Original Paper

Empirically Derived Dietary Patterns and Hypertension Likelihood: A Meta-Analysis

Cui-Jiang Wang You-Xia Shen Yun Liu

Division of Foot and Ankle Surgery, Linyi People's Hospital, Linyi, Shandong, China

Key Words

Dietary patterns • Hypertension • Alcohol-consumption • A meta-analysis

Abstract

Background/Aims: Dietary patterns, which represent whole-diet and a complex integration of food and nutrient, have been reported to play an important role in the development of hypertension. However, the results have yielded conflicting findings. Herein, we performed this meta-analysis to evaluate the associations between different dietary patterns and the likelihood of hypertension. **Methods:** MEDLINE and EBSCO were searched to identify relevant articles published until the end of March 2016. A random-effects model was used to account for possible heterogeneity between studies. A total of twenty-seven studies met the inclusion criteria and were included in this meta-analysis. **Results:** There was evidence of a decreased likelihood for hypertension in the highest compared with the lowest categories of healthy pattern (odds ratio (OR)=0.81; 95% confidence interval(CI): 0.67-0.97; $P=0.02$). An increased likelihood of hypertension was shown for the highest compared with the lowest category of heavy drinking pattern (OR=1.62; 95% CI: 1.16-2.26; $P=0.004$), whereas no statistically significant association with western-style and light-moderate drinking pattern were observed (OR=1.04, 95% CI: 0.83-1.31; OR=1.20, 95% CI: 0.94- 1.53; $P>0.05$). **Conclusions:** Our results of this systematic review and meta-analysis suggest that dietary pattern may be associated with the likelihood of hypertension.

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Introduction

Hypertension is one the most common chronic diseases, affecting about 25% of the adult population worldwide [1]. In China, the prevalence of hypertension has increased by almost one third from 1991 to 2002, which comprises approximately 200 million people [2, 3]. In United States, hypertension is also a significant health problem, with an estimated one-third of the general population having hypertension [4]. It is well-known that hypertension is a multifactorial disease that results from complex interactions of some risk factors, including

Yun Liu

Division of Foot and Ankle Surgery, Linyi People's Hospital, Taihe Road Number 21,
Lanshan district, Linyi 276000, Shandong (China)
Tel. +86-539-8297-793, Fax +86-539-8297-793, E-Mail liuyun545420@sina.com

alcohol drinking, high salt, genetic factors, and dietary factors [5-7].

In past several decades, some epidemiological studies have particularly focused on dietary modification as an important risk factor in the development of hypertension, and examined the relationship between the intakes of individual foods or nutrients and the risk of hypertension [8-12]. However, because of the complexity of diet and the potentially synergistic effect of individual foods or nutrients on health, these analyses revealed limited impact of diets on hypertension [13]. Consequently, dietary pattern analysis has emerged as an alternative approach in examining the association between diet and diseases, considering the combined effects of foods and potentially facilitate nutritional recommendations [14].

Recently, several studies have indicated that there is a growing interest in medical research on the associations between overall dietary patterns and hypertension likelihood [15-19]. However, the findings from these studies remain inconsistent. Although some previous studies reported a positive association between healthy/prudent pattern and hypertension [15-16], other also reported an inverse association between this pattern and hypertension [18-19]. Therefore, we conducted this meta-analysis of studies published from January 1990 up to March 2016, to identify the potential relation between dietary patterns and the likelihood of hypertension.

Materials and Methods

Literature search strategy

An electronic literature search was performed in the MEDLINE and EBSCO databases to identify human studies written in the English and Chinese languages published from January 1990 up to March 2016, with the following keywords or phrases: “dietary pattern” OR “dietary patterns” OR “food pattern” OR “food patterns” OR “eating pattern” OR “eating patterns” OR “alcohol drinking” OR “alcohol consumption” AND “hypertension” OR “high blood pressure”. Furthermore, we manually reviewed the reference lists of relevant studies to search for additional studies.

Studies included criteria

Two reviewers (CJ Wang and Y Liu) independently read the abstracts of articles retrieved in the initial search to identify studies that examined the associations between dietary patterns and odds of hypertension. Differences between the two independent reviewers were resolved by consensus and referred to the third reviewer if necessary. When all agreed (CJ Wang, YX Shen and Y Liu), the full-text versions of articles were reviewed against inclusion criteria for this meta-analysis. To be eligible, a study must meet the following criteria: (1) It was an original report on the associations between dietary patterns and the likelihood of hypertension; (2) Dietary pattern was identified by factor analysis and/or principal component analysis; (3) Odds ratios, hazards ratio or relative risks and percentage of hypertension (or sufficient information to calculate them) had been presented; (4) If the data in original publication lacked sufficient detail, the corresponding author of the study was contacted for additional information by email.

To minimize error, the authors ensured that the selected dietary patterns were similar with regard to factor loadings of foods, which are consumed within those dietary patterns. For example, the healthy pattern is characterized to have high loadings of foods such as vegetables and fruit, whole grain, fish, soy and antioxidants (e.g. Vitamin C and E, flavonoids, and carotenoids) and low fat dairy. The western-style pattern is characterized to have high consumption of red and/or processed meat, refined grains, sweets, high-fat dairy products, butter, potatoes and high-fat gravy, and low intakes of fruits and vegetables. The heavy drinking pattern tend to have high loadings of beers, wines, and white spirits. The light-moderate drinking pattern is characterized to have moderate consumption of beers, wines, and white spirits. Finally, twenty-seven studies relevant to the role of dietary patterns and/or food and the odds of hypertension were included in this meta-analysis.

Data extraction

Data was extracted from all eligible studies, including the first author, the year of publication, country, study design, sample size, number of hypertension, dietary assessment method, identification of dietary patterns and the adjusted factors in the present analysis.

Definition of “heavy drinking” and “light-moderate drinking”

The different forms of alcohol consumption were converted into grams of ethanol per day. Alcohol consumption of $>25\text{g/d}$ for men or $>12.5\text{g/d}$ for women was defined as a heavy drinking, alcohol consumption of $<12.5\text{g/d}$ for men or $<7.5\text{g/d}$ for women was defined as a low drinking, and alcohol consumption of $>12.5\text{g/d}$ and $<25\text{g/d}$ for men or $>7.5\text{g/d}$ and $<12.5\text{g/d}$ for women was defined as a light-moderate drinking [20]

Quality assessment

The reviewers independently assessed the risk of bias using the Newcastle-Ottawa Quality Assessment scale for studies included in this meta-analysis [21]. A maximum of nine points was assigned to each study. Only these studies which the majority of the questions were deemed satisfactory (i.e. with a score of 6 or higher) were considered to be of high methodological quality.

Statistical analysis

All statistical analyses were performed using Review Manager, version 5.0 (Nordic Cochrane Center, Copenhagen, Denmark) and STATA software, version 12.0 (STATA Corp, College Station, TX, USA). *P* values less than 0.05 were considered significant, and statistical tests were two-sided. The original papers reported the results of dietary patterns in terms of tertiles, quartiles, and quintiles of dietary factor scores and the odds of hypertension. We used meta-analysis to evaluate the likelihood of hypertension in the highest versus the lowest categories of healthy, western-style and drinking patterns. Heterogeneity of study results was measured by Cochran's *Q* statistic and *I*² statistic. A *P* value of *Q*-test >0.10 or *I*² $<50\%$ indicated an absence of heterogeneity between studies, and a fixed-effects model was used to calculate the pooled ORs. If a *P* value of *Q*-test ≤ 0.10 or *I*² $\geq 50\%$ indicated a high degree of heterogeneity among studies, then a random-effects model (DerSimonian and Laird method) was used [22]. OR and 95% CIs from individual studies were combined to produce an overall OR. Publication bias was assessed by inspection of the funnel plot and by formal testing for “funnel plot” asymmetry using Begg's test and Egger's test [23]. Subgroup analyses were carried out based on age (>50 and <50 y), sample size (>5000 and <5000), race (white, and yellow and other) and study design (cross-sectional and cohort).

Results

An electronic search in the databases of MEDLINE and EBSCO identified 894 papers, 867 of which were excluded based on the following reasons (in Figure 1). Twenty-seven articles [9, 13, 15-19, 24-43] met the inclusion criteria and were included in this meta-analysis, including 16 cohort studies [13, 25, 27, 30-32, 34-43] and 11 cross-sectional studies [9, 15-19, 24, 26, 28-29, 33]. Descriptive information of each included study was presented in Table 1.

Healthy pattern

The healthy pattern is characterized to have high loadings of foods such as vegetables, fruits, whole grains, olive oil, fish, soy, poultry and low fat dairy. There was obvious evidence of a decreased likelihood for hypertension in the highest compared with the lowest categories of healthy pattern in Figure 2 (OR=0.81; 95%CI: 0.67-0.97; *P*=0.02). A random-effects model is used to assess the including data. The heterogeneity was apparent in all the studies (*P* <0.00001 ; *I*²=94%).

Western-style pattern

The western-style pattern is characterized to have high intake of red and/or processed meat, refined grains, sweets, high-fat dairy products, butter, potatoes and high-fat gravy, and low intakes of fruits and vegetables. Figure 3 shows the forest plot for the likelihood of hypertension in the highest compared with the lowest category of western-style pattern. There was significant heterogeneity (*I*²=96%, *P* <0.00001) and hence the effect was assessed using the random-effects model. The results demonstrated that western-style pattern was not associated with an increased risk of hypertension (OR=1.04; 95%CI: 0.83-1.31; *P*=0.74).

Fig. 1. Flow chart of article screening and selection process.

Fig. 2. Forest plot for ORs of the highest compared with the lowest category of intake of the healthy pattern and hypertension.

Table 1. Characteristics of 27 studies included in the meta-analysis (1990–2016)

Author Publication Year	Location	Study design	Total number of subjects	Age	Diet- assessment method	Factors adjusted for in analysis	Dietary patterns identified
Qin et al 2014 [19]	China	Cross- sectional	2518	>20y	FFQ	household, age and gender,SES, BMI, physical activity and energy intake	Traditional, Macho, Sweet tooth, Healthy
Chen et al 2006 [24]	Bangladesh	Cross- sectional	11116	≥18y	FFQ	Age, sex, and total energy intake,smoking status , length of education, BMI, energy-adjusted intakes of riboflavin, vitamin B-12, vitamin B-6, folate, ratio of sodium,to potassium, protein, total fat, ratio of saturated to unsaturated fat, fiber, carbohydrate, and magnesium	Balanced, Animal protein, Gourd and root vegetable
Schulze et al 2003 [25]	European	Cohort	8552 women	35-64y	FFQ	body mass index, alcohol consumption, smoking status , history of cardiovascular disease or diabetes mellitus (yes/no), regular use of mineral supplements (yes/no), employment status , education , systolic blood pressure, diastolic blood pressure, waist:hip ratio (tertiles), leisure-time physical activity level (tertiles), occupational physical activity, dietary change within the year prior to the baseline examination (yes/no), and total energy intake (MJ/day).	Traditional cooking; Fruits and vegetables
Naja et al 2013[17]	Lebanon	Cross- sectional	323	≥18y	FFQ	age, sex, marital status, education, crowding index, physical activity,and smoking	Fast food/dessert; Traditional Lebanese; High protein
Selem et al 2014 [26]	Brazil	Cross- sectional	1102	>20y	FFQ	self-reported hypertension(yes, no), sex, age, self-reported skin color , education, per capita family income, marital status, smoking, alcohol intake, body mass index, body weight dissatisfaction, self reported chronic diseases, health insurance,hospitalization in the last 12 months (yes, no), and healthservice attendance in the last 15 days (yes, no).	Prudent, Traditional; Modern
Shin et al 2013 [27]	Korean	Cohort	11883	20-64y	FFQ	age, sex, education, income, BMI, smoking, physical activity, energy intake	Traditional, Western, Dairy and carbohydrate
Park et al 2014[15]	Korean	Cross- sectional	5308	>20y	FFQ	study phase, age, sex, total energy, BMI, educational level, marital status, smoking status, alcohol consumption, vitamin or mineral supplement use (yes, no) and physical activity (low, medium, high).	Whole food, Western, Drinking
Lee et al 2010[9]	China	Cross- sectional	39252 men	40-74y	FFQ	Age, BMI, education, income, cigarette smoking, weight gain since age 20 years and total dietary energy intake compared to subjects with normal blood pressure	Vegetable, Fruit and milk, Meat
Wang et al 2011 [28]	China	Cross- sectional	23671	18-59y	FFQ	Age, sex,living area (urban/rural), education level, presence or absence of a family history of hypertension, annual household income per family member, alcohol consumption , total energy intake, physical activity level , and smoking status ,body mass index	Western, Traditional northern, Traditional southern
Liu et al 2012 [29]	China	Cross- sectional	2929	18-80y	FFQ	Age, BMI, sex, economic income, education	Balanced,Alcohol,Beverage, Simple
Safdar et al 2015 [13]	Pakistan	Cohort	6257	>15y	FFQ	Gender, age; marital status, formal education,body mass index; physical activity, tobacco use	Fat and sweet, Fruit and vegetable,Seafood and yogurt
Gadgil et al 2015 [30]	United states	Cohort	892	40-84y	FFQ	kcal/24 h, study site, age, sex, income, education, smoking, alcohol intake, exercise, BMI and waist circumference	Animal food, Fried snacks, sweets, and high-fat dairy, Fruit, vegetables, nuts and legumes
Heidemann et al 2011 [31]	German	Cohort	7124	18-79y	FFQ	Age (years), sex and total energy intake,socio-economic status (low, middle and high), sport activity and smoking status	Processed foods, Health-conscious
Kim et al 2009 [32]	Korean	Cohort	1869 men	20-65 y	FFQ	age, education, smoking status and drinking status, physical activity, energy intake	Traditional, Western, Drinker
Nkondjock et al 2010[33]	Cameroon	Cross- sectional	571	21-59 y	FFQ	age, body mass index, rank, vigorous physical activity and total energy intake	Fruits and vegetables, meats
Shimazui et al 2007 [34]	Japan	Cohort	40574	40-79y	FFQ	age (in years), sex, smoking status, walking duration , educationand total energy intake (continuous).	Japanese, Animal food, DFA
Esmailzadeh et al 2008 [16]	Iran	Cross- sectional	486 women	40-60y	FFQ	Age (y), energy intake (kcal/d), smoking (yes or no), current estrogen use, family history of diabetes and stroke , menopausal status (yes or no), socioeconomic status , and physical activity (MET-h/wk).	Healthy, Western, Iranian
Wang et al 2015 [35]	China	Cohort	4968	>15y	FFQ	No	Protein, Balanced, Beans, Prudent, Traditional
Garduño-Díaz et al 2013 [36]	United Kingdom	Cohort	100	>30y	FFQ	Age, education, body mass index, smoking, physical activity	Eastern, Mixed, Western
Zhang et al 2014 [18]	China	Cross- sectional	2116	Mean:52.6	FFQ	Age, sex, maritu status, education, income, smoking, drinking, the history of hypertension, coronary heart disease, diabetes, stroke	Animal food, Plant food, Sea food
Chan et al 2013 [37]	China	Cohort	2735	≥65 y	FFQ	Age,education, smoking, energy intake	Vegetables-fruits,Snacks-drinks-milk, Meat-fish
Nakanishi et al 2001 [38]	Japan	Cohort	1310 male	30-59y	interview	age, body mass index, cigarette smoking, total cholesterol level, triglyceride level, and fasting plasma glucose level at study entry	Drinker
Sesso et al 2008 [39]	United states	Cohort	28848women 13455 men	Female:≥45y Male:40-84y	Questionnaire	age (in years), exercise, d parental history of MI 60 years (no or yes). Additional covariates for men included aspirin and-carotene treatment and smoking status; for women they included aspirin, -carotene, and vitamin E treatment, postmenopausal status , smoking status, and hormone replacement therapy.BMI, history of high cholesterol (no or yes), and history of diabetes mellitus (no or yes).	Alcohol consumption
Ohmori et al 2002 [40]	Japan	Cohort	1101	≥40y	Questionnaire	age and body mass index	Alcohol intake
Tsuruta et al 2000 [41]	Japan	Cohort	573	40-76y	24-h dietary recall	Age,BMI,BP, family history of hypertension, smoking	Alcohol intake
Thadhani et al 2002 [42]	United states	Cohort	70891 women	25-42y	Questionnaire	Age, body mass index, race, smoking, history of elevated cholesterol level, family history of hypertension, physical activity, and oral contraceptive use	Alchoic drinkers
Nakanishi et al 2002 [43]	Japan	Cohort	5275 male	23-59y	Interviews	age, body mass index, family history of hypertension, cigarette smoking, total cholesterol level, triglyceride level, and fasting plasma glucose level	Drinkers

FFQ: Food frequency questionnaire;SES:socio-economic status;BMI:Body mass index

Fig. 3. Forest plot for ORs of the highest compared with the lowest category of intake of the western-style pattern and hypertension.

Fig. 4. Forest plot for ORs of the heavy drinking compared with the non-drinking of intake of the heavy drinking pattern and hypertension.

Drinking pattern

The drinking pattern is characterized by high consumption of alcohol containing beers, wines, and white spirits. Nine articles identified a heavy drinking pattern and six articles identified a light-moderate drinking pattern in this meta-analysis. An increased likelihood of hypertension was shown for the heavy drinking compared with non-drinking of heavy drinking pattern in Figure 4 (OR=1.62; 95%CI:1.16-2.26; $P=0.004$). Data from these studies were assessed using a random-effects model, and there was obvious evidence of heterogeneity ($P<0.00001$; $I^2=96\%$). Figure 5 showed no association between light-moderate drinking pattern and hypertension (OR=1.20, 95% CI:0.94-1.53, $P=0.13$).The data from six studies were assessed using the random-effects model, and there was significant heterogeneity ($I^2= 93\%$, $P<0.00001$).

Subgroup analyses

To further detect the association between dietary patterns and hypertension, a subgroup analysis was performed. Age, sample size, race and study design had an effect on hypertension and dietary patterns. When the highest categories were compared with the lowest categories

Fig. 5. Forest plot for ORs of the light-moderate drinking compared with the non-drinking of intake of the light-moderate drinking pattern and hypertension.

Table 2. Dietary patterns and hypertension: subgroup analysis

		Healthy dietary pattern	Heterogeneity		Western-style dietary pattern	Heterogeneity	
Subgroup	Category	OR(95% CI)	I²(%)	P-value	OR(95% CI)	I²(%)	P-value
Age	>50	0.81(0.57, 1.17)	94.0	<0.0001	1.22(0.81, 1.83)	97.0	<0.0001
	<50	0.80(0.63, 1.01)	90.0	<0.0001	0.97(0.69, 1.34)	96.0	<0.0001
Sample size	Large (>5000)	0.86(0.66, 1.12)	96.0	<0.0001	0.95(0.65, 1.38)	98.0	<0.0001
	Small (<5000)	0.75(0.55, 1.04)	92.0	<0.0001	1.10(0.83, 1.48)	86.0	0.004
Race	White	0.69(0.48, 1.00)	46.0	0.12	1.34(1.09, 1.65)	0.0	0.95
	Yellow and Other	0.83(0.68, 1.02)	95.0	<0.0001	1.00(0.78, 1.29)	97.0	<0.0001
Study design	Cross-sectional	0.72(0.56, 0.94)	93.0	<0.0001	1.20(0.93, 1.56)	91.0	<0.0001
	Cohort	0.96(0.80, 1.16)	84.0	<0.0001	0.86(0.65, 1.14)	94.0	<0.0001

Table 3. Drinking patterns and hypertension: subgroup analysis

		Heavy drinking pattern	Heterogeneity		Light-moderate drinking pattern	Heterogeneity	
Subgroup	Category	OR(95% CI)	I²(%)	P-value	OR(95% CI)	I²(%)	P-value
Age	>50	1.62(1.02, 2.57)	96.0	<0.0001	1.18(0.86, 1.63)	93.0	<0.0001
	<50	1.56(0.90, 2.70)	91.0	<0.0001	1.28(0.65, 2.53)	95.0	<0.0001
Sample size	Large (>5000)	1.49(1.00, 2.22)	97.0	<0.0001	1.07(0.85, 1.35)	95.0	<0.0001
	Small (<5000)	1.80(0.77, 4.19)	90.0	<0.0001	2.52(0.50, 12.68)	80.0	0.007
Race	White	1.01(0.75, 1.37)	95.0	<0.0001	0.86(0.69, 1.06)	94.0	<0.0001
	Yellow and Other	2.02(1.15, 3.55)	94.0	<0.0001	1.95(1.23, 3.09)	72.0	0.01
Study design	Cross-sectional	1.59(0.41, 6.20)	97.0	<0.0001	-	-	-
	Cohort	1.62(1.14, 2.30)	95.0	<0.0001	1.20(0.94, 1.53)	96.0	<0.0001

of healthy pattern, the inverse association between hypertension and dietary patterns was more obvious in these studies which were in cross-sectional studies and subjects were white. In contrast, when comparing the highest categories with the lowest categories in western-style patterns, the positive association between hypertension and dietary patterns was more obvious in which subjects were white. In addition, the positive association was obvious for those in the high alcohol consumption compared with non-alcohol consumption of heavy drinking pattern in studies which had large sample size and was cohort design, and subjects aged more than 50 years and white. Finally, when the results were analyzed by removing white subjects, the difference in the odds of hypertension was shown in light-moderate drinking pattern. As these variables have a strong effect on association between dietary patterns and odds of hypertension, their differences may partially explain the observed heterogeneity between studies (Table2-Table3).

Publication bias

Inspection of funnel plots revealed little evidence of asymmetry. Egger's tests for publication bias was not statistically significant(highest compared with lowest categories: healthy $P=0.521$; Western-style $P=0.261$; heavy drinking $P=0.885$; light-moderate drinking $P=0.925$).

Table 4. (Appendix) Dietary patterns and hypertension: Assessment of Study Quality

Studies	Selection				Comparability		Outcome			Score
	1	2	3	4	5A	5B	6	7	8	
Safdar et al 2015	*		*	*	*		*	*		*****
Qin et al 2014	*	*			*		*	*		*****
Chen et al 2006	*	*			*		*	*		*****
Schulze et al 2003	*	*	*	*	*	*	*	*		*****
Naja et al 2013		*			*		*	*		****
Selem et al 2014	*	*			*	*	*	*		*****
Shin et al 2013	*	*	*	*	*		*		*	*****
Park et al 2014	*	*			*	*	*	*		*****
Lee et al 2010	*	*			*	*	*	*	*	*****
Wang et al 2011	*	*			*	*	*	*	*	*****
Liu et al 2012	*	*			*		*	*		*****
Gadgil et al 2015		*		*	*		*	*		*****
Heidemann et al 2011	*	*	*	*	*	*	*	*		*****
Kim et al 2009	*	*	*	*	*		*	*		*****
Nkondjock et al 2010		*			*		*	*		*****
Shimazui et al 2007	*	*	*	*	*	*	*	*	*	*****
Esmailzadeh et al 2008		*			*		*	*	*	*****
Wang et al 2015	*	*		*	*		*	*		*****
Garduño-Díaz et al 2013		*		*	*		*	*		*****
Zhang et al 2014	*	*			*	*	*	*		*****
Chan et al 2013	*	*	*	*	*		*	*		*****
Nakanishi et al 2001		*	*	*	*		*	*		*****
Sesso et al 2008	*	*	*	*	*		*	*		*****
Ohmori et al 2002		*	*	*	*	*	*	*	*	*****
Tsuruta et al 2000		*	*	*	*		*	*		*****
Thadhani et al 2002	*	*	*	*	*		*	*	*	*****
Nakanishi et al 2002		*	*	*	*		*	*		*****

Quality assessment

The quality of each included study in terms of population and sampling methods, description of exposure and outcomes, and statistical adjustment of data, is summarized in Table 4. All studies received a score of 6 or higher on the Newcastle-Ottawa Quality assessment scale and were considered to be of high methodological quality [9, 13, 15-16, 18-19, 24-28, 31-32, 34-35, 37-43].

Discussion

To the best of our knowledge, this is the latest meta-analysis reporting the associations between dietary patterns and the likelihood of hypertension. In the present meta-analysis, we have an update on the previous systematic review [6] and further assess the associations between drinking pattern and hypertension likelihood. The pooled results from this meta-analysis indicate that healthy pattern is significantly associated with a decreased odds of hypertension, whereas heavy drinking pattern is associated with an elevated odds of hypertension. Data from 27 studies involving 295799 participants were included in this meta-analysis. Our findings have further confirmed the significant associations between different dietary patterns and the odds of hypertension.

In our analyses, the healthy pattern was associated with a reduced odds of hypertension. This was in agreement with previously reported findings from China in which healthy/prudent patterns were reported to be associated with reduced odds of hypertension [15-16]. This favorable association might be explained by the beneficial effects of whole grains, vegetable and fruits on blood pressure. These foods are good sources of dietary fiber and antioxidants (e.g. Vitamins C and E, other carotenoid compounds). A previous meta-analysis of randomized, controlled clinical trials showed the beneficial effects of high fiber intake on blood pressure [44]. Similarly, Shu et al. [45] found that high dietary fiber consumption was associated with a reduced risk of obesity, which was considered as important risk for

hypertension. Besides, several studies found that antioxidants (e.g. vitamin A, C, and E) could slow the rate of oxidation, protecting endothelial cells and vascular [46], thereby decreasing the risk of hypertension. Some previous studies have also indicated that the polyphenols, especially flavonoids found in vegetables and fruits may be contributing to the lowering effect on the blood pressure [47]. To our knowledge, flavonoids may exhibit a range of biological activities in vitro that may explain their potential cardioprotective properties, including anti-oxidant and anti-inflammatory effects and induction of apoptosis [48]. Furthermore, this pattern was characterized to have rich sources of Ca, Mg and K. Epidemiological studies and clinical trials indicated that these nutrients had vasodilation properties, and thus may decrease the level of blood pressure [49-50].

The western-style pattern was not associated with the odds of hypertension in this meta-analysis. Our results were inconsistent with some previous studies [17, 27], which reported the positive associations between red and processed meat and the risk of hypertension. There are several plausible explanations that may explain this null association. Firstly, the consumption of foods with a rich source of calcium, potassium, and several vitamins along with “unhealthy” food may change the effect of western-style pattern to non-significant. Clinical and epidemiological studies have suggested that these beneficial nutrients like calcium, potassium and vitamins, play important roles in the prevention and the inhibition of blood pressure elevation [51-52]. Thus, these foods with high content of calcium, potassium, and several vitamins may counteract the harmful effects of other unhealthy items loaded on western-style pattern, which may explain the result [53]. Secondly, the BMI has been adjusted as a potential confounder in included studies. A number of previous studies has observed the significant association between obesity and the risk of hypertension [45, 54]. Finally, the null association may be associated with some unknown or unmeasured potential confounders which were not considered in our analyses.

The heavy drinking pattern was associated with an increased odds of hypertension, whereas light-moderate drinking pattern was not associated with the odds of hypertension in our analyses. A previous systematic review and meta-analysis of alcohol consumption and risk of hypertension concluded that heavy alcohol consumption was significantly associated with an increased risk of hypertension [5]. In fact, high alcohol intake has been considered as an important risk factor for hypertension [55]. The mechanisms for increased odds of hypertension may be explained such as impairment of the baroreceptors, an imbalance of the central nervous system, stimulation of the renin-angio-tensin-aldosterone system and the endothelium to release vasoconstrictors, increased cortisol levels, increased vascular reactivity [56]. Moreover, Kim et al. [57] found that alcohol consumption was inversely associated with a reduction in eGFR in Korean men. Furthermore, to our knowledge, light-moderate alcohol intake may raise the concentration of HDL-C and decrease the levels of fasting insulin, which may be associated with the decreased risk of hypertension [58, 59]. However, in our analyses, we did not observe the significant association between light-moderate drinking pattern and the odds of hypertension. This may be related to the amount of alcohol and physical activity level. Thus, alcohol consumption of light-moderate drinking pattern need to be defined in the different countries.

Strengths and limitations

This meta-analysis holds its own strengths. Firstly, the cases of hypertension were confirmed based on clinician, avoiding misdiagnosis. Secondly, this is the latest meta-analysis reporting the associations between dietary patterns and the likelihood of hypertension. Besides, we further explored the associations between drinking pattern and the likelihood of hypertension. The pooled results were consistent with a previous systematic review and meta-analysis [5], which suggested that heavy alcohol consumption might increase the likelihood of hypertension. Thirdly, no signs of publication bias were evident in the funnel plot, and the statistical test for publication bias was non-significant. However, some limitations should be considered in this meta-analysis. Firstly, the principal limitation of this study was the use of potentially biased evidence. There was an inconsistent adjustment for potential confounders among the included studies. Consequently, the data included in our

analyses might suffer from differing degrees of completeness and accuracy. Secondly, 16 of 27 studies used a cross-sectional design, which is more susceptible to recall and selection bias, especially dietary recall bias, than a cohort design. Thirdly, the geographical regions mainly covered in Asia, including China, Japan, and Korea in the present meta-analysis. Therefore, our findings have limited generalization to all the populations.

Conclusion

This meta-analysis indicated that the healthy pattern was associated with a decreased odds of hypertension, whereas heavy drinking pattern was associated with an elevated odds of hypertension. Our findings highlight the importance of whole-diet for the prevention of hypertension. Therefore, findings from the present meta-analysis add to existing literature by supporting the associations between different dietary patterns and the odds of hypertension.

Disclosure Statement

The authors declared no conflict of interest.

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Reference

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