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Original article

Potato consumption is prospectively associated with risk of hypertension: An 11.3-year longitudinal cohort study

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SUMMARY

Background & aims: Government has popularized potatoes as the staple food in China. Potatoes as a potassium-rich food show high glycemic responses after consumption. Whether potato consumption is prospectively linked with the risk of hypertension remains unclear in oriental populations. In this study, we aimed to investigate the association of potato consumption with the risk of hypertension among Chinese people.
Methods: A total of 11,763 adults (≥20 years old) who were free of hypertension at baseline were enrolled from China Health and Nutrition Survey (CHNS) Cohort study in 1989–2011. Participants were excluded if they were <20 years old, identified to be pregnant, and previously diagnosed with hypertension, cancers, infarction, apoplexy and diabetes at baseline. Cox proportional hazards regression models were used to estimate the associations after adjusting for potential confounders.
Results: During average 11.3 years of follow-up, 4033 incident cases of hypertension were ascertained. People who consumed more amounts of total potatoes, stir-fried potatoes, and non stir-fried potatoes had higher risk of hypertension (*P* for trend = 0.1225, 0.2168 and 0.0456, respectively). Multivariable hazard ratios (HRs) for increased consumption of total potatoes were 1.402 (95% confidence interval [CI], 1.270–1.548), 1.198 (95% CI, 1.014–1.415), and 1.120 (95% CI, 0.929–1.349) compared with non-consumers. However, the participants with higher intake of potato consumption were inclined to have lower risk of hypertension when excluding the non-consumers of total potatoes or stir-fried potatoes (*P* for trend = 0.0271 and 0.0001). In addition, a positive association of sweet potatoes intake with hypertension risk was only found in urban residents (*P* for trend = 0.0239).
Conclusions: Our results showed that potato consumption was prospectively associated with hypertension in Chinese population. As the urbanization process continues along with the transition to Western-style diets, more consideration should be taken before the formulation of potato popularization is promoted in China.

1. Introduction

Government agencies in China have popularized potatoes (*Solanum tuberosum*), together with wheat, rice, and corn, as the fourth kind of staple food nationwide [1]. The new guidance about advancing development of potato industry issued by the Chinese Ministry of Agriculture has showed that the potato consumption as a staple food will be expected to account for 30% of the total potato consumption by 2020 [2]. The guidance will not only meet the ever-

Abbreviations: BMI, Body mass index; CHNS, The China Health and Nutrition Survey; CI, Confidence interval; CVD, Cardiovascular diseases; DBP, diastolic blood pressure; GI, Glycemic index; HR, Hazard ratio; SBP, Systolic blood pressure; T2D, Type 2 diabetes.

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growing staple food requirements in future but also promote the industry of potatoes and their processed products [1].

Potatoes are considered as a superior crop due to high nutritive value and production yield [3]. Historical evidence from human socioeconomic development revealed that the introduction of potatoes plays an incredible role in contributing population and urbanization in Western world [4]. According to the report from Food and Agriculture Organization Statistical Databases of United Nation (FAOSTAT), Asia and Europe are major potato-producing regions worldwide accounting for more than 80% yields all over the world [5]. China is the largest potato source of origin covering a quarter of worldwide production, followed by India, Russia, and USA [6]. The potato production as well as consumption has enhanced in developing countries but continuously declined in developed countries during the last decade [6].

Potatoes are carbohydrate-rich food products with a high glycemic response after consumption, which is closely related to hypertension, a well-known risk factor of cardiovascular diseases (CVD) [7]. Also, potatoes contain high levels of potassium, which is needed to counteract the effect of sodium and reduce the high blood pressure [3,8]. Recently, a systematic review revealed that no convincing evidence has been available from clinical intervention and observational studies yet, suggesting a null association between intake of potatoes and CVD risk [9]. However, epidemiologic survey from Iranian population showed that potato consumption could increase the risk factors of CVD, such as elevated glucose levels and reduced serum high-density lipoprotein levels [10]. Recently, three U.S. large longitudinal cohort studies have reported an independent and prospective association between the consumption of French fries, baked, boiled, or mashed potatoes and the risk of hypertension [11]. Unfortunately, the associations of long-term potatoes intake with the risk of hypertension have not been examined in Chinese people yet. Unlike French fries and baked, boiled, and mashed potatoes consumed in Western countries, potato products in China are commonly prepared through traditional stir-frying ways as a vegetable side dish on the dining table [1]. The glycemic index (GI) value of potatoes, an indicator for assessing the effects of dietary carbohydrate on blood glucose levels [12], varies greatly depending on different cultivars and food processing or cooking methods [3]. Thus, the potential effects of potatoes intake on the prevalence of hypertension remain largely unknown among Chinese people.

Sweet potatoes (*Ipomoea batatas*) are another abundant source of potassium with high nutritional and caloric values [4]. Traditionally, Chinese people are more accustomed to consuming sweet potatoes in their diets than most Western people. In 2013, approximately 59.1% of sweet potatoes worldwide have been supplied by China, corresponding to nearly 2.9-fold of per capita consumption of sweet potatoes all over the world [5]. Since the GI value of sweet potatoes varies significantly by different ways to food preparation, the potential effects of long-term sweet potato consumption on developing hypertension also appear unclear [13].

We therefore explored the prospective associations of consumption of total potatoes, sweet potatoes, stir-fried potatoes, and non stir-fried potatoes with the risk of hypertension in general populations from the China Health and Nutrition Survey (CHNS) cohort study from 1989 to 2011.

2. Methods

2.1. Study design and population

CHNS is an ongoing, large-scale and household-based cohort study aiming to monitor the health and nutritional status of Chinese population during the socio-economic development. Initiated from 1989, the CHNS was then followed up every 2–4 years. The data used for the analysis were from CHNS 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011 through multistage cluster random sampling over a 22-year period, covering 12 representative provinces (CHNS 1989-2011: Heilongjiang, Liaoning, Jiangsu, Shaanxi, Shandong, Henan, Hubei, Hunan, Guizhou, Guangxi, Yunnan, and Zhejiang) and 3 centrally-administered municipalities (CHNS 2011: Beijing, Chongqing, and Shanghai) in China. More details about project description, design and methods, quality control procedures and research teams of the CHNS have been reported elsewhere [14,15].

In this study, we restricted analyses to people who had hypertension during the follow-up duration, and excluded the individuals who were aged <20 years ($n = 8509$), identified to be pregnant ($n = 329$), or previously diagnosed with hypertension ($n = 2498$), cancers (n = 74), infarction ($n = 34$), apoplexy ($n = 55$), and diabetes ($n = 146$) at baseline. Finally, 11,763 individuals were involved in our analyses. Ethics permission was obtained from the Institutional Review Boards of the University of North Carolina at Chapel Hill and the Institute of Nutrition and Food Safety, and Chinese Center for Disease Control and Prevention. Written informed consent was obtained from all participants.

2.2. Assessment of hypertension

The anthropometric measurements and definitions of hypertension have been reported previously according to the 7th Joint National Commission guidelines [16,17]. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by well-trained physicians and the mean of three measures were calculated. Briefly, a standard mercury sphygmomanometer with an appropriate-sized cuff was used on the right arm after 10-minute of seated rest and a 30-second interval between cuff inflations. Participants who suffered from hypertension should be with SBP ≥140 mm Hg or DBP ≥90 mm Hg, previously diagnosed by a physician, or with current use of anti-hypertensive drugs. In addition, participants who had hypertension diagnosed after the baseline survey were identified as the incident cases of hypertension for the prospective analysis.

2.3. Assessment of potato consumption

Dietary assessment for three consecutive days has been conducted by the trained technicians from the National Institute of Nutrition and Food Safety, an affiliation of Chinese Center for Disease Control and Prevention, using three-day dietary recalls in combination with a weighing and measuring technique [14,15]. Briefly, for household food consumption, the changes of food inventory during the same three randomized days among the week were recorded each entire day. All processed foods including purchases, home production, and processed snack foods available in the household were examined on a daily basis for the food inventory. For individual dietary intake, trained interviewers recorded all types and amounts of foods consumed based on 24-hour recalls both away from home and at home for three consecutive days. Finally, more than 99% of the samples for the full three-day record were available in the study. Based on the collection data, the frequency and the quantity of daily average consumption of total potatoes, sweet potatoes, stir-fried potatoes, and non stir-fried potatoes (g/day) were calculated. The cumulative average consumption was adopted to reduce within-individual variation. In addition, the data quality and man-made errors were further examined through comparing the food consumption between household collection and individual collection. More details about dietary measurement could be referred elsewhere [14,17].

2.4. Assessment of covariates

Information on age (years), sex, residency (urban or rural), education levels (less than/equal to/more than compulsory education or middle school), household income inflated to 2009 (yuan), marital status (unmarried, married, or others), physical activity (low, medium, or high), medical insurance statue (yes or no), smoking status (never, former, or current smoker), and alcohol drinking statue (abstainer or drinker) were obtained from adult and/or household questionnaires at each follow-up survey. Body mass index (BMI, kg/m^2) was calculated as weight in kilograms divided by height in meters squared. Potential dietary variables, including total energy intake, total meat intake (including red meat, poultry meat, and fish meat), total fruit intake, total vegetable intake, and total whole grains intake, were also obtained from the CHNS. In addition, the nutritional information on total carbohydrates, total proteins and total fats intake, total saturated, polyunsaturated and monounsaturated fats intake, total sodium intake and total potassium intake was calculated according to their compositions in the Chinese food-composition table (FCT) [17].

2.5. Statistical analysis

The percentages of participants who did not consume any types of potatoes, sweet potatoes, stir-fried potatoes, or non stir-fried potatoes were approximately 42.7%, 85.0%, 48.2%, and 71.9%, respectively. Thus, in our primary analyses we categorized the non-consumers of potatoes or sweet potatoes as a group. The daily average consumption of total potatoes and stir-fried potatoes were evaluated and categorized according to tertiles based on the weighted distribution in each consumer group. In detail, we grouped the consumption of total potatoes and stir-fry potatoes into four categories: 0 g/day, <25 g/day, 25–66.7 g/day and >66.7 g/day, and 0 g/day, <20.6 g/day, 20.6–50 g/day and >50 g/day, respectively, whereas the consumption of sweet potatoes and non-fried potatoes were both grouped into two categories: 0 g/day and >0 g/day. Then, Cox proportional hazards regression models were used to analyze the hazard ratios (HRs) with 95% confidence intervals (CIs) for the risk of developing hypertension compared with the reference group (0 g/day). The potential factors updated as time varying covariates through a continuous flow of questionnaires and examinations were selectively used for step-by-step adjusting the models. Since people from different regions of China consumed varying amounts of potatoes, the robust standard errors clustering for geographical area were used along with adjustment for the same variable. Model 1 was adjusted for age and sex; model 2 was further adjusted for marital status, education levels, household income, and residency based on model 1; model 3 was adjusted for BMI, physical activity, medical insurance, smoking status, and alcohol drinking status, plus the covariates in model 2; model 4 presented our full model and was further adjusted for total energy intake, total meat intake, total vegetables intake, total fruits intake, total sodium intake and total potassium intake based on the model 3. In addition, the associations of consumption levels with the risk of hypertension were re-evaluated and re-categorized according to quartiles or dichotomy after adjusting for the covariates based on the full model. The category depended on the weighted distributions in the study population after the exclusion of the non-consumers. In detail, the consumption of total potatoes was grouped into 4 categories, <19.4 g/day, 19.4–41.7 g/day, 41.7–82.4 g/day and >82.4 g/day, while the consumption of stir-fried potatoes was also grouped into 4 categories, <16.7 g/day, 16.7–33.3 g/day, 33.3–61.1 g/day and >61.1 g/day. However, the consumption of sweet potatoes and non-fried potatoes were both grouped into two categories, $\leq$26.7 g/day and >26.7 g/day.

We also conducted several secondary analyses based on our full models. First, we estimated potential effects of replacing the one serving a day of whole grains and mixed beans with potatoes or sweet potatoes in substitution model, which was used to mimic an intervention study on whether dietary changes of potato consumption would impact the subsequent risk of hypertension. Second, we repeatedly employed the full models to re-analyze the associations after replacing the covariates of total carbohydrates intake, total proteins intake, and total fats intake with total meat intake, total vegetables intake and total fruit intake, introducing the covariates of total saturated fats intake, total polyunsaturated fats intake and total monounsaturated fats intake, or excluding the covariate of BMI. Third, we performed subgroup analyses with multiplicative interaction terms to show whether the associations of potato or sweet potato consumption with hypertension risk were varied by age, sex, region (north or south), residency, marital status, education levels, household income, BMI, physical activity, smoking status, alcohol drinking status, as well as medical insurance status. Finally, we conducted sensitivity analyses to evaluate the robustness of results after excluding the participants who had extreme values of follow-up years ($\leq$2 years), total energy intake (<500 kcal or >4000 kcal), or BMI (<18.5 kg/m^2 or >40 kg/m^2).

SAS software (version 9.2, SAS Institute Inc., Cary, NC) was used for all statistical analyses and sample design. All P values were two-sided and $P \leq 0.05$ was presented at the significance level.

3. Results

3.1. Characteristics of participants

Of the 11,763 participants, 5344 men and 6419 women were enrolled, ranging from 20 to 93 years old. The flow chart of enrolled participants in current study is shown in Supplemental Figure 1. People who consumed potatoes, sweet potatoes, stir-fried potatoes, and non stir-fried potatoes accounted for 57.3%, 15.0%, 51.8%, and 28.1%, respectively. There were about 90.4% people who consumed potatoes through the stir-frying method. Table 1 and Supplemental Table 1 show the baseline characteristics of participants in the cohort according to daily consumption levels of total potatoes, sweet potatoes, stir-fried potatoes, and non stir-fried potatoes. People who consumed more potatoes tended to have lower household income, lower total meat intake, higher total fruit intake, and higher total mixed beans intake. Compared with non-consumers, the potato consumers were younger, and had higher marriage rates and higher BMI values. In addition, rural residents, smokers, drinkers, heavy workers, and people who had no medical insurance intended to have the highest consumption of potatoes among all consumption levels. Similar results were also found in categories of the consumption of stir-fried potatoes and non stir-fried potatoes. By contrast, people who consumed sweet potatoes were more likely to be older, non-smokers and abstainers, and have lower BMI values and total fruit intake than those who never consumed sweet potatoes.

3.2. Potato consumption and hypertension

During 132,804 person years of follow-up, 4033 participants were identified to suffer from hypertension from 1989 to 2011. Table 2 shows the associations between potatoes or sweet potatoes intake and hypertension risk. The consumption of potatoes, stir-fried potatoes and non stir-fried potatoes was associated with elevated risk of hypertension compared with those who did not consume any potato-based food in our full model (P for trend = 0.1225, 0.2168 and 0.0456, respectively). Multivariable HRs for the risk of hypertension with increasing consumption were

Table 1
Baseline characteristics of participants according to the consumption of total potatoes and sweet potatoes in CHNS 1989-2011[a].

Variable	Total potatoes (g/day)					Sweet potatoes (g/day)		
	0	0–25	25.0–66.7	>66.7	P_{trend}	0	>0	P_{trend}
N	5019	2247	2460	2037		9993	1770	
Age, years	40.6 (0.21)	38.9 (0.26)	39.2 (0.25)	38.0 (0.27)	<0.0001	39.4 (0.14)	40.4 (0.31)	0.0047
Female (%)	2726 (54.31)	1273 (56.65)	1372 (55.77)	1048 (51.45)	0.1708	5431 (54.35)	988 (55.82)	0.2519
Married (%)	4142 (82.53)	1993 (88.70)	2167 (88.09)	1769 (86.84)	0.0090	8482 (84.88)	1589 (89.77)	0.7998
Compulsory education (%)	2821 (56.21)	1366 (60.79)	1500 (60.98)	1141 (56.01)	0.0060	5968 (59.72)	860 (48.59)	<0.0001
Household income, yuan	19976 (354)	19520 (443)	18966 (409)	15101 (379)	<0.0001	19479 (232)	15081 (341)	<0.0001
North area (%)	1311 (26.12)	838 (37.29)	1398 (56.83)	1472 (72.26)	<0.0001	4242 (42.45)	777 (43.90)	0.2561
Urban residency (%)	1714 (34.15)	903 (40.19)	1062 (43.17)	558 (27.39)	0.1707	3716 (37.19)	521 (29.44)	<0.0001
BMI, kg/m^2	21.6 (0.04)	22.1 (0.06)	22.3 (0.06)	22.1 (0.06)	<0.0001	22.0 (0.03)	21.8 (0.07)	0.0592
High physical activity (%)	1838 (36.62)	778 (34.62)	824 (33.50)	1011 (49.63)	0.1722	3620 (36.23)	831 (46.95)	0.5677
Medical insured (%)	1175 (23.41)	546 (24.30)	584 (23.74)	344 (16.89)	<0.0001	2382 (23.84)	267 (15.08)	0.7149
Current smoker (%)	1003 (19.98)	436 (19.40)	481 (19.55)	531 (26.07)	0.0395	2133 (21.34)	318 (17.97)	<0.0001
Alcohol drinker (%)	1180 (23.51)	537 (23.90)	579 (23.54)	572 (28.08)	0.0011	2523 (25.25)	345 (19.49)	<0.0001
Total energy intake, kcal	2181.5 (8.9)	2163.5 (9.5)	2168.8 (9.9)	2201.9 (10.9)	0.4098	2172.9 (5.6)	2212.9 (11.5)	0.0046
Total meat intake, g/day	235.2 (3.0)	198.8 (3.3)	161.7 (2.9)	133.1 (3.4)	<0.0001	201.8 (1.8)	158.0 (4.1)	<0.0001
Total vegetables intake, g/day	493.7 (3.5)	424.1 (3.6)	439.2 (4.3)	531.2 (6.5)	0.1171	468.1 (2.4)	517.5 (5.7)	<0.0001
Total fruit intake, g/day	35.2 (1.1)	44.0 (1.5)	52.1 (1.8)	58.2 (2.2)	<0.0001	45.6 (0.9)	37.7 (1.6)	0.0003
Total whole grains intake, g/day	591.4 (3.5)	526.9 (4.0)	551.9 (4.4)	616.3 (5.2)	0.3191	567.5 (2.3)	618.1 (5.3)	<0.0001
Total mixed beans intake, g/day	4.1 (0.3)	5.1 (0.3)	6.1 (0.4)	8.5 (0.6)	<0.0001	5.5 (0.2)	5.5 (0.4)	0.9573
Total sodium intake, mg/day	6437 (664)	4904 (284)	5606 (317)	5387 (287)	0.1867	5967 (353)	4784 (107)	0.1590
Total potassium intake, mg/day	2477 (18)	2279 (20)	2375 (21)	2722 (31)	<0.0001	2448 (13)	2532 (23)	0.0074

[a] Data are presented as mean (SE) or number (percentage). Compulsory education: equal to or more than middle school. Household income: inflated to 2009 of the RMB. Total meat: including processed and unprocessed red meat, poultry meat, and fish meat. P_{trend}, P for trend.

Table 2
Hazard ratios (95% CIs) for hypertension risk for consumption of potatoes and sweet potatoes in CHNS 1989-2011[a].

Consumption	Case	N	Model 1		Model 2		Model 3		Model 4	
			HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}
Total potatoes (g/day)				0.0531		0.1121		0.1287		0.1225
0	1525	5019	1.000		1.000		1.000		1.000	
0–25	947	2247	1.557 (1.355–1.788)		1.526 (1.339–1.740)		1.481 (1.322–1.659)		1.402 (1.270–1.548)	
25.0–66.7	897	2460	1.357 (1.088–1.693)		1.333 (1.057–1.681)		1.266 (1.044–1.535)		1.198 (1.014–1.415)	
>66.7	664	2037	1.228 (0.978–1.542)		1.188 (0.921–1.533)		1.144 (0.916–1.430)		1.120 (0.929–1.349)	
Sweet potatoes (g/day)				0.1636		0.3995		0.4067		0.4498
0	3268	9993	1.000		1.000		1.000		1.000	
>0	765	1770	1.118 (0.945–1.322)		1.070 (0.898–1.274)		1.065 (0.903–1.256)		1.055 (0.904–1.231)	
Stir-fried potatoes (g/day)				0.0642		0.1443		0.1721		0.2168
0	1739	5666	1.000		1.000		1.000		1.000	
0–20.6	866	2033	1.546 (1.308–1.828)		1.509 (1.272–1.790)		1.463 (1.279–1.674)		1.382 (1.226–1.558)	
20.6–50.0	817	2179	1.360 (1.117–1.657)		1.328 (1.080–1.633)		1.273 (1.070–1.516)		1.192 (1.029–1.383)	
>50.0	611	1885	1.147 (0.963–1.367)		1.107 (0.908–1.349)		1.073 (0.904–1.274)		1.052 (0.912–1.213)	
Non stir-fried potatoes (g/day)				0.0188		0.0467		0.0434		0.0456
0	2787	8457	1.000		1.000		1.000		1.000	
>0	1246	3306	1.249 (1.049–1.487)		1.220 (1.004–1.483)		1.183 (1.006–1.390)		1.149 (1.003–1.315)	

[a] Adjusted covariates: model 1 = age, and sex; model 2 = model 1 + marital status, education levels, household income, and residency (urban, rural); model 3 = model 2 + BMI, physical activity, medical insurance, smoking status, and alcohol drinking status; model 4 = model 3 + total energy intake, total meat intake (red meat, poultry meat, and fish meat), total vegetables intake, total fruit intake, total sodium intake and total potassium intake. CI, confidence interval. HR, hazard ratio. P_{trend}, P for trend.

1.402 (95% CI, 1.270–1.548), 1.198 (95% CI, 1.014–1.415), and 1.120 (95% CI, 0.929–1.349) for total potatoes; and 1.382 (95% CI, 1.226–1.558), 1.192 (95% CI, 1.029–1.383), and 1.052 (95% CI, 0.912–1.213) for stir-fried potatoes. In addition, multivariable HRs for the risk of hypertension was 1.149 (95% CI, 1.003–1.315) for non stir-fried potato consumers when compared with the non-consumers. However, the consumption of sweet potatoes was not associated with hypertension risk (P for trend = 0.4498).

Table 3 presents substitution and residual confounding analyses for the hypertension risk affected by the consumption of potatoes and sweet potatoes. The associations were not altered after substituting one serving a day of total potatoes, sweet potatoes, and stir-fried potatoes for equivalent combination of whole grains and mixed beans, while the association slightly weakened after substituting one serving a day of non stir-fried potatoes. Our results did not change or slightly strengthened when using the covariates of total carbohydrates intake, total proteins intake, and total fats intake instead of total meat intake, total vegetables intake and total fruit intake, as well as the addition of the covariates of total saturated fats intake, total polyunsaturated fats intake and total monounsaturated fats intake. In addition, after removing the covariate BMI from our full model, the associations for non stir-fried potato consumption were slightly strengthened.

To further analyze the associations between consumption levels of different types of potatoes and hypertension risk, we excluded the non-consumers from the whole study population. Table 4 indicates the investigated associations only among potato consumers groups. After excluding the non-consumers, people who consumed more total potatoes and stir-fried potatoes had lower risk of hypertension (P for trend = 0.0271 and 0.0001, respectively). The HRs across increasing quartiles were 0.900 (95% CI, 0.777–1.043), 0.854 (95% CI, 0.747–0.975), and 0.773 (95% CI, 0.603–0.990) for total

Table 3
Hazard ratios (95% CIs) for hypertension risk for consumption of potatoes and sweet potatoes in substitution model and analysis models in CHNS 1989-2011[a].

Consumption	Substitution for whole grains and mixed beans		Alternation of the covariates nutritional factors[b]		Addition of the covariates nutritional factors[c]		Exclusion of the covariate BMI	
	HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}
Total potatoes (g/day)		0.0927		0.0530		0.1065		0.0874
0	1.000		1.000		1.000		1.000	
0–25	1.392 (1.258–1.539)		1.429 (1.279–1.597)		1.393 (1.258–1.542)		1.437 (1.296–1.594)	
25.0–66.7	1.202 (1.014–1.425)		1.243 (1.037–1.491)		1.184 (1.018–1.376)		1.255 (1.045–1.506)	
>66.7	1.152 (0.937–1.417)		1.193 (0.969–1.468)		1.113 (0.940–1.318)		1.163 (0.938–1.442)	
Sweet potatoes (g/day)		0.3240		0.3822		0.5243		0.4839
0	1.000		1.000		1.000		1.000	
>0	1.077 (0.915–1.269)		1.065 (0.910–1.248)		1.045 (0.898–1.215)		1.053 (0.895–1.238)	
Stir-fried potatoes (g/day)		0.1707		0.0900		0.1983		0.1512
0	1.000		1.000		1.000		1.000	
0–20.6	1.369 (1.208–1.552)		1.415 (1.242–1.612)		1.373 (1.225–1.539)		1.417 (1.239–1.621)	
20.6–50.0	1.193 (1.021–1.394)		1.242 (1.053–1.467)		1.180 (1.036–1.343)		1.241 (1.054–1.459)	
>50.0	1.078 (0.922–1.261)		1.115 (0.945–1.315)		1.047 (0.923–1.187)		1.082 (0.923–1.268)	
Non stir-fried potatoes (g/day)		0.0576		0.0303		0.0400		0.0402
0	1.000		1.000		1.000		1.000	
>0	1.141 (0.995–1.309)		1.199 (1.022–1.406)		1.144 (1.008–1.299)		1.178 (1.009–1.375)	

[a] Other adjusted covariates were based on model 4 (age, sex, marital status, education levels, household income, residency (urban, rural), BMI, physical activity, medical insurance, smoking status, alcohol drinking status, total energy intake, total meat intake (red meat, poultry meat, and fish meat), total vegetables intake, total fruit intake, total sodium intake and total potassium intake.

[b] Using the covariates total carbohydrates intake, total proteins intake, and total fats intake instead of total meat intake, total vegetables intake and total fruit intake.

[c] Addition of the covariates total saturated fats intake, total polyunsaturated fats intake and total monounsaturated fats intake. CI, confidence interval. HR, hazard ratio. P_{trend}, P for trend.

Table 4
Hazard ratios (95% CIs) for hypertension risk for consumption levels (>0 g/day) of potatoes and sweet potatoes in CHNS 1989–2011.

Consumption	Case	N	Full model		Substitution model[a]	
			HR (95% CI)	P_{trend}	HR (95% CI)	P_{trend}
Total potatoes (g/day)				0.0271		0.0907
<19.4	708	1683	1.000		1.000	
19.4–41.7	677	1750	0.900 (0.777–1.043)		0.905 (0.777–1.053)	
41.7–82.4	602	1625	0.854 (0.747–0.975)		0.866 (0.754–0.994)	
>82.4	521	1686	0.773 (0.603–0.990)		0.802 (0.595–1.081)	
Sweet potatoes (g/day)				0.3392		0.3840
≤26.7	419	904	1.000		1.000	
>26.7	346	866	0.904 (0.720–1.136)		0.907 (0.710–1.159)	
Stir-fried potatoes (g/day)				0.0001		0.0017
<16.7	759	1786	1.000		1.000	
16.7–33.3	494	1169	0.910 (0.801–1.035)		0.912 (0.799–1.040)	
33.3–61.1	586	1604	0.887 (0.812–0.969)		0.895 (0.817–0.981)	
>61.1	455	1538	0.688 (0.586–0.807)		0.707 (0.574–0.872)	
Non stir-fried potatoes (g/day)				0.6168		0.8055
≤26.7	673	1657	1.000		1.000	
>26.7	573	1649	0.969 (0.845–1.113)		0.984 (0.846–1.143)	

[a] Substitution for whole grains and mixed beans. Adjusted covariates were based on model 4 (age, sex, marital status, education levels, household income, residency (urban, rural), BMI, physical activity, medical insurance, smoking status, alcohol drinking status, total energy intake, total meat intake (red meat, poultry meat, and fish meat), total vegetables intake, total fruit intake, total sodium intake and total potassium intake. CI, confidence interval. HR, hazard ratio. P_{trend}, P for trend.

potatoes; and 0.910 (95% CI, 0.801–1.035), 0.887 (95% CI, 0.812–0.969) and 0.688 (95% CI, 0.586–0.807) for stir-fried potatoes compared with the lowest quartile. However, such reverse associations were not observed in sweet potato and non stir-fried potato consumers. Besides, the investigated associations were not materially altered in further substitution analyses except the significant association of total potatoes with hypertension risk disappeared.

3.3. Subgroup and sensitivity analyses

Subgroup analyses revealed that the interaction effect between age and total potato consumption or stir-fried potato consumption on the risk of hypertension was also significant (P for interaction = 0.0099 and 0.0075, respectively (Table 5 and Supplemental Table 2). In addition, people who lived in urban town with higher education levels and higher household income, people who had higher BMI and lower physical activity, and were non-smokers were more inclined to have hypertension in consumers of non stir-fried potatoes than non-consumers (Supplemental Table 3). People who lived in urban town appeared to have a higher risk of hypertension in sweet potato consumers than non-consumers (Supplemental Table 4).

Sensitivity analyses showed that the exclusion of people with extreme follow-up years, extreme BMI values or extreme energy intake levels obviously strengthened our findings (Table 6). Particularly, the associations between sweet potatoes consumption and hypertension remained unchanged, whereas the positive association between total potatoes intake, stir-fried potatoes, non stir-fried potatoes and hypertension was more pronounced when extreme BMI values were removed.

Table 5
Hazard ratios (95% CIs) for hypertension risk for consumption of total potatoes in subgroup analyses in CHNS 1989-2011[a].

Subgroup	Total potatoes consumption (g/day)				P_{trend}	$P_{interaction}$
	0	0–25	25.0–66.7	>66.7		
Age						
<50 years	1.000	1.415 (1.235–1.622)	1.239 (1.036–1.482)	1.184 (0.978–1.432)	0.0379	
≥50 years	1.000	1.360 (1.183–1.565)	1.074 (0.862–1.340)	0.997 (0.778–1.277)	0.8147	0.0099
Sex						
Male	1.000	1.390 (1.160–1.666)	1.183 (0.965–1.451)	1.084 (0.904–1.300)	0.2148	
Female	1.000	1.410 (1.327–1.498)	1.219 (0.965–1.539)	1.153 (0.853–1.559)	0.2433	0.2902
Marital status						
Never married	1.000	1.535 (0.967–2.436)	1.279 (0.923–1.772)	1.293 (0.765–2.183)	0.1739	
Married	1.000	1.388 (1.231–1.564)	1.193 (0.989–1.439)	1.135 (0.924–1.395)	0.1391	0.6977
Region						
North	1.000	1.345 (1.126–1.607)	1.052 (0.776–1.426)	0.931 (0.847–1.022)	0.8340	
South	1.000	1.459 (1.234–1.724)	1.306 (1.112–1.535)	1.182 (0.842–1.661)	0.2405	0.1311
Residency						
Urban	1.000	1.401 (1.206–1.627)	1.222 (1.002–1.490)	1.188 (0.940–1.502)	0.0299	
Rural	1.000	1.398 (1.209–1.616)	1.195 (0.993–1.440)	1.104 (0.893–1.364)	0.2826	0.2014
Education levels						
Low	1.000	1.351 (1.212–1.507)	1.115 (0.908–1.369)	1.112 (0.893–1.384)	0.2980	
High	1.000	1.694 (1.451–1.979)	1.586 (1.294–1.942)	1.137 (0.816–1.584)	0.0442	0.6015
Household income						
Low	1.000	1.375 (1.242–1.524)	1.178 (0.948–1.463)	1.105 (0.898–1.361)	0.2920	
High	1.000	1.462 (1.276–1.676)	1.240 (1.061–1.449)	1.146 (0.947–1.387)	0.0165	0.3814
BMI						
<24 kg/m^2	1.000	1.326 (1.185–1.484)	1.174 (0.986–1.398)	1.073 (0.886–1.300)	0.2628	
≥24 kg/m^2	1.000	1.673 (1.394–2.008)	1.271 (1.042–1.551)	1.266 (0.970–1.651)	0.0417	0.4222
Physical activity						
Low to medium	1.000	1.585 (1.365–1.841)	1.314 (1.166–1.480)	1.151 (0.934–1.419)	0.0189	
Heavy	1.000	1.193 (1.063–1.338)	1.048 (0.799–1.373)	1.048 (0.892–1.230)	0.6473	0.7459
Smoking status						
Never	1.000	1.556 (1.380–1.753)	1.333 (0.994–1.788)	1.270 (1.059–1.523)	0.0288	
Former or current	1.000	1.417 (1.163–1.726)	1.181 (0.961–1.453)	1.096 (0.855–1.405)	0.2420	0.7149
Alcohol drinking status						
Abstainer	1.000	1.328 (1.234–1.430)	1.178 (1.007–1.377)	1.087 (0.845–1.397)	0.2719	
Drinker	1.000	1.645 (1.293–2.094)	1.280 (0.966–1.695)	1.215 (0.944–1.565)	0.1314	0.5605
Medical insurance						
Yes	1.000	1.604 (1.194–2.154)	1.469 (1.017–2.123)	1.070 (0.815–1.405)	0.0522	
No	1.000	1.365 (1.218–1.531)	1.120 (0.912–1.374)	1.119 (0.892–1.403)	0.3549	0.1372

[a] Adjusted covariates: age, sex, marital status, education levels, household income, residency (urban, rural), BMI, physical activity, medical insurance, smoking status, alcohol drinking status, total energy intake, total meat intake (red meat, poultry meat, and fish meat), total vegetables intake, total fruit intake, total sodium intake and total potassium intake. CI, confidence interval; HR, Hazard ratio. P_{trend}, P for trend; $P_{interaction}$, P for interaction.

Table 6
Hazard ratios (95% CIs) for hypertension risk for consumption of potatoes and sweet potatoes in sensitivity analyses in CHNS 1989-2011[a].

Consumption	Excluded extreme follow-up years		Excluded extreme energy intake		Excluded extreme BMI	
	HR (95%CI)	P_{trend}	HR (95%CI)	P_{trend}	HR (95%CI)	P_{trend}
Total potatoes (g/day)		0.0126		0.0055		0.0049
0	1.000		1.000		1.000	
0–25	1.398 (1.285–1.520)		1.389 (1.278–1.510)		1.413 (1.294–1.543)	
25.0–66.7	1.179 (1.081–1.287)		1.186 (1.088–1.293)		1.206 (1.101–1.320)	
>66.7	1.103 (1.001–1.215)		1.115 (1.013–1.227)		1.125 (1.016–1.245)	
Sweet potatoes (g/day)		0.2745		0.2346		0.2071
0	1.000		1.000		1.000	
>0	1.046 (0.965–1.134)		1.050 (0.969–1.137)		1.056 (0.970–1.149)	
Stir-fried potatoes (g/day)		0.0811		0.0492		0.0435
0	1.000		1.000		1.000	
0–20.6	1.374 (1.262–1.495)		1.373 (1.262–1.493)		1.387 (1.269–1.516)	
20.6–50.0	1.179 (1.080–1.288)		1.185 (1.086–1.292)		1.195 (1.091–1.309)	
>50.0	1.035 (0.939–1.140)		1.044 (0.948–1.149)		1.053 (0.951–1.165)	
Non stir-fried potatoes (g/day)		0.0001		<0.0001		0.0002
0	1.000		1.000		1.000	
>0	1.145 (1.068–1.229)		1.153 (1.076–1.236)		1.147 (1.067–1.233)	

[a] Adjusted covariates: age, sex, marital status, education levels, household income, residency (urban, rural), BMI, physical activity, medical insurance, smoking status, alcohol drinking status, total energy intake, total meat intake (red meat, poultry meat, and fish meat), total vegetables intake, total fruit intake, total sodium intake and total potassium intake. CI, confidence interval. HR, hazard ratio. P_{trend}, P for trend.

4. Discussion

To our knowledge, this is the first study to examine the association between potato consumption and the incidence of hypertension in Chinese population. In current prospective cohort, we found that long-term intake of potatoes was significantly and positively associated with the incidence of hypertension compared with the non-consumption. However, higher consumption levels of total and stir-fried potatoes were associated with lower risk of hypertension among the potato consumers. The associations were independent of well-known risk factors of hypertension, mainly including various dietary factors such as total meat intake, total vegetables intake and total fruit intake. In addition, for sweet potatoes intake, the significant and positive association was only observed in the subgroup of urban residents.

Potatoes are one of the most common food items in Western diets. Chinese people consume fewer potatoes and potato products compared with Western people as FAOSTAT data shown [5]. Rice (*Oryza sativa* L.) is the predominant staple food in most of Chinese traditional dietary patterns, which accounts for approximately 30% of total daily energy intake in Chinese population [18–20]. However, several studies reported that rice consumption is positively associated with the prevalence of type 2 diabetes (T2D), which is more pronounced in Asian countries compared with Western world [20–22]. The evidence shows that glycemic responses to glucose and rice are appreciably more sensitive in Chinese than European populations [23]. Since a steeply rising risk of various chronic diseases like diabetes occurs in China, the popularization of potato for replacing a portion of milled rice may be an alternative recipe regarding the dietary carbohydrate amongst rice-consuming populations.

Given the global importance of potatoes as one of predominant staples, many studies focused on the causality between potatoes consumption and various health effects with controversial outcomes. For example, an inverse association between potato consumption and risk of developing T2D was reported in China [24], while a positive result was shown in American people [25]. Recently, a systematic review of clinical intervention and observational studies summarized that the evidence of positive association between potato consumption and the risk of obesity, T2D, or CVD appears insufficiently convincing [9]. However, the investigation mainly focused on overall potatoes prepared by boiling, baking, and mashing ways. Although total potato consumption was not associated with mortality, a recent 8-year longitudinal cohort study reported that the consumption of fried potatoes could increase the risk of mortality [26]. Recent findings from Nurses' Health Study (NHS), Nurses' Health Study II (NHS II) and Health Professionals Follow-up Study (HPFS) showed that the intake of baked, boiled or mashed potatoes was positively associated with the risk of hypertension compared with the reference intake of potatoes [11]. Similarly, in our study we found that people who consumed potatoes had significantly higher risk of hypertension in China than people who did not consume potatoes.

Here we hypothesized that different glycemic responses after potato consumption with diverse dietary patterns and food preparation styles may be the reason for explaining these inconsistent outcomes among different populations. Potatoes belong to carbohydrate-rich food with high glycemic responses. Evidence showed that different food preparation methods have significant effects on the GI of potatoes [27]. Dietary GI and glycemic load (GL) indicate the quantity and quality of consumed carbohydrates that influence the glycemic responses in humans [28]. Previous studies revealed that high-glycemic diets could initially elevate blood glucose and insulin levels, followed by hypoglycemia reaction, hormone secretion, and serum free fatty acid elevation. These responses may lead to the excessive diet, dyslipidemia, and β-cell and endothelial dysfunction, which may be related to the risk of developing obesity, diabetes and CVD in physiological mechanisms [29]. In addition, a systematic review and meta-analysis concluded that in general healthy people with habitual consumption of low GI and GL meals is significantly beneficial for the maintenance of regular blood pressure profiles [7]. Therefore, long-term consumption of potatoes may not be in favor of healthy blood pressure and instead increase the risk of hypertension.

The rising risk of hypertension may also be ascribed to the body weight gain after long-term consumption of potato products. In our study, people who consumed total potatoes, stir-fried potatoes and non stir-fried potatoes had significantly higher BMI than those who did not consume. In contrast, people who consumed sweet potatoes had slightly lower BMI than those who did not consume. In addition, our analyses of removing the covariate BMI based on the full model showed more pronounced associations between the potato consumption and hypertension risk (data not shown). Previous study showed independent associations between dietary behaviors and long-term weight gain. Especially, results from NHS, NHS II and HPFS indicated that long-term weight change was strongly associated with the intake of potato chips, boiled or mashed potatoes and French fries among various dietary factors based on incremental daily servings of individual dietary components [30].

Food processing methods may be another indispensable reason for elucidating the investigated associations. Previous study showed the consumption of French fries exhibited a stronger positive association with weight gain than the consumption of boiled, baked, or mashed potatoes [30]. The study explicitly stated the impact of different processing methods on the association outcomes. For instance, more edible oil was needed in the preparation of French fries than baked, boiled, or mashed potatoes. Unlike Western countries, potatoes are consumed traditionally as a vegetable dish on the menu after stir-frying with oil and salts in China. The stir-frying cooking allows the exposure of food to high temperature with probable atmospheric oxidation and thus may destruct some nutrients and bioactive components that exhibit health-promoting properties, such as multi-vitamins, phenolics and anthocyanins [6,31]. Moreover, the addition of oil and salts during stir-frying introduces additional intake of fat and salts for humans [32]. In view of multiple ingredients in potatoes, the reducing sugars and lipids can react with amino acids or proteins through a sequence of thermal reactions such as the Maillard reaction [6,33,34]. Subsequently, a wide range of unhealthy reaction products are formed, including *trans* fat, advanced glycation/lipoxidation end products, acrylamide and heterocyclic amines, all of which may not be in favor of human health [35–37].

Among potato consumers in our study, we found that the high-level consumers were inclined to have lower risk of hypertension than the low-level consumers. Different dietary patterns and lifestyles may be responsible for this finding since high-level consumers were more likely to be rural residents with low incomes, unhealthy lifestyles and heavy physical activity in the study. There are great differences of daily dietary and lifestyle patterns between Chinese urban and rural populations [19]. For example, urban people especially young groups are inclined to consume potatoes as snacks such as potato chips and French fries. However, rural people are inclined to consume potatoes as staple food such as steamed and boiled potatoes for providing essential energy. Similarly, potatoes are served as an energy source to provide basic life needs in the food deprivation and poverty regions worldwide, but are processed as "convenient" snacks in developed countries [6]. However, Western-style processing potato products including French fries, potato chips and fried potatoes have more negative health effects than steamed and boiled potatoes [38]. Thus, potatoes prepared through frying, chipping and puffing with oil may be regarded as a risk factor of hypertension even with low-level consumption. It is noteworthy that urbanization continues in China, which has been producing ever-growing transition to Western-style diets and lifestyles in Chinese people [39]. The formulation of potato popularization may increase the consumption of Western-style potato products, which is related to the incidence of hypertension.

In current study, the consumption of sweet potatoes was positively associated with hypertension risk only in urban population. Although sweet potato consumption is much lower than potato consumption in China, Chinese people consume sweet potatoes mainly as staple food through boiling, steaming or dehydrating without the addition of oil or condiments rather than stir-frying with oil and salts as a dish on menu. In addition, we found the intake of sweet potatoes was positively associated with the risk of hypertension in urban residents. The GI values of sweet potatoes vary significantly by different food processing methods. Baked and roasted sweet potatoes have higher GI than fried sweet potatoes while boiled sweet potatoes have the lowest GI among processed sweet potatoes [13]. Taken together, urban people consumed more processed products of sweet potatoes such as fried sweet potato chips and sugar-curing sweet potato fries than rural people, which may be related to corresponding positive associations during subgroup analyses.

There are several strengths in current study. We have tracked the profile changes of blood pressure levels, hypertension incident and management over two decades. In addition, the study covered 15 provinces and centrally-administered municipalities that varied substantially in geography, economic development, public resources, and health indicators in China. Besides, a wide range of data provided the ability to adjust for enough potential confounders during model establishment and estimation. However, some limitations should be noted. First, the assessment of potato consumption about potato chips and French fries were unavailable due to the limited and insufficient food frequency questionnaire. Nonetheless, the consumption of these snacks was very limited in Chinese adults. Second, there are various types of potatoes consumed in China. Different types have various levels of starch and may be processed or prepared in various ways for obtaining different potato products, which may also have potential effects on the association of potato consumption with hypertension. Third, we did not consider the consumption of energy drinks or electrolytes in this study as they also might contribute to the observed hypertension. In addition, we also did not adjust the consumption of some micronutrients, such as calcium, magnesium, zinc, selenium, and vitamins since they could be considered as primary factors in the development of hypertension. Moreover, the residual confounders for the generation of food-processing contaminants, such as *trans* fat, acrylamide and advanced glycation end products were not fully considered [40,41]. Finally, the possible change of dietary patterns during the follow-up period was not taken into consideration, which might introduce bias from the change of dietary behaviors.

In current Chinese perspective cohort study, long-term potato intake was significantly and positively associated with the risk of developing hypertension compared with non-consumption. Nonetheless, higher consumption of total and stir-frying potatoes was associated with lower risk of hypertension when excluding non-consumers, which might attribute to the potato cooking or processing methods. More studies are warranted to elucidate the role of potato consumption on the risk of hypertension in Chinese population. As urbanization accelerates in China, the tendency of transition to Western-style diets and lifestyles appears continuously and steeply growing. More and more potatoes will be consumed as processed potato products, which may be a potential risk factor for the occurrence of hypertension. Thus, further large-scale and nationwide epidemiological evidence is needed before the formulation of potato popularization should be promoted in China.

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Conflict of interest

The authors declare no conflicts of interest.

Statement of authorship

Authors' contributions to manuscript: M. Huang and Y. Zhang designed the research; M. Huang, P. Zhuang, J. Jiao, J. Wang, and X. Chen conducted the research; M. Huang and P. Zhuang provided essential materials; M. Huang, P. Zhuang, and J. Wang analyzed the data and performed the statistical analysis; M. Huang wrote the manuscript; Y. Zhang had primary responsibility for the final content. All authors read and approved the final manuscript.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.06.973

References

[1] Huang G. China to grow and eat more potatoes. Front Ecol Environ 2015;13:68.
[2] Chinese Ministry of Agriculture 2016. http://www.moa.gov.cn/govpublic/ZZYGLS/201603/t20160301_5034313.htm. [Accessed 15 October 2017].
[3] Camire ME, Kubow S, Donnelly DJ. Potatoes and human health. Crit Rev Food Sci Nutr 2009;49:823–40.
[4] Nunn N, Qian N. The potato's contribution to population and urbanization: evidence from a historical experiment. Q J Econ 2011;126:593–650.
[5] Food and Agriculture Organization (FAO). http://www.fao.org/faostat/en/?%20-%20data/CC#home. [Accessed 15 October 2017].
[6] Zaheer K, Akhtar MH. Potato production, usage, and nutrition—a review. Crit Rev Food Sci Nutr 2016;56:711–21.
[7] Evans CE, Greenwood DC, Threapleton DE, Gale CP, Cleghorn CL, Burley VJ. Glycemic index, glycemic load, and blood pressure: a systematic review and meta-analysis of randomized controlled trials. Am J Clin Nutr 2017;105:1176–90.
[8] Buendia JR, Bradlee ML, Daniels SR, Singer MR, Moore LL. Longitudinal effects of dietary sodium and potassium on blood pressure in adolescent girls. JAMA Pediatr 2015;169:560–8.
[9] Borch D, Juul-Hindsgaul N, Veller M, Astrup A, Jaskolowski J, Raben A. Potatoes and risk of obesity, type 2 diabetes, and cardiovascular disease in apparently healthy adults: a systematic review of clinical intervention and observational studies. Am J Clin Nutr 2016;104:489–98.
[10] Khosravi-Boroujeni H, Mohammadifard N, Sarrafzadegan N, Sajjadi F, Maghroun M, Khosravi A, et al. Potato consumption and cardiovascular disease risk factors among Iranian population. Int J Food Sci Nutr 2012;63:913–20.

[11] Borgi L, Rimm EB, Willett WC, Forman JP. Potato intake and incidence of hypertension: results from three prospective US cohort studies. BMJ 2016;353:i2351.

[12] Jenkins DJ, Wolever TM, Taylor RH, Barker H, Fielden H, Baldwin JM, et al. Glycemic index of foods: a physiological basis for carbohydrate exchange. Am J Clin Nutr 1981;34:362–6.

[13] Bahado-Singh PS, Riley CK, Wheatley AO, Lowe HI. Relationship between processing method and the glycemic indices of ten sweet potato (Ipomoea batatas) cultivars commonly consumed in Jamaica. J Nutr Metab 2011;2011: 584832.

[14] China Health and Nutrition Survey (CHNS). http://www.cpc.unc.edu/projects/china/. [Accessed 15 October 2017].

[15] Zhang B, Zhai FY, Du SF, Popkin BM. The China health and nutrition survey, 1989-2011. Obes Rev 2014;15(Suppl. 1):2–7.

[16] Lenfant C, Chobanian AV, Jones DW, Roccella EJ. Seventh report of the Joint National Committee on the prevention, detection, evaluation, and treatment of high blood pressure (JNC 7): resetting the hypertension sails. Hypertension 2003;41:1178–9.

[17] Du S, Batis C, Wang H, Zhang B, Zhang J, Popkin BM. Understanding the patterns and trends of sodium intake, potassium intake, and sodium to potassium ratio and their effect on hypertension in China. Am J Clin Nutr 2014;99:334–43.

[18] Xu X, Hall J, Byles J, Shi Z. Dietary pattern is associated with obesity in older people in China: data from China Health and Nutrition Survey (CHNS). Nutrients 2015;7:8170–88.

[19] Batis C, Sotres-Alvarez D, Gordon-Larsen P, Mendez MA, Adair L, Popkin B. Longitudinal analysis of dietary patterns in Chinese adults from 1991 to 2009. Br J Nutr 2014;111:1441–51.

[20] Ma RC, Lin X, Jia W. Causes of type 2 diabetes in China. Lancet Diabetes Endocrinol 2014;2:980–91.

[21] Hu EA, Pan A, Malik V, Sun Q. White rice consumption and risk of type 2 diabetes: meta-analysis and systematic review. BMJ 2012;344:e1454.

[22] Dong F, Howard AG, Herring AH, Popkin BM, Gordon-Larsen P. White rice intake varies in its association with metabolic markers of diabetes and dyslipidemia across region among Chinese adults. Ann Nutr Metab 2015;66: 209–18.

[23] Kataoka M, Venn BJ, Williams SM, Te Morenga LA, Heemels IM, Mann JI. Glycaemic responses to glucose and rice in people of Chinese and European ethnicity. Diabet Med 2013;30:e101–7.

[24] Villegas R, Liu S, Gao YT, Yang G, Li H, Zheng W, et al. Prospective study of dietary carbohydrates, glycemic index, glycemic load, and incidence of type 2 diabetes mellitus in middle-aged Chinese women. Arch Intern Med 2007;167: 2310–6.

[25] Muraki I, Rimm EB, Willett WC, Manson JE, Hu FB, Sun Q. Potato consumption and risk of type 2 diabetes: results from three prospective cohort studies. Diabetes Care 2016;39:376–84.

[26] Veronese N, Stubbs B, Noale M, Solmi M, Vaona A, Demurtas J, et al. Fried potato consumption is associated with elevated mortality: an 8-y longitudinal cohort study. Am J Clin Nutr 2017;106:162–7.

[27] Kinnear T, Wolever TM, Murphy AM, Sullivan JA, Liu Q, Bizimungu B. Effect of preparation method on the glycaemic index of novel potato clones. Food Funct 2011;2:438–44.

[28] Foster-Powell K, Holt SH, Brand-Miller JC. International table of glycemic index and glycemic load values: 2002. Am J Clin Nutr 2002;76:5–56.

[29] Ludwig DS. The glycemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. JAMA 2002;287:2414–23.

[30] Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in diet and lifestyle and long-term weight gain in women and men. N Engl J Med 2011;364:2392–404.

[31] Tian J, Chen J, Lv F, Chen S, Chen J, Liu D, et al. Domestic cooking methods affect the phytochemical composition and antioxidant activity of purple-fleshed potatoes. Food Chem 2016;197:1264–70.

[32] Tian J, Chen J, Ye X, Chen S. Health benefits of the potato affected by domestic cooking: a review. Food Chem 2016;202:165–75.

[33] Persson E, Sjöholm I, Nyman M, Skog K. Addition of various carbohydrates to beef burgers affects the formation of heterocyclic amines during frying. J Agric Food Chem 2004;52:7561–6.

[34] van Boekel M, Fogliano V, Pellegrini N, Stanton C, Scholz G, Lalljie S, et al. A review on the beneficial aspects of food processing. Mol Nutr Food Res 2010;54:1215–47.

[35] Brownell KD, Pomeranz JL. The trans-fat ban–food regulation and long-term health. N Engl J Med 2014;370:1773–5.

[36] Tamanna N, Mahmood N. Food processing and Maillard reaction products: effect on human health and nutrition. Int J Food Sci 2015;2015:526762.

[37] Felton JS, Knize MG. A meat and potato war: implications for cancer etiology. Carcinogenesis 2006;27:2367–70.

[38] Na L, Han T, Zhang W, Wu X, Na G, Du S, et al. A snack dietary pattern increases the risk of hypercholesterolemia in Northern Chinese adults: a prospective cohort study. PLoS One 2015;10:e0134294.

[39] Gong P, Liang S, Carlton EJ, Jiang Q, Wu J, Wang L, et al. Urbanisation and health in China. Lancet 2012;379:843–52.

[40] Baumann M. Role of advanced glycation end products in hypertension and cardiovascular risk: human studies. J Am Soc Hypertens 2012;6:427–35.

[41] Liska DJ, Cook CM, Wang DD, Szpylka J. Maillard reaction products and potatoes: have the benefits been clearly assessed? Food Sci Nutr 2015;4:234–49.