
ABSTRACT

Objective To explore the associations between the consumption frequencies of alcohol, tea and sugar-sweetened beverages (SSBs) and the hypertension risk among Chinese adults.

Design A longitudinal study of the effect of beverage consumption on hypertension risk.

Setting Nine provinces in China, including Jiangsu, Hubei, Hunan, Guangxi, Guizhou, Liaoning, Heilongjiang, Shandong and Henan.

Participants The longitudinal data of the China Health and Nutrition Survey from 2004 to 2015 were used. A total of 4427 participants from 9 provinces were included at baseline.

Outcome First incidence of hypertension.

Results During a mean follow-up of 8.7 years, 1478 participants developed hypertension. Alcohol consumption more than twice a week in young men (HR 1.86, 95% CI 1.09 to 3.18) or middle-aged men (HR 1.37, 95% CI 1.01 to 1.87) was associated with a higher hypertension risk. Middle-aged women who consumed tea frequently (HR 0.71, 95% CI 0.52 to 0.97), or young women who consumed SSBs less than once a week (HR 0.31, 95% CI 0.14 to 0.67) had a lower risk of hypertension.

Conclusions High-frequency alcohol consumption increased the risk of hypertension in men, and frequent tea consumption and low-frequency SSBs consumption were associated with lower risk of hypertension in women. Consumption frequency of beverages was also suggested to be considered in the prevention and control of hypertension.

INTRODUCTION

Hypertension itself is the most common chronic disease worldwide; meanwhile, it is a major risk factor for various chronic diseases, such as cardiovascular disease, chronic kidney disease and stroke. The global prevalence of hypertension is still on the rise in recent decades. It is estimated that the age-standardised prevalence rate of hypertension for men and women aged 50–79 in the world is 34% and 32%. In China, 23.2% of adults suffer from hypertension, of which the incidence of hypertension among people aged 18–35 is 5.2%, showing an obvious trend of youth.

Hypertension is the main cause of premature death, 7.8 million all-cause deaths worldwide (14% of all deaths) are related to hypertension, and 2.54 million Chinese people died of high systolic pressure in 2017. What is more, hypertension leads to a huge economic burden, including the direct costs of healthcare expenditure, and the indirect costs of productivity reduction caused by hypertension complications. As reported, hypertension-related medical costs have accounted for about 10% of the world’s total healthcare expenditure, 7.2% in East Asia. In China, the direct medical cost of hypertension accounts for 6.6% of the total health healthcare expenditure. In order to achieve the goal of ‘reducing the prevalence of hypertension by 33% between 2010 and 2030’, and ease the financial burden of hypertension, it is necessary to understand the associated modifiable factors of hypertension.

Alcohol, tea and sugar-sweetened beverages (SSBs) are widely consumed and have modifiable characteristics, and their effects
on hypertension risk have attracted extensive attention of scholars. Studies have demonstrated that the alcohol consumption frequency is positively associated with the risk of hypertension in men. However, existing evidence remains inconclusive about the effect of alcohol consumption frequency on hypertension risk for women, the effects of tea and SSBs on hypertension risk for both men and women, and the effects of the three beverages on hypertension risk for people with different body mass index (BMI) levels. Some studies indicated positive associations between the consumption frequencies of alcohol and the risk of hypertension in women, but others reported no links. For tea, some studies showed that tea had a preventive effect on hypertension, while others revealed that consuming tea habitually or daily can increase the risk of hypertension. The positive associations between SSBs consumption and the hypertension risk were observed in Iranian college students with all BMI levels, Korean with BMI ≥25 kg/m² or Taiwanese women with BMI <27 kg/m². It indicates that more studies are needed to shed light on who may reap the health benefits from changing the consumption frequency of beverage.

Generally speaking, many prior studies with larger populations tend to pay attention to the association between the amount of beverage consumption and hypertension risk, but less to explore the impact of beverage consumption frequency on the risk of hypertension. Therefore, the purpose of this study was to explore the associations between consumption frequencies of alcohol, tea and SSBs and the risk of hypertension in Chinese adults, preliminary identify the people who can benefit most from changing the frequency of beverage consumption, and provide new evidence for the prevention of hypertension.

METHODS

Patient and public involvement

This study extracted data from the China Health and Nutrition Survey (CHNS), which is an open, multipurpose longitudinal survey from 1989 to 2015. We used five rounds of data collected in 2004, 2006, 2009, 2011 and 2015 for this study, and the baseline date of each participant was set on the date of the CHNS survey in 2004. This study included participants aged 18–60. According to the exclusion criteria, participants with chronic diseases (diabetes, myocardial infarction, stroke, cancer), lack of baseline information (educational level, marital status, smoking status, fast food, fruit, vegetable, and labor intensity, sleep duration, waist circumference (WC), BMI, and beverage consumption frequency) and no follow-up after the baseline visit were excluded from this study. A total of 4427 participants were included in the final analysis due to the lack of follow-up data on blood pressure (BP) values of 85 participants (figure 1).

Measures

Demographic and lifestyle information

The following confounding factors were collected through the questionnaire: age (18–34/35–49/50–60 years old), gender (men/women), province (the southern refers to Jiangsu, Hubei, Hunan, Guangxi and Guizhou/the northern refers to Liaoning, Heilongjiang, Shandong and Henan), education level (low for primary school and below/middle for junior high school/high for senior high school and above), marital status (unmarried/married/divorced or widowed), smoking status (yes/no), fast food, fruit and vegetable (like/neutral/dislike), labour intensity (light/medium/heavy). According to the quartile of sleep duration (including daytime and nighttime) in this study, sleep duration was divided into three groups: <8 hours, 8–9 hours and ≥9 hours.

Physical indicators (height, WC and weight) were measured by well-trained CHNS staffs, and accurate to 0.1 cm or 0.1 kg. BMI was calculated by weight in kilograms divided by the square of height in metres (kg/m²). Based on the revised Asia-Pacific BMI criteria by the WHO, BMI was divided into four levels: underweight (<18.5 kg/m²), normal weight (18.5 kg/m²–24.0 kg/m²), overweight (24.0 kg/m²–28.0 kg/m²) and obesity (≥28.0 kg/m²). For WC, women WC ≥85 cm or men WC ≥90 cm were defined as central obesity.

Measurement of beverage consumption frequency

Participants in the survey were asked two kinds of questions to obtain information about beverage consumption. Questions and answers about alcohol in the questionnaire: (1) Last year, did you drink beer or any other alcoholic beverage? No/yes/unknown; (2) How often did you drink beer or any alcoholic beverage? Almost every day/3–4 times a week/once or twice a week/once or twice a month/no more than once a month/unknown. About tea: (1) Do you normally drink tea? No/yes/unknown;
(2) How often did you drink tea during the past 30 days? Almost every day/4–5 times a week/2–3 times a week/no more than once a week/2–3 times in the past 30 days/ only once in the past 30 days/nine in the past 30 days/ unknown. The questions about SSBs are as follows, and the answer is the same as that to alcohol. (1) Last year, did you drink soft drinks or sugared fruit drinks? (2) How often did you drink soft drinks or sugared fruit drinks?

According to the quartile of consumption frequency, the consumption frequencies in this study were merged into three groups: none/low (alcohol: ≤twice a week; SSBs: <once a week) or moderate (tea: ≤five times a week)/high (alcohol: >twice a week; tea: >five times a week; SSBs: ≥once a week).

Blood pressure
All BP values were measured three times by well-trained personnel with an interval of at least 1–2 min, and the average value of the three times was recorded as the BP value for analyses. Hypertension was defined as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg and/or taking antihypertensive drugs.

Statistical analysis
SPSS V.26.0 and R V.4.2.2 software were used for statistical analysis and statistical graphs. Baseline characteristics were represented by frequency and percentage, and comparisons between groups were performed by χ² test. Cox proportional hazards model was used to estimate the HRs of hypertension, and to explore the associations between consumption frequencies of beverages and the hypertension risk after adjusting for the confounding variables (including age, gender, province, educational level, marital status, smoking status, fast food, fruit, vegetable, activity intensity, BMI, sleep duration, WC). The statistical significance level was defined as a two-tailed p<0.05.

RESULTS
Baseline characteristics of the research population
During a mean follow-up of 8.7 years, a total of 1478 (33.4%) participants developed hypertension (table 1). Compared with participants in non alcohol consumption, those in high-frequency consumption were more likely to be 35–60 years old, men, married, smoking, with normal weight/overweight, light/heavy labour intensity, medium education level, short to medium sleep duration. In general, with the increase of alcohol consumption frequency, the proportion of participants developing hypertension is increasing. Participants aged 35 and above and southerners preferred to consume tea at high frequency, participants with medium/high educational level and light labour intensity tend to high-frequency SSBs consumption (online supplemental tables S1 and S2).

The data of the four follow-ups showed that participants who consumed alcohol had a higher cumulative risk of hypertension than those who did not (figure 2A), while the cumulative risk of hypertension among participants who consumed tea or SSBs was lower than that of non-drinkers (figure 2B,C).

Associations of beverage consumption frequencies with hypertension
Among all participants in this study, any frequency of consuming increased the hypertension risk (low: HR 1.20, 95% CI 1.06 to 1.37; high: HR 1.51, 95% CI 1.32 to 1.73). High-frequency consumption of SSBs was a preventive factor for hypertension (figure 3). After adjusting the confounding factors, the preventive effects of SSBs on hypertension disappeared, while the association between frequent alcohol consumption and high hypertension risk was still significant.

Stratified analyses
In the stratified analysis of age and gender (figure 4), frequent alcohol consumption increased the risk of hypertension in men aged 18–34 (HR 2.04, 95% CI 1.24 to 3.38), and men aged 50–60 (HR 1.36, 95% CI 1.01 to 1.82) (online supplemental table S3). After adjusting province, educational level, marital status, smoking status, fast food, fruit, vegetable and labour intensity, the association between alcohol and hypertension disappeared among men aged 50–60, while the roles of high-frequency alcohol consumption for women aged 35–49 (HR 2.01, 95% CI 1.06 to 3.81) in increasing the risk of hypertension became significant. After further adjusting BMI, WC and sleep duration, high-frequency alcohol consumption still significantly increased the risk of hypertension in men aged 18–34 and 50–60.

Low consumption frequencies of SSBs showed preventive effects on hypertension in women aged 18–34 (HR 0.42, 95% CI 0.20 to 0.87) (online supplemental table S3), but this effect was not observed at a higher consumption frequency. Consuming tea at a high frequency may reduce the hypertension risk of women aged 50–60 (HR 0.71, 95% CI 0.53 to 0.94). After fully adjustment, these associations remained unchanged, even the low-frequency SSBs consumption showed a more significant protective effect on hypertension in women aged 18–34 (HR 0.31, 95% CI 0.14 to 0.67).

In the stratified analysis of BMI (figure 5), low consumption frequency of SSBs increased the risk of hypertension among underweight participants in model 3 (HR 2.58, 95% CI 1.15 to 5.83). In normal weight participants, frequent alcohol consumption increased the risk of hypertension, while consuming SSBs more than once a week reduced the hypertension risk; however, these associations were not observed after fully adjustment (model 3). In overweight participants, alcohol consumption at any frequency increased the risk of hypertension. After adjustment, the associations remained basically unchanged (online supplemental table S4).
**DISCUSSION**
This cohort study explored the effects of consumption frequencies of three popular beverages on the hypertension risk in a Chinese population. This study showed that consuming alcohol frequently increased the risk of hypertension in men, low-frequency SSBs consumption reduced the hypertension risk in young women and high-frequency tea consumption showed a

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Baseline characteristics of participants stratified by alcohol consumption</th>
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<tbody>
<tr>
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<tr>
<td>Age</td>
<td>18–34</td>
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<td></td>
<td>35–49</td>
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<td></td>
<td>50–60</td>
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<td></td>
<td>Women</td>
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<tr>
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<td>Southern</td>
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<tr>
<td></td>
<td>Northern</td>
</tr>
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</tr>
<tr>
<td></td>
<td>High</td>
</tr>
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<tr>
<td></td>
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<td>Labour intensity</td>
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<td></td>
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<td>Central obesity</td>
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<tr>
<td>Sleep duration</td>
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<td>&gt;9 hours</td>
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<td>Hypertension</td>
<td>Non-hypertension</td>
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<td></td>
<td>Hypertension</td>
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BMI, body mass index; WC, waist circumference.
weak preventive effect on hypertension in middle-aged women.

Our study showed that more than twice a week alcohol consumption increased the risk of hypertension among men, consistent with many studies revealed that the frequency of consuming alcohol twice or more a week increased the risk of hypertension.\(^{11-12,14,15}\) For women, after adjusting for some variables, our findings found that more than twice a week alcohol consumption increased the risk of hypertension in women aged 35–49. However, this association disappeared after adjusting for BMI, WC and sleep duration. Contrary to our results, some studies reported null associations between the alcohol consumption frequency and the risk of hypertension in women.\(^{12-14,15}\) only a study on Chinese adults revealed that there was a significant positive association between consuming alcohol less than twice a week and hypertension risk in women over the age of 18.\(^{11}\) The causes of this difference might be the sample size, the inclusion criterion of participants and the further subgroup analyses of age.

In addition, we also analysed the significance of the effect of alcohol consumption frequency on the risk of hypertension in people with different BMI levels, which has only been explored in a Japanese study. We found that there was a significant association between alcohol consumption frequency and hypertension risk among overweight people (24.0 kg/m\(^2\) ≤ BMI < 28.0 kg/m\(^2\)). Different from us, a study conducted in Japan with 5116 men aged 23–39, suggested that the association between drinking frequency and hypertension risk was significant only in men with BMI < 25 kg/m\(^2\).\(^{12}\) Perhaps this can be explained by the following reasons. First, the participants’ age, gender and the grouping criteria for BMI are different. This study divided participants into four groups based on the revised WHO Asia-Pacific BMI classification; while the Japanese study, with the boundary of 25 kg/m\(^2\), separated the participants into two groups.\(^{12}\) Second, the classifications of consumption frequency are different. Drinking frequency was categorised into rarely, 1–3, 4–6 days/week and daily in Japanese study,\(^{12}\) while our study divided the consumption frequency into three groups: none, 1–2 and 3–7 times/week, which may underestimate the effect of high-frequency alcohol consumption on hypertension risk. Finally, the genotype and...
activity of aldehyde dehydrogenase, the alcohol consumption preference may be different among different ethnic backgrounds.29 30 Possible mechanisms for this association were that alcohol consumption activates sympathetic nerve and renin–angiotensin aldosterone system,31–33 damages vascular endothelium and causing arteriosclerosis,34 35 Another potential mechanism may be that frequent alcohol consumption may cause sleep disturbance,36 indirectly exacerbating the disorder of hormone levels in the body, leading to BP elevation.

Our findings suggested that high-frequency (≥5 times/week) tea consumption may decrease the hypertension risk in women aged 50–60, which was supported by a previous study. The prospective study was conducted in China, including 38913 participants aged 18 years or older, which found that habitually consuming tea (≥3 times/week for at least 6 months) significantly reduced the risk of hypertension incidence for women over the age of 18.29 Due to the changes of hormone levels before and after menopause, the preventive effect of catechin and kaempferol in tea on cardiovascular disease37 38 may be more significant in menopausal women with low oestrogen levels. However, the Singapore Chinese Health Study and the Shanghai Women’s/Men’s Health Study reported a weak positive association between consistent tea consumption and hypertension incidence in people aged 40–74,24 26 which was inconsistent with our findings. This may be due to the different living backgrounds, tea types, concentrations and brewing methods, resulting in different proportions of caffeine, tea polyphenols and flavonoids contained in tea.39 Caffeine activates the sympathetic nerve and renin–angiotensin system to increase BP.40 While tea polyphenols and flavonoids have endothelial protection and anti-inflammatory effects, and they can also relax vascular smooth muscle by increasing the level of NO and enhancing the bioactivity of nitric oxide,41 42 thus playing a prevention role in hypertension.

Regarding SSBs, interestingly, we found that consuming SSBs less than once a week reduced the risk of hypertension in women aged 18–34. This preventive effect was only reported in a cross-sectional study, which showed that the ideal level (based on the dietary evaluation criteria developed by the American Heart Association) of SSBs consumption was associated with low risk of hypertension in Americans not less than 18 years old.43 Sugar is one of the main energy sources for human beings, and the low consumption frequency of SSBs can reduce the hypertension risk by relaxing people’s emotions.44

In addition, our findings showed that SSBs consumption increased the risk of hypertension in underweight (BMI <18.5 kg/m²) participants, which is in accord with the prior study.19 20 While a study in Korea reported that consuming SSBs significantly increased the hypertension risk in middle-aged and elderly people with BMI ≥25 kg/m².18 The cause of this difference might be the criteria of high consumption frequency and the consumption situation of SSBs in different countries. The Korean study divided participants into obese and non-obese groups and used the quartile of weighted consumption frequency to determine the consumption frequency groups, while we divided participants into four groups (underweight, normal weight, overweight and obesity), and divided the consumption frequency into three groups: none, once a week and once a week. The possible mechanism for this association is that frequent stimulation of SSBs inducing rapid rise of blood glucose and insulin levels, causing lipid abnormality, oxidative stress and inflammatory reaction, thus leading to endothelial damage and arteriosclerosis, increasing the risk of hypertension.45 46 Moreover, SSBs may lead to weight gain by stimulating appetite, then increases hypertension risk.18

The advantages of this study included its large sample size of CHNS participants, the prospective design and with a mean follow-up of 8.7 years. Furthermore, we simultaneously stratified the age and gender of participants to identify the groups greatly affected by beverage consumptions. Several limitations of our study should also be considered. On the one hand, all beverage consumption information came from the participants’ self-reports...
and beverage consumption habits may change over time, which may affect our risk estimates. On the other hand, the item of the family history of hypertension was not designed within the questionnaire, limiting further adjustment, which may cause deviation in results.

CONCLUSION

Our findings found that alcohol consumption may increase the risk of hypertension in overweight people, consuming SSBs less than once a week and high-frequency tea consumption had a weak preventive effect on hypertension in women. More attention should be paid to health promotion to improve the lifestyle of the young adults in China. Further studies are needed to confirm our findings, and to explore the potential mechanisms of SSBs affecting hypertension, as well as the most beneficial tea type and brewing method to prevent hypertension.

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Contributors XW and CW contributed to the conception and design of the work, the acquisition and analysis of the data, the writing of the original draft, and the review and editing of the paper. JS, WH and XR contributed to the analysis of the data, the review and editing of the paper. M-WX contributed to the analysis, review and editing of the paper. XW and M-XW revised the manuscript, both of whom are corresponding author. SL contributed to the reanalysis of the data and the transformation of tables and graphs in the first revision. CW, as guarantor, takes full responsibility for the overall content of the study, had access to the data, and controlled the decision to publish.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The China Health and Nutrition Survey (CHNS) was approved by the Institutional Review Committees of the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention; written informed consent of each participant have obtained. However, the ethical review ID was not made public.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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