} percentiles of intake by controls were chosen as cut-points, resulting in four increasing levels of exposure, with the lowest level taken as the reference category. Rice noodle consumption was categorized into two groups based on the 50^{th} percentile because of its small variation among the participants. Besides crude and adjusted odds ratios (OR) and associated 95% confidence intervals (CI), tests for linear trend of continuous rice food variables were conducted to assess their dose-response relationship with the stroke risk. Other independent variables considered in the logistic regression models were age, gender, education level, body mass index (BMI < 24 or ≥ 24 kg/m^2), lifelong physical activity exposure, smoking status, smoking pack-years, alcohol drinking status, presence of hypertension, hyperlipidemia and diabetes, together with weekly total energy intake and weekly consumption of red meat, fish, poultry, fruit and vegetables. These variables were either plausible risk factors obtained from the literature or considered potential confounders according to the univariate analysis. Statistical analyses were performed using the STATA package release 10 (Stata Corporation, Texas, USA).

RESULTS

A total of 500 incident stroke patients and 600 eligible controls were initially approached. Of the 427 cases and 512 controls signed the consent form and agreed to participate, 374 cases and 464 controls eventually completed the interview, representing a final response rate of 74.8% and 77.3%, respectively. No significant differences were found in mean age and gender distribution between consented participants and those refused or withdrew from the study.

Characteristics of participants by gender are showed in Table 1. Age and BMI were similar between case and control groups for both genders. As expected, the cases had higher prevalence of hypertension and diabetes, were physically less active over their life course but more likely to be smokers than the controls. In terms of dietary intake, the weekly mean consumptions of fruits and vegetables were significantly lower among cases than controls, while the reported mean intakes of red meat, poultry, and fish were similar between the two groups. Overall, the average consumption of white rice-based foods appeared to be higher among cases than controls, especially for rice noodles ($p < 0.01$). .

Results of univariate and multivariate logistic regression analyses for the three rice-based foods are presented in Table 2. Increased consumptions of cooked rice, congee and rice noodle were all associated with higher risks of ischemic stroke after controlling for plausible confounding factors. The adjusted ORs (95% CI) for the highest versus lowest level of intake were 2.73 (1.31-5.69), 2.93 (1.68-5.13), and 2.03 (1.40-2.94), respectively. The corresponding dose-response relationships were also significant, as evident from the test for linear trend with p values 0.006, 0.001 and 0.029.

DISCUSSION

This was the first study to investigate the relationship between habitual rice product consumption and risk of ischemic stroke in Southern China where rice-based foods are commonly consumed. Higher intakes of cooked rice, congee and rice noodle were found to be associated with increased risk of ischemic stroke independent of other risk factors, with significant dose-response relationships observed. The results are consistent with previous studies on refined carbohydrate conducted in the Western populations (11, 22-24). A prospective cohort study suggested that high consumption of refined carbohydrates could increase the risk of hemorrhagic but not ischemic stroke (24), whereas another cohort study reported a positive association between stroke mortality and a diet high in glycemic index and low in fiber (11). In China, rice-based foods provide the major source of carbohydrate and energy. According to the national Health and Nutrition Survey, about 60% of total energy intake of Chinese came from carbohydrate (13). Indeed, the three rice-based foods contributed a high proportion to mean carbohydrate (case 81.6%, control 73.9%) and total energy intake (case 48.2%, control 42.9%) among our study participants.

It is known that a high intake of refined carbohydrates can result in rapid increase of blood glucose level (25). In particular, cooked rice and congee are found to have mean Glycemic Index of 83.2 and 70 respectively (26), and belong to the high GI food category (27). They can also induce rapid glucose response for type-2 diabetic patients (28). Although no data are available for rice noodle, similar elevation in blood glucose is expected because of its high content in refined carbohydrate. It is suggested that frequent rapid increase of blood glucose may increase the risk of type-2 diabetes (9). Moreover, high intake of refined carbohydrate in

the long term can reduce insulin sensitivity, which in turn is associated with an increased risk of hyperlipidemia (6). Both diabetes and hyperlipidemia are established risk factors of stroke.

The present case-control study has several strengths and limitations. Firstly, thrombosis and embolism could not be confirmed by the current clinical practice in China, so that differentiations between these two stroke subtypes were not made. This study did not consider haemorrhage because it is different from ischemic stroke aetiologically. The association between rice products and haemorrhage should be investigated in future studies. Habitual food consumptions, including white rice-based foods, were measured using a validated and reliable questionnaire specifically developed for the Southern Chinese population. Information on frequency and quantity of intake was recorded in detail. Another strength was the inclusion of only incident first-ever ischemic stroke patients with brain image confirmed, whereas all control subjects were screened for stroke symptoms by a neurologist to ensure no misclassification of the case-control status. Although fatal cases were excluded, an inspection of hospital records indicated that stroke-related fatality was only 4.8% among all image-confirmed cases in this part of Southern China.

The self-reported responses from the stroke patients would inevitably incur some recall error due to possible memory and/or cognitive loss from stroke. Therefore, face-to-face interviews were conducted in the presence of their next-of-kin to increase the response rate and to improve the accuracy of their answers. In addition, all interviews were conducted by the first author to eliminate inter-interviewer bias. Proxy information was used in 22% of the cases, yet no differences were found between index patient and next-of-kin on mean weekly cooked rice ($p = 0.77$), congee ($p = 0.46$) and rice noodle ($p = 0.23$) consumption. Selection bias was unavoidable because all participants were voluntary and the hospital-based controls were not

randomly selected from the community. Although the three participating hospitals serve the entire Foshan catchment region so that our subjects were representative of the target population, further replications are required before generalizing the findings to other populations. Information bias and recall bias were unlikely because the potential adverse effects of rice products are not known in China. Nevertheless, residual confounding might still exist even though all plausible risk factors have been accounted for and adjusted in the multivariate logistic regression analyses.

In conclusion, a high consumption of white-rice based foods was found to be associated with increased risk of ischemic stroke in a Southern Chinese population. Rice foods and products constitute a major component of the Chinese daily diet and reduction of their consumption is difficult. Nevertheless, for prevention of ischemic stroke, it is recommended to include more vegetables in each meal so as to reduce the refined carbohydrate intake and control the rise in blood glucose level induced by the rice foods.

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Table 1. Characteristic of subjects by gender and case-control status

	Male (n = 474)		Female (n = 364)	
Variable*	Case (n = 226)	Control (n = 248)	Case (n = 148)	Control (n = 216)
Age (years)	69.6 (8.0)	68.7 (7.0)	69.1 (9.2)	69.0 (9.0)
BMI (kg/m^2)	22.9 (2.7)	23.1 (3.0)	21.5 (3.6)	22.8 (3.6)
Primary school education: n (%)	104 (46%)	88 (35.5%)	82 (55.4%)	103 (47.7%)
Hypertension: n (%)	119 (52.7%)	71 (28.6%)	76 (51.4%)	60 (27.8%)
Hyperlipidemia: n (%)	51 (22.6%)	23 (9.3%)	17 (11.5%)	36 (16.7%)
Diabetes: n (%)	48 (21.2%)	8 (3.2%)	31 (21%)	4 (1.9%)
Alcohol drinker: n (%)	157 (69.5%)	147 (59.3%)	13 (8.8%)	43 (19.9%)
Smoker: n (%)	162 (71.7%)	139 (56.1%)	15 (10.1%)	11 (5.1%)
Smoking pack-years	18.5 (22.1)	17.1 (22.2)	1.3 (6.8)	1.0 (5.5)
Lifelong physical activity: n (%)				
never been involved	71 (31.4%)	56 (22.6%)	60 (40.5%)	63 (29.2%)
previously but not any more	84 (37.2%)	53 (21.4%)	39 (26.4%)	49 (22.7%)
active just recently	12 (5.3%)	15 (6.1%)	10 (6.8%)	19 (8.8%)
intermittently active	22 (9.7%)	29 (11.7%)	6 (4.1%)	25 (11.6%)
always been involved	37 (16.4%)	95 (38.3%)	33 (22.3%)	60 (27.8%)
Fruit consumption (g/week)	465 (636)	913 (765)	499 (599)	1038 (849)
Vegetable consumption (g/week)	2109 (904)	2845 (1122)	2148 (1004)	2491 (1122)
Red meat consumption (g/week)	660 (470)	645 (422)	506 (384)	506 (367)
Poultry consumption (g/week)	274 (294)	279 (293)	244 (249)	223 (242)
Fish consumption (g/week)	706 (525)	735 (617)	572 (459)	601 (504)
Cooked rice consumption	1992	1924	1626	1559

(g/week)	(902)	(799)	(737)	(815)
Congee consumption	352.3	244.5	273.6	242.7
(g/week)	(246.9)	(253.6)	(219.8)	(218.8)
Rice noodle consumption	215.4	152.6	164.3	96.4
(g/week)	(274.8)	(267.6)	(202.7)	(194.1)
Total energy intake	17,286	16,923	12,403	13,957
(kcal/week)	(6281)	(5165)	(3652)	(4790)

* Mean (SD) unless indicated as n (%)

Table 2. Risk of ischemic stroke for white rice-based food consumption

Rice food consumption	Case n (%)	Control n (%)	Crude OR	95% CI	Adjusted OR*	95% CI
Cooked rice (white rice used; g/week)					p for trend = 0.006	
< 1100	54 (14.4)	91 (19.6)	1.00		1.00	
1100-1449	151 (40.4)	167 (36.0)	1.56	(1.03, 2.37)	1.52	(0.90, 2.57)
1450-2449	86 (23.0)	110 (23.7)	1.49	(0.94, 2.37)	1.81	(0.97, 3.38)
≥ 2450	83 (22.2)	96 (20.7)	1.72	(1.08, 2.75)	2.73	(1.31, 5.69)
Congee (white rice used; g/week)					p for trend = 0.001	
< 25	45 (12.0)	112 (24.1)	1.00		1.00	
25-199	93 (24.9)	138 (29.7)	1.52	(0.97, 2.39)	1.74	(1.01, 3.00)
200-399	135 (36.1)	133 (28.7)	2.25	(1.45, 3.49)	2.21	(1.30, 3.74)
≥ 400	101 (27.0)	81 (17.5)	2.95	(1.85, 4.69)	2.93	(1.68, 5.13)
Rice noodle (dry weight; g/week)					p for trend = 0.029	
< 50	156 (41.7)	291 (62.7)	1.00		1.00	
≥ 50	218 (58.3)	173 (37.3)	2.25	(1.69, 3.01)	2.03	(1.40, 2.94)

* model adjusted for age, gender, BMI, education level, lifelong physical activity involvement, smoking status, smoking pack-years, alcohol drinking status, presence of hypertension, hyperlipidemia and diabetes, total energy intake and weekly dietary intake of red meat, fish, poultry, fruit and vegetables.