

Original Article

Diet-related factors for risk of hypertension in China: a case-control study

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Abstract: *Aim:* This study aimed to explore the association between diet-related factors and the risk of hypertension in China. *Methods:* A total of 200 patients with hypertension were recruited from January 2018 to June 2018. Two hundred healthy people were selected as the control group. Differences about the baseline characteristics of the subjects between the hypertension group and the healthy control group were analyzed by two-tailed unpaired student's t-test for continuous data and the Chi-square test for categorical data. The odds ratio (OR) and 95% confidence intervals (CI) were calculated. *Results:* After adjustment for sex, age, area, smoking status, family history of hypertension, activity, education, employment status, body mass index (BMI) and pulse, higher intake of vegetable and fruits (FVs), vegetable, fruit, eggs, and nuts could significantly reduce the hypertension risk (OR = 0.71, 95% CI = 0.47-0.95; OR = 0.62, 95% CI = 0.42-0.82; OR = 0.54, 95% CI = 0.34-0.74; OR = 0.72, 95% CI = 0.50-0.95 and OR = 0.75, 95% CI = 0.56-0.94, respectively) when compared with never or rarely intake. *Conclusions:* Findings from this study suggest that intake of FVs, vegetables, fruits, eggs, and nuts is associated with decreased risk of hypertension in China.

Keywords: Diet, risk factors, hypertension, China

Introduction

Hypertension is a major concern in public health because it is a risk factor for high-risk cardiovascular disease [1]. It is reported that hypertension kills 9 million people each year [1]. According to national data from 2003 to 2012, the overall prevalence of hypertension was 26.7% among Chinese [2]. Therefore, it is necessary to explore the risk factors of hypertension from the perspective of primary prevention.

Evidence from large cohort studies has suggested that several risk factors for hypertension are related, including parental hypertension [3, 4], smoking [3], and a high body mass index (BMI) [3]. However, dietary factors are not considered. Diet-related factors play an important role in the prevention and management of hypertension, and they are potentially modifi-

able. Previous study suggested that a high proportion of fruits, vegetables, and low-fat dairy products, and a low proportion of total and saturated fats and sugar, is reportedly effective for controlling blood pressure in patients with hypertension [5]. However, few studies, especially in Chinese adults, have been published to explore the association between dietary factors and hypertension risk. Therefore, in the present study, a case-control analysis of whether a high intake of fruit, vegetable, vegetable and fruits (FVs), nuts, and eggs could reduce the incidence of hypertension, taking into account the known risk factors in Chinese adults.

Methods

Study population, setting, and design

This study was a population-based case-control study with the aim of exploring a possible asso-

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Table 1. Distribution of baseline characteristics of all participants

Demographics		Cases (200)	Control (200)	P-value
Age (years)	Mean (SD)	51.6 (5.1)	51.7 (5.0)	0.917
	<65	161	160	0.900
	≥65	39	40	
Sex	Male	89	91	0.841
	Female	111	109	
Area	Urban	134	127	0.462
	Rural	66	73	
Smoking status	Smokers	59	53	0.504
	Non-smokers	141	147	
Family history of hypertension	Yes	63	26	<0.001
	No	137	174	
Activity	Physical	154	161	0.392
	Sedentary	46	39	
Education	Illiterate	21	15	0.699
	Junior school	37	40	
	Junior high school	72	69	
	High school or above	70	76	
Employment status	Employed	113	122	0.361
	Unemployed	87	78	
Body mass index, kg/m ²	Mean (SD)	24.3 (4.2)	23.4 (4.7)	0.562
Pulse (bpm)	Mean (SD)	75 (13)	76 (15)	0.761

SD: Standard deviation.

ciation between dietary factors and hypertension among Chinese population in Weifang city, which is in the middle of Shandong province, northeast China. A total of 242 hypertension patients aged between 25 and 74 years were recruited from January 2018 to June 2018 in Weifang traditional Chinese medicine hospital. Hypertension was defined as an average systolic blood pressure (SBP) at least 140 mmHg, and/or diastolic blood pressure (DBP) at least 90 mmHg without any anti-hypertensive medication use [6]. Physician consent was obtained before contacting potential participants. Among the potentially eligible cases who were contacted, a total of 200 of which was interviewed. Individuals without hypertension were selected as controls from a random sample within the same city, with an age/sex distribution similar to that of all hypertension cases in the study. Of the 223 potentially eligible controls that were selected, 200 of which were interviewed. Participants, both cases and controls, who agreed to participate in this study were asked to sign an informed consent form, and were provided with contacts of the investi-

gators for any further inquiries. Detailed data about all participants are present in **Table 1**.

Data collection

Face to face interviews were conducted by trained and experienced staff from researchers in participants' home. To properly identify factors which are associated with hypertension prevalence, essential data about sex (male or female), age (<65 years or ≥65 years), area (urban or rural), smoking status (smokers or non-smokers), family history of hypertension (yes or no), activity (physical or sedentary), education (illiterate, junior school, junior high school, high school or above), employment status (employed or unemployed), weight (kg), height (cm) and pulse (bpm) were collected. Furthermore, in order to evaluate the dietary factors and hypertension are related, relevant data, which was consisted of quantity of intake of a list of foods in the past 12 months, were collected and managed using a pre-tested food frequency questionnaire (FFQ) method. The daily intake over a year was calculated from the FFQ data for average intake frequency (never or

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Table 2. Odds Ratios (OR) and 95% confidence Intervals (CI) for hypertension according to dietary intake of food groups

Food groups	Cases/controls	Crude OR (95% CI)	Adjusted OR (95% CI)*
Total vegetables			
Less than once a month	12/8	1	1
Less than once a week	28/10	1.05 (0.51-1.59)	1.01 (0.55-1.47)
About once a day	71/80	0.59 (0.31-0.87)	0.68 (0.47-0.89)
Twice or more a day	89/102	0.58 (0.37-0.79)	0.62 (0.42-0.82)
Total fruits			
Less than once a month	9/5	1	1
Less than once a week	45/25	0.99 (0.47-1.51)	1.00 (0.72-1.28)
About once a day	79/90	0.49 (0.23-0.75)	0.55 (0.33-0.77)
Twice or more a day	67/80	0.46 (0.19-0.73)	0.54 (0.34-0.74)
Total vegetables plus fruits			
Less than once a month	12/9	1	1
Less than once a week	52/43	0.91 (0.60-1.22)	0.90 (0.61-1.19)
About once a day	77/80	0.72 (0.47-0.97)	0.77 (0.58-0.96)
Twice or more a day	59/68	0.65 (0.39-0.91)	0.71 (0.47-0.95)
Nut			
Never or rarely	23/18	1	1
Less than once a week	59/45	1.02 (0.39-1.65)	1.01 (0.42-1.60)
Less than once a day	76/88	0.68 (0.49-0.87)	0.72 (0.51-0.93)
Once or more a day	42/49	0.67 (0.41-0.93)	0.75 (0.56-0.94)
Eggs			
Never or rarely	19/15	1	1
Less than once a week	21/15	1.10 (0.41-1.79)	1.08 (0.47-1.69)
Less than once a day	74/79	0.74 (0.53-0.95)	0.76 (0.58-0.94)
Once or more a day	86/91	0.75 (0.56-0.94)	0.72 (0.50-0.95)

OR: odds ratio; CI: confidence interval. *OR adjusted for sex (male or female), age (<65 years or ≥65 years), area (urban or rural), smoking status (smokers or non-smokers), family history of hypertension (yes or no), activity (physical or sedentary), education (illiterate, junior school, junior high school, high school or above), employment status (employed or unemployed), BMI and pulse (bpm), further adjusted for coffee consumption, tea consumption, red and/or processed meat consumption, fish consumption, drinking.

rarely, once a month, two or three times a month, once or twice a week, three or four times a week, five or six times a week, once a day, twice a day, and three times or more a day). These foods included fruit, vegetable, FVs, nuts, and eggs.

Statistical analysis

Differences about the baseline characteristics of the subjects between the hypertension group and the health control group were analyzed by two-tailed unpaired student's t-test for continuous data and the Chi-square test for categorical data. The association between dietary factors and risk of hypertension was

analyzed with multiple logistic regression models adjusted for the essential variables. Dietary intake of total vegetables, total fruits, and FVs were divided into four parts: less than once a month, less than once a week, about once a day and twice or more a day. Dietary intake of eggs and nuts were divided into another four parts: never or rarely, less than once a week, less than once a day and once or more a day. The odds ratio (OR) and 95% confidence intervals (CI) were calculated. All data were analyzed by R software. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

Results

A total 200 hypertension cases and 200 health controls were included in this study. **Table 1** presents the distribution of baseline characteristics of hypertension cases and control subjects. There was no significant difference in age, sex, area, smoking status, activity, education, employment status, BMI and pulse ($P = 0.917$, $P = 0.841$, $P = 0.462$, $P = 0.504$, $P = 0.392$, $P = 0.699$, $P = 0.361$, $P = 0.562$ and $P = 0.761$, respectively) between hypertension cases group and health control group. However, hypertensive cases were more likely to have a family history of hypertension when compared with health control participants ($P < 0.001$).

Table 2 shows the crude and adjusted OR with 95% CI for hypertension risk according to dietary intake of food groups. When comparing less than once a month intake of total vegetables, twice or more a day intake could signifi-

cantly reduce the hypertension risk (crude OR = 0.58, 95% CI = 0.37-0.79, adjusted OR = 0.62, 95% CI = 0.42-0.82). Similarly, twice or more a day intake of total fruits had a positive association against hypertension risk than those with less than once a month intake (crude OR = 0.46, 95% CI = 0.19-0.73, adjusted OR = 0.54, 95% CI = 0.34-0.74). Furthermore, a positive association between total FVs intake and the risk of hypertension (crude OR = 0.65, 95% CI = 0.39-0.91, adjusted OR = 0.71, 95% CI = 0.47-0.95) was observed.

The association between nut and egg consumption and hypertension risk was also analyzed. The study found that once or more a day intake of nut could significantly reduce the risk of hypertension while comparing with those people who were never or rarely intake (crude OR = 0.67, 95% CI = 0.41-0.93, adjusted OR = 0.75, 95% CI = 0.56-0.94). The results also showed that once or more a day intake of eggs had a lower risk of hypertension (crude OR = 0.75, 95% CI = 0.56-0.94, adjusted OR = 0.72, 95% CI = 0.50-0.95).

Discussion

Findings from this case-control study involving of 400 participants (200 hypertension cases and 200 health controls) indicated that a positive association was found between dietary vegetables and fruits intake and the risk of hypertension. A positive association between eggs and nuts consumption and hypertension risk was observed.

Results from this study are consistent with some previous epidemiological studies. Lian et al. conducted a case-control study about vegetable consumption and hypertension risk in China. Results from that study suggested that greater vegetable consumption had a lower hypertension risk (OR = 0.28, 95% CI = 0.14-0.57; $p < 0.001$) [7]. A large cohort of 28,082 middle-aged and older women in United States was performed to assess the prospective association between intake of fruits and vegetables and the risk of hypertension [8]. The paper suggested that it could significantly reduce the hypertension risk with total fruits and vegetables among the people who consumed ≥ 8 servings/day compared with those consuming < 2 servings/day. However, when fruits and vegetables were analyzed separately, higher intake

of all fruits, but not all vegetables, remained significantly associated with reduced risk of hypertension after adjustment for lifestyle and dietary factors [8]. A recent publication with three prospective cohort studies was conducted to examine the independent association of whole fruit and vegetable intake [9]. They concluded that greater long-term intake and increased consumption of whole fruits, but not whole vegetables, may reduce the risk of hypertension. However, analyses of individual vegetables yielded different results. A higher consumption level of broccoli, carrots, tofu or soybeans was associated with lower hypertension risk [9]. The mechanisms of fruits and vegetables may be associated with hypertension are probably multiple. One hypothesis pertains to the high flavonoid content of several fruits and vegetables, such as berries, apples, broccoli and others [10].

Our study suggested that increased consumption of nuts could reduce the risk of hypertension. A previous cohort study was conducted to assess the nut consumption and hypertension risk [11]. Prospective cohort of 15,966 participants from the Physicians' Health Study suggested that nut consumption of greater or equal 7 times/week had a lower risk for hypertension when compared with those people who did not consume nuts [RR = 0.82, 95% CI = 0.71-0.94] [11]. Martínez-Lapiscina et al. conducted another cohort study followed-up biennially for a median of 4.3 years to assess the association between nut consumption and the risk of hypertension [12]. Results from this cohort study indicated that no significant association was found between nut consumption and the risk of hypertension. However, in this study, nut consumption was classified into four categories (rarely/never, 1-3 times/month, 1 time/week, and 2+ times/week), which was different with the first prospective cohort study we mentioned above and our present study [12]. Nut consumption had been associated with a lower risk of type 2 diabetes and weight gain [13, 14]. Since obesity and abnormal glucose metabolism contribute to the development of hypertension, it is possible that nut consumption may reduce the risk of hypertension.

Few studies have been conducted to explore the association between eggs consumption and hypertension risk. Golzarand et al. con-

ducted a study to determine the possible effect of protein foods group and its subgroups on the risk of hypertension after 3-year follow-up in Iranian adults [15]. Their study resulted that 3-year incidence of hypertension was significantly decreased in the highest tertile of eggs when compared with the lowest tertile (OR = 0.54, 95% CI = 0.32-0.91; P for trend = 0.02) [15]. The results of this study are consistent with the above mentioned cohort study.

The present study has several limitations. First, it was a case-control study, and therefore may bring about the selection and recall bias. Furthermore, subjects in the health control group might not be as representative of the population as subjects in the case group, and the case subjects might have better recall. However, the OR which adjusted possible confounding factors, was also stable for the risk of hypertension. Second, only the frequency of foods intake, not amounts of foods intake, was set in our food frequency questionnaire. In this case, the amounts that were better for hypertension risk were not assessed. Third, the association between total vegetables and total fruits and hypertension risk but did not analyze the individual vegetables and fruits for risk of hypertension. Future studies with detailed individual vegetables and fruits are wanted to further explore the potential relationship for hypertension risk.

In conclusion, positive associations between vegetables intake and fruits intake and hypertension risk were identified in Chinese population. Inverse associations were also found between egg and nut consumption and hypertension risk. However, some potential limitations exist in the study. Future large-scale prospective cohort studies examining the causal effects of foods intake and hypertension risk are needed.

Disclosure of conflict of interest

None.

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