Original Article

Association between dietary patterns and dyslipidemia in adults from the Henan Rural Cohort Study

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Background and Objectives: The aim of the study was to explore the association between dietary patterns and lipid levels in Henan rural area. **Methods and Study Design:** Fasting blood samples, information on dietary intakes (with food frequency questionnaires) and other data were collected from the Henan Rural Cohort Study. Principal component analysis was used to identify the dietary patterns. Binary logistic regression and restricted cubic spline regression models were performed to obtain odds ratios (ORs) and 95% confidence intervals (95%CI). The study recruited 38,983 available participants aged from 18 to 79 from rural areas in Henan province. **Results:** The study showed that, three patterns were identified by higher factor loadings: namely the "meat" (high intakes of red meat, white meat and fish), "grain-egg-nut complex" (high intakes of nuts, milk, eggs, grains and beans), and "vegetables-staple food-fruits" pattern (high intakes of vegetables, staple food and fruits). "Grain-egg-nut complex" pattern was significantly positively related to the risk of dyslipidemia (OR: 1.10; 95% CI: 1.05–1.16, $p<0.05$). The multivariable-adjusted ORs across tertiles of each dietary pattern were significantly associated with each component of dyslipidemia indexes. **Conclusions:** Grain-egg-nut complex dietary pattern was positively associated with dyslipidemia. All three dietary patterns were associated with blood lipid profiles aberrations.

Key Words: dyslipidemia, dietary pattern, Henan rural area, lipid levels, adults

INTRODUCTION

Dyslipidemia is a well-established risk factor for cardiovascular disease (CVD).[1] Despite the recent declining trend in developed areas, the social economic loss caused by CVD is still huge due to its increasing prevalence in the developing countries.[2] A recent study has shown the prevalence of dyslipidemia in China was 62.1% overall.[3] Besides of the high proportion of prevalence, the awareness, treatment and control rates of dyslipidemia were generally low (<54%, 36%, and 15%, respectively) in rural areas of China,[4] suggesting that dyslipidemia remained a serious threat to public health in the general population.

Fortunately, controlling of blood lipid level may effectively avoid the occurrence and the development of the CVD.[5,6] Several studies have proved that dyslipidemia can be treated with medical interventions and lifestyle changes, for instance, healthy diets, physical activities, drinking and smoking prohibitions.[1,7-10] Public health organization affirmed that dietary improvement is one of the efficient approaches to prevent and control dyslipidemia and CVD.[11] Thus, dietary research is of great significance to the prevention of dyslipidemia.

Meanwhile, compared with single nutrient intake, general dietary pattern may create a comprehensive reflection on the food intake of the population, and provide more effective measures for the intervention of dyslipidemia.[12] Principal component analysis (PCA), one of the most commonly used statistical approaches in dietary pattern analysis, utilizes correlations of different foods according to the frequency and intake of each food group.[13,14] With the help of which, associations among dietary patterns, blood lipid levels and risk of multiple diseases have been established over a series of cohorts and cross-sectional studies across the world.[15-20] Notably, PCA can directly obtain the actual dietary patterns of a specific population and thus possess a high value to thepublic health researches of Henan rural area.

Therefore, the linkage between prevailing dietary patterns and lipid profiles in undeveloped areas is of great significance. And we try to establish a dose-response relationship between different dietary pattern factor scores and

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levels of blood lipids via restricted cubic spline regression models. The current study may provide us with the potential dietary trends that pose threats to lipid status in China rural areas.

METHODS

Study population

Study population were recruited from the Henan Rural Cohort Study, which was launched in five rural areas on Henan province, China, from July 2015 to September 2017. Detailed study objectives and designs were described elsewhere.[21] In brief, 39,259 participants aged from 18-79 years were included in the baseline survey. Among the eligible subjects, participants with either incomplete information on dietary data (n=79), or missing information on blood lipid indices (n=196) were excluded. The final figure was fixed at 38,983 (15,334 males and 23,649 females). This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Committee of Zhengzhou University. Written informed consent was obtained from all subjects.

Dietary assessment

At the baseline survey, by following standard operating procedures, food frequency questionnaire (FFQ) which has been proved to be validated before[22] was conducted in face-to-face investigations to assess the food intake by well-trained interviewers for the past 12 months. The questionnaire contains 13 food categories, including staple food which contained fine processed grain like polished rice, noodle, steamed twisted roll, steamed bread and other fine processed grains and cereals; red meat such as pork, lamb and beef; white meat such as chicken and duck; fish; eggs; milk and dairy products; fresh fruits; fresh vegetables; legumes and products; nuts and peanuts; pickles and salt vegetables; grains like sweat potato, maize, oats and sorghum; and animal oil like lard and tallow. The consumption of each food group per person per day was calculated in grams.

Subjects were questioned about every food product they had eaten. The amount of food per standard serving was clearly defined (also shown in a series of pictures), as "jin" (a jin is equal to 500 grams) and "liang" (a liang is equal to 50 grams) were used for weight measuring. Frequency of food consumption was categorized into five levels: never, daily, weekly, monthly, and yearly. The intakes of energy, carbohydrate, protein, fat, and micronutrients among the participants were analysed based on the China Food Composition table.[23]

Data collection

Sociodemographic variables including age, gender, education, socioeconomic status, smoking status, drinking status, physical activity, family history of dyslipidemia were collected in the on-set baseline survey. Education attainment was categorized into primary school or below, junior high school, high school and above, respectively. Socioeconomic status was evaluated based on income per capita monthly (<500, 500~, and ≥1000 renminbi (RMB)). Current smokers were defined as smoking at least one cigarette per day in past 6 months, and current drinkers were defined as alcohol drinking (liqueur, beer, wine, and other alcohol beverages) at least 12 times per year. Physical activity was categorized into either low, mediate or high level according to the International Physical Activity Questionnaire-short (IPAQ-short).[24,25] Family history of dyslipidemia was defined as having at least one grandparent, parent, or sibling with the disease.

Anthropometric measures were also assessed by trained research staffs. Each subject was measured twice in light indoor clothing without shoes according to standard protocols. The participants' data were obtained from the average of two measurements. Body mass index (BMI) was calculated as weight (kg) divided by square of height in meters (m^2). Waist and hip circumferences were measured for three times using calibrated equipment.[26]

Serum samples were separated immediately from whole blood samples from participants after fasting for at least 8h, through centrifugation at for 10 min at 3000 rpm, 4°C. Subsequently, blood samples were used to measure total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) in Roche Cobas C501 automatic biochemical analyzer.

Ascertainment of dyslipidemia

On the one hand, the diagnostic index of this study was based on the standard of diagnosis and treatment of dyslipidemia in Chinese adult population, which was suitable for participants in this study. On the other hand, this diagnostic criteria for dyslipidemia with marginal elevation can be used to analyze the blood lipid levels and dietary intake of people with possible dyslipidemia.

Thus, dyslipidemia was identified according to the Guidelines on Prevention and Treatment of Dyslipidemia for Chinese Adults (2016). In present study, the definition of dyslipidemia was modified as exceeding at least one of marginal values: for TC ≥5.2 mmol/L, TG ≥1.7 mmol/L, HDL-C <1.0 mmol/L, and LDL-C ≥3.4 mmol/L. Meanwhile, the clinical diagnosis standard for abnormal lipid levels were as follows: TC ≥6.2 mmol/L, TG ≥2.3 mmol/L, LDL-C ≥4.1 mmol/L, HDL-C < 1 mmol/L.[27]

Statistical analysis

Data extraction and dimensionality reduction of diet intake information were conducted with PCA from the 11 food groups which had mentioned above except for pickles and animal oil. We rotated the factors with varimax orthogonal transformation (factor analysis in SPSS) to identify the structures. The identified factors were retained by scree plot, evaluated eigenvalues (>1) and interpretability. The sample adequacy was checked by the Kaiser-Mayer-Olkin (KMO) test.

Continuous variables presented as mean ± standard deviation (SD) were compared using one-way ANOVA analysis, while categorical variables presented in numbers and proportions were compared using chi-square test. The associations between dietary patterns and dyslipidemia and single lipid level were performed by binary logistic regression models for the obtaining of odds ratios (ORs) and 95% confidence intervals (CIs). The trend tests were conducted using the median of each category as a continuous variable. Restricted cubic spline regression was used to depict the dose-response relationship between dietary factor scores at 3 nodes in the quartile (25th, 50th, 75th, respectively) and dyslipidemia, with the lowest dietary factor scores quartile as the reference.

All statistical analyses were produced using SPSS 25.0 software (IBM Corp., Armonk, NY, USA). R software (version 3.4.1) was used to shape the figures of restricted cubic spline. Statistical significance was set at a two-side, $p<0.05$.

RESULTS

Dietary patterns among participants

The naming of these patterns was based on the higher food group factor loadings.[28] Three dietary patterns were obtained by the principal component analysis: the "Meat", "Grain-egg-nut complex", and "Vegetable-staple food-fruits". Table 1 showed the factor loadings of each pattern after orthogonal rotation. The scree plots were illustrated in Supplemental figure 1, as all three factors explained 43.6% of the variance in total food intake. The meat pattern explained 17.64% of the variance due to the great contribution of white meat, fish and red meat. Grain-egg-nut complex pattern was characterized by high intake of grains (i.e., sweet potato/corn), eggs, nuts (i.e. peanut, melon seed), bean and milk, whereas vegetable-staple food-fruits pattern in this study is featured in main consumption of plant food like staple food, vegetables[29] and fruits. The latter two patterns accounted for 13.62% and 12.30% of the variation in food intakes, respectively.

Characteristics of study participants grouped by dietary patterns

A total of 38,983 remaining participants (15,334 males and 23,649 females) were included in further analysis, among which 19,148 subjects (53.8% of total population) were with dyslipidemia. Related socio-demographic and health-related variables for subjects with different dietary patterns were described in Table 2. According to the classification of diet patterns, there were significant differences in the characteristics of the subjects ($p<0.001$). Subjects from meat pattern were likely to be younger, higher education level, more socialized, current smokers and drinkers, as well as inheritor of dyslipidemia than those of other two group. Additionally, the meat pattern group had higher TG levels but lower HDL-C levels when comparing with other dietary patterns. Meanwhile, the grain-egg-nut complex pattern group had more females, and fewer current smokers and drinkers than other pattern groups; participants who were subjected to the grain-egg-nut complex pattern had higher TC and LDL-C levels. Subjects from vegetable-staple food-fruits pattern were likely to be older, male, poorly educated, shared a low monthly income, had higher level of physical activity and more energy intake, but lower BMI.

Association between dietary patterns and lipid profile

The relationship between each component of dyslipidemia across tertiles of different dietary patterns factor loading were shown in Table 3. After adjusting for gender, age, education, income, marital status, smoking, drinking, physical activity, BMI, family history of dyslipidemia and energy intake, the meat dietary pattern was not significantly correlated with neither high LDL-C level nor low HDL-C level, but connected strongly high TG level and high TC level. In a group of participants in the highest tertile of vegetable-staple food-fruits dietary pattern, the risks for high TG level was significantly higher than that in T1, while risks for high TC level and high LDL-C level decreased dramatically. However, low HDL-C levels were not significantly correlated with the vegetable-staple food-fruits pattern, regardless of the adjustment.

In model 2, individuals in the highest tertile of the grain-egg-nut complex dietary group shared significantly decreased risks of high TG level and low HDL-C level as compared with those in the lowest tertile. Meanwhile the very dietary pattern was significantly associated with increased risks of high TC level and high LDL-C level.

Relationship between dietary patterns and dyslipidemia

Supplemental table 1 showed increasing intake of food groups compatible with tertile of factor scores under different dietary patterns. Adjusted OR and 95 % CIs for dyslipidemia in the tertiles of different dietary patterns were presented in Table 4. After fully adjusted by covariates (model 3), the meat pattern and vegetable-staple food-fruits dietary pattern were not significantly associated with dyslipidemia. In contrast, grain-egg-nut complex pattern was strongly associated with dyslipidemia in model 3.

Furthermore, restricted cubic spline regressions were performed to shape the association between factor loadings

Table 1. Factor-loading matrix for dietary patterns identified by PCA

Food Group	Meat pattern†	Grain-egg-nut complex pattern†	Vegetable-staple food-fruits pattern†
White meat	0.78		
Fish	0.73		
Red meat	0.73		
Grains		0.61	
Eggs		0.53	
Nuts		0.52	
Bean		0.51	
Milk		0.43	
Vegetable			0.75
Staple food			0.71
Fruits			0.40

PCA: Principal component analysis
†The patterns were interpreted and named according to high factor loadings >0.3.

Table 2. Characteristics of study participants in different dietary patterns

Variables	Meat pattern (n=12145)	Grain-egg-nut complex pattern (n=12899)	Vegetable-staple food-fruits pattern (n=13939)	$p^{†‡}$
Age, years	52.8 (12.70)	56.6 (12.83)	57.1 (10.61)	<0.001
Male	4978 (41.0)	4443 (34.4)	5913 (42.4)	<0.001
Education				<0.001
Elementary school or below	4666 (38.4)	5692 (44.1)	7119 (51.1)	
Junior high school	5200 (42.8)	4882 (37.8)	5444 (39.1)	
High school or above	2279 (18.8)	2325 (18.0)	1376 (9.9)	
Married/cohabitation	11027 (90.8)	11490 (89.1)	12478 (89.5)	<0.001
Per capita monthly income				<0.001
<500 RMB	3568 (29.4)	4749 (36.8)	5605 (40.2)	
500~RMB	4011 (33.0)	4347 (33.7)	4461 (32.0)	
1000~RMB	4566 (37.6)	3803 (29.5)	3873 (27.8)	
Current smoker	2827 (21.8)	2046 (15.9)	2710 (19.4)	<0.001
Current drinker	2827 (23.3)	1935 (15.0)	2228 (16.0)	<0.001
Physical activity				<0.001
Low	4070 (33.5)	4873 (37.8)	3656 (26.2)	
Moderate	4747 (39.1)	4154 (32.2)	5823 (41.8)	
High	3328 (27.4)	3872 (30.0)	4460 (32.0)	
Family history of dyslipidemia	494 (4.1)	393 (3.0)	490 (3.5)	<0.001
Energy intake(kcal/d)	1924 (636.5)	1849 (551.7)	2213 (646.4)	<0.001
BMI (kg/m^2)	24.9 (3.58)	24.9 (3.63)	24.7 (3.48)	<0.001
TC (mmol/L)	4.68 (0.94)	4.94 (1.04)	4.65 (0.92)	<0.001
TG (mmol/L)	1.71 (1.19)	1.60 (1.05)	1.71 (1.12)	<0.001
HDLC (mmol/L)	1.32 (0.33)	1.33 (0.33)	1.33 (0.33)	<0.05
LDLC (mmol/L)	2.86 (0.81)	2.94 (0.84)	2.87 (0.82)	<0.001
Dyslipidemia	6695 (55.1)	7600 (58.9)	7688 (55.2)	<0.001

SD: standard deviation; BMI: body mass index; TC: total cholesterol; TG: triglycerides; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.
†Data are presented as the mean (SD) for continuous variables and n (%) for categorical variables.
‡The p-values were derived from one-way ANOVA analysis for continuous variables and from χ^2 test for categorical variables

of dietary patterns and dyslipidemia (Figure 1). U-shaped associations were found in the meat pattern (*p* for nonlinearity <0.05) and in vegetable-staple food-fruits pattern groups (*p* for nonlinearity <0.001) which indicated that balanced dietary intakes were essential to balance the individual lipid level. As for the Grain-egg-nut complex pattern, compared with the reference of the lower tertile, the risk of dyslipidemia increased gradually along with the increasing of dietary factor loadings, suggesting that significant liner dose-response relationships between factor loading and dyslipidemia might be existed (*p* overall significance <0 .001, *p* for nonlinearity >0.05).

DISCUSSION

The Henan Rural Cohort Study included 38,983 eligible participants aged from 18 years to 79 years, providing an ideal target for the relationship research among dietary patterns, dyslipidemia and lipid profiles. Three dietary patterns were derived by PCA which were named as "Meat pattern", "Grain-egg-nut complex pattern", and "Vegetable-staple food-fruits pattern", respectively. Taking the factor score of each dietary pattern in the lowest tertile as a reference, the grain-egg-nut complex pattern with high intakes of grains, bean, nuts, milk and eggs was positively associated with dyslipidemia. The meat pattern was in positive correlation with high TG level, but negatively correlated to high TC content. In addition, Grain-egg-nut complex pattern showed a positive relationship with high TC and LDL-C levels, while it was negatively related to high TG and low HDL-C levels. After adjustment for all covariates, vegetable-staple food-fruits pattern was significantly positively related to high TG content, and negatively correlated with high level of TC and LDL-C.

Our results showed a probably connection between grain-egg-nut complex pattern consuming (with high intake of grain, nuts, beans, milk and eggs) and dyslipidemia. The identified "grain-egg-nut complex pattern" is not common as an independent pattern in the previous studies.[15,20,28,30] Partially because of dietary composition and classification, for that grains in current study, included refined corns and sweat potatoes, which may indeed increase the risk of dyslipidemia or coronary heart disease (CHD).[31] Additionally, milk and dairy consumption[32] which was also a part of grain-egg-nut complex pattern, has been suggested to raise the mortality risk including CVD mortality.[33] Meanwhile, research has found that dietary cholesterol was related to serum cholesterol in Chinese urban adults, showing a higher risk of dyslipidemia at high levels of cholesterol intakes.[34] Taking egg for example, as the main source of dietary cholesterol intake, which was associated with increasing serum TC and LDL-C[35] and in consideration of high-oil content in the way they are cooked.[36] Furthermore, Maria L.F et al suggested that most foods that are rich in cholesterol are also high in saturated fatty acids and thus may increase the risk of CVD due to the saturated fatty acid content.[37]

The vegetable-staple food-fruits pattern include staple foods (e.g. wheat flour and rice), vegetables and fruits, which was in consistent with other several studies.[30,38] We found that vegetable-staple food-fruits pattern contains more recommended ingredients like vegetables and fruits, which would in turn inhibit dyslipidemia within a proper

Table 3. Odds ratios (95% CI) for abnormal lipid levels in the tertiles of different dietary patterns

Variable	Tertile	Meat Pattern		Grain-egg-nut complex Pattern		Vegetable-staple food-fruits pattern	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
High TG	T1†	1	1	1	1	1	1
	T2†	1.127 (1.056,1.202)**	1.103 (1.031,1.180)*	0.906 (0.851,0.964)*	0.887 (0.831,0.946)**	1.012 (0.948,1.080)	1.076 (1.002,1.156)*
	T3†	1.261 (1.183,1.344)**	1.209 (1.126,1.298)**	0.797 (0.748,0.850)**	0.766 (0.716,0.819)**	1.268 (1.190,1.350)*	1.480 (1.362,1.607)**
	p-trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
High TC	T1†	1	1	1	1	1	1
	T2†	0.774 (0.710,0.844)**	0.844 (0.772,0.922)**	1.590 (1.441,1.754)**	1.680 (1.520,1.857)**	0.638 (0.585,0.696)**	0.707 (0.644,0.778)**
	T3†	0.617 (0.563,0.677)**	0.846 (0.765,0.935)*	1.958 (1.780,2.153)**	2.286 (2.070,2.524)**	0.505 (0.461,0.554)**	0.654 (0.581,0.736)**
	p-trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
High LDL-C	T1†	1	1	1	1	1	1
	T2†	0.857 (0.781,0.940)*	0.935 (0.850,1.028)	1.205 (1.093,1.327)**	1.244 (1.127,1.372)**	0.815 (0.744,0.893)**	0.879 (0.796,0.971)*
	T3†	0.791 (0.720,0.870)**	1.046 (0.943,1.160)	1.267 (1.151,1.395)**	1.392 (1.260,1.538)**	0.665 (0.604,0.733)**	0.808 (0.714,0.915)*
	p-trend	<0.001	>0.05	<0.001	<0.001	<0.001	<0.001
Low HDL-C	T1†	1	1	1	1	1	1
	T2†	1.070 (1.000,1.145)	1.019 (0.948,1.094)	0.966 (0.904,1.033)	0.954 (0.890,1.023)	1.045 (0.976,1.118)	1.063 (0.986,1.146)
	T3†	1.118 (1.058,1.211)*	0.956 (0.886,1.032)	0.922 (0.861,0.986)*	0.910 (0.847,0.977)*	1.088 (1.017,1.164)*	1.066 (0.974,1.166)*
	p-trend	<0.001	>0.05	<0.05	0.001	<0.05	>0.05

TG: triglycerides; TC: total cholestero; LDL-C: low density lipoprotein cholesterol; HDL-C: high density lipoprotein cholesterol.
Model 1 was unadjusted; Model 2 was adjusted for age, gender, education, monthly income, marital status, smoking, alcohol consumption, exercise, BMI, family history of dyslipidemia, and energy intake.
†T1-T3, the tertile of the factor loadings. Factor loadings of "meat" pattern were categorized as: T1: <-0.602, T2: -0.602-0.175, and T3: ≥0.175; factor loadings of "grain-egg-nut complex" pattern were categorized as: T1: <-0.550,T2: -0.550-0.320, and T3: ≥0.320; factor loadings of "vegetable-staple food-fruits" pattern were as T1: <-0.483,T2: -0.483-0.332, and T3 ≥0.332.
*p-value<0.05, **p-value <0.001.

Table 4. Odds ratios (95% CI) for dyslipidemia in the tertiles of different dietary patterns

Variable	Tertile	Crude	Model 1	Model 2	Model 3
Meat Pattern	T1†	1	1	1	1
	T2†	0.93 (0.89,0.98)*	0.98 (0.93,1.03)	0.96 (0.91,1.01)	0.961 (0.914,1.011)
	T3†	0.88 (0.84,0.93)**	0.99 (0.94,1.05)	0.954 (0.906,1.005)	0.978 (0.927,1.031)
	p-trend	<0.001	>0.05	>0.05	>0.05
Grain-egg-nut complex pattern	T1†	1	1	1	1
	T2†	1.012 (0.964,1.063)	1.025 (0.976,1.077)	1.013 (0.964,1.065)	1.019 (0.969,1.070)
	T3†	1.069 (1.018,1.123)*	1.090 (1.038,1.145)*	1.079 (1.026,1.134)*	1.104 (1.049,1.1.161)**
	p-trend	<0.05	<0.05	<0.05	<0.001
Vegetable-staple fruits pattern	T1†	1	1	1	1
	T2†	0.884 (0.841,0.928)**	0.880 (0.838,0.924)**	0.903 (0.859,0.949)**	0.935 (0.887,0.985)*
	T3†	0.902 (0.858,0.947)**	0.908 (0.864,0.954)**	0.949 (0.902,0.998)*	1.025 (0.963,1.092)
	p-trend	<0.001	<0.001	<0.05	>0.05

Crude was unadjusted; Model1 was adjusted for age, gender; Model 2 was adjusted for age, gender, education, marital status, income, smoking, alcohol consumption, exercise, family history of dyslipidemia; model 3 was additionally adjusted for energy intake.
†T1-T3, the tertile for the factor loadings. Factor loadings of "meat" pattern were categorized as: T1: <-0.602, T2: -0.602-0.175, and T3: ≥0.175; factor loadings of "grain-egg-nut complex" pattern were categorized as: T1: <-0.550, T2: -0.550-0.320, and T3: ≥0.320; factor loadings of "vegetable-staple food-fruits" pattern were as T1: <-0.483, T2: -0.483-0.332, and T3 ≥0.332
*p-value<0.05, **p-value <0.001.

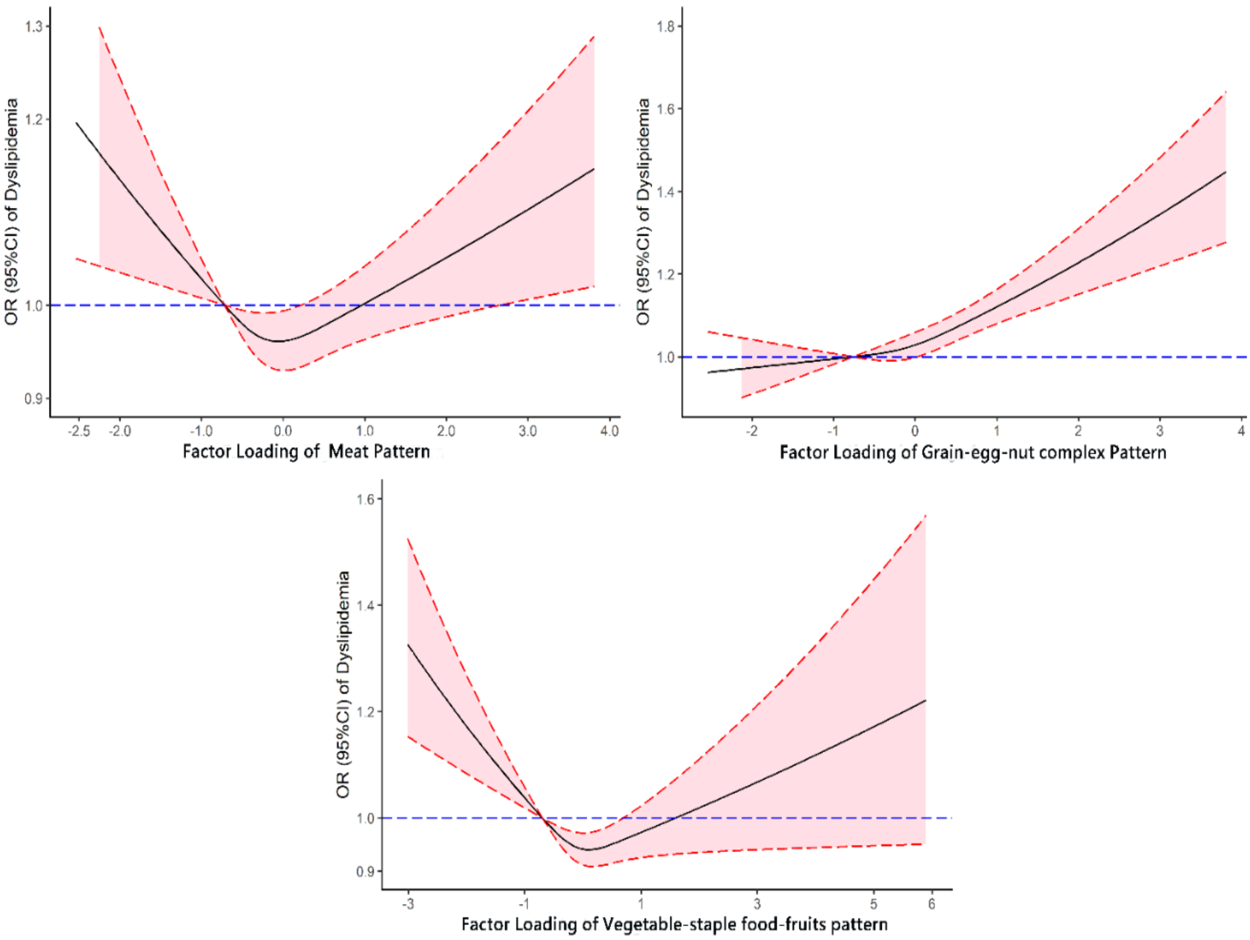

Figure 1. Dose-reponse relationships between different dietary patterns and dyslipidemia. All models were adjusted for age, gender, education level, per capita monthly income, marital status, smoking, alcohol drinking, physical activity, family history of dyslipidemia, and intake of energy.

range of factor scoring. Several studies suggested that diets rich in vegetables and fruits may resist non-communicable diseases, such as, metabolic syndrome, heart disease and cancer.[3,39] Consistent with previous studies, current results indicated that the high-carbohydrate diets like foods in vegetable-staple food-fruits pattern not only raised plasma TG[40] but also reduced the risk for high LDL-C.[41] Nevertheless, excessive intake of staple food such as refined grain[42] like rice and starchy food, as well as lack of vegetables and fruits[43,44] may increase the risk of abnormal lipids expressions. In accordance with previous studies,[31] the "vegetable-staple food-fruits" dietary pattern contained healthful plant food like vegetables and unhealthful food like starchy food which may contributed to the no relationship observed between dyslipidemia and this pattern in our study. More fundamentally, participants in this pattern may consume less cholesterol than other patterns, which well lead to serum TC concentration fluctuations.[45] Moreover, regular consumption of dietary fiber was also seen to aid the prevention of dyslipidemia,[46] and dietary fiber was highly contained in fruits and vegetables,[4] also suggesting that this dietary pattern might be beneficial to lipid metabolism.

Meat pattern in the present study containing red meat like pork, lamb and beef, white meat like chicken and fish, which was not significantly associated with dyslipidemia. However, the result remains a debatable point. Sacks FM et al reported an adverse effect of beef consumption on plasma lipid.[47] And meat consumption was also cross-sectionally associated with high level of TG for the content of saturated fatty acid from red meat consumption.[48] While an open-labeled, randomized, cross-over study showed no correlation existed between lipid responses and lean red meat intake. A meta-analysis pointed out that consumption of red meat had no influence on either blood lipids, lipoproteins expressions or blood pressures.[49] After all, the no relationship between meat consumption and dyslipidemia in current results was in accordance with previous studies.[50,51]

Strengths of our study included large sample size and strict methods of outcome ascertainment. Selection of diagnostic criteria for dyslipidemia revealed the association of dietary intake in rural areas with the primitive warning on dyslipidemia. Besides, presented data represented dietary status in Henan rural areas, which may provide reference for improvements achieved in less resourced real-world practice. In this paper, there were also several study limitations. Firstly, we obtained dietary information via FFQ, there may have been recall bias in the reporting of food intake due to memory errors or between participant variability in the extent. Secondly, in consideration of the nature of the cross-sectional study, causal relationship cannot be determined. Thirdly, residual confounding factors may affect the results, while study collected a wide range of data, which allowed to take potential factors into account. For instance, the relationship between dietary patterns and dyslipidemia remained stable, when excluded potential over- and under reporter of daily energy intake.[52] In addition, the current study did not collect data about cooking oil, thus we could not able to capture such source of variation and the possibility of other confounders from unmeasured intake of cooking oil cannot be completely ruled out. The intake of cooking oil would be taken into account in further research. Finally, our results may not be generalizable to the Chinese population as a whole given that the Henan Rural Cohort Study comprises rural adults in a specific region in central China.

In conclusions, three individual dietary patterns were identified from the Henan Rural Cohort Study: meat pattern, grain-egg-nut complex pattern and vegetable-staple food-fruits pattern. Our results indicated that grain-egg-nut complex pattern characterized by high intakes of nuts, grains, eggs, milk and bean was positively associated with dyslipidemia. Our findings may provide valuable data for developing dietary interventions and policies making to prevent dyslipidemia in Henan rural area and other undeveloped area. Further studies should be conducted to validate these findings and to explore other potential risk factors of dyslipidemia.

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AUTHOR DISCLOSURES

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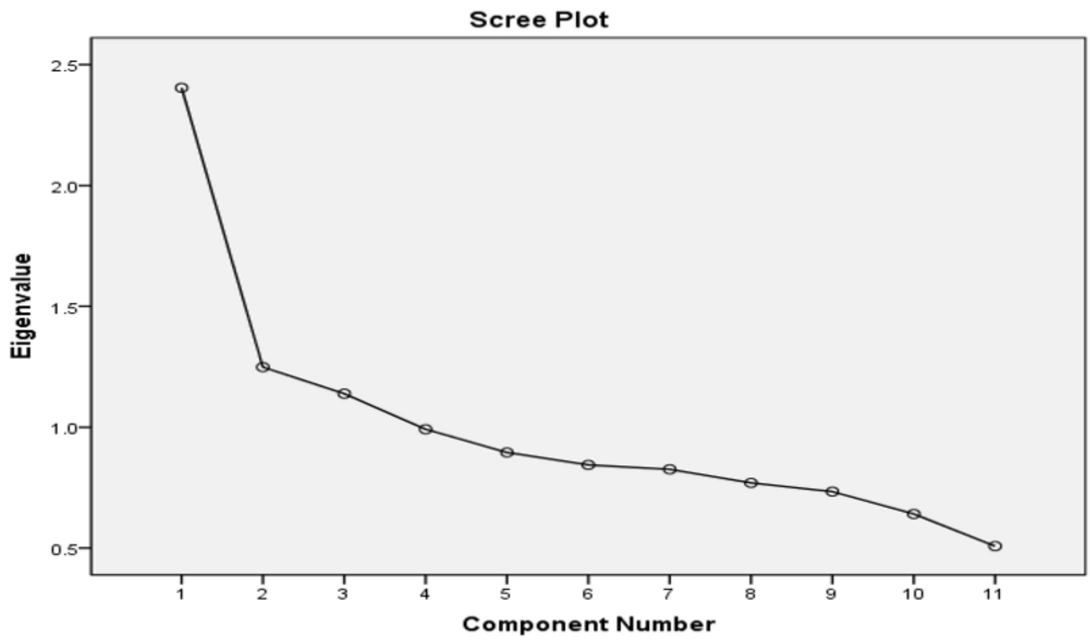

Supplemental figure 1. The scree plot of the component number. Result of Principle Components Analysis The Kaiser–Meyer–Olkin index=0.739>0.7; Bartlett's test $\chi 2$= 36841.740，p=0.000. Three factors explained 43.56% of the variance.

Supplemental table 1. Mean intakes of food groups and nutrients according to tertiles of three dietary patterns

	Meat pattern			Grain-egg-nut complex pattern			Vegetable-staple food-fruits pattern		
Food group and nutrients intake	T1†	T2†	T3†	T1†	T2†	T3†	T1†	T2†	T3†
Food groups (g/d)									
Staple food‡	285	333	416	281	329	369	363	436	558
Red meat	4.24	21.3	66.9	4.46	12.8	25.5	4.46	12.4	24.2
White meat	1.03	7.42	29.1	0.91	3.92	9.63	1.49	4.55	11.8
Fish	0.26	1.84	9.14	0.28	1.13	2.70	0.29	0.99	2.83
Egg	15.7	27.5	47.2	31.7	54.7	82.3	27.6	36.7	59.9
Milk§	1.05	6.51	15.4	1.49	12.3	23.5	0.77	2.65	5.36
Fruit	27.1	71.3	163	34.9	81.0	156	37.8	90.0	187
Vegetable	154	187	300	157	207	293	204	277	484
Bean	6.98	18.3	40.0	9.84	23.8	51.6	7.41	15.0	23.4
Nut	2.02	5.75	17.6	3.60	10.1	27.5	2.59	6.22	14.7
Grain	19.6	24.9	44.7	51.7	60.5	116	22.3	29.7	43.3
Nutrients									
Carbohydrate (g/d)	231	277	367	239	289	357	293.2	359	474.1
Protein (g/d)	37.8	52.0	83.2	41.0	56.1	78.3	48.7	62.9	88.2
Fat (g/d)	8.16	17.2	40.0	10.2	18.4	32.1	10.6	16.6	27.3
Insoluble fiber (mg/d)	47.3	121	353	78.2	206	544	60.5	133.	301
Cholesterol (mg/d)	85.6	169	334	168	298	459	147	204	341
Total energy intake (kcal/d)	1130	1449	2125	1193	1521	1994	1442	1810	2455

†T1-T3, the tertile for the factor scores.
‡Staple food which contains fine processed grain like polished rice, noodle, steamed twisted roll, steamed bread and other fine processed grains and cereals.
§The unit is ml/day.