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Prevalence and Determinants of Hyperlipidemia in Moderate Altitude Areas of the Yunnan-Kweichow Plateau in Southwestern China

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Abstract

Deng, Bingjun, Tingguang Luo, Yanfei Huang, Tianhang Shen, Jing Ma. Prevalence and determinants of hyperlipidemia in moderate altitude areas of the Yunnan-Kweichow Plateau in Southwestern China. *High Alt. Med. Biol.* 13:13–21.—The objective of the current study was to determine the prevalence and determinants of hyperlipidemia among the populations living at moderate altitude on the Yunnan-Kweichow Plateau in Southwestern China. We randomly recruited 1415 people for this study. These subjects underwent a physical examination and a comprehensive questionnaire regarding their daily habits and diets. Furthermore, blood samples from the participants were collected for assessing the lipid profile. We found that 49.3% of participants (95% CI: 46.7–51.9%) suffered from hyperlipidemia. The prevalence in men was significantly higher than that in women (53.6% vs. 44.7%, $p < 0.01$). The prevalence of hypercholesterolemia was 23.3% and of hypertriglyceridemia was 34.1%. Low HDL-C showed a prevalence of 17.5% and high LDL-C of 9.0%. The prevalence of hyperlipidemia also increased with age, as did the prevalence of high TC, TG, and LDL-C. Hyperlipidemic subjects tended to be older and have a higher BMI and WHR than the normolipidemic subjects in the study cohort ($p < 0.05$). The hyperlipidemic subjects, both men and women, tended to dine out often and consume more animal-based foods and alcohol. In addition, the hyperlipidemic men in our cohort consumed more salted food then their normolipidemic counterparts ($p < 0.01$). Normolipidemic subjects of both sexes were also found to prefer a vegetarian diet ($p < 0.01$). Age, alcohol consumption, a preference for meat and animal products, regular dining out, and BMI were found to be the main determinants of hyperlipidemia in women, whereas a prevalence of salted food was observed to be related to hyperlipidemia in men from the Yunnan-Kweichow Plateau subpopulation under study ($p < 0.05$). The average daily energy, and protein and fat intakes of the sampled subjects were also higher than the levels set by the Chinese Recommendation Nutrient Intakes (RNI), while hyperlipidemic subjects had an even higher average daily intake of total fat, cholesterol, and lower dietary fiber compared with the normolipidemic subjects in the study group ($p < 0.05$). In conclusion, this study reveals a higher prevalence of hyperlipidemia, hypercholesterolemia, hypertriglyceridemia, increased BMI and WHR values in men, as well as a slightly higher prevalence of low HDL-C and high LDL-C in women from Yunnan-Kweichow Plateau. The incidence of hyperlipidemia also increased with age, as did the prevalence of an abnormal TC, TG, LDL-C, and WHR in our study cohort. A high BMI, and less healthy living habits and dietary preferences thus play significant roles in the onset of hyperlipidemia.

Key Words: hyperlipidemia; moderate altitude; lifestyle; dietary pattern.

Introduction

Cardiovascular disease (CVD) has become the most common cause of mortality in many countries in recent decades. Coronary heart disease (CHD) is therefore the most frequent cause of morbidity, mortality, and loss of potentially functional life years (Mohanna et al., 2006). In China, from 1980 to 2000, the mortality associated with CHD increased

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from 386 to 713 per million in urban areas, and from 186 to 316 per million in rural areas, and approximately 3.8 million Chinese people suffered from CHD in 1991 (Wu et al., 2003). Among the various risk factors, and as a component of metabolic syndrome, hyperlipidemia plays an important role in the onset and progression of CHD. Changes in the serum lipoprotein profile are associated with an altered risk of CHD (i.e., +1% cholesterol, +2%–3% risk; +1% LDL-C, +1.2%–2.0% risk; −1% HDL-C, +3% risk) (Anderson et al., 2001). Results from recent trials have also shown that premature death and disability from CHD can be decreased by increasing the number and type of patients receiving lipid-lowering therapy (Cannon et al., 2004; Colhoun et al., 2004; Sever et al., 2003).

Although genetic predisposition has been suggested to be an important determinant of hyperlipidemia (Andreotti et al., 2009; Liao et al., 2008; Willer et al., 2008), genetic factors alone cannot explain the recent increase in prevalence of hyperlipidemia and CHD. Unhealthy living habits and an unbalanced diet have been identified as the most significant risk factors for development of hyperlipidemia and for which an intervention can be most effectively designed (Mohanna et al., 2006).

Since altitude has been reported to be associated with risk factors for CHD such as obesity (Sherpa et al., 2010), physical activity, and diet, we predict that the lipid distribution may differ among people with varied altitudes. Many studies on the prevalence and the related factors associated with hyperlipidemia have now been conducted in China and other countries, but a survey of populations living at moderate altitude on the Yunnan-Kweichow Plateau, Southwestern China are few, particularly in relation to lifestyles and dietary preferences.

The aims of our present study were to determine the prevalence of hyperlipidemia and related risk factors of abnormal lipid profiles in a subpopulation living at a moderate altitude (1500–2500 m) on the Yunnan-Kweichow Plateau in Southwestern China.

Materials and Methods

Study population

A cross-sectional study was conducted from July to October 2010 among a sample group of residents living at a moderate altitude in mountainous rural areas of Yunxian County (Yunnan province), known as the Yunnan-Kweichow Plateau, in Southwestern China. Three towns (Yongbao, Dachaoshanxi, and Chafang) located at 1500–2500 m above the sea level were selected randomly from a total of nine in this area, and two groups of resident committees were chosen randomly from each selected town. Individuals who had resided for more than 10 years continuously in the selected committees, and were 20 years of age or older were recruited into the study cohort. Pregnant women and those who were mentally or physically unfit to undergo the study were excluded, including individuals with psychiatric disorders, hypophrenia, paralysis, and cancer. Subjects out of the random selection list who had volunteered were also rejected. A total of 1430 subjects were eventually invited to participate. Only 15 persons (1.0%) in this group declined to participate due to time constraints. The final study cohort comprised 724 men and 691 women aged 22–84 years.

Tests include a physical examination, completion of a comprehensive questionnaire, and plasma lipid profiles. All data were collected by trained medical personnel. The study was approved by a Regional Ethics Committee and verbal informed consent was obtained from all participants.

Measurements and data collection

A formal invitation letter was sent to appropriate local departments one month prior to commencing the study. This correspondence outlined the objectives of the survey and provided details regarding administration and procedures. The selected participants were asked to gather at a designated address of the resident committee. Anthropometric measurements including weight, height, and waist and hip circumference were taken. The body mass index (BMI) and waist-to-hip ratio (WHR) were also calculated for the participants. In addition, all participants completed a five-page questionnaire on their sociodemographic characteristics, personal and family medical history, medications, smoking habits, alcohol consumption, physical activities, and dietary habits. A validated quantitative food frequency questionnaire was also included. Some of the questions were modified to suit local customs and language. The ages of the participants were divided into five groups: 20–30, 31–40, 41–50, 51–60, and 61 + years. Ethnicity was classified as Han or Minority. Cigarette smoking was categorized as "yes" (occasional or daily smokers) or "no" (nonsmokers or ex-smokers). Data on the frequency of alcohol consumption were obtained by asking the question "Do you drink alcoholic beverages at least once a week and has this been the case for more than 6 months?" Physical activity was defined as taking exercise or participating in physical labor activities more than twice each week for at least 30 minutes each time. In accordance with the Dietary Guidelines of China, we defined seven food groups for the purposes of this study: cereals, vegetables, fruits, nuts, beans, animal foods (for which the subgroups are milk products, meat, fish, and eggs) and others (coffee, tea, drink, and edible oil). A total of 71 kinds of food were included in our food frequency questionnaire. There were four levels of frequency to choose on the survey: never, daily, weekly, and monthly. Data were obtained by asking "Do you eat…?", "How often do you eat…?" and "How many do you eat…per time?" Bowl, cup, spoon, and food photographs were used to assist the participant in estimating their food intake levels. Dietary data were converted into nutriment data using Food Calculator software 2.1 (Chinese Center for Disease Control and Prevention, Beijing, China).

Laboratory measurements

Venous blood samples were collected following fasting for 8–12 hours and with no alcohol consumption from the previous night. Samples were then clotted at room temperature and centrifuged at 2000 rpm for 15 min. Serum obtained was then subjected to the measurements of total serum cholesterol (TC), triglyceride (TG), high density lipoprotein-cholesterol (HDL-C), and low density lipoprotein-cholesterol (LDL-C). These biomarkers were assayed using an automated biochemical analyzer (Hitachi, 7080, Tokyo, Japan). The concentrations of TC and TG were determined using enzymatic colorimetric tests. HDL-C and LDL-C concentrations were measured by direct methods. Commercial kits were purchased from the Sichuan Maker Biotechnology Co. Ltd., (Chengdu, China). The analyzers were calibrated each morning using a standard liquid. All laboratory analyses were carried out at the Department of Clinical Chemistry, People's

Hospital of Yunxian County, Yunnan Province, China. This laboratory routinely participates in formal quality assurance exercises.

Definitions

In accordance with the guidelines for dyslipidemic prevention and treatment in Chinese adults (Joint Commission, 2007), hyperlipidemia was defined as meeting at least one of the following three criteria: hypercholesterolemia, TC ≥ 5.18 m*M*; hypertriglyceridemia, TG ≥ 1.70 m*M*; low HDL-C, HDL-C < 1.04 m*M*. Other definitions included high LDL-C (≥ 3.37 m*M*); abnormal BMI (≥ 24.0 kg/m^2); and an abnormal WHR [> 0.92 (men); > 0.81(women)].

Statistical analysis

SPSS statistical software package version 11.5 (SPSS, Inc., Chicago, IL) was utilized to perform statistical analyses. The data are expressed as the mean ± standard deviation (SD) or frequencies at 95% confidence intervals (95% CI) and were calculated for all prevalence estimates. Interval-scaled, normally distributed data were analyzed using the Student's *t* test to investigate differences between two groups (e.g., hyperlipidemia and normolipidemia). Qualitative data and data not normally distributed were analyzed using the Mann Whitney U-test, chi-square test. Multiple logistic regression analysis was applied to evaluate ordinary characteristics, lifestyle, and physiological markers (independent factors) in relation to the incidence of hyperlipidemia (independent factors). A two-sided *p* value of less than 0.05 was considered to be statistically significant. Sample size calculations were based on a previous prevalence study of hyperlipidemia in Yunxian County (Deng et al., 2011). Given an estimated prevalence of hyperlipidemia of 50%, a maximum relative error of 25% was set for estimators, with a confidence interval of 95%. A sample size of 1430 subjects was thus estimated to be required for statistical purposes. To facilitate comparisons with other studies, age-standardized prevalence estimates for the total subpopulation, separately for men and women are presented, and were calculated in accordance with the reported age and gender composition of the Chinese population in 2007.

Results

Characteristics of the study cohort

Of the 1430 participants selected, 1415 subjects (corresponding to 99.0% of all those invited) comprising 724 men and 691 women completed all interviews and tests. The ethnic composition of the cohort was 51% Han and 49% other minorities, including Yi, Bulang, Lahu, Dai, Miao, Hui, Lisu, Wa, and Naxi. The broad characteristics of this cohort are listed in Table 1. Women in this group tended to be older and have a lower level of education. A higher proportion of the single, divorced, and widowed participants were also women. Men were more likely to be smokers, alcohol consumers, and more frequently to take exercise or participate in physical labor.

Prevalence of hyperlipidemia in the study cohort

Among the 1415 subjects who lived at moderate altitudes (1500–2500 m) in Yunxian County, 697 (49.3%, 95%CI: 46.7–51.9%) were found to suffer from hyperlipidemia.

Table 1. Ordinary Characteristics of the Study Participants

	Total		*Men*		*Women*		
Characteristic	n	%	n	%	n	%	p
Age (years)							< 0.001**
20–30	135	9.5	50	6.9	85	12.3	
31–40	517	36.5	312	43.1	205	29.7	
41–50	410	29.0	214	29.6	196	28.4	
51–60	173	12.2	61	8.4	112	16.2	
61 +	180	12.7	87	12.0	93	13.5	
Ethnicity							0.314
Han	732	51.7	384	53.0	348	50.4	
Minority	683	48.3	340	47.0	343	49.6	
Marital status							0.037*
Single	94	6.6	35	4.8	59	8.5	
Married	1306	92.3	684	94.5	622	90	
Divorced	8	0.6	3	0.4	5	0.7	
Widow(er)	7	0.5	2	0.3	5	0.7	
Education							0.001**
Never	21	1.5	6	0.8	15	2.2	
Elementary school	116	8.2	38	5.2	78	11.3	
Junior-middle school	348	24.6	171	23.6	177	25.6	
Senior-high school	386	27.3	220	30.4	166	24.0	
Higher	544	38.4	289	39.9	255	36.9	
Current smoking	476	33.6	414	57.2	62	9.0	< 0.001**
Current drinking	557	39.4	461	63.7	96	13.9	< 0.001**
Exercise or physical labor	806	57.0	439	60.6	367	53.1	0.004**
Total	1415	100.0	724	100.0	691	100.0	

*$p < 0.05$, **$p < 0.01$, men compared with women.

Table 2. Proportion of Abnormal Physiological or Biochemical Marker Profiles by Age Group and Sex

	Age-groups											
	20–30years (n=135)		*31–40years (n=517)*		*41–50years (n=410)*		*51–60years (n=173)*		*61 and over (n=180)*		*Total (n=1415)*	
	%	*95% CI*	*%*	*95% CI*	*%*	*95% CI*	*%*	*95% CI*	*%*	*95% CI*	*%*	*95% CI*
Men												
TC	10.0	1.7–18.3	21.8	17.2–26.4	36.4	30.0–42.8	37.7	25.5–49.9	37.9	27.7–48.1	28.6	25.3–31.9
TG	32.0	19.1–44.9	41.3	35.8–46.8	45.3	38.6–52.0	42.6	30.2–55.0	50.6	40.1–61.1	43.1	39.5–46.7
HDL-C	16.0	5.8–26.2	15.1	11.1–19.1	17.3	12.2–22.4	14.8	5.9–23.7	14.9	7.4–22.4	15.7	13.0–18.4
LDL-C	6.0	0.0–12.6	6.4	3.7–9.1	8.4	4.7–12.1	8.2	1.3–15.1	10.3	3.9–16.7	7.6	5.7–9.5
BMI	32.0	19.1–44.9	43.9	38.4–49.4	53.7	47.0–60.4	41.0	28.7–53.3	57.5	47.1–67.9	47.4	43.8–51.0
WHR	36.0	22.7–49.3	35.6	30.3–40.9	58.4	51.8–65.0	37.3	25.5–49.9	59.8	49.5–70.1	45.4	41.8–49.0
Women												
TC	9.4	3.2–15.6	17.6	12.4–22.8	19.9	14.3–25.5	20.5	13.0–28.0	17.2	9.5–24.9	17.7	14.9–20.5
TG	25.9	16.6–35.2	22.4	16.7–28.1	20.9	15.2–26.6	25.0	17.0–33.0	35.5	25.8–45.2	24.6	21.4–27.8
HDL-C	15.3	7.6–23.0	20.5	15.0–26.0	19.4	13.9–24.9	13.4	7.1–19.7	28.0	18.9–37.1	19.4	16.5–22.3
LDL-C	5.9	0.9–10.9	8.3	4.5–12.5	8.7	4.8–12.6	16.1	9.3–12.9	16.1	8.6–23.6	10.4	8.1–12.7
BMI	21.2	12.5–29.9	25.4	19.4–31.4	24.0	18.0–30.0	29.5	21.1–37.9	21.5	13.2–29.8	24.6	21.4–27.8
WHR	29.4	19.7–39.1	35.6	29.0–42.2	33.7	27.1–40.3	39.3	30.3–48.3	38.7	28.8–48.6	35.3	31.7–38.9

CI, confidence interval.

Among the participants with hyperlipidemia, 14.1% had hypercholesterolemia (98/697), 25.1% had hypertriglyceridemia (175/697), mixed hyperlipidemia was found in 45.6% (318/697), and 15.2% showed low HDL-C (106/697). The prevalence of hyperlipidemia in men was 53.6% (388/724) and in women was 44.7% (309/691). This gender difference was found to be statistically significant (($^2=11.138$, $p=0.001$). After standardization using the reported demographics for the whole population of China in 2007 for age and gender, the prevalence of hyperlipidemia was determined to be 49.0% for the whole study cohort (54.2% of the men and 44.8% of the women).

Profiles of the physiological and biochemical markers of hyperlipidemia among the study participants

The prevalence of high TC, TG, or LDL-C was found to increase with age in both sexes in the study cohort (Table 2), as did the overall prevalence of hyperlipidemia. The prevalence of hyperlipidemia was similar in the men and women in the youngest age group of the cohort (36.0% vs. 36.5%), but was higher in the men in the older age groups (Fig. 1).The WHR also showed a similar change in the men and women in the study group, but this trend was not obvious for the HDL-C and BMI markers. The incidence of a higher BMI and WHR was clearly higher in the men.

Age, BMI, and WHR characteristics of the study cohort

The male participants showed higher BMI and WHR values and these differences were statistically significant (BMI: $t=8.785$, $p<0.001$; WHR: $t=20.664$, $p<0.001$). Statistical significance was also observed for the participants with higher age, BMI, and WHR values of the hyperlipidemic subjects when compared with the normolipidemic subjects regardless of sex (Table 3).

Lifestyle and dietary characteristics of the study cohort

A high frequency of dining out, and an increased consumption of animal-based food products and alcohol were associated with hyperlipidemia in both sexes in our study cohort, but this was more pronounced in men. The intake of salted foods was significantly higher in hyperlipidemic compared with normolipidemic male subjects, whereas the rate of smoking was significantly higher in hyperlipidemic compared with normolipidemic female subjects. In addition, we found that a vegetarian diet was more prominent among normolipidemic subjects, regardless of genders (Table 4).

Determinants of hyperlipidemia

Based on the aforementioned results, the following variables were tested as determinants of hyperlipidemia using multiple logistic regression analysis: age, gender, smoking status, current alcohol consumption, consumption of animal-based foods, vegetarian dietary preference, consumption of salted food, frequency of dining out, BMI, and WHR. These analyses revealed that a higher age and alcohol intake, consumption of animal-based foods, regular dining out and a higher BMI were the main determinants of hyperlipidemia in

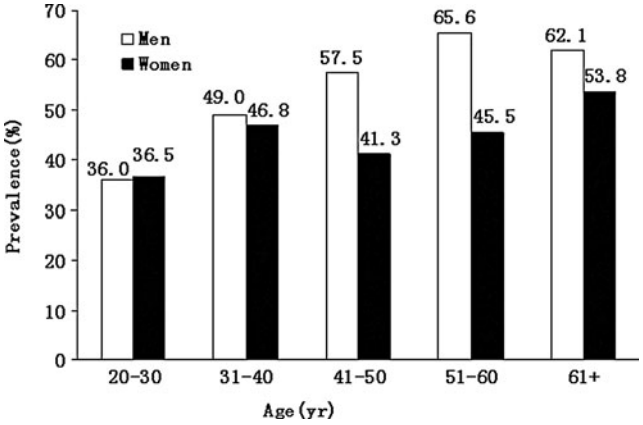

FIG. 1. Sex-specific prevalence of hyperlipidemia by age groups.

Table 3. Characteristics of Participants with and without Hyperlipidemia

	BMI		*WHR*		*Age*	
	Men	*Women*	*Men*	*Women*	*Men*	*Women*
Total ($n=1415$)	23.8 ± 3.4	22.3 ± 2.7	0.89 ± 0.08	0.82 ± 0.06	43.2 ± 11.3	45.3 ± 13.5
Hyperlipidemia ($n=697$)	24.7 ± 3.3	23.1 ± 3.0	0.91 ± 0.07	0.83 ± 0.07	44.7 ± 11.3	46.5 ± 14.3
Normalipidemia ($n=718$)	22.7 ± 3.2	21.7 ± 2.4	0.87 ± 0.08	0.81 ± 0.05	41.5 ± 11.1	44.4 ± 12.7
t	−8.462	−6.468	−7.439	−4.252	−3.832	−2.027
P	< 0.001**	< 0.001**	< 0.001**	< 0.001**	< 0.001**	0.043*

Data are the means ± standard deviation (SD).
*$p<0.05$, **$p<0.01$, hyperlipidemic compared with normalipidemic subjects.

the female participants in our study cohort. In the men from this group, we found that a preference for salted food instead of animal-based food was most strongly related to hyperlipidemia (Table 5).

Nutriment intake among the study cohort

The average daily energy, and protein and fat intakes of the study participants were found to be higher than the current Chinese Recommendation Nutrient Intakes (RNI), and hyperlipidemic subjects in our cohort had a higher average daily intake of total fat, cholesterol, and a lower consumption of dietary fiber than the normolipidemic study participants ($p<0.01$). In addition, the normolipidemic subjects showed a higher intake of carbohydrate than the hyperlipidemic participants, but this was not statistically significant (Table 6).

Discussion

Yunnan-Kweichow Plateau is located in Southwestern China at an altitude of 1000–3000 meters above sea level. In addition to the ethnic Han majority, 26 ethnic minorities live in this region, and some of the rural communities still practice traditional agriculture and animal breeding. Because of the geographical characteristics of Yunnan-Kweichow Plateau, including chronic hypoxia and distinctive cultural habits, many of the populations in this region show various levels of economic development, urbanization, and disease status. Moreover, with the changes in lifestyle and dietary choices that have come about in recent decades, the potential risk of developing various chronic noncommunicable diseases has gradually increased. Based on the basic information available from local hospital records, there are approximately three deaths from CVD each day, and a mortality rate of 50% in 2009. These numbers are higher than that of other districts and above the national average of China (Lin LP, 2005).

Hyperlipidemia is one of the main risk factors for CVD, and it is positively associated with the risks of ischemic heart disease, ischemic stroke, and other vascular disorders (Primatesta et al., 2006; Ravnskov U, 1992). The increased cardiovascular risks associated with elevated blood lipids appear to be common worldwide. In a World Health Report in 2002, raised cholesterol was listed as one of the top five leading causes of global mortality (World Health Organization, 2002). We therefore wanted to evaluate whether hyperlipidemia is related to the high prevalence of CVD in Yunnan-Kweichow Plateau, as there was a paucity of information regarding the prevalence and distribution of abnormal lipids in the inhabitants of this region.

The data collected in this cross-sectional study revealed a 49.3% prevalence of hyperlipidemia among the participants, 53.6% in men and 44.7% in women. Following standardization of these figures using the age and gender composition of the Chinese population reported in 2007, the prevalence of hyperlipidemia was revised to 49.0% among all of the study

Table 4. Living and Dietary Habits of the Study Participants

	Men		*Women*	
	Hyperlipidemia (n = *388*)	*Normalipidemia* (n = *336*)	*Hyperlipidemia* (n = *309*)	*Normalipidemia* (n = *382*)
Have breakfast every day	315 (81.2%)	279 (83.0%)	265 (85.8%)	340 (89.0%)
Dine out often	167 (43.0%)*	110 (32.7%)	91 (29.4%)*	87 (22.8%)
Eat snacks often	62 (16.0%)	58 (17.3%)	121 (39.2%)	143 (37.4%)
Take late night snack often	80 (20.6%)	53 (15.8%)	23 (7.4%)	26 (6.8%)
High intake of fried foods	34 (8.8%)	28 (8.3%)	38 (12.3%)	40 (10.5%)
Moderate intake of fried foods	112 (28.9%)	97 (28.9%)	49 (15.9%)	47 (12.3%)
Low intake of fried foods	242 (62.4%)	211 (62.8%)	222 (71.8%)	295 (77.2%)
Like to eat sweetmeat	121 (31.2%)	98 (29.2%)	161 (52.1%)	177 (46.3%)
Like to eat animal-based foods	332 (85.6%)*	268 (79.8%)	230 (74.4%)*	248 (64.9%)
Like to eat vegetarian foods	152 (39.2%)*	160 (47.6%)	234 (75.7%)*	313 (81.9%)
Like to eat salted foods	211 (54.4%)*	156 (46.4%)	169 (54.7%)	195 (51.0%)
Smoker	225 (58.0%)	189 (56.2%)	36 (11.7%)*	26 (6.8%)
Consume alcohol	261 (67.3%)*	200 (59.5%)	60 (19.4%)**	36 (9.4%)
Physical activity	232 (59.8%)	207 (61.6%)	167 (54.0%)	200 (52.4%)

Data are expressed as n (%).
*$p<0.05$, **$p<0.01$, hyperlipidemic compared with normolipidemic subjects.

Table 5. Evaluation of Variables Related to the Incidence of Hyperlipidemia by Multiple Logistic Regression Analysis

	Total (n = *1415*)		*Men* (n = *724*)		*Women* (n = *691*)	
	OR (95% CI)	p	*OR (95% CI)*	p	*OR (95% CI)*	p
Age (per 10 years)	1.246 (1.219, 1.273)	< 0.001**	1.271 (1.232, 1.311)	0.001**	1.209 (1.174, 1.245)	0.003**
Consumes alcohol (yes/no)	2.462 (1.613, 3.760)	< 0.001**	1.430 (1.038, 1.971)	0.029*	2.165 (1.368, 3.426)	0.001**
Like to eat animal-based foods (yes/no)	1.646 (1.261, 2.148)	< 0.001**	/	/	1.777 (1.233, 2.561)	0.002**
Like to eat salted foods (yes/no)	/	/	1.400 (1.026, 1.909)	0.034*	/	/
Dine out often (yes/no)	1.556 (1.223, 1.980)	< 0.001**	1.575 (1.140, 2.175)	0.006**	1.555 (1.082, 2.236)	0.017*
BMI ($\geq 24.0\,kg/m^2$)	2.649 (2.101, 3.341)	< 0.001**	2.906 (2.127, 3.970)	< 0.001**	2.482 (1.725, 3.572)	< 0.001**

*$p < 0.05$, **$p < 0.01$. Method, Forward: Conditional.
Variables entered in steps 1–5:
Total: BMI, Consume alcohol, Age, Like to eat animal-based foods, Dine out often.
Women: BMI, Consume alcohol, Like to eat animal-based foods, Age, Dine out often.
Men: BMI, Age, Dine out often, Consume alcohol, Like to eat salted foods.

participants, 54.2% in men and 44.8% in women. These small differences indicated that our sample population was a representative and unbiased cohort. However, it is noteworthy that the prevalence of hyperlipidemia in Chinese adults was reported in 2002 to be 18.6%, indicating a very large increase in this condition throughout China, even in moderate altitude areas which are less developed and have higher relative poverty levels.

Among the types of hyperlipidemia, hypertriglyceridemia (25.1%) is the most prevalent one, consistent with the main prevalent type in Chinese. In this cohort, however, the prevalence of hypercholesterolemia was 23.3%, hypertriglyceridemia was 34.1%, low HDL-C was 17.5%, and high LDL-C was 9.0%. In contrast to these findings, a survey conducted in 2006 reported a slightly higher prevalence of hypercholesterolemia at 31.0%, and low HDL-C at 22.4% among highland communities in Lhasa, Tibet (3660 m), but the prevalence of hypertriglyceridemia in these communities was considerably lower at 12.2% (Sherpa et al., 2011). Likewise, a high hypercholesterol and low HDL-C prevalence of 34.3% and 30.4% have been reported among high altitude natives of Peru (4100 m) in which the prevalence of hypertriglyceridemia was considerably higher at 53.9% of the tested subjects (Mohanna et al., 2006). In a previous survey of the resident committees of Hunan province (100–1000 m) in 2002, a prevalence of 15.6% was reported for hyperlipidemia, 7.9% for hypercholesterolemia, 10.9% for hypertriglyceridemia, and 2.9% for low HDL-C (Lin et al., 2006). These observations collectively suggest that a low altitude has a "protective" effect against hyperlipidemia, and hyperlipidemia alone cannot explain the high prevalence and mortality of CVD on Yunnan-Kweichow Plateau. However, these remarkable disparities might be due to differences in the designs as the respective studies, including the investigation time, the diagnostic criteria used, the sample sizes, the demographic characteristics of the subjects, and ethnic differences (de Koning et al., 2008; Zhang et al., 2010). More surveys in each of these regions and in adjacent areas or districts at a similar altitude are thus needed.

The prevalence of an abnormal WHR increased with age for both genders in our current study cohort, as did the TC, TG, and LDL-C levels. The odds ratios for the risk of hyperlipidemia associated with a 10-year increase in age were 1.246 for the total cohort, 1.271 for men and 1.209 for women. In the process of aging, there is a progressive increase in visceral adiposity and lean tissue decrease, causing a reduction in the insulin sensitivity of the organism (Denino et al., 2001). This phenomenon also has been demonstrated in a Peruvian study of highland communities (Medina-Lezama et al., 2007).

The mean BMI measurement in our present study (23.1 ± 3.2) is comparable with that reported previously for Chinese adults in rural plain area of Tianjin (23.7 ± 3.8) (Huiguang Tian et al., 2009) and for rural Bolivians (22.7 ± 0.4) (Frisancho et al., 1995), although the value is lower than that described for high-altitude Quechua populations from the Peruvian Central Andes (24.2 ± 2.1) (Toselli, 2001) and the SPC district of Peru (25.4 ± 3.7) (Mohanna et al., 2006). The WHRs measured in our current study were 0.85 ± 0.08 for the total group, 0.89 ± 0.08 in men and 0.82 ± 0.06 in women, which are different from those of other reports: 0.90 ± 0.09 in men and 0.91 ± 0.10 in women in a population-based sample of 12,514

Table 6. Average daily intake of Dietary Nutrients Among the Study Participants

	Energy (kJ/d)	*Protein (g/d)*	*Fat (g/d)*	*CHO (g/d)*	*Diet fiber (g/d)*	*Cholesterol (mg/d)*
Hyperlipidemia ($n = 697$)	10255.0 ± 3788.5	102.47 ± 34.58	89.11 ± 38.39	298.68 ± 129.80	11.84 ± 5.37	315.50 ± 117.44
Normalipidemia ($n = 718$)	9798.8 ± 3739.3	96.44 ± 34.53	73.14 ± 33.67	306.94 ± 136.74	14.07 ± 6.78	280.98 ± 101.35
t	2.101	3.035	7.504	−1.066	−6.624	5.323
p	0.036*	0.002**	< 0.001**	0.287	< 0.001**	< 0.001**

Data are expressed as the mean ± standard deviation (SD).
*$p < 0.05$, **$p < 0.01$, hyperlipidemic compared with normalipidemic subjects.

Iranian adults (Ali et al.,2010); 0.95 ± 0.03 in both men and women aged over 40 years in the health survey in Yangpyeong County, Korea in 2004–2005 (Min et al.,2010); and 0.96 ± 0.006 in healthy men, 0.92 ± 0.005 in healthy women, 1.01 ± 0.003 in men with metabolic syndrome, and 0.97 ± 0.004 in women with metabolic syndrome in people aged 30 years and above of Asian Indian origin (Das et al., 2010). Our measurements are also lower than those reported for a Chinese cohort from the Plain of Shenyang (Yong Liu et al., 2011). However, these data may not be strictly amenable to a direct comparison due to the differences between the survey times and other factors, but the crude data indicate that the BMI and WHR levels in the Yunnan-Kweichow Plateau population are relatively lower than other areas of China and other countries.

The BMI and WHR can typically be used as predictors of chronic noncommunicable diseases such as high blood pressure, diabetes, hyperlipidemia, and CVD. However, the proposed cut-off values for these indicators remain controversial. The World Health Organization Western Pacific Region report (2000) suggests a cut-off value for defining obesity as a BMI of $\geq 25\,kg/m^2$. In contrast, a recent Chinese study (Yong Liu et al., 2011) suggests that the appropriate BMI cut-off values for predicting the presence of multiple metabolic risk factors are $22.85\,kg/m^2$ and $23.30\,kg/m^2$ in men and women, respectively. The results of our present study indicate that populations living at a moderate altitude on the Yunnan-Kweichow Plateau have a generally lower than average BMI and WHR, but show an increased prevalence of hyperlipidemia and an abnormal lipid profile, most notably in men. Moreover, by multiple logistic regression analysis, we found that a high BMI ($\geq 24.0\,kg/m^2$) increased the risk of hyperlipidemia by 2.649-fold in the total study cohort (2.906-fold for men and 2.482-fold for women). Hence, choosing an appropriate cut-off BMI and WHR value to predict the risk of CVD or other diseases may be particularly important in these regional areas.

Our study has further shown that hyperlipidemic participants in the sample cohort of both genders tended to dine out more often and consume more alcohol. The consumption of salted food was found to be the most significant risk factor for dyslipidemia in men in our study cohort, whereas in the female participants this was animal-based foods. In addition, the normolipidemic subjects among the participants were more likely to be vegetarian in both men and women. At the same time, we found that established unhealthy behaviors were more pronounced in men, which likely explains the differences in the blood lipid profile between the men and women in our cohort. There was also a high proportion (63.7%) of men in the study group who consumed alcohol, whereas in women this number was much lower (13.9%). We found from our analysis that drinking habits increased the risk of hyperlipidemia by 2.462-fold for total population, 1.430-fold for men and 2.165-fold for women. These findings are consistent with those of other surveys (de Campos et al., 2010; Neuhouser et al., 2002). Smoking was not selected as a determinant of hyperlipidemia in our logistic regression model because a very high smoking rate in men compared with women was found for both hyperlipidemic or normolipidemic participants, and we thus focused on more pronounced differences between these groups. It is noteworthy in this regard that in a previous investigation from our laboratory, an extremely high prevalence of hyperlipidemia (58.1%) was found in smoking men from Yunxian County, Yunnan Province (Deng et al., 2011). The reported results of other surveys have also reinforced the conclusion that smoking is closely associated with hyperlipidemia (Craig et al., 1989; Freedman et al., 1986).

The traditional dietary pattern among the residents of Yunnan-Kweichow Plateau is Oriental and is therefore dominated by plant-based foods that are known to be beneficial in the prevention of disorders such as hyperlipidemia and CVD. Economic prosperity in these districts has however produced a shift away from the more traditional lifestyles that has included changes in dietary habits. When compared against the current Dietary Guidelines of China, our current study population had a lower than optimal average intake of coarse grains, beans, vegetables, fruit, and milk, whereas the intake of meat was found to be higher than the recommended levels. This was particularly true for red meats such as pork and beef. Furthermore, the average daily energy, and protein and fat intakes in our cohort were higher than those advised by the RNI of China, and the differences in these intakes were found to be significant between the hyperlipidemic and normolipidemic subjects. It is worth noting that some of the current study participants reside in districts where the transport of nonlocal foods, including fish or sea food, is quite difficult. These individuals are therefore usually dependent on local livestock for their source of meat and this is commonly salted. It is well known that high salt foods are associated with hypertension and other chronic metabolic diseases, and animal-based food consumption has been shown to increase the total and/or LDL cholesterol levels in most previous reports. It is widely accepted that proper nutrition is the cornerstone of hyperlipidemia and CHD prevention (Castro et al., 2005; Eilat-Adar, 2010; Marinangeli et al., 2010; Sirtori et al., 2008). An earlier review has also summarized the cumulative evidence to date from randomized controlled trials showing that supplementation with plant soluble fiber, plant sterols and stanols, soy protein, and nuts lowers the LDL-C levels (Nijjar et al., 2010). Moreover, primary plant-based and ovolactovegetarian dietary interventions have been associated with decreases in the TC and LDL cholesterol levels of about 10%–15%, whereas vegan dietary interventions have been found to result in decreases of approximately 15%–25%, and combination dietary interventions (vegetarian diets with additional fiber, soy, and nuts) with decreases of approximately 20%–35%, in these levels (Ferdowsian et al., 2009).

It is undeniable that in a similar manner to the Tibetans (Xu et al., 2008), the population of Yunnan-Kweichow Plateau is undergoing an epidemiological transition, which may influence future health outcomes at the population level. For example, reduced physical activity and poor dietary choices can cause an increase in sedentary lifestyles and a higher incidence of obesity. Our current study confirms that these remain the most significant risk factors for hyperlipidemia, and that this is true for men and women of all ethnic groups.

Conclusions

Observations and analyses in this study reveal a higher prevalence of hyperlipidemia, hypercholesterolemia, hypertriglyceridemia, and elevated BMI and WHR values in men, and a marginally higher prevalence of low HDL-C and high LDL-C profiles in women from the Yunnan-Kweichow Plateau in Southwestern China. The prevalence of hyperlipidemia was found to increase with age, as did the prevalence of

an elevated TC, TG, LDL-C, and WHR. Our analyses confirm that a high BMI and unhealthy living and dietary habits also play significant roles in the onset of hyperlipidemia. Additional studies of the health characteristics and related factors that can contribute to the prevention of diverse chronic noncommunicable diseases in populations living at moderate altitudes are needed.

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