Dietary diversity and diabetes and subgroup analysis under covariates

Xiangyi Wang*

Medical college, Macau University of Science and Technology, Macau, 999078, China

Abstract: Previous studies have suggested the protective effect of good dietary pattern on diabetes, but research on the effect of dietary diversity still remain limited. In order to fill this gap, we used the data derived from the China Longitudinal Health and Longevity Survey (CLHLS) to explore the association between dietary diversity and the prevalence of diabetes. Food Variety Score (FVS) was adopted to reflect food variety and logistic regression model was used to evaluate its potential effect on diabetes. After adjustment for covariates, higher dietary diversity was associated with a decreased risk of diabetes among all participants (OR: 0.821, 95% CI:0.727-0.928) and those without hypertension (OR: 0.689, 95% CI:0.502-0.945). The findings of this study provide prospective evidence, highlighting the relationship between food diversity and the risk of diabetes.

1. Introduction

Diabetes poses a significant challenge in the contemporary era, with approximately 422 million people worldwide suffering from this disease. Moreover, it is projected that by the year 2035, the number of individuals affected by diabetes will reach a staggering 600 million[1]. Concurrently, there is a noticeable global trend toward population aging, which is accompanied by an increasing probability and risk of diabetes among the elderly. On average, approximately one in every five individuals aged 65 to 99 is afflicted with diabetes[2]

In 2013, the median age of individuals diagnosed with diabetes in China was reported to be 55.8 years, with approximately one-quarter of the global diabetic population residing in the country. However, by 2018, the median age had decreased to 51.3 years. Concurrently, the prevalence of prediabetes among Chinese adults was estimated to be around 15.5%. As of 2021, the overall diabetic population in China has reached approximately 140 million, representing nearly 10.6% of the total population(statista).

Complications arising from diabetes, such as renal, ocular, and foot-related complications, continue to afflict this population. However, a growing body of research suggests that improvements in lifestyle habits can contribute to the prevention and management of diabetes, with diet being one of the crucial factors. Multiple cross-sectional and cohort studies have indicated that various aspects of diet, including dietary diversity and patterns, can potentially reduce the incidence of diabetes. A substantial body of literature has established a negative association between the consumption of processed meat, fried fast food, refined grains, and diets high in animal fat, and the occurrence of diabetes. Conversely, dietary patterns characterized by a high intake of vegetables have consistently demonstrated a preventive effect against diabetes. Furthermore, adequate intake of vitamin D has shown promising efficacy in reducing the risk of diabetes. However, there exist divergent viewpoints among various sources regarding the influence of fruit consumption on the prevalence of diabetes. While some studies suggest a potential risk-reducing effect of fruit intake, others propose a limited or inconsequential association with the development of diabetes.

The objective of this study is to delve deeper into the relationship between dietary diversity and the prevalence of diabetes. Moreover, we also did some subgroup analysis to see the impact of gender, age, drinking, smoking, exercise and whether having hypertension on diabetes.

2. Materials and methods

2.1. Data collection and population

The data cited in this article is derived from the China Longitudinal Health and Longevity Survey (CLHLS) conducted in eight longevity regions in China from 2017 to 2018. These regions include Xiayi County in Henan Province, Zhongxiang City in Hubei Province, Laizhou City in Shandong Province, Yongfu County in Guangxi Autonomous Region, and Sanshui District in Guangdong Province. The CLHLS is a community-based study aimed at evaluating the health status and factors influencing the elderly population in regions known for longevity. The study population consisted of elderly individuals aged 65 and above (N=2493), from whom blood samples were

*Corresponding author's e-mail: wang10050805@163.com

collected. Informed written consent forms were obtained from all participants.

For data collection, standardized survey questionnaires were utilized during in-home interviews. The collected data encompassed three main aspects, including demographic information, health-related lifestyle factors and medical status. Specifically, the demographic information comprised age (<80 years, ≥80 years), gender (male, female), place of residence (city, town, and rural), nationality (Han nationality, Hui nationality, Zhuang nationality, Yao nationality, Korea nationality, Man nationality, and Mongolia nationality), schooling years (0-6 years, 6-12 years, and more than 12 years), current marital status (single, married), etc. Health-related lifestyle factors consisted of smoking status (yes, no), drinking status (yes, no), exercise status (yes, no), etc. Medical status contained self-reported diabetes, systolic blood pressure (SBP), diastolic blood pressure (DBP), presence of hypertension, etc. Following the in-home interviews, anthropometric measurements, including blood pressure readings, were conducted. Trained research assistants carried out two arterial blood pressure measurements with at least a one-minute interval, while participants maintained an upright posture and relaxed their abdomen, breathing gently. The average values were then calculated for systolic blood pressure, and diastolic blood pressure, respectively.

2.2. Food variety measurement

In order to assess the food variety among older adults in 2018, we utilized the Food Variety Score (FVS), which reflects the diversity of food types. This score was determined by considering the frequency of consumption of 13 different foods from the CLHLS questionnaire. The food items included fresh fruits, vegetables, meat, fish, eggs, soy products, salted vegetables, sugar, garlic, dairy products, nut products, mushroom plants, and tea. For each food item, a score of 1 was assigned if the respondents reported consuming it daily or often, while a score of 0 was given if they reported occasional or infrequent consumption. The final FVS for each individual was obtained by summing the scores for all 13 food items, resulting in a range from 0 to 13. A higher FVS indicates a greater level of dietary diversity. Previous research has established that a score below 7 represents a low FVS, while a score of 7 or higher indicates a high FVS. Therefore, individuals are categorized based on whether their FVS is greater than or equal to 7 or less than 7.

2.3. Diabetes

The diabetes status of the subjects in this study is mainly based on whether the patients said they have diabetes or not. Participants in this study will be queried regarding two questions: "Is it confirmed by the hospital?" and "Is it taking related drugs?" If the answer to either of these questions is "Yes," the individual will be classified as having diabetes.

2.4. Covariates

Covariates included demographic characteristics, socioeconomic status, and health-related variables. Age (<80 years, ≥80 years), gender (female, male), place of residence (city, town, and rural), nationality (Han nationality, Hui nationality, Zhuang nationality, Yao nationality, Korea nationality, Man nationality, and Mongolia nationality) and current marital status (single, married) were considered demographic characteristics. Socioeconomic status encompassed, schooling years (0-6 years, 6-12 years, and more than 12 years), main source of financial support (retirement wages, spouse, child(ren), grandchild(ren), other relative(s), local government or community, work by self, and others). Health-related variables included smoking status (yes, no), drinking status (yes, no), exercise status (yes, no), BMI, diastolic blood pressure, systolic blood pressure, and presence of hypertension.

2.5. Statistical analysis

We utilized a chi-square test to compare the baseline characteristics of food diversity between high FVS and low FVS. In order to evaluate the impact of food diversity on the risk of diabetes, we constructed a logistic regression model. Initially, an unadjusted crude model was employed for the analysis, followed by which incorporated adjustments for gender and age (Model 1). Additionally, further adjustments for age, gender, place of residence, nationality, current marital status, schooling years, main source of financial support, smoking status, drinking status, exercise status, BMI, diastolic blood pressure, systolic blood pressure, and presence of hypertension (Model 2). All tests were conducted with 2-sided at a significance level of $p<0.05$. The statistical analyses were performed using SPSS version 27. Moreover, we also did some subgroup analysis to see the impact of gender, age, drinking status, smoking status, exercise status and whether having hypertension on diabetes.

3. Results

Table 1 presents the baseline characteristics of elderly individuals in China based on food variety type. Among the study population, 5,182 individuals (33.85%) had low dietary diversity, while 10,126 individuals (66.15%) had high dietary diversity. A greater proportion of individuals exhibit higher dietary diversity compared to those with lower levels and the distribution of Food Variety Score (FVS) varied across different demographic factors. There were significant differences in gender, region, ethnic, smoking status, drinking status, exercise status, schooling year, BMI level, main source of financial support, age, systolic pressure, and diastolic pressure ($p<0.05$).

Table 1. Baseline characteristics of Chinese older adults by the food variety score.

Characteristic	Food Variety Score < 7	Food Variety Score ≥ 7	p
n (%)	5182 (33.85%)	10126 (66.15%)	<0.001
Gender			<0.001
Male	2441(36.5%)	4248 (63.5%)	
Female	2741(31.8%)	5878(68.2%)	
Place of residence			< 0.001
City	748(21.7%)	2702(78.3%)	
Town	1861(37.0%)	3173(63.0%)	
Rural	2573(37.7%)	4251(62.3%)	
Nationality			< 0.001
Han nationality	4113(33%)	8339(67%)	
Hui nationality	25(26.3%)	70(73.7%)	
Zhuang nationality	263(52.7%)	236(47.3%)	
Yao nationality	17(48.6%)	18(51.4%)	
Korea nationality	1(33.3%)	2(66.7%)	
Man nationality	8(13.3%)	52(86.7%)	
Mongolia nationality	0(0)	2(100%)	
Others	32(34.4%)	61(65.6%)	
Missing	2(50%)	2(50%)	
Smoking status			< 0.001
No	4203(32.5%)	8719(67.5%)	
Yes	942(42.1%)	1297(57.9%)	
Drinking status			< 0.001
No	4311(33.3%)	8629(66.7%)	
Yes	803(37.6%)	1334(62.4%)	
Exercise status			< 0.001
No	3729 (35.3%)	6842 (64.7%)	
Yes	1380 (30.5%)	3138 (69.5%)	
Schooling year			< 0.001
Missing or don't know	8 (17.4%)	38(82.6%)	
0-6 years	3727(34.9%)	6961(65.1%)	
6-12 years	550(28.2%)	1401(71.8%)	
More than 12 years	117(25.4%)	343(74.6%)	
Current marital status			0.353
Single	3072 (33.4%)	6118 (66.6%)	
Married	2049 (34.4%)	3916 (65.6%)	
Don't know or missing	3 (50%)	3 (50%)	
Presence of hypertension			0.417
No	2738 (33.8%)	5370 (66.2%)	
Yes	2017 (33.1%)	4073 (66.9%)	
BMI (kg/m2)			< 0.001
< 18.5	865 (36.2%)	1523(63.8%)	
18.5-24	2508(34.3%)	4805(65.7%)	
24-28	1077(32.8%)	2211(67.2%)	
≥28	345 (29.5%)	826(70.5%)	
Main source of financial support			< 0.001
Retirement wages	979 (26.1%)	2767(73.9%)	
Spouse	123(30.6%)	279(69.4%)	
Child(ren)	2477(35.9%)	4414(64.1%)	
Grandchild(ren)	88(34.6%)	166(65.4%)	
Other relative(s)	13(35.1%)	24(64.9%)	
Local government or community	587(39.6%)	896(60.4%)	
Work by self	473 (38.7%)	749 (61.3%)	
Others	294(35.1%)	543 (64.9%)	
Missing	1(100%)	0(0)	
Age (years)			0.003
< 80	2014 (35.3%)	3686 (64.7%)	
≥80	3168(33%)	6440 (67%)	
Systolic blood pressure (mmHg)			0.011
< 90	35 (37.6%)	58 (62.4%)	

90-130	1539 (32.1%)	3258 (67.9%)	
≥130	3099 (34.5%)	5874 (65.5%)	
Diastolic blood pressure (mmHg)			0.311
< 60	225 (35.4%)	411 (64.6%)	
60-110	4379 (33.6%)	8664 (66.4%)	
≥110	69(37.9%)	113(62.1%)	

Table 2 presents the correlation between baseline food types and the risk of frailty among the elderly. In comparison to individuals with low dietary diversity at baseline, those with higher dietary diversity did demonstrate a lower prevalence of diabetes across in Crude model and Model 1. The odds ratios (OR) and corresponding 95% confidence intervals (CI) were 0.832 (95% CI, 0.737-0.939), 0.821 (95% CI, 0.727-0.928).

Table 2. Logistic regression analysis of food type factors and the incidence of diabetes.

	Crude model	Model 1	Model 2
FVS			
≤7	1 (reference)	1 (reference)	1 (reference)
> 7	0.832 (0.737-0.939)	0.821 (0.727-0.928)	0.959 (0.814-1.129)

Notes: Crude model: Using logistic regression model without any adjustment. Model 1: Using logistic regression model adjusted for age and gender. Model 2: Using logistic regression model adjusted for age, gender, place of residence, nationality, current marital status, schooling years, main source of financial support, smoking status, drinking status, exercise status, BMI, diastolic blood pressure, systolic blood pressure, and presence of hypertension.

Table 3 presents the subgroup analysis examining the impact of age, gender, smoking status, drinking status, exercise status, and presence of hypertension on the prevalence of diabetes. In the participants without hypertension, higher food variety was associated with an decreased risk of diabetes in model 2 (OR: 0.689, 95% CI:0.502-0.945).

Table 3. Logistic subgroup analysis of different factors and incidence rate of diabetes.

Age	Crude model	Model 2
< 80	0.857 (0.726-1.013)	0.967 (0.777-1.204)
≥80	0.775 (0.648-0.926)	0.972 (0.761-1.242)
Gender	Crude model	Model 2
Male	0.881 (0.735-1.056)	1.001 (0.789-1.271)
Female	0.802 (0.681-0.944)	0.928 (0.741-1.162)
Smoking status	Crude model	Model 2
yes	0.756(0.525-1.089)	0.811(0.513-1.283)
no	0.869(0.763-0.989)	0.984(0.826-1.172)
Drinking status	Crude model	Model 2
yes	0.893(0.612-1.301)	0.965(0.586-1.588)
no	0.840(0.739-0.956)	0.962(0.809-1.144)
Hypertension	Crude model	Model 2
yes	0.880(0.760-1.020)	1.095(0.903-1.329)
no	0.686(0.531-0.871)	0.689(0.502-0.945)
Exercise status	Crude model	Model 2
yes	0.702(0.570-0.866)	0.904(0.696-1.174)
no	0.960(0.826-1.117)	0.991(0.804-1.222)

Notes: Using logistics regression to get odds ratio of FVS >7 while FVS ≤7 was set as the reference group. Model 2 was adjusted for age, gender, place of residence, nationality, current marital status, schooling years, main source of financial support, smoking status, drinking status, exercise status, BMI, diastolic blood pressure, systolic blood pressure, and presence of hypertension.

4. Discussion

The findings of this cohort study provide support for the hypothesis that a diverse range of food types is associated with a decreased risk of diabetes. Additionally, among individuals with high Food Variety Score (FVS), being female, not having hypertension, engaging in smoking, and participating in regular exercise were found to be associated with a reduced likelihood of diabetes.

In recent years, the available literature on the relationship between food diversity and the risk of

diabetes is limited, with only two identified articles. One prospective epidemiological study found a potential association between the combined intake of fruits and vegetables and a lower risk of type 2 diabetes (T2D). After adjusting for potential confounding factors and intake levels, an 8% reduction in T2D incidence was observed with an increased weekly intake of two different types of fruits and vegetables, although the underlying mechanism remains unclear. It should be noted that this study primarily focused on fruits and vegetables and did not evaluate other food types, thus having a narrower scope compared to the present study.

In contrast, another study examining the relationship between dietary diversity and T2D risk among multiracial American residents reported no significant association, which contradicts the findings of the aforementioned study. The discrepancy in results may be attributed to differences in the definition of dietary diversity between the two studies. In this study, food diversity is conceptualized based on three aspects: counting, uniformity of food intake distribution, and differences in food consumption. The counting method aligns with the statistical approach employed in this article, while the other two aspects are reflected by the modified Simpson index, generating a quantitative index of dietary diversity (QUANTIDD). However, due to limitations in this study, the quantitative index of dietary diversity could not be specifically investigated or applied. Additionally, it is worth noting that the classification of food categories in this study differs from that of the present study, which may contribute to the divergent conclusions reached in both studies.

It is important to acknowledge that the limited number of articles available and the methodological differences between studies hinder a comprehensive understanding of the relationship between food diversity and the risk of diabetes. Further research is required to explore the diverse aspects of food diversity and its potential implications for diabetes risk.

Regarding the subgroup analysis results, previous studies have generally shown similar prevalence rates of diabetes between men and women in terms of gender. However, men tend to be more susceptible to obesity and sedentary behaviors, leading to fat accumulation, while women exhibit greater insulin sensitivity[3]. Hypertension has been frequently associated with diabetes, as the two conditions often coexist due to shared underlying pathogenic mechanisms. Nearly two-thirds of individuals with diabetes also have hypertension. Regular exercise has been shown to reduce the risk of diabetes to some extent. However, since this study did not account for exercise intensity and frequency, the calculated impact results may be subject to bias. Different types of exercise can have varying effects on diabetes, requiring further exploration and refinement[4].

Regarding smoking and drinking, the results of this study indicate that smoking may contribute to a certain degree of risk reduction for diabetes, while drinking does not appear to have a significant effect on the risk[5]. However, it is worth noting that other studies have shown that smoking is actually a predictor of glucose intolerance, and any level of alcohol consumption lacks health benefits. The contradictory findings of this study may be attributed to the limited number of smokers included in the dataset, which may have provided insufficient information and affected the outcome results[6].

One of the strengths of this study lies in its cross-sectional design, which enables the examination of dietary frequency across a wide range of food items and the summarization of the impact of dietary diversity on diabetes risk, rather than being limited to specific foods or dietary patterns. Additionally, subgroup analysis was conducted to explore the influence of different variables on the risk of diabetes in the context of varying levels of dietary diversity. However, there are certain limitations that should be acknowledged[7]. Firstly, the dietary information relied on self-reporting, which may introduce some degree of recall bias. Secondly, since the study population was limited to elderly individuals living in the community, the findings may not be generalizable to individuals residing in institutional settings, and the sample size for certain variables may be relatively small. Lastly, despite considering and adjusting for various potential confounding factors in the analysis, there may still be residual confounding factors that were not accounted for[8].

5. Conclusions

In this cross-sectional study conducted among community-dwelling elderly individuals demonstrates that maintaining a high level of dietary diversity is associated with a reduced risk of diabetes. Furthermore, being female and not having hypertension were identified as factors associated with a lower risk of diabetes. The findings of this study provide prospective evidence highlighting the relationship between food types and the risk of diabetes. Encouraging the early adoption and long-term adherence to a diverse diet may be beneficial in reducing the risk of diabetes.

Reference

1. Zimmet, P. Z., Magliano, D. J., Herman, W. H., & Shaw, J. E. (2014). Diabetes: a 21st century challenge. The lancet Diabetes & endocrinology, 2(1), 56-64.
2. Sinclair, A., Saeedi, P., Kaundal, A., Karuranga, S., Malanda, B., & Williams, R. (2020). Diabetes and global ageing among 65–99-year-old adults: Findings from the International Diabetes Federation Diabetes Atlas. Diabetes research and clinical practice, 162, 108078.
3. Tramunt, B., Smati, S., Grandgeorge, N., Lenfant, F., Arnal, J.-F., Montagner, A., & Gourdy, P. (2020). Sex differences in metabolic regulation and diabetes susceptibility. Diabetologia, 63, 453-461.
4. Aihemaitijiang, S., Zhang, L., Ye, C., Halimulati, M., Huang, X., Wang, R., & Zhang, Z. (2022). Long-Term high dietary diversity maintains good physical function in Chinese elderly: a cohort study based on CLHLS from 2011 to 2018. Nutrients, 14(9), 1730.

5. Baleato, C. L., Ferguson, J. J., Oldmeadow, C., Mishra, G. D., & Garg, M. L. (2022). Plant-Based Dietary Patterns versus Meat Consumption and Prevalence of Impaired Glucose Intolerance and Diabetes Mellitus: A Cross-Sectional Study in Australian Women. Nutrients, 14(19), 4152.
6. Wang, L., Peng, W., Zhao, Z., Zhang, M., Shi, Z., Song, Z., Zhang, X., Li, C., Huang, Z., & Sun, X. (2021). Prevalence and treatment of diabetes in China, 2013-2018. Jama, 326(24), 2498-2506.
7. Yin, X., Chen, Y., Lu, W., Jin, T., & Li, L. (2020). Association of dietary patterns with the newly diagnosed diabetes mellitus and central obesity: a community based cross-sectional study. Nutrition & diabetes, 10(1), 16.
8. Tan, S., Lu, H., Song, R., Wu, J., Xue, M., Qian, Y., Wang, W., & Wang, X. (2021). Dietary quality is associated with reduced risk of diabetes among adults in Northern China: A cross-sectional study. British Journal of Nutrition, 126(6), 923-932.