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Original article

Chilli intake is inversely associated with hypertension among adults

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S U M M A R Y

Background & aims: This study aimed to examine the association between chilli intake and the incidence of hypertension in a Chinese adult population.
Methods: Adults aged 20–75 years in the China Health and Nutrition Survey were followed from 1991 to 2011. Dietary data were collected during home visits using a 3-day food record in 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011. Cox regression was used in the analysis. Blood pressure was measured at each data collection point.
Results: 13,670 adults were followed for a median of 9.0 years. During 132,089 person years of follow-up 4040 subjects developed hypertension. Chilli consumption was inversely associated with the incidence of hypertension. The incidence rate of hypertension was 30.5, 33.4, 31.9, and 24.0 per 1000 person years among those who consumed no chilli or 1–20, 20.1–50, ≥50.1 g/day respectively. Adjusting for age, gender, energy intake, sodium and fat intake, smoking, alcohol consumption and physical activity, those with increasing cumulative average chilli intake were less likely to develop hypertension: 0, 1–20, 20.1–50 and ≥50.1 g/day had a hazard ratio (HR) for hypertension of 1.00, 0.80 (95%CI 0.73–0.88), 0.81 (0.73–0.89) and 0.65 (0.57–0.75) (p for trend <0.001) respectively. The association was independent of overall dietary patterns and BMI. There was no significant interaction between chilli intake and gender, income, education and residence (urban/rural) in relation to the risk of hypertension.
Conclusions: Chilli intake is inversely associated with the risk of developing hypertension in Chinese adults.

Hypertension is one of the leading preventable risk factors for premature mortality in the Chinese population [1], similar to many other populations across the world. Data from the 2002 Chinese National Nutrition Survey indicate that one in six adults are hypertensive [2]. Only 19% of those with hypertension have adequate blood pressure control [2]. Sodium intake increases the risk of hypertension in the Chinese population [3], however, other dietary factors have also been found to be associated with hypertension [4].

Chilli is one of the most commonly used spices [5] in the world with a substantial geographical variation in intake (e.g. the actual chilli intake (grams/day) is higher in Asia than Europe [6]). About a third of adults in China consume spicy food, including chilli, daily [7].

Chilli and its active component capsaicin have been reported to have a range of health benefits including reducing obesity [8] and rhinitis [9], and increasing muscle strength [10]. Recently, two large population studies in China and the USA found that chilli consumers had a lower risk of mortality compared with non-consumers [7,11].

Evidence from animal studies suggest that capsaicin may prevent hypertension and cardiovascular disease via activation of the ion channel transient receptor potential vanilloid subtype 1 (TRPV1). Activation of TRPV1 has been shown to inhibit vascular oxidative stress [12], increase urinary sodium excretion [12] and increase the production of nitric oxide [13]. In addition, activation of TRPV1 has been shown to blunt cardiac hypertrophy and fibrosis [14]. Further, capsaicin supplementation reduced diet-induced hypertriglyceridemia in rodents [15]. Capsaicin has also been shown to have beneficial effects in animal models of disease. For

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example, in diabetic mice capsaicin suppresses vascular oxidative stress and improves endothelium-dependent relaxation [16]. In a small clinical trial (n = 84), it has been shown that administration of capsaicin and isoflavone reduces blood pressure in hypertensive, but not normotensive, human subjects. This is thought to occur via increasing serum levels of insulin-like growth factor-1 (IGF-I) [17].

The association between chilli consumption, hypertension and cardiovascular disease (CVD) has not been well studied in large population based observational studies [12]. Therefore, it is unknown whether the findings from the animal studies and short term clinical trials can be translated to the general population. Using data from the China Health and Nutrition Survey (CHNS), we have recently found chilli intake was associated with a reduced risk of developing overweight/obesity [18]. As obesity is an important risk factor for hypertension, it can be hypothesized that chilli intake may either directly or indirectly reduce the risk of hypertension.

Using data from the CHNS, we aimed to assess the association between chilli consumption and the incidence of hypertension in a Chinese adult population.

1. Methods

1.1. Study sample

The CHNS study is a household based study and uses a multistage random-cluster sampling process to select a sample in both urban and rural areas in nine provinces in China. Nine waves of data collection (i.e. 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011) have been conducted [19,20]. All the members in the selected households were invited to participate in the study, however dietary intake measurement in 1989 only involved middle aged adults. Due to rural migration and city construction, loss to follow-up is high but new households in the same community joined the survey as a replenishment sample for those lost to follow-up since 1997. The response rate based on those who participated in 1989 and remained in the 2006 survey was above 60%. The survey was approved by the institutional review committees of the University of North Carolina (USA) and the National Institute of Nutrition and Food Safety (China). Informed consent was obtained from all participants. Between the 1991 and the 2011 survey, there were 29,220 participants aged 20 years and older. We excluded those without a dietary intake measurement (n = 13,793), those who had an implausible estimated daily energy intake (men: >6000 kcal or <800 kcal; women: >4000 or <600 kcal) (n = 651), pregnant women or those breastfeeding (n = 798), or individuals with an implausible BMI (<14 or >45 kg/m^2, n = 38), or aged>75 years (n = 2202) during a survey year (otherwise included during other survey years). In total, 18,611 individuals participated in at least two waves of data collection and had an estimated chilli intake. After excluding those that were hypertensive at baseline (n = 4815), 13,670 participants were included in the final analysis.

1.2. Outcome variable: hypertension

Blood pressure was measured three times on the right arm in sitting position using a mercury sphygmomanometer after at least a 10-min rest. The mean of three readings was used in the analysis. Hypertension was defined as systolic blood pressure above 140 mmHg and/or diastolic blood pressure above 90 mmHg, or having known hypertension.

1.3. Exposure variables: chilli intake

Detailed description of the dietary measurement has been published previously [19]. At each wave, all food and condiments in the home inventory, purchased from markets or picked from gardens, and food waste, were weighed and recorded by interviewers at the beginning and end of the three-day food consumption survey. Individual dietary intake data in each household were collected by a trained investigator using a 24 h dietary recall on each of 3 consecutive days. Cooking oil and condiment consumption for each individual in the household was estimated using household estimated intake weighted by individual energy intake. The dietary assessment method has been validated for energy intake [21]. Nutrient intake was calculated using the Chinese Food Composition Tables.

A cumulative average intake of chilli (sweet capsicum was not included) was calculated for each individual at each time period to reduce variation within individuals and to represent long term habitual intake [22]. For example, the 1991 intake was used for the follow-up between 1991 and 1993, the cumulative average of the 1991 and 1993 intake was used for the follow-up between 1993 and 1997, the cumulative average of the 1991, 1993 and 1997 intake was used for the follow-up between 1997 and 2001, and so on.

Habitual intake of spicy food was only asked in 2009 by the questions “Do you like to eat hot pepper or spicy food? 1) No, 2) Sometimes (≤2 times/week), 3) Often (3–4 times/week), 4) Usually (≥5 times/week), 5) Unknown”, and “What kind of spicy food do you like? 1) A little bit hot, 2) Moderate hot, 3) Very hot, 4) Unknown”.

1.4. Covariates

A structured questionnaire was used to collect information on sociodemographic and lifestyle factors in each wave. The following constructed variables were used as indicators of socioeconomic status: education (low: illiterate/primary school; medium: junior middle school, and high: high middle school or higher), per capita annual family income (recoded into tertiles as low, medium and high), urbanization levels [19] (recoded into tertiles as low, medium and high).

Physical activity level (metabolic equivalent of task, (MET)) was estimated based on self-reported activities (including occupational, domestic, transportation, and leisure time physical activity) and duration using a Compendium of Physical Activities. Smoking status was categorized as non-smokers, ex-smokers and current smokers. Alcohol consumption was recoded as none, 1–2 times/week, 3–4 times/week, and daily. Height and weight were measured at each wave. Overweight/obesity was defined as BMI ≥25 kg/m^2.

1.5. Statistical analysis

Chilli intake was recoded into four levels: non-consumers, 1–20, 20.1–50, ≥50.1 g/day.

The chi square test was used to compare differences between groups for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. We used Cox proportional hazards models with time varying cumulative chilli consumption and covariates to compute hazard ratios for hypertension. Four models were used: model 1 adjusted for age, gender and energy intake; model 2 further adjusted for intake of fat, smoking, alcohol consumption, income, urbanization, education, and physical activity. Model 3 further adjusted for two dietary patterns (traditional south pattern and modern pattern, determined using factor analysis based on our previous publication [23]). The dietary patterns were constructed based on 35 food groups aggregated from 3-day food records to reflect the overall dietary intake. Traditional south pattern is characterised by a high intake of rice, pork, and vegetables, and low intake of wheat; a modern dietary pattern had a high