Dietary patterns and sarcopenia in a Chinese population

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ABSTRACT

Background and Objectives: Malnutrition is implicated as a key modifiable risk factor for sarcopenia. As such, a dietary pattern analysis, rather than an analysis of single food items or nutrients, may provide insights into the comprehensive contribution of diet and nutrition to the risk of sarcopenia. Accordingly, the aim of this study was to evaluate the relationships between main dietary patterns and sarcopenia. **Methods and Study Design:** A total of 591 participants aged over 40 years were included in this cross-sectional study. A validated food-frequency questionnaire was used to assess their dietary intake, and principal component analysis (PCA) was used to identify the main dietary patterns. A multivariate logistic regression model was used to explore the associations between their main dietary patterns and the risk of sarcopenia. **Results:** This study identified 56 cases of sarcopenia, equating to an overall detection rate of 9.48%. The PCA revealed four major dietary patterns among the participants: "coarse cereals and vegetables"; "beverages and animal organs"; "poultry, fish and shrimp"; and "fruits and pasta". After adjusting for age, sex, physical activity and smoking, individuals with the "coarse cereals and vegetables" dietary pattern had a 63.0% reduction in the risk of sarcopenia. **Conclusions:** The "coarse cereals and vegetables" dietary pattern is negatively correlated with sarcopenia, and may reduce the risk of sarcopenia.

Key Words: dietary patterns, sarcopenia, Principal Component Analysis

INTRODUCTION

Sarcopenia is an age-related disease characterized by the loss of skeletal muscle mass and a decrease in physical performance and function.[1] Sarcopenia increases the hospitalization, mortality and disability rates in the elderly population, which directly increases the medical expenditure and healthcare costs.[2] Approximately 50 million people worldwide aged over 60 are currently suffering from sarcopenia, and this number is expected to increase to 2 billion by 2050.[3] Thus, sarcopenia is an important public health problem that must be addressed

Sarcopenia is a multifactorial disease whose pathogenesis remains unknown. In 2018, the European Working Group on Sarcopenia in Older People (EWGSOP2) updated their initial definition of sarcopenia to take into account the scientific and clinical evidence gathered during the previous 10 years. The new consensus: (1) focuses on low muscle strength as a key characteristic of sarcopenia (cutoff points: grip strength <27 kg for men and <16 kg for women, and chair stand >15 seconds (s) for five rises for both sexes), uses detection of low muscle quantity and quality to confirm the sarcopenia diagnosis (cutoff points: appendicular skeletal muscle mass <20 kg for men and <15 kg for women), and identifies poor physical performance as indicative of severe sarcopenia (cutoff points: gait speed ≤0.8 m/s); (2) updates the clinical algorithm that is used for sarcopenia case-finding, diagnosis and confirmation, and severity determination; and (3) provides distinct cutoff points for the measurements of indicators that identify and characterize sarcopenia.[4]

Sarcopenia can be affected by multiple factors such as age, malnutrition, physical inactivity and environmental factor.[5] However, the precise risk factors for sarcopenia are complex and remain controversial. Malnutrition, which frequently coexists with sarcopenia, is a key modifiable risk factor for sarcopenia.[6] Indeed, consuming more than 25–30 g of high-quality protein per meal has been shown to reduce the risk of sarcopenia onset.[7] However, given the complexity of nutrient interactions, studying single food items or nutrients cannot accurately and comprehensively reveal the relationship between nutrition and chronic conditions.[8,9] In this context, a dietary pattern analysis may help to overcome the limitations of the traditional methods used for evaluating the effects of single food items or nutrients.

Notably, the research on the relationship between dietary patterns and sarcopenia is inadequate. In addition, almost all relevant studies were conducted in regions outside China. For instance, a United States-based study reported that the "high-protein poultry" dietary pattern had no adverse effects on sarcopenia, whereas the "alcohol" dietary pattern contributed significantly to sarcopenia.[10] Moreover, the "Mediterranean" dietary pattern was found to reduce the risk of sarcopenia onset in people aged over 55 years in Iran [odds ratio (OR)=0.42, 95% confidence interval (CI): 0.18–0.97] and in post-menopausal women (OR=0.42, 95% CI: 0.18–0.97). However, no significant associations were found between Western dietary patterns and the risk of sarcopenia onset.[11,12] Compared with the populations outside China, the population in China exhibits significant differences in terms of beliefs, lifestyles, eating habits, culture, age distribution, economic situation and the consumption concept. Here, we investigated the effects of dietary patterns on sarcopenia onset in Zhengzhou, China. Our findings may provide a scientific basis for sarcopenia prevention via dietary interventions.

MATERIALS AND METHODS

Study population and data collection

This cross-sectional study recruited individuals aged over 40 who underwent health examinations in a 3A hospital in Zhengzhou, China. A total of 660 participants underwent health examinations from March 2018 to January 2019. After excluding individuals with missing dietary data or incomplete data from health examinations, a sample of 591 participants was included in this study. All of the participants signed informed consent forms, and the Life Science Ethics Committee of Zhengzhou University approved the study.

Assessment of dietary intake

Dietary intake data were collected using a food frequency questionnaire. Participants were asked to record the frequency of consumption of food groups as per day, per week, per month, per year or never. In addition, standard tableware and dietary map were provided to assist the participants to quantify food consumption accurately.

The food items were classified into food groups according to the similarity of their nutritional composition, following the Chinese Food Composition Table.[13] For instance, milk powder, yoghurt and dried milk are all rich in high-quality protein. Therefore, they were classified as milk and dairy products. Accordingly, 67 food items in this study were classified into 19 food groups, as shown in Supplementary Table 1.

A principal component analysis (PCA) of the 19 food groups was performed to identify the main dietary patterns, and orthogonal rotation was used to rotate the obtained factors. The Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test were used to determine the appropriate PCA conditions. We used the "eigenvalue >1" criterion, the scree test, and interpretability to determine the number of factors to retain. To calculate the factor score for each dietary pattern, we summed the intake of the component food groups weighted by the factor loadings (the correlation coefficient between a food group and a particular dietary pattern). Variables with factor loadings ≥0.35 were included in the weighted average. A factor score for each dietary pattern was calculated for every object of study. The continuous dietary pattern scores were categorized into tertiles.

Anthropometric measures

Height and weight measurements were performed according to standard protocols with the participants in light clothing and without shoes, and the average of two measurements was recorded. For these measurements, a standard measuring instrument was used, as recommended by the World Health Organization.[14] To assess the muscle strength, the participants were asked to hold and squeeze a hand dynamometer with their maximal force for 15s. Three 15-s tests were performed with 1-minute intervals between each test, and the highest values (in kg) were used.

To analyze gait speed, the participants were asked to walk 6 m at their usual gait speed (in m/s), and the time taken was recorded using a stopwatch. Two independent measurements were taken for each participant, and the maximum value was used. A body composition analyzer (Inbody720) was used to analyze the body compositions of the participants. Each participant was analyzed standing barefoot, with the heel and plantar making contact with the two electrodes. Measurements were taken after inputting the participant's name, age, height, sex and number.

Diagnostic criteria for sarcopenia

According to the criteria established by the EWGSOP, sarcopenia was defined as the presentation of both low muscle mass and function (strength or performance). A low muscle mass was defined as a relative skeletal muscle mass index <7.0 kg/m^2 in men and <5.7 kg/m^2 in women. A low muscle strength was defined as a handgrip strength <26 kg in men and <18 kg in women. A low physical performance was defined as a walking speed <0.8 m/s. We further classified sarcopenia into three groups: early stage, defined as a low muscle mass without any impact on muscle strength or physical performance; middle stage, defined as a low muscle mass accompanied by any type of low muscle function (strength or physical performance); and late stage, defined as both low muscle mass and function. We defined the middle and late stages of sarcopenia as severe sarcopenia.

Assessment of other potential risk factors

The participants were interviewed face-to-face by trained healthcare staff using a standard questionnaire to collect information on their demographic characteristics, smoking, physical activity and dietary intake. Smokers were defined as those who had smoked more than 100 cigarettes during their lifetime. Physical activity was classified as low, moderate and high intensity by the International Physical Activity Questionnaire scoring protocol.[15]

Statistical analysis

All data were double inputted using EpiData3.1 software, and a database was established and analyzed using SPSS 25.0 statistical software. The mean ± standard deviation (SD) or median was used to describe measurement data, and the differences between the groups were analyzed using a t-test. Percentages were used to describe and analyze the count data, and the differences between the groups were analyzed using a chi-square test.

A PCA was used to construct the main dietary patterns by data extraction and dimensionality reduction from the 19 food groups. A logistic regression model was used to analyze the relationships between the main dietary patterns and sarcopenia, and $p < 0.05$ was considered statistically significant.

RESULTS

Baseline characteristics of the participants

A total of 519 participants were included in this cross-sectional study. The participants had a mean age of 59.3 years (SD, 8.87 years), and 231 (39.1%) were female (Table 1). There were 338 (57.2%) retirees, and 294 participants (49.8%) were older than 60 years. The study identified 56 cases of sarcopenia, equating to an overall detection rate of 9.48%. The detection rate of sarcopenia increased with age, reaching 12.2% for participants aged over 60 ($p \leq 0.02$). However, no significant difference was observed in sarcopenia prevalence between the sexes, education levels, occupation types, physical activity levels, smoking statuses and income levels ($p > 0.05$).

Establishment of dietary patterns

Our applicability test (KMO=0.75 $\geq$0.5) and Bartlett' s spherical test ($p < 0.001$) showed that the data of this study were suitable for a principal component factor analysis. Using this analysis, four main dietary patterns (named according to the main foods they comprised) were extracted, and their cumulative contribution rate to the total variance was 39.3%. Our results showed that the "coarse cereals and vegetables" dietary pattern (coarse cereals, vegetables, beans and nuts) explained 11.0% of the variance; the "beverages and animal organs" dietary pattern (sugar-sweetened beverages, animal organs and eggs) explained 9.67% of the variance; the "poultry, fish and shrimp" dietary pattern (poultry, fish and shrimp, fungi and algae) explained 9.67% of the variance; and the "fruits and pasta" dietary pattern (fruits, pasta, milk and alcohol) explained 9.0% of the variance. Table 2 and Supplementary Table 2 present the factor loadings and cumulative variance contribution rates of the four dietary patterns, respectively. Supplementary figure 1 shows the scree plot representing the number of dimensions extracted.

Logistic regression analysis of dietary patterns and sarcopenia

We defined T1 and T3 as the low and high factor scores, respectively, for each dietary pattern. No confounding factors were adjusted in model 1; age and sex were adjusted in model 2; and age, sex, smoking and physical activity were adjusted in model 3. Our results showed that the "coarse cereals and vegetables" dietary pattern was closely associated with sarcopenia (Table 3). Notably, among the three adjusted models, the correlation was strongest in model 3, which showed a reduction in sarcopenia risk by 63%. No other significant correlation was observed.

The "coarse cereals and vegetables" dietary pattern was then analyzed using a logistic regression analysis to explore the association between this dietary pattern and severe sarcopenia (middle or late stage). Among the three adjusted models, no confounding factor was adjusted in model 1; age and sex were adjusted in model 2; and age, sex, physical activity and smoking were adjusted in model 3. Our results showed that this dietary pattern was closely correlated with severe sarcopenia as well (Table 4).

DISCUSSION

Our results showed that the detection rate of sarcopenia in our cohort of participants was 9.48% (10.4% in women and 8.89% in men). The difference in the sarcopenia detection rate between the sexes may be attributable to hormone levels, but it was not statistically significant (possibly due to the small sample size of this study). As expected, we observed that the incidence of sarcopenia increased with age. Previous studies in elderly populations outside China have reported that the prevalence of sarcopenia was 7–27% and 10–23% in men and women aged over 60 years, respectively, and 12.3% and 4.8% in men and women aged over 70 years, respectively.[16,17] The prevalence of sarcopenia in Hong Kong has been reported to be 7.3–9.0%.[18] We speculate that these differences in sarcopenia prevalence may be due to differences in the study populations and the age and eating habits of the participants between the studies.

Relationships between dietary patterns and sarcopenia

The dietary pattern in Iran is characterized by a high intake of refined cereals and carbohydrates, similar to those in the Middle East, Europe and the United States.[19] A study in the United States showed that the "alcohol" dietary pattern was a risk factor for sarcopenia, but found no significant association between the "poultry" dietary pattern and sarcopenia.[10] In another prospective study, no significant correlations between arbitrary dietary patterns and sarcopenia were found in female participants.[18] A diet dominated by vegetables and fruits, whole wheat grains and fatty fish can improve muscle function and prevent muscle insufficiency.[20] A study in an elderly cohort in Hong Kong reported that the "high vegetables and fruits" dietary pattern and the "snack drinks and dairy products" dietary pattern significantly reduced muscle loss.[18] In China, the "staple food plus pickled vegetables" dietary pattern has been reported to be negatively correlated with grip strength.[21] As grip strength is closely related to muscle function,[18] long-term intake of this dietary pattern may increase the risk of sarcopenia.

Among the four main dietary patterns identified in this study, we found that in the high-score T3 group, the factor score of the "coarse cereals and vegetables" dietary pattern was inversely correlated with the risk of sarcopenia in all three adjusted models. Moreover, increasing the adjusted variables increased the correlation between this dietary pattern and sarcopenia. However, sarcopenia was not correlated with the other three main dietary patterns.

Relationship between the "coarse cereals and vegetables" dietary pattern and sarcopenia

Similar to the "Mediterranean" dietary pattern, the "coarse cereals vegetable" dietary pattern is rich in vegetables, nuts, whole grains and beans. The "Mediterranean" dietary pattern is known to contribute to the prevention of chronic diseases, including sarcopenia.[22] The positive effects of the "coarse cereals vegetable" dietary pattern on human health can be explained by several mechanisms. For example, the accumulation of reactive oxygen species in the body can result in oxidative damage and loss of muscle mass and strength.[23] In this case, dietary patterns rich in vegetables, which typically contain high concentrations of antioxidants, vitamin C and vitamin B, may prevent muscle injury and preserve muscle function by reducing oxidative stress.[24,25] In addition, the "coarse cereals and vegetables" dietary pattern contains a large amount of basic food groups that are important for the prevention of acidosis[26] and the maintenance of muscle function during aging.[27] Furthermore, the antioxidants and omega-3 polyunsaturated fatty acids found in nuts affect the inflammatory response, which in turn affects muscle function.[20,28-30] As a source of isoflavones and estrogen, soy products can reduce the risk of muscle loss[18] and promote skeletal muscle health.[31, 32]

Similar to T1, the "coarse cereals and vegetables" dietary pattern in T3 was also inversely correlated with severe sarcopenia. The relationship between the two patterns was statistically significant and had a higher adherence to this dietary pattern after adjustment for variables. This was consistent with the relationship between sarcopenia (including early-, middle- and late-stage sarcopenia) and the "coarse cereals vegetable" dietary pattern identified in this study.

Relationship between the "poultry, fish and shrimp" dietary pattern and sarcopenia

The "poultry, fish and shrimp" dietary pattern is characterized by a high intake of poultry meat, fish and shrimp and a low intake of fruits and miscellaneous cereals, and is therefore associated with an increased intake of protein and a reduced intake of dietary vitamins and dietary fiber. This pattern is similar to the "meat fish" dietary pattern defined in a Hong Kong-based study,[18] but contains more meat and fish, and to the "high-protein poultry" dietary pattern defined in a United States-based study.[10] Our results showed that the "poultry, fish and shrimp" dietary pattern, and therefore the previously defined "meat fish" and "high-protein poultry" dietary patterns, were not significantly associated with the risk of sarcopenia. This may be explained by the low vegetable and fruit contents (hence antioxidants) in these diets. Furthermore, compared with healthy individuals, people with sarcopenia may exercise stricter diet control to include more antioxidant-rich food items. Studies have shown that the intake of high-quality protein has protective effects against sarcopenia.[30]

Relationships between other dietary patterns and sarcopenia

The "fruits and pasta" dietary pattern is characterized by a high intake of fruits, pasta and milk and a low intake of meat and miscellaneous cereals. Unexpectedly, no associations were found between this dietary pattern and the risk of sarcopenia. One possible reason for this observation is that alcohol in this dietary pattern (the absolute value of the factor load was more than 0.4) is known to promote sarcopenia[10] by impairing protein synthesis in muscles,[33] which overrides the positive effects associated with the dietary intake of milk, fruits and pasta.

The "beverages and animal organs" dietary pattern is characterized by a high intake of animal organs, eggs and sugar-sweetened beverages and a low intake of vegetables, bacteria, algae and fruits. No significant associations were observed between this dietary pattern and sarcopenia.

In this study, we used standard tableware and dietary maps to characterize the dietary patterns as accurately as possible. This allowed us to reduce recall bias and more accurately record food consumption in our selected cohort. However, our study is limited by a small sample size. Further studies with a longer follow-up duration and a larger simple size are required to validate our results.

Conclusion

In this study, four dietary patterns were extracted by PCA. Our findings suggest that the "coarse cereals and vegetables" dietary pattern is negatively correlated with sarcopenia onset, and may reduce the risk of sarcopenia. Thus, food items containing coarse cereals, vegetables, nuts and beans are recommended to be included in the daily diet to reduce the risk of sarcopenia. Dietary guidance could be given to the public based on this dietary pattern which might prevent or retard the progression of sarcopenia.

AUTHOR DISCLOSURE

The authors have no conflict of interest to declare.

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Table 1. Comparison of the demographic characteristics of the participants

Characteristics	Sarcopenia n (%)		Total	χ^2	p
	Yes	No	n (%)		
Age					
≤60 years	20 (6.73)	277 (93.3)	297 (50.3)	5.23	0.02
>60 years	36 (12.3)	258 (87.8)	294 (49.8)		
Sex					
Male	32 (8.89)	328 (91.1)	360 (60.9)	0.37	0.54
Female	24 (10.4)	207 (89.6)	231 (39.0)		
Education					
Primary school and below	10 (13.2)	66 (86.8)	76 (12.9)	2.10	0.35
Middle school	37 (9.56)	350 (90.4)	387 (65.5)		
College or above	9 (7.03)	119 (93.0)	128 (21.7)		
Occupation					
Brain work	7 (7.69)	84 (92.3)	91 (15.4)	0.48	0.79
Manual labor	15 (9.26)	147 (90.7)	162 (27.4)		
Retirement and other	34 (10.0)	304 (90.0)	338 (57.2)		
Physical activity					
Low	14 (7.14)	182 (92.9)	196 (33.6)	4.44	0.11
Middle	25 (13.0)	167 (87.0)	192 (32.9)		
High	16 (8.21)	179 (91.8)	195 (33.5)		
Smoking					
Always	24 (11.7)	182 (88.4)	206 (34.9)	5.46	0.07
Once	4 (3.7)	104 (96.3)	108 (18.3)		
Never	28 (10.1)	249 (89.9)	277 (46.9)		
Average monthly income					
≤1800 Yuan	15 (10.3)	130 (89.7)	145 (24.5)	0.89	0.64
1800–5000 Yuan	35 (9.78)	323 (90.2)	358 (60.6)		
>5000 Yuan	6 (6.82)	82 (93.2)	88 (14.9)		

Table 2. Factor-loading matrix for the dietary patterns

Food type [‡]	Dietary pattern[†]			
	Coarse cereals and vegetables	Beverages and animal organs	Poultry, fish and shrimp	Fruits and pasta
Coarse cereals	0.68			
Vegetables	0.60			
Beans and bean products	0.58			
Nuts	0.44			
Eggs and egg products		0.69		
Animal organs		0.67		
Sugar-sweetened beverages		0.55		
Poultry			0.74	
Fish and shrimp			0.61	
Fungi and algae			0.53	
Fried food			0.46	
Fruits				0.65
Flour and flour products				-0.61
Milk and milk products				0.58
Alcohol				-0.47

[†]The dietary patterns were interpreted and named based on high factor loadings (≥0.35).
[‡]To simplify data presentation, loadings with an absolute value <0.35 are not shown.

Table 3. Logistic regression analysis of dietary patterns and sarcopenia

Dietary pattern	Sarcopenia n (%)		Odds ratio (95% confidence interval)		
	No	Yes	Model 1†	Model 2‡	Model 3§
"Coarse cereals and vegetables" dietary pattern					
T1	172 (32.2)	24 (42.9)	1	1	1
T2	178 (33.3)	19 (33.9)	0.66 (0.35–1.24)	0.68 (0.35–1.29)	0.70 (0.36–1.33)
T3	185 (34.6)	13 (23.2)	0.43 (0.20–0.85)	0.40 (0.19–0.82)	0.37 (0.17–0.77)
p_{trend}			0.05	0.05	0.04
"Beverages and animal organs" dietary pattern					
T1	178 (33.3)	19 (33.9)	1	1	1
T2	179 (33.5)	17 (30.4)	0.69 (0.34–1.38)	0.67 (0.33–1.34)	0.61 (0.29–1.24)
T3	178 (33.3)	20 (35.7)	0.95 (0.49–1.81)	1.02 (0.52–1.97)	1.05 (0.54–2.05)
p_{trend}			0.55	0.44	0.28
"Poultry, fish and shrimp" dietary pattern					
T1	178 (33.3)	19 (33.9)	1	1	1
T2	181 (33.8)	16 (28.6)	1.00 (0.49–2.03)	1.02 (0.50–2.08)	1.03 (0.50–2.12)
T3	176 (32.9)	21 (37.5)	1.33 (0.69–2.62)	1.52 (0.77–3.03)	1.52 (0.76–3.09)
p_{trend}			0.61	0.39	0.41
"Fruits and pasta" dietary pattern					
T1	179 (33.5)	18 (32.1)	1	1	1
T2	184 (34.4)	13 (23.2)	0.94 (0.46–1.92)	0.82 (0.39–1.72)	0.86 (0.40–1.84)
T3	172 (32.2)	25 (44.6)	1.40 (0.73–2.75)	1.22 (0.59–2.55)	1.27 (0.61–2.70)
p_{trend}			0.43	0.55	0.53

†Unadjusted.
‡Adjusted for age and sex.
§Adjusted for age, sex, smoking, and physical activity.

Table 4. Logistic regression analysis of the "coarse cereals and vegetables" dietary pattern and severe sarcopenia

Dietary pattern	Dietary pattern score tertiles (odds ratio, 95% confidence interval)			p trend
	T1	T2	T3	
Model 1[†]	1.00	0.90 (0.37–2.19)	0.35 (0.10–0.99)	0.05
Model 2[‡]	1.00	0.95 (0.39–2.34)	0.35 (0.09–0.98)	0.04
Model 3[§]	1.00	0.96 (0.38–2.36)	0.34 (0.09–0.86)	0.04

[†]Unadjusted.
[‡]Adjusted for age and sex.
[§]Adjusted for age, sex, smoking, and physical activity.

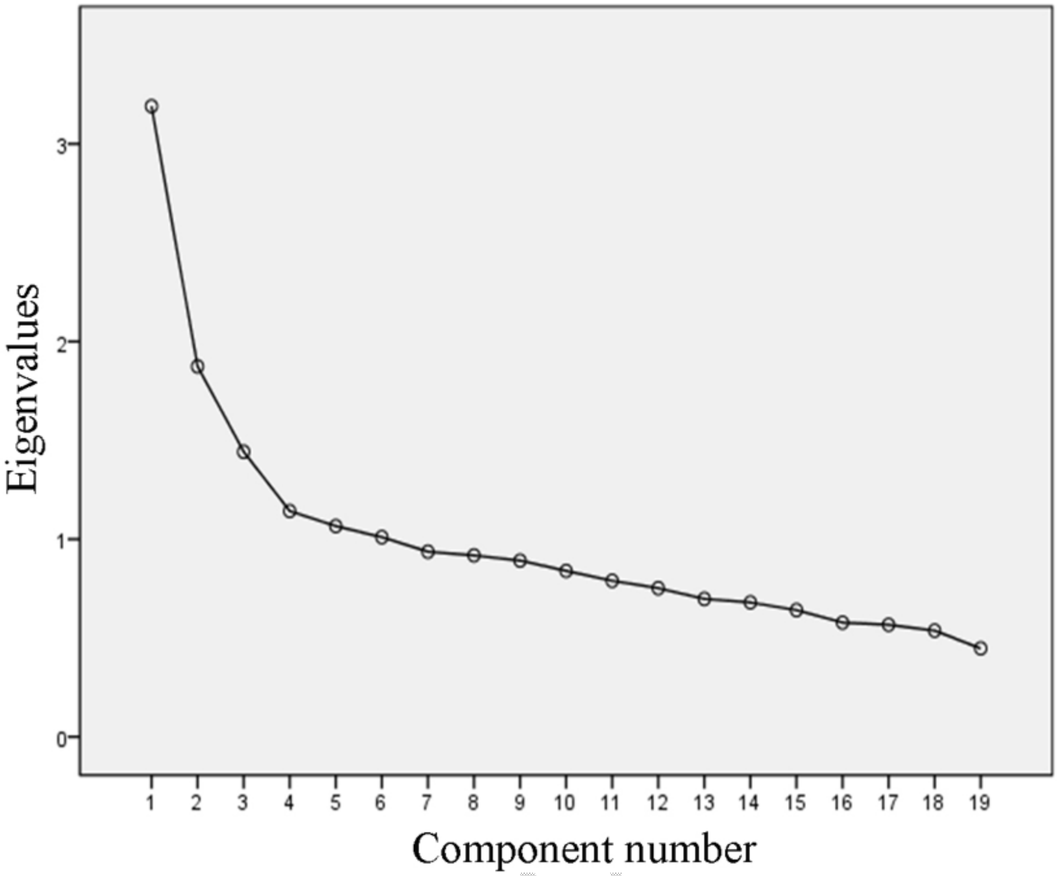
Supplementary table 1. Grouping of food items

Food type	Specific foods
Miscellaneous food	including graham flour, miscellaneous beans, corn, graham bread, oats, potatoes and sweet potatoes
Green groceries	including radish, eggplant, cabbage and lotus root
Beans and its products	including soybeans, black beans, soy milk and tofu
Nuts	including walnuts, almonds, cashews, peanuts and melon seeds
Eggs and its products	including eggs, duck eggs, and egg custard
Animal viscera	including heart, liver, intestines, lungs and tongue
Sugar-sweetened beverages	including sprite, coke and orange juice
Meat	including pork, beef, mutton and rabbit
Poultry	including chicken, duck and goose
Seafood	including fish, shrimp, crabs and shellfish
Homonemeae	including fungus, mushroom, flammulina and seaweed
Fried food	including fried chicken, instant noodles and French fries
Fruits	including apples, oranges and bananas
Flour and its products	including flour, noodles and steamed bread
Milk and its products	including milk, milk powder and yoghurt
Alcohol	including red wine, white wine and beer
Rice	including rice and rice soup
Baked food	including mung bean cake
Pickled food	including mustard, bacon and salted eggs

Supplementary table 2. Cumulative variance contribution rates of four pattern

Principal component	Sum	Variance (%)	Cumulative variance contribution rate (%)
1†	2.08	11.0	11.0
2‡	1.84	9.67	20.6
3§	1.84	9.67	30.3
4¶	1.71	9.0	39.3

†Principal component 1 corresponds to the "coarse cereals and vegetables" dietary pattern;
‡Principal component 2 corresponds to the "beverages and animal organs" dietary pattern;
§Principal component 3 corresponds to the "poultry, fish and shrimp" dietary pattern;
¶Principal component 4 corresponds to the "fruits and pasta" dietary pattern.



Supplementary figure 1. A scree plot of eigenvalues versus component number.