

Association Between Dietary Patterns and the Risk of Hypertension Among General Population in China and America

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Abstract. Hypertension is one of the risk factors of many diseases such as cardiovascular disease and stroke, and it has become increasingly prevalent worldwide. Although elevated blood pressure is related to many different factors, some studies have found that people's dietary patterns seem to be closely related to the development of hypertension. This paper aimed to compare the dietary patterns in China and America and to explore how they affect the incidence of hypertension in both countries. Through analysis, high sodium diets, substandard vegetable intake, and high-temperature cooking methods in both countries were found to be hazard factors that might increase the prevalence of hypertension. The difference was that the high sodium intake in America mainly comes from processed food, while the sodium intake in China mainly comes from salt added during cooking. In addition, the relatively high intake of whole-grain diet in China may also be one of the reasons for the relatively low prevalence of hypertension in China. In terms of intervention on hypertension, although America has higher compliance with the DASH diet, it is still important to popularize dietary guidelines and hypertension-related knowledge in order to help the public better improve their health status. However, the current research has no definite evidence to prove the relationship between diet and hypertension, so more research and data still need to be found.

Keywords: Dietary pattern, Dietary guideline, Hypertension, China, America.

1. Introduction

Hypertension is a complex long-term condition with elevated blood pressure, and it is one of the major risk factors that lead to mortality and potential morbidity in the world. This disease influenced more than 1.4 billion people, and more than 28,000 were killed by it every year. Although patients would not have obvious symptoms when they are diagnosed with hypertension initially, if it is not controlled and treated in time, it could lead to many serious diseases like stroke, heart disease, and kidney disease. Hypertension is caused by various factors. In addition to lifestyle factors such as lack of physical activity, smoking, and alcohol drinking, bad dietary habits such as having high sodium and high-fat diets also play a crucial role. Whether in America as a developed country or in China as an emerging economy, the incidence rates of hypertension were both increasing rapidly. This article compared the differences in dietary patterns between America and China, and summarized the relationship between dietary patterns and the incidence of hypertension. The importance of this topic is to make more people aware of the harm of high blood pressure. By understanding the relationship between dietary patterns and hypertension, people's dietary habits can be improved. The public needs to pay more attention to the control and treatment of hypertension. Thus, the overall health level of citizens can be improved, and the burden of future cardiovascular diseases can be eliminated. The passage systematically summarized the current research studies that compared the dietary pattern between China and America, focusing on the association between dietary patterns and hypertension to promote the public with healthy diet and lifestyle.

2. Hypertension Mortality and Morbidity

Globally, high blood pressure is defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg. More than a quarter of the total population has hypertension worldwide. An estimated 1.39 billion adults between the ages of 30 to 79 had hypertension, and the number of cases is still increasing. In 2015, 45% of American adults (about 108 million) had hypertension. In addition, the blood pressure level showed an increasing trend among American children and teenagers and seniors aged 60 and over. Meanwhile, over a quarter of Chinese adults (244.5 million people) had high blood pressure as well. In addition, according to the Chinese guideline, another 435.3 million Chinese showed the symptoms of prehypertension, and people with prehypertension had a greater chance of developing hypertension in the future.

In terms of health effects, hypertension increases the risk of potential cardiovascular diseases, such as coronary heart disease and stroke. Worst of all, hypertension is associated with a high risk of morbidity. Hypertension was responsible for 8.5 million deaths globally due to stroke, ischemic heart disease, various vascular illnesses, and kidney failure. America showed a similar trend, heart attack and stroke that were associated with hypertension accounted for the majority of causes of death. Besides, high blood pressure that is not treated or controlled appropriately also led to serious medical and financial repercussions. The economic cost of hypertension was about 51.2 billion USD in 2013, including spending on health care services, medication, treatments, and the labor loss due to premature death. In China, hypertension claimed 2.043 million lives. Hypertension not only damages the physical health and life quality of patients but also leads to a great economic burden on individuals, families, and the whole society with the rising medical costs. In 2013, high blood pressure deaths caused a small economic burden of 660.9 billion yuan. Generally speaking, it accounted for about 7% of China's total health expenditure, which seriously affected the health of residents and caused a heavy burden of disease.

3. Major Risk Factors of Hypertension

The dietary pattern, which is symphysis on ultra-processed food, desserts, sugar-sweetened beverages, fried foods, and high-fat foods, has been linked to a higher incidence of hypertension. A high salt intake is also a leading cause, since it can let the body retain more water than usual, and the blood pressure increases due to a larger amount of blood. High animal products intake and low vegetables and fruits are also associated with hypertension. The alkali-rich nutrients, such as magnesium and potassium, in fruits and vegetables, help to produce potential bicarbonate precursors in vivo. In contrast, animal products have phosphorus-rich and sulfur-rich components, which will lead to proton load and low pH value in blood. More acid-precursors than base precursors lead to a net acid accumulation. Thus, people with habitual animal products might more easily develop chronic diseases, such as hypertension. Except for the dietary factor, aging, diabetes, and sedentary lifestyle are also factors that are associated with a high risk of developing hypertension.

4. Geographic Pattern

People with hypertension lived all over America, but the southern part had nine of the ten states with the highest incidence of hypertension, as can be seen from Figure 1A. This phenomenon might be led by the different ethnic groups and low household income. In China, the frequency of hypertension was equal in rural and urban environments, with the greatest prevalence of hypertension found in three municipalities, which were Beijing, Tianjin, and Shanghai, as shown in Figure 1B. In terms of geographic pattern, Southern China had a lower prevalence of hypertension than Northern China due to variations in demographics, cultural practices, and lifestyle habits. This was mostly due to fast economic, social, and cultural advancements in Southern China, which have resulted in improved nutrition and a new way of life for people in recent decades.

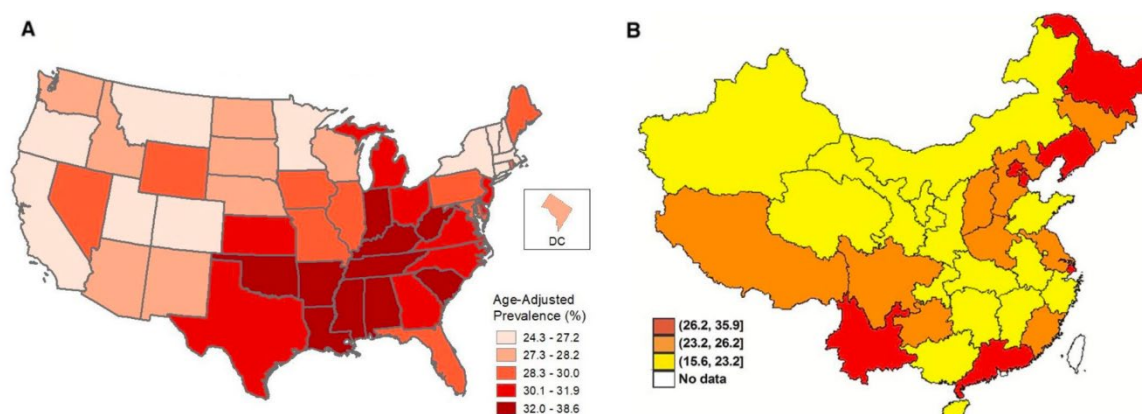


Figure 1. Prevalence of Hypertension, 2017 U.S. Adults Ages 20 and Older by Province (A), 2015 Chinese Adults Ages 18 or Older by Province (B)

5. Dietary Pattern and Hypertension

The quantity, variety, or mix of different foods and beverages in a diet, as well as the regularity with which they are eaten, is referred to as a dietary pattern. The dietary patterns are different from country to country, which is a result of the culture and ethnic history, as well as a variety of environmental factors, such as food availability, people's purchase ability, the effectiveness of food advertising, and the governments' efforts for promoting healthy diets. Examining dietary patterns and the possible interaction effects among nutrients that may impact health outcomes may be more suitable than identifying intake of individual food items in evaluating the link between dietary pattern and chronic disease-related risk factors. Because dietary patterns consist of a number of food items, and it can suggest overall eating habits and nutrients intake.

5.1 Chinese Dietary Pattern

Traditional Chinese diet usually includes four food groups, which are grains, vegetables, fruit, and meat. The staple food is mainly based on whole grain-based carbohydrates, with wheat in the northern part and rice in the southern part of China. Due to lactose intolerance, dairy products are not usually consumed by Chinese people; instead, they consume a variety of soy products, which are also good protein sources. The diet is heavily based on fresh vegetables and fruits. Chinese people do not have canned and frozen foods frequently, and they only have western desserts such as cakes and cookies on special occasions such as parties and birthdays. In addition, the Chinese diet has some distinct characteristics between North and South. Generally, the diet in the North usually contains more salt and the Southern diet contains more sugar. Furthermore, due to the diversity of geography, climate, and culture, a complex Chinese diet system was formed in China during ancient times, which contained eight styles of cuisine: Chuan (Sichuan), Xiang (Hunan), Yue (Guangdong), Min (Fujian), Su (Jiangsu), Zhe (Zhejiang), Hui (Anhui) and Lu (Shandong).

However, as the economy developed in recent decades, the population has no longer followed the traditional Chinese diet. Despite the population increasing the consumption of vegetables, fruit, eggs, nuts, dairy products, and unsaturated fatty acids, the intake of refined grain, red meat, sugar-sweetened beverages, and fried food were also increasing dramatically, which led to various health issues, such as cardiovascular diseases, hypertension, diabetes, hyperlipidemia, etc.

Based on the data from China Health and Nutrition Survey (CHNS) in 2014, the three-day average energy intake is 2146 kcal and the average intake of carbohydrate, protein, and fat are 319g, 65g, and 66g (see Table 1.). A prospective study in 2004 that focused on nutrition transition in China has found that, the average consumption of rice was 280g/day, legumes were 50g/day, vegetables and fruits were 369g and 29g per day, pork, poultry, and fish were 62g, 15g and 30g per day, milk and eggs were 16 and 26 g per day, salt and sugar were 5g and 10g per day and vegetable oil were 33g per day.

5.2 Correlation between Chinese Dietary Pattern and Hypertension

One national cross-sectional study applied Food Frequency Questionnaire to analyze the frequently consumed food groups and summarized dietary patterns that were existing in China. These dietary patterns included the traditional northern pattern, the traditional southern pattern and the western pattern. Specifically, the traditional northern pattern included relatively high consumption of wheat flour and starchy tubers, relatively low intake of protein sources (pork, beef, poultry, aquatic products) and dairy products. The traditional southern pattern is characterized by a high intake of rice, fruits and vegetables, pork, poultry, aquatic products and nuts. In comparison, the western pattern consisted of beef, lamb, dairy products, sugar-sweetened beverages and deep-fried food .

According to the data from the 2002 National Nutrition and Health Survey in China (CNHS), the proportion of energy intake from cereals was significantly negatively associated with the risk of hypertension, and the proportion of energy intake of fat was significantly positively associated with the risk of hypertension . The traditional northern pattern had a significantly positive association with the prevalence of hypertension. After adjusting for various factors such as Body Mass Index (BMI), age, gender, education level, family history, etc, the association was attenuated but still remained significantly positive. Meanwhile, the traditional southern pattern showed a negative association with the prevalence of hypertension even after adjusting for the factors mentioned above in the northern pattern. A significant positive association showed before adjusting for age and gender for the Western pattern, but the association disappeared after further adjustment .

It still remained unclear which of the exact dietary factors may have detrimental effects that may lead to hypertension. Some studies indicated that sodium intake might only have a partial effect on the association [19, 21]. High consumption of refined carbohydrates, low intake of vegetables and fruits, and seafood may also be dietary factors that contribute to the high prevalence of hypertension. More data and research studies are required in this area.

5.3 American Dietary Pattern

It has been estimated that approximately 2500 to 3600 calories were consumed on average each day by Americans (50% carbohydrate, 15% protein, 35% fat of total calories intake) (see Table 1) . The modern dietary pattern in America was high in salt and saturated fat, low in fruits, vegetables, fish, legumes and whole grain. The data has shown that the average American consumes about 17 teaspoons of added sugar each day which means that the consumption of sugar in America was very high as well . In addition, too much red meat and low-quality carbohydrates were consumed by people in America. Animal foods such as processed meat and deli were the primary source of their protein intake. People in America also preferred eating fast food . However, fast foods such as frozen pizza, high amounts of sugar, saturated fat, and sodium are contained because of the combination of ingredients. It might be added a lot of salt since the manufacturers had to ensure the flavor could be maintained in the pizza when it was cooked .

5.4 Correlation Between American Dietary Pattern and Hypertension

The major cause of high blood pressure in America was the sodium from salt. Packaged processed food was the primary source of sodium instead of the table salt . Americans relied heavily on processed and ultra-processed food . There were about 63% calories in the standard American diet from refined and processed foods such as packaged snacks and soft drinks. There was also a study that found that the average American gets 57.9% of their calories from ultra-processed foods . The recommended daily sodium intake is less than 2300 mg for the general population and less than 1500 mg for the higher-risk subpopulation. However, the intake of sodium in America has increased a lot over the past 40 years and the averages in 2010 were about 3400 mg per day which has already exceeded the Upper Intake (UL) levels of the Institute of Medicine . Besides, Animal-based foods accounted for about 25% of American calories. Plant-based foods accounted for approximately 12% of calories in American diets and half of them were from French fries. Therefore, only 6% of calories in American diets came from healthy foods such as fruit, vegetables, whole grains, nuts, and seeds .

All these high sodium, high fat, and low vegetables diets caused the American population to have a higher risk of developing hypertension.

6. Differences and Similarities among both Dietary Patterns, and Link to Hypertension

6.1 Macronutrients Intake

As Table 1. shows that China had a higher intake of carbohydrates (59% of total calories), a relatively lower intake of protein (12% of total calories) and fat (28% of total calories) . Starting from the 21st century, the Chinese population gained a significant improvement in the quality of diet and nutrition intake status, leading to a lower incidence of malnutrition and nutrition deficiencies. However, the Chinese diet was shifting from the traditional diet to the diet with a high intake of fat and animal products, which led to higher risks for developing diet-related non-communicable diseases, such as hypertension, as discussed in this article. As mentioned above, America's macronutrients intake of carbohydrates, protein, and fat were 50%, 15%, and 35% of total calories intake, respectively . American people had a high intake of red meat, and low-quality carbohydrates, such as refined grains and sugar-sweetened beverages. A poor diet led to higher calorie intake and weight gain, and a higher risk of certain diseases, such as hypertension.

Table 1. The Comparison of Macronutrients Between China and America

Macronutrient	China	America
Carbohydrate	319 g (59%)	312.5 – 450 g (50%)
Protein	65 g (12%)	93.8 – 135 g (15%)
Fat	66 g (28%)	97.2 – 140 g (35%)
Total Calories	2146 kcal/day	2500 – 3600 kcal/day

6.2 Sodium

There is a strong correlation between excessive sodium intake and hypertension. Both American and Chinese people had a high sodium intake in day-to-day life, but the source of sodium was different. 90% of Americans took too much sodium in daily life, about 3400mg, while over 70% of it came from processed food or food from restaurants, for example, frozen food, pickled food, and deli. As for China, the major source of sodium was salt added during cooking. Condiments were also major sources of sodium, such as soy sauce and chicken essence .

6.3 Cooking Methods

High-temperature cooking methods could lead to a higher risk of hypertension development, and the temperature is between 205 °C and 315°C. Routinely eating grilled or well-done beef, chicken, or fish may raise the risk of high blood pressure. More specifically, people who ate the most charred meat had a 17 percent higher risk of high blood pressure, and those who ate their meat well-done boosted their risk by 15 percent .

High-temperature cooking methods are used prevalently in both China and America. Stir-frying is the most widely used method to cook Chinese food, and the temperature used by it is from 180°C to 250°C. The deep-frying technique, for fried spring rolls and pork balls, also requires a high heat cooking method. Another health risk is related to oil. In northern China, people like to cook with boiling oil, which usually ruins the good mono- and polyunsaturated fat and turns it into saturated or trans-fat . In America, grilling, roasting and drying are the primary cooking techniques that are used in day-to-day life, which all require high temperature, and have an adverse health effect on American people.

6.4 Grains

People who consumed the whole grain might be healthier since more fiber, healthy fats, and vitamins and minerals were consumed by them and less sugar, unhealthy fat, and cholesterol were consumed. A high intake of whole grain and dietary fiber is associated with a lower risk of type 2 diabetes and cardiovascular diseases. In China, grains serve as a staple food and the main component of the traditional diet. In 2015, more than 35% of the whole population met the requirement for grains that were high in fiber, such as corn, millet, oat, and barley. Less than 1.0 and 8.0 % percent of children and adults in America, respectively, met whole-grain recommendations in 2011–12. As the statistic showed, a higher proportion of the Chinese population met the dietary requirement for whole grain, which may be associated with less population who developed hypertension compared to America.

7. Compliance Rate With Dietary Guidelines in China and America

As detailed American dietary patterns showed previously, most American people do not follow America's Food Guideline. First of all, Americans consumed a higher amount of saturated fat than the maximum recommended amount, which led to overweight and obesity. A higher average calorie intake, around 2800 Kcal, was also due to a high intake of added fat and sugar, flour and grain products, and sweeteners. Secondly, 90% of Americans took too much sodium in daily life, about 3400mg, while the guideline recommended 2300mg of sodium per day. In terms of vegetables, Americans consumed just a quarter of the required dark green vegetables, a third of the recommended red and orange vegetables, a third of the recommended legumes, half of the needed starchy vegetables, and insufficient amounts of "other vegetables". Last but not least, the majority of American people did not meet the requirement for dairy. Reduced dairy intake led to a drop in the intake of vitamin D, vitamin A, vitamin B12, and essential minerals. Nearly all the people in America failed to follow the recommended amount of vegetables and whole grains in dietary guidelines. Most people's intake of fruits, milk, and oils was fewer than the recommendations. Young adults were the most likely group who fail to meet the intake standards, which may increase their risk of developing hypertension in the future.

In terms of China, energy and nutrition intake were also imbalanced. In China mainland, the intake of three macronutrients was adequate, and the energy provided by these macronutrients was sufficient. The sodium intake was also high among the Chinese population, which was 5013 mg per day. The high sodium intake was due to the salt added during cooking, soy sauce and chicken essence accounted for that. In recent years, it was a frequent problem that people ate too much fat but not enough micronutrients like vitamins, calcium, iron, and zinc.

Overall, the majority of American people and Chinese people did not follow the dietary guidelines in their life, which led to an increased risk of developing hypertension. Children and adolescents who failed to meet the dietary guidelines may have a higher risk of developing chronic diseases like hypertension in their future lives.

8. Intervention

8.1 Intervention in China

There is much evidence that support the DASH diet has antihypertensive effects, but the DASH diet was not commonly endorsed in Asia. Further clarification might be needed to increase the feasibility and acceptability of the DASH diet in Asia, especially among the places where the majority of people have lactose intolerance, and cannot consume a large number of dairy products. China launched a salt reduction campaign and revised the national dietary guidelines in 2007 to reduce the daily intake of salt among citizens, and to decrease the risk of developing hypertension. The campaign was focused on reducing the added salt during the cooking process since 72% of the Chinese's sodium

intake was from it. The main parts were the distribution of free cooking tools by the government, such as 1-gram salt measuring spoons, which were used to measure the amount of added salt during cooking processes. And health education was also provided to children and adults.

Except for diet intervention, medication and treatment for hypertension were also generally used among Chinese people. Antihypertensive treatment was recommended to be followed specially by the hypertension patients that were newly diagnosed. According to the patients' conditions, the blood pressure was reduced gradually to the target level in 4 to 12 weeks to prevent the risk of complications like stroke, heart failure and renal insufficiency. Some Traditional Chinese Medicine (TCM) also has clinical efficacy to reduce blood pressure. Tianma Gouteng Yin Formula (TGYF), which contains eleven commonly used herbs, can treat primary hypertension with efficacy and safety. It has been widely used to treat hypertension-related signs and symptoms in clinical practice for centuries in China.

8.2 Intervention in America

The DASH (Dietary Approaches to Stop Hypertension) diet, which is commonly used among American people, shows an inverse risk of developing hypertension. It encourages a high intake of vegetables, fruits, low-fat dairy products, and a low intake of sodium and saturated fatty acid. The DASH diet was easy to follow in America, since it used common foods that can be purchased from the grocery store. The DASH diet has similar recommendations as to the American Food Guideline. Besides, the Mediterranean dietary pattern is also highly recommended for high blood pressure patients and shows effectiveness in lowering blood pressure. Compared to the DASH diet, the Mediterranean diet is high in monounsaturated fat, and can decrease the low-density lipoprotein particles, and reduce fasting triglycerides and coagulation factors. The most common medications used to treat hypertension in America are, for example, diuretics, angiotensin-converting enzyme (ACE) inhibitors, angiotensin II receptor blockers (ARBs), and calcium channel blockers.

8.3 Similarities and Differences Between Chinese and American Intervention Methods

America and China had different situations in terms of health risk factors. The sodium intake among American people was mostly due to the high intake of processed food and take-out food. In contrast, sodium intake among Chinese people was due to the addition of excess salt during the cooking process. This phenomenon led to different dietary interventions on hypertension between China and America. The main difference was that American people with hypertension commonly follow the DASH diet, whereas the Chinese population had a relatively low rate of following the DASH diet. Instead, the Chinese government initiated a salt reduction campaign to advocate for the population to reduce added salt and provide corresponding nutrition knowledge. Besides, salt measuring spoons were used by the Chinese population.

However, even though there were differences between China and America on applying the dietary approach to prevent and intervene hypertension, the central point of these approaches were the same. Both China and America were advocating lower sodium intake and saturated fat intake.

In terms of the medication treatment for hypertension in China and America, the common medications are antihypertensive medications which are used both in China and America, while China also use Traditional Chinese Medicine for hypertension treatment.

8.4 Adherence Rate of Hypertension Intervention Among Chinese and American Population

The prevalence of hypertension in China was relatively lower than that in America, but the average blood pressure in China was higher and the major proportion of patients with severe high blood pressure level which is $\geq 160/100$ mm Hg in China. The rate of hypertension treatment in China was 46.8%, which was lower than 77.9% in America. China also had lower blood pressure control rates compared with America, which was 20.3% versus 54.7%.

In America, it has been found by the study that when the food was provided to the patients with hypertension, a high adherence rate to the DASH diet was reported. However, if patients with

hypertension were only advised to follow the DASH diet but were not provided with food, it would become difficult for them to adhere to this diet. In fact, some previous studies have shown that even though the patients in America did not perfectly insist on the DASH diet, they still could get big improvements in their dietary patterns. After the intervention, the intake of total fat, saturated fat, and cholesterol significantly decreased while the intake of dietary fiber and many vitamins and minerals increased. Besides, some other studies proved that intake of some dietary fat and minerals like potassium, magnesium, and sodium were improved.

Research has shown that the patients with hypertension in China had poor antihypertensive treatment adherence. However, the level of the city influenced the treatment adherence for AHT drugs significantly, and the patients with hypertension in municipalities were found to have a higher treatment adherence. Besides, treatment adherence was positively influenced by the population with older age and the presence of comorbidity. A study has shown that older patients who were older than 65 years had higher adherence to AHT drugs than patients with younger age.

9. Conclusion

As the paper mentioned previously, hypertension is one of the major risk factors that lead to death in modern society. It has caused millions of deaths globally, and millions of costs that the population spent on healthcare services. Dietary pattern is one of the influence factors that may contribute to preventing and treating chronic diseases, such as hypertension, as discussed in this paper.

This paper focused on the association between dietary patterns and hypertension by comparing them between China and America, in order to further promote healthy diet and lifestyles for the population. However, the association between dietary pattern and hypertension remains unclear. Some research considered having an association, whereas some did not. Therefore, more research studies and data are further needed on this topic. It is important to have a better understanding of dietary behavior and hypertension, thus, better prevent hypertension from a dietary aspect.

There is still a huge gap between the current dietary intake and the recommended dietary guidelines of the general population in both China and America. Future efforts are required to fill the gap and improve the health status of citizens. For example, nutrition education focusing on dietary guidelines is crucial to make the population be familiar with the dietary guidelines, thus, willing to follow them, and ultimately build healthy dietary habits and healthy lifestyle. Furthermore, the early diagnosis rate and hypertension control rate are low in both China and America. Hence, the importance of early screening and treatment is supposed to be advocated to the public. On the other hand, different dietary patterns represent different cultures to some extent. Therefore, it is also important for health care professionals to consider the cultural background of the patients and clients when providing nutrition education or conducting nutrition intervention plans.

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