Original Article

Attenuated associations between increasing BMI and unfavorable lipid profiles in Chinese Buddhist vegetarians

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Obesity is related to hyperlipidemia and risk of cardiovascular disease. Health benefits of vegetarian diets have well-documented in the Western countries where both obesity and hyperlipidemia were prevalent. We studied the association between BMI and various lipid/lipoprotein measures, as well as between BMI and predicted coronary heart disease probability in lean, low risk populations in Southern China. The study included 170 Buddhist monks (vegetarians) and 126 omnivore men. Interaction between BMI and vegetarian status was tested in the multivariable regression analysis adjusting for age, education, smoking, alcohol drinking, and physical activity. Compared with omnivores, vegetarians had significantly lower mean BMI, blood pressures, total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol, total cholesterol to high density lipoprotein ratio, triglycerides, apolipoprotein B and A-I, as well as lower predicted probability of coronary heart disease. Higher BMI was associated with unfavorable lipid/lipoprotein profile and predicted probability of coronary heart disease in both vegetarians and omnivores. However, the associations were significantly diminished in Buddhist vegetarians. Conclusions: Vegetarian diets not only lower BMI, but also attenuate the BMI-related increases of atherogenic lipid/lipoprotein and the probability of coronary heart disease.

Key Words: vegetarian diet, BMI, lipid, lipoprotein, Chinese

INTRODUCTION

The beneficial effects of vegetarian diets on health have been well documented in the Western populations.[1,2] Vegetarian diets were associated with lower plasma total cholesterol (TC) and low-density lipoprotein (LDL), lower prevalence of hypertension and type 2 diabetes, as well as lower cardiovascular and overall mortality.[1-3] The relation between vegetarian diets and health has also been studied in several Asian populations mainly from Taiwan, Hong Kong, South Korea, and Thailand.[4-8] Few studies have been conducted in Mainland China.[9] In China, vegetarianism originates from the Buddhism which has been practiced for centuries. Buddhist vegetarian diet mainly consists of grains (primary rice), vegetables, fruits, and significant amount of soybeans and soybean products. No meat, fish, or poultry is consumed, but small amount of eggs or dairy products may be consumed occasionally. Buddhist monks eat their meals prepared centrally within the temple. They follow restricted vegetarian diets without large variations. Study on this population provides a unique opportunity to examine the impact of vegetarian diets on health.

One of the health hazards in affluent countries is obesity which is associated with unfavorable lipid and lipoprotein profile.[10] Many unfavorable effects of excess weight on lipids and lipoproteins can be reversed with weight reduction.[11] Meta-analysis of 70 weight reduction studies, mostly from the United States, Canada, and Europe, estimated that the product-moment correlations between change in body weight and change in TC, LDL, and high density lipoprotein cholesterol (HDL) were 0.32, 0.29, and -0.32, respectively (all $p<0.05$).[11]

Populations in China are generally leaner and have lower mean TC level than those in Western countries.[12] Within China there are large geographic variations in

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cardiovascular risk factor levels and mortality. Sino-MONICA project reported that the average BMI was 2.5 kg/m^2 higher in men in Beijing (North China) than men in Fujian (South China), where our study participants were located.[13] In 2000-2001, the age-standardized prevalence of hypertension was 10 percentage points and the mean total serum cholesterol (TC) was 0.21 mmol/L higher in the North than in the South.[14,15] There was a 33-fold difference in the incidence of coronary heart disease (CHD) and a 17-fold difference in the incidence of cerebrovascular disease among men living in 17 different areas of the country, lower in the south than in the north.[16] In this report, we studied the association between BMI and lipid profiles in lean populations with low lipid levels in Southern China. We examined whether similar associations that were observed primarily from Western populations with high prevalence of overweight and hyperlipidemia, exist in our populations with low cardiovascular risk. We compared the associations between BMI and lipid profiles among Buddhist vegetarians and among omnivores, and explored whether vegetarian diets modified the BMI-lipids relationship and the impact of the vegetarian diet on the relationship between BMI and lipid/lipoprotein, and between BMI and CHD probability.

MATERIALS AND METHODS

Study participants

A total of 296 men (170 vegetarians and 126 omnivores) aged 21 years or older participated in the study between April and August, 2008 in Xiamen, a coastal city in Fujian province at the southeast corner of China. Vegetarians were recruited from Buddhist monks at the Nan Pu Tuo Temple. It is forbidden to kill any living beings according to Buddhist doctrine. Buddhist monks eat plant foods and no flesh which include meat, poultry, or fish. Milk and egg are allowed, but was not popularly consumed. Omnivore men were recruited from a government administrative office in the same city. Most of these men were office administrators or managers. The omnivores were not on special diets (eg, lipid-lowing or weight-loss diet). Participants signed informed consents, and the study protocol was approved by the Human Research Ethics Committee of the First Affiliated Hospital of Xiamen University.

Data collection

Information was collected on education level, smoking status, alcohol usage, history of hypertension (including antihypertensive medication usage) and diabetes. Diabetes was defined as having a previous clinical diagnosis of diabetes or if the fasting blood glucose was at least 7.0 mmol/L (120 mg/dL). Participants were asked to recall their frequency and duration of time spent in moderate leisure time physical activities (eg, brisk walking, slow jogging, bicycling, dancing, or practicing Taiji) and vigorous activities (eg, long-distance running, playing soccer or badminton, swimming, aerobics, or weight lifting) in the past year. Three leisure time physical activity levels (none, some, and active) were classified. The lowest level ("none") was defined as participating in no physical activity. The highest level ("active") was defined as participating in at least two hours and thirty minutes a week of moderate activities, or at least one hour and fifteen minutes a week of vigorous activities, or an equivalent combination of the two. The intermediate level ("some") was defined as doing some physical activities but not reaching the highest level. Three systolic (SBP) and fifth-phase diastolic blood pressures (DBP) measurements were taken on the right arm with a mercury sphygmomanometer, and the average of the three readings was used in the analysis. Hypertension was defined as SBP $\geq$140 and/or DBP $\geq$90 mmHg or on antihypertensive medication. Body weight was measured by using a spring scale, with participants wearing light clothing without shoes. Height was measured by using a vertical ruler. BMI was calculated as weight in kilogram (kg) divided by height in squared meter (m^2). Overweight (including obesity) was defined as BMI of 25 kg/m^2 or higher.

Participants were asked to fast for at least 10 hours before blood samples were drawn. TC, high-density lipoprotein cholesterol (HDL), and triglycerides were determined by enzymatic methods with automatic multichannel chemical analyzer (Hitachi 7450, Hitachi Corp, Tokyo, Japan). Serum apolipoprotein A-I and apolipoprotein B levels were assessed by the immunoturbidimetric immunoassay using a commercial kit (Daiichi Pure Chemicals Co, Ltd, Tokyo, Japan). Low-density lipoprotein cholesterol (LDL) was calculated by Friedewald's formula.[17]

Dietary assessment was conducted using a simplified semi-quantitative food frequency questionnaire. In China, grains are the staple food consumed every day and even with every meal with little variations for the same individual. The participants were asked about their usual, daily intake of the following staple foods (grains food group): rice, bun, noodle/pasta, and Chinese Pancake. We also asked about the frequency and the quantity of other food items consumed in the week prior to the study. These food items included "red" meats (eg, pork, beef, or liver, including processed or non-processed), poultry, fish, egg, milk, dark green vegetables (eg, kale, broccoli, spinach, mustard greens), non-green vegetables (eg, cauliflower, tomato, squash, turnip, bean sprouts), tofu (soybean) products, and fruits. Fat intakes from cooking oil were estimated through collecting information of the total amount of cooking oil used in the past week in the temple for Buddhist monks and in the family for omnivores. A database for Chinese food composition was used to calculate the daily energy and nutrient intake.[18]

Data analysis

We calculated the absolute 10-year risk of CHD based on the predictive function by Liu *et al*,[19] which is a recalibration of the Framingham function applied to the Chinese population. The factors considered in this function were age, gender, cigarette smoking, diabetes status, SBP, DBP, TC, and HDL. In the two-group comparisons (vegetarians versus omnivores), the Student's t-test was used to compare means of a continuous variable. The chi-square test, Fisher exact test if appropriate, was used to compare the percentages of a categorical variable. Multivariable linear regressions were performed to examine the differences in lipid profiles between the two groups adjusting for multiple covariates. The multivariable regression models

were also used to assess the relationship between dietary intakes and each of the lipid/lipoprotein measure and to examine if the selected food items and the nutrient intakes accounted for the differences in lipid profiles between the two comparison groups.

The association between BMI and a lipid/lipoprotein measure was evaluated by two approaches. Firstly, age-adjusted mean of the lipid/lipoprotein measure was calculated for each BMI tertiles: <22.4, 22.4 - 25.7, and ≥25.7 kg/m^2. Test for trend was performed by linear regression with BMI tertile as an ordinal independent variable. Secondly, BMI was treated as a continuous independent variable in the multivariate regression model adjusting for all the covariates. To examine whether the association between BMI and a lipid/lipoprotein measure was similar between vegetarians and omnivores, we combined the data from vegetarians and omnivores and tested the interaction term, BMI×vegetarian, in the multivariable regression model. Triglycerides and TC/HDL ratio were log-transformed to normalize the distributions in the t-test and linear regression analyses. Two-sided values of $p<0.05$ were considered statistically significant. The analyses were performed with SAS, version 9.2.

RESULTS

Table 1 compares demographics, selected health behaviors, anthropometrics, and laboratory measures between vegetarians and omnivores. The mean age was not significantly different between the two groups. Since omnivores were recruited from the employees of an administrative office, they had much higher education level than monks in this study ($p<0.001$). Very few monks smoked or drank. They had much lower leisure time physical activity level than did omnivores. Mean height and body weight was significantly lower in vegetarians than in omnivores. Mean BMI was marginally (0.8 kg/m^2 or 3.3%, $p=0.042$) lower in vegetarians. Although fewer vegetarians than omnivores were overweight (ie, BMI ≥25 kg/m^2), the difference was not statistically significant. Mean SBP and DBP, as well as prevalence of hypertension was much lower in vegetarians. Diabetes was uncommon in both groups of men. However, mean plasma glucose concentration was significantly lower in vegetarians than in omnivores ($p=0.001$).

Compared with omnivores, vegetarians had significantly lower levels of TC, LDL, and triglycerides ($p<0.001$) (Table 1). Despite a lower mean HDL, vegetarians had a significantly lower TC/HDL ratio than did omnivores ($p=0.006$). Likewise, both apolipoprotein B and apolipoprotein A-I was significantly lower in vegetarians than in omnivores. Overall, vegetarians had a favorable lipid profile. Vegetarians also had a significantly lower 10-year predicted probability of CHD than did omnivores ($p<0.001$) (Table 1). Multivariable regression analyses show that vegetarians still had significantly lower TC, LDL, HDL, TC/HDL ratio, apolipoprotein B and apolipoprotein A-I then did omnivores ($p<0.001$ to $p<0.05$) after adjusting for the difference in either body weight or

Table 1. Characteristics in Buddhist vegetarians and omnivores

	Vegetarian (n=170)		Omnivore (n=126)		*p* value
Characteristics	Mean or %	SD	Mean or %	SD	
Age (year)	32.4	12.6	34.3	6.0	0.092
Education level (%)					<0.001
Less than high school	11.2%		0.0%		
High school	48.2%		2.4%		
College	40.6%		97.6%		
Current smoking (%)	4.1%		38.9%		<0.001
Alcohol drinkers (%)	1.8%		61.9%		<0.001
Physical activity level (%)					0.003
None	33.5%		16.7%		
Some	15.3%		23.8%		
Active	51.2%		59.5%		
Height (cm)	167	7.0	171	5.4	<0.001
Weight (kg)	66.4	13.3	71.7	8.9	<0.001
BMI (kg/m^2)	23.6	4.0	24.4	2.7	0.042
Weight category (%)					0.308
Normal	61.8%		56.4%		
Overweight†	38.2%		43.7%		
Systolic blood pressure (mmHg)	117	16.5	126	14.7	<0.001
Diastolic blood pressure (mmHg)	71.3	10.5	79.2	10.0	<0.001
Hypertension (%)	10.0%		26.6%		0.010
Glucose (mmol/L)	4.87	2.07	5.06	0.69	0.001
Diabetes (%)	2.4%		2.4%		0.988
Total cholesterol (mmol/L)	4.26	0.63	5.04	0.92	<0.001
LDL (mmol/L)	2.58	0.58	3.11	0.80	<0.001
HDL (mmol/L)	1.13	0.21	1.23	0.22	<0.001
Total cholesterol/HDL ratio	3.87	0.86	4.24	1.19	0.006
Triglycerides (mmol/L)	1.20	0.89	1.54	1.50	0.008
Apolipoprotein B (g/L)	0.75	0.15	0.88	0.20	<0.001
Apolipoprotein A-I (g/L)	1.07	0.12	1.23	0.14	<0.001
10-year CHD probability	0.57	1.14	0.94	1.03	<0.001

†Defined as body mass index ≥ 25 kg/m^2. Abbreviations: SD=Standard deviation.

Table 2. Daily intakes of selected food items and macronutrients in Buddhist vegetarians and Omnivores

	Vegetarian		Omnivore		*p* value
	Mean or %	SD	Mean or %	SD	
Food items					
Grains (g/day)	304	117	365	165	0.001
Meat					
Red meat (%)	0		94.4		<0.001
Red meat (g/day)	0		79.1	72.4	<0.001
Poultry (%)	0		72.2		<0.001
Poultry (g/day)	0		24.1	31.7	<0.001
Fish (%)	0		93.7		<0.001
Fish (g/day)	0		64.7	78.0	<0.001
Egg (%)	2.4		93.7		<0.001
Egg (g/day)	0.7	5.9	41.0	19.2	<0.001
Milk (%)	4.1		68.3		<0.001
Milk (g/day)	11.7	117	85.1	81.6	<0.001
Vegetable (g/day)					
Dark green	330	201	239	169	<0.001
Non-green	228	163	136	106	<0.001
Fruit (g/day)	134	120	132	78.6	0.873
Soybean product (g/day)	35.4	26.9	22.1	21.4	<0.001
Nutrient Intakes					
Energy (kcal)	1,775	503	2,364	642	<0.001
Carbohydrate (in % en)	60.4	7.8	57.3	7.3	<0.001
Protein (in % en)	11.8	2.3	15.1	3.0	<0.001
Total fat (in % en)	28.7	8.3	27.5	5.5	0.155
SFA (in % en)	6.3	2.2	8.4	2.4	<0.001
MUFA (in % en)	8.9	2.6	9.3	2.2	0.074
PUFA (in % en)	13.6	4.4	9.9	1.9	<0.001
P/S ratio	2.3	0.7	1.3	0.4	<0.001
Cholesterol (mg)	15.2	48.3	285	156	<0.001
Fiber (g)	17.3	16.2	16.5	15.4	0.339

Abbreviations: SD=Standard deviation; en, energy; P/S ratio=ratio of PUFA to SFA.

BMI, as well as age, education, current smoking, alcohol intake, and levels of physical activity. However, triglycerides level was no longer statistically different ($p>0.05$) between the two groups in the multivariate analysis.

The estimated daily intakes of selected food items and macronutrients are shown in Table 2. Buddhist monks consumed significantly less grains as the staple foods than did omnivores. They did not eat any meat or fish and very few of them reported eating eggs and milk. In Buddhist monks, the daily combined intakes of fruits and vegetables were more than double of that of grains. As expected, vegetarians consumed significantly more soybean product than did omnivores. Although most of the omnivores in this study ate meat, fish, eggs, and milk, the amounts of consumption were moderate. Buddhist monks consumed significantly less energy and percentage of energy from protein, but higher percentage of energy from carbohydrate. Although there was no significant difference in the percentage of energy consumption from fat between the two groups of men, vegetarians consumed significantly less saturated fatty acid (SFA) and more polyunsaturated fatty acid (PUFA) than did omnivores. Thus, the PUFA to SFA (P/S) ratio was much higher in vegetarians than in omnivores. Multivariable regression analyses found that energy intake was positively associated with LDL ($p=0.025$) and apolipoprotein B ($p=0.016$). However, no significant association was found between individual food item and nutrient with each lipid/lipoprotein measure ($p>0.05$). The differences between Buddhist monks and omnivores remained statistically significant in the lipid/lipoprotein measures (except triglycerides), after adjusting for the differences in the intakes of food items and nutrients as well as other covariates.

The age-adjusted means of lipid/lipoprotein measures by tertile of BMI are presented in Table 3. For both vegetarians and omnivores, higher BMI tertile was significantly associated with higher TC, TC/HDL ratio, triglycerides, and apolipoprotein B, and lower HDL and apolipoprotein A-I. However, the *p* values for trends were smaller among omnivores than among vegetarians for TC, LDL, HDL, and apolipoprotein A-I indicating larger impacts of BMI on these lipid/lipoprotein measures in omnivores. The estimated average 10-year probability of CHD significantly increased with higher BMI tertile among omnivores but not among vegetarians.

To compare with the findings in literature,[11] we performed bivariate correlation analyses. The correlations between body weight and TC, LDL, and HDL were 0.31, 0.19, and -0.20, respectively (all $p<0.05$) among omnivores. Most correlations were much lower among Buddhist vegetarians, ie, 0.09 ($p=0.24$), -0.07 ($p=0.38$), and -0.23 ($p<0.05$), for the three lipid measures, respectively.

Table 4 presents the results of multivariable analyses of association between BMI (as a continuous variable) and lipid/lipoprotein measures adjusting for age, education, smoking, drinking, and physical activity. The β coefficients (ie slope) of BMI were smaller among vegetarians than those among omnivores for all measures. For example, β coefficients of BMI was 0.023 ($p=0.063$) for TC

Table 3. Age-adjusted means of lipids and lipoproteins by tertile of BMI in Buddhist vegetarians and omnivores

	BMI						*p* for trend
	1st tertile		2nd tertile		3rd tertile		
	Mean	SE	Mean	SE	Mean	SE	
Total cholesterol (mmol/L)							
Vegetarian	4.08	0.07	4.42	0.10	4.36	0.08	0.006
Omnivore	4.59	0.16	5.08	0.11	5.28	0.13	<0.001
LDL (mmol/L)							
Vegetarian	2.53	0.07	2.65	0.09	2.58	0.08	0.577
Omnivore	2.84	0.15	3.26	0.10	3.07	0.12	0.062
HDL (mmol/L)							
Vegetarian	1.18	0.02	1.14	0.03	1.07	0.02	0.018
Omnivore	1.41	0.04	1.20	0.03	1.16	0.03	<0.001
Total cholesterol/HDL ratio							
Vegetarian	3.50	0.09	4.06	0.12	4.19	0.10	<0.001
Omnivore	3.32	0.20	4.29	0.14	4.76	0.17	<0.001
Triglycerides (mmol/L)							
Vegetarian	0.82	0.10	1.39	0.13	1.55	0.11	<0.001
Omnivore	0.75	0.27	1.36	0.19	2.31	0.22	<0.001
Apolipoprotein B (g/L)							
Vegetarian	0.69	0.02	0.78	0.02	0.80	0.02	<0.001
Omnivore	0.76	0.03	0.91	0.02	0.93	0.03	<0.001
Apolipoprotein A-I (g/L)							
Vegetarian	1.09	0.01	1.08	0.02	1.04	0.01	0.044
Omnivore	1.31	0.03	1.21	0.02	1.21	0.02	0.005
10-year CHD probability							
Vegetarian	0.48	0.10	0.67	0.13	0.62	0.11	0.454
Omnivore	0.46	0.16	0.95	0.11	1.24	0.13	0.002

BMI 1st tertile: <22.4; 2nd tertile: 22.4 - 25.7; and 3rd tertile: ≤25.7 kg/m^2.
Abbreviations: SE=Standard error.

Tables 4. Association between BMI and lipid/lipoprotein measures in Buddhist vegetarians and Omnivores

Dependent variables	Vegetarians			Omnivores			*p* for interaction†
	β	SE	*p*	β	SE	*p*	
Total cholesterol (mmol/L)	0.023	0.012	0.063	0.125	0.031	<0.001	<0.001
LDL cholesterol (mmol/L)	0.001	0.011	0.953	0.045	0.029	0.121	0.012
HDL cholesterol (mmol/L)	-0.012	0.004	0.002	-0.022	0.001	0.009	0.233
Total cholesterol/HDL ratio	0.072	0.015	<0.001	0.187	0.041	<0.001	<0.001
Triglycerides (mmol/L)	0.074	0.016	<0.001	0.221	0.054	<0.001	0.026
Apolipoprotein B (g/L)	0.010	0.003	0.001	0.026	0.007	<0.001	0.002
Apolipoprotein A-I (g/L)	-0.004	0.002	0.079	-0.007	0.005	0.221	0.502
10-year CHD probability	0.019	0.015	0.217	0.079	0.027	0.004	0.045

†*p* value for BMI × vegetarian interaction.
Abbreviations: β=regression coefficient for body mass index; SE=standard error of β.

among vegetarians, while it was 0.125 (p<0.001) among omnivores. We examined whether the two slopes differed significantly between the two comparison groups by testing the interaction term, BMI×vegetarian, in the multivariate regression model. Almost all interaction terms were statistically and negatively significant (except for HDL-C and apolipoprotein A-I), indicating that the associations between BMI and lipid/lipoprotein measures were less pronounced among vegetarians than among omnivores. Likewise, increasing BMI was significantly associated with increasing probability of CHD in omnivores (β=0.079, p=0.004), but not in vegetarians (β=0.019, p=0.217) and the BMI-vegetarian interaction was statistically significant (p=0.045).

DISCUSSION

This study showed that despite a lower socio-economic status (eg, education) and physical activity level compared with omnivores, Chinese Buddhist vegetarians had a significantly lower cluster of cardiovascular risk factors, including BMI, blood pressure, plasma glucose, and lipid/lipoprotein profile, as well as the predicted probability of CHD. BMI was positively associated with plasma TC, TC/HDL ratio, triglycerides, and apolipoprotein B, while inversely associated with HDL in both group of men including Buddhist monks with a low lipid/lipoprotein level. However, vegetarian diets modified the associations between BMI and lipid/lipoprotein, as well as between BMI and probability of CHD. These associations were attenuated among Buddhist vegetarians.

Our data show that the adverse effect of increasing body weight on lipid and lipoprotein profile found in Western countries also existed in the lean and low risk populations in southern China.[11] The product-moment correlations between body weight and TC, LDL, and HLD among omnivores were similar to those reported in the meta-analysis.[11] However, the correlations were much smaller among Buddhist vegetarians. Although our observation study cannot be directly compared with the meta-analysis on weight reduction studies, it appears that weaker weight-lipids relationships were apparent in vegetarians with lower intake of meat, total fat (especially SFA and cholesterol), and higher intake of plant foods.

With few exceptions,[6] most epidemiologic studies have shown that vegetarians are thinner than non-vegetarians.[20, 21] A meta-analysis estimated that the mean weight for male vegetarians was 7.6 kg less than non-vegetarians, which resulted in a 2 kg/m^2 lower BMI.[21] Berkow *et al* reviewed 40 studies mostly from the United States, Europe, and Australia, reporting that the weight of male vegetarians ranged from 4.6 kg to 12.6 kg lower, and BMI ranged from 4.6% to 16.3% lower than that of male non-vegetarians.[20] In our study the average weight was 5.3 kg lower and BMI was 0.8 kg/m^2 (3.3%) lower in Buddhist monks than omnivorous men. These differences were smaller to those observed in Western populations. Omnivores in our study were highly educated administrators and could have been more health conscious. They had a much higher level of leisure time physical activity than did Buddhist monks. Although omnivores ate animal products, carbohydrates were still the main nutrients consumed with an energy contribution of 57%, whereas fats contributed to less than 30% of the total energy intake. Hence, the beneficial impact of vegetarian diet may be underestimated in our study.

Buddhist vegetarianism in China excludes all animal products as well as vegetables in the Allium family such as onion, garlic, scallions, and leeks.[22] Although the Buddhist monks can be defined as lacto-vegetarians, very few of them consume milk. Monks consumed soybean products as the major source of dietary protein. This dietary pattern differs from the Western vegetarian diets that contain more nuts, seeds, dairy products and eggs.[23] The P/S ratio was 2.3 in the Buddhist monks. An increasing body of literature suggests that soy protein and its isoflavones may have a beneficial role in obesity.[24] Several intervention studies indicate that consumption of soy protein reduces body weight and fat mass in addition to lowering plasma cholesterol and triglycerides.[24]

Although a favorable plasma lipid and lipoprotein profile has been reported for persons whose habitual diet is high in carbohydrate and low in fat, some authors have concern about reports of a decrease in HDL.[25] On average, HDL and apolipoprotein A-I levels were lower in Buddhist monks than in omnivores. Omnivores in our study had a much higher physical activity level and more alcohol drinkers than did monks. These could contribute, as least in part, to the relatively lower HDL-C and apolipoprotein A-I concentrations observed in monks as compared with omnivores. Mortality studies in populations who consumed low-fat vegetarian diets, such as American Seventh-Day Adventists and persons living in China suggested that decreased HDL associated with low-fat vegetarian diets was not associated with poor cardiovascular health.[26,27] Our study also shows that despite a lower level of HDL-C, Buddhist vegetarians had a lower predicted probability of CHD as compared with omnivores.

It is surprising to note that although the diet of Buddhist was based mostly on plant foods and grains, the total fat intake in Buddhist vegetarians was similar to that in omnivores. In China, eating raw vegetables (ie, salad) is uncommon. The most common method of cooking vegetables is to stir fry them with non-hydrogenated vegetable oil. Some authors found a positive association between intake of vegetable-rich food pattern and obesity in China due to liberal use of vegetable oil for cooking vegetables resulting in a high intake of energy.[28] Such vegetable-rich patterns considered to be healthy in the Western diets may lead to a risk of over consumption in terms of energy relative to energy needs in China. Hence, when making recommendation on vegetable intake in the Chinese context, consumption of vegetable oil and cooking method should be considered.[28]

China has been undergoing rapid socioeconomic development in the past 30 years. Although this has resulted in a marked increase in the standard of living in the country, China is facing an obesity epidemic. During a short 10-year period from 1992 through 2002, the combined prevalence of overweight and obesity increased from 14.6% to 21.8% in adults.[29] The traditional diet in South China contained high complex carbohydrates (eg, rice) and dietary fiber (eg, cereals, starchy roots), fresh fruits, and vegetables, with few meat and animal foods. However, China is undergoing a remarkably fast, yet undesirable, nutritional transition dominated by increasing intake of processed food, meat, high-fat and energy-dense foods.[30] Prosperous economic growth, commercialization, and availability of foods resulted in more people eating out or eating out more often. By international standards, both the incidence and mortality rate of CHD in China, especially in the south, were low.[16] However, with increasing industrialization and urbanization, major lifestyle changes have been occurring in China. It has been predicted that if the unfavorable trends in BMI, obesity, cholesterol, and blood pressure in the population continue together with population aging and growth, cardiovascular disease will increase more than a half over the coming 20 years.[31] The results of the present study reveal the important role of dietary factors on obesity and lipid profile and ultimately on the prevention of the cardiovascular disease epidemic, in the current low risk Chinese population.

There are several limitations of this study. Firstly, this is a cross-sectional study. We cannot establish causal relationship through observed associations. Secondly, besides diets, there were other life-style and behavior differences (including religion) between Buddhist monks and the compared men. Differences in these factors may affect the observed differences in BMI-lipid/lipoprotein relationships between the two groups. Finally, the control participants in this study were recruited from a government administrative office and were not random samples of the general populations. Healthy employee effect may underestimate the true impact of vegetarian diet.

In conclusions, increasing BMI was associated with unfavorable lipid profile and increasing probability of CHD in lean populations with low cardiovascular risk in South China. Vegetarian diets not only lower BMI, but also attenuate the BMI-related increases of atherogenic lipid/lipoprotein and the probability of CHD.

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AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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Original Article

Attenuated associations between increasing BMI and unfavorable lipid profiles in Chinese Buddhist vegetarians

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素食膳食影响中国人的 BMI 及相关的血脂代谢水平

肥胖往往伴随着血脂升高和心血管疾病的风险增加。在肥胖和高脂血症高发的西方国家，素食已经被证实能够给患者带来益处。本文着重探讨低心血管风险的中国南方人的 BMI 和血脂代谢水平，以及其与心血管风险预测值的关系。本研究共纳入 170 名素食者和 126 普通饮食的正常男性，运用交互作用多元回归等统计方法探讨 BMI 和心血管多种危险因素的关系。结果显示，素食组的 BMI、血压、總胆固醇、LDL 胆固醇、HDL 胆固醇、總胆固醇/HDL 胆固醇、三酸甘油酯、载脂蛋白 B、载脂蛋白 A-I，以及心血管风险预测值等均明显比普通饮食组較低。不管是素食组或者普通饮食组，随着 BMI 升高，研究对象的血脂水平和心血管风险预测值均呈现升高的趋势。然而，相比于普通饮食组，素食组 BMI 与血脂水平和心血管风险预测值的交互作用明显下降。结论：素食不仅降低研究对象的 BMI 水平，同时能够改善 BMI 相关的血脂紊乱和心血管风险增加。

关键词：素食、BMI、血脂、血脂蛋白、中国人群