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Hyperlipidaemia and its risk factors in the Guangxi Bai Ku Yao and Han populations

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Abstract

Objective: To compare the differences in hyperlipidaemia prevalence and its risk factors between the Guangxi Bai Ku Yao and Han populations.
Design: Cross-sectional study of hyperlipidaemia.
Setting: Both populations were from Lihu and Baxu villages in Nandan County, Guangxi Zhuang Autonomous Region, People's Republic of China.
Subjects: A total of 1170 healthy subjects of Bai Ku Yao and 1173 participants of Han Chinese aged 15–89 years were surveyed by a stratified randomized cluster sampling. Information on demographic, dietary and lifestyle characteristics was collected by standard questionnaires. Blood pressure, height, weight, waist circumference, serum lipids and apolipoproteins were measured, and BMI (kg/m^2) was calculated as weight divided by the square of height.
Results: The prevalence rates of hypercholesterolaemia, hypertriacylglycerolaemia and hyperlipidaemia in Bai Ku Yao and Han were 12·4% *v.* 26·2% ($P<0·001$), 15·0% *v.* 14·8% ($P>0·05$) and 24·4% *v.* 33·9% ($P<0·001$), respectively. Hyperlipidaemia was positively correlated with BMI, waist circumference, total energy and total fat intakes, and negatively associated with physical activity and total dietary fibre intake in Bai Ku Yao ($P<0·05$ to $0·001$). Hyperlipidaemia was positively associated with age, alcohol consumption, BMI, waist circumference, total energy and total fat intakes, and inversely correlated with physical activity and total dietary fibre intake in Han ($P<0·05$ to $0·001$).
Conclusions: The prevalence of hypercholesterolaemia and hyperlipidaemia was significantly lower in the Bai Ku Yao than in the Han population, which might result from different dietary habits, lifestyle choices and physical activity level, as well as genetic factors between the two ethnic groups.

Keywords
Lipids
Apolipoproteins
Hyperlipidaemia
Prevalence
Risk factors

Coronary artery disease has a multifactorial origin, including hereditary and acquired risk factors which may be the direct cause of the disease or merely associated with it[1,2]. Disorders in lipid metabolism such as high levels of plasma or serum total cholesterol (TC)[3], TAG[4], LDL cholesterol (LDL-C)[5] and apo B[6], and low levels of HDL cholesterol (HDL-C)[7], play a relevant role in the progression of atherosclerosis[8]; thus the laboratory assessment of lipids is of fundamental importance to diagnose, treat and prevent this condition[9]. Although a great deal of research effort has been focused on the determinants of these lipid phenotypes in different ethnic groups and diseases[10–12], very few data are available about the prevalence of hyperlipidaemia and its risk factors in isolated minority groups.

There are fifty-six ethnic groups in China. Han is the largest group and Yao is the eleventh largest minority among the fifty-five minority groups according to population size. Bai Ku Yao (White-trouser Yao), an isolated subgroup of the Yao minority, is so named because all of the men wear white knee-length knickerbockers. The population size is about 30 000. Because of their isolation from other ethnic groups, special customs and cultures including their clothing, intra-ethnic marriages, dietary

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habits, and corn wine and rum intakes are still completely preserved to the present day. Little is known about the prevalence of hyperlipidaemia and its risk factors in this population. Therefore, the present study was undertaken to compare the differences in hyperlipidaemia prevalence and its risk factors between the Guangxi Bai Ku Yao and Han populations.

Methods

Subjects

The subjects of Bai Ku Yao residing in Lihu and Baxu villages in Nandan County, Guangxi Zhuang Autonomous Region, People's Republic of China, were surveyed by a stratified randomized cluster sampling. First, teams (resident communities; inhabitants) were selected randomly from the two villages. Then, sexes in each team were separated for the survey. Finally, the sampled resident sections were determined from the local population registers. A total of 1230 subjects from sixteen teams were asked to participate in the study and 1193 subjects actually participated. The response rate was 97·0 %. Twenty-three persons (1·9 %) with a history or evidence of other diseases were excluded from the analysis. A total of 1170 subjects were included in the present study. The ages of the subjects ranged from 15 to 85 years, with an average age of 37·5 (SD 16·7) years. There were 588 males (50·3 %) and 582 females (49·7 %). All subjects were peasants. The age distribution was as follows: <20 years, 185 people (15·8 %); 20–29 years, 261 people (22·3 %); 30–39 years, 239 people (20·4 %); 40–49 years, 210 people (18·0 %); 50–59 years, 139 people (11·9 %); 60–69 years, eighty-three people (7·1 %); ≥70 years, fifty-three people (4·5 %). The subjects accounted for 3·9 % of the total Bai Ku Yao population.

During the same period, a total of 1235 subjects of Han Chinese from fifteen teams were asked to participate in the study by the same method and 1205 subjects completed the survey. The response rate was 97·6 %. Thirty-two people (2·7 %) with a history or evidence of other diseases were excluded. A total of 1173 subjects were included in the present study. The mean age of the subjects was 38·3 (SD 16·8) years (range 15 to 89 years). There were 589 men (50·2 %) and 584 women (49·8 %). All of them were also peasants. The age distribution was as follows: <20 years, 180 persons (15·3 %); 20–29 years, 241 persons (20·5 %); 30–39 years, 251 persons (21·4 %); 40–49 years, 208 persons (17·7 %); 50–59 years, 139 persons (11·8 %); 60–69 years, eighty-five persons (7·2 %); ≥70 years, sixty-nine persons (5·9 %).

All study subjects were essentially healthy and had no evidence of any chronic illness, including hepatic, renal or thyroid disease, heart attack or myocardial infarction, stroke, congestive heart failure or diabetes mellitus. They were not taking medications known to affect serum lipid levels (lipid-lowering drugs such as statins or fibrates, beta-blockers, diuretics or hormones). The present study was approved by the Ethics Committee of the First Affiliated Hospital, Guangxi Medical University. Informed consent was obtained from all subjects after they received a full explanation of the study.

Epidemiological survey

The survey was carried out using internationally standardized methods, following a common protocol[13]. Information on demographics (age, gender, residential area), socio-economic status (education level achieved, marital status, annual household income), cigarette smoking, alcohol consumption and physical activity was collected with standardized questionnaires. The 24 h dietary recall method was used to determine the dietary intakes of each subject[14]. Detailed descriptions of all foods, beverages and supplements consumed during the 24 h period before the interview, including the quantity, cooking method and brand names, were recorded by a chief physician. The interviewer used food models and pictures depicting portion sizes and followed a standardized protocol for determining the weight of food consumed. The intakes of macronutrients from the ingredients were determined by using the *2002 Chinese Food Composition Table*[15]. Although a 24 h dietary recall may be inaccurate when diets are highly variable, the Bai Ku Yao diet is consistent throughout the year and among individuals because of the Bai Ku Yao's reliance on a limited number of locally available food items. Overall physical activity was ascertained with the use of a modified version of the Harvard Alumni Physical Activity Questionnaire[16], which included questions about the number of hours per day (mean of a regular weekday and a regular weekend day) spent sleeping and in sedentary, light, moderate and vigorous activities; the interviewer ensured that the total time added up to 24 h. The alcohol information included questions about the number of grams of rice wine, wine, beer or liquor consumed during the preceding 12 months. At the physical examination, several parameters including height, weight and waist circumference were measured. Sitting blood pressure was measured three times with the use of a mercury sphygmomanometer after a rest of at least 15 min, and the average of the three measurements was used for the level of blood pressure. Systolic blood pressure was determined by the first Korotkoff sound and diastolic blood pressure by the fifth Korotkoff sound. Body weight, to the nearest 50 g, was measured using a portable balance scale. Subjects were weighed without shoes and in a minimum of clothing. Height was measured, to the nearest 0·5 cm, using a portable steel measuring device. From these two measurements BMI (kg/m^2) was calculated. Waist circumference was measured with a non-stretchable measuring tape, at the level of the smallest area of the waist, to the nearest 0·1 cm.

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Measurements of lipids and apolipoproteins

A venous blood sample was drawn from an antecubital vein in all subjects after an overnight fast. The blood was transferred into glass tubes and allowed to clot at room temperature. Immediately following clotting serum was separated by centrifugation for 15 min at 3000 rpm. The levels of TC, TAG, HDL-C and LDL-C in samples were determined enzymatically using commercially available kits: Tcho-1, TG-LH (RANDOX Laboratories Ltd, Crumlin, UK), Cholestest N HDL and Cholestest LDL (Daiichi Pure Chemicals Co., Ltd, Tokyo, Japan), respectively. Serum apo A1 and apo B levels were measured by an immunoturbidimetric assay (RANDOX Laboratories Ltd). All determinations were performed with an autoanalyser (type 7170A; Hitachi Ltd, Tokyo, Japan) in the Clinical Science Experiment Center of the First Affiliated Hospital, Guangxi Medical University[17,18].

Diagnostic criteria

The normal values of serum TC (mmol/l), TAG (mmol/l), HDL-C (mmol/l), LDL-C (mmol/l), apo A1 (g/l), apo B (g/l) and the ratio apo A1:apo B in the Clinical Science Experiment Center were 3·10–5·17, 0·56–1·70, 0·91–1·81, 2·70–3·20, 1·00–1·78, 0·63–1·14 and 1·00–2·50, respectively. The individuals with TC > 5·17 mmol/l and/or TAG > 1·70 mmol/l were defined as hyperlipidaemic[17,18]. Hypertension was diagnosed according to the criteria of the 1999 WHO/International Society of Hypertension guidelines for the management of hypertension[19,20]. The diagnostic criteria of overweight and obesity were according to the Cooperative Meta-analysis Group of China Obesity Task Force. Normal weight, overweight and obesity were defined as BMI < 24, 24–28 and >28 kg/m^2, respectively[21].

Statistical analysis

The data were organized and analysed using Excel XP (Microsoft, Seattle, WA, USA) and the SPSS for Windows statistical software package version 11·5·0 (SPSS Inc., Chicago, IL, USA). Means and standard deviations as well as frequency distributions of participant characteristics were calculated. The difference in mean values of parameters between Bai Ku Yao and Han was tested by Student's unpaired *t* test. The difference in percentage values was tested by the χ^2 test. The influences of sex, age, physical activity, BMI, waist circumference, alcohol consumption and cigarette smoking were adjusted for in the statistical analyses. In order to evaluate the risk factors for hyperlipidaemia, unconditional logistic regression analysis was also performed in the combined population of Bai Ku Yao and Han, the Bai Ku Yao and the Han, respectively. The backward multiple logistic regression method was used to select the risk factors significantly associated with hyperlipidaemia. Total intake of each nutrient was summed over all foods consumed. The Matlab 5·0 software (The MathWorks, Inc., Natick, MA, USA) was used for processing these procedures by the method of multiplication of matrix[22]. A P value of less than 0·05 was considered statistically significant.

Results

Comparison of general characteristics between Bai Ku Yao and Han

The demographic, dietary and other lifestyle characteristics of Bai Ku Yao and Han are shown in Table 1. The level of physical activity and the intakes of carbohydrate, vegetal protein and total dietary fibre were higher in Bai Ku Yao than in Han ($P < 0·001$ for all), whereas educational level, height, weight, BMI, waist circumference, blood pressure levels including systolic, diastolic and pulse pressure, hypertension and the intakes of total energy, total fat, total protein, dietary cholesterol and salt were higher in Han than in Bai Ku Yao ($P < 0·05$ to 0·001). In addition, there were also significant differences in the staple and subsidiary foods and drinks between the two ethnic groups. For the great majority of Bai Ku Yao people, corn (gruel or tortillas) was the staple food and rice, soya, buckwheat, sweet potato and pumpkin products were the subsidiary foods all the year round. Approximately 90 % of the beverages comprised corn wine and rum that they brewed themselves, the alcohol content is about 15 % (v/v). The subjects of Bai Ku Yao were also accustomed to drinking hempseed soup. In contrast, rice was the staple food and corn, broomcorn, potato and taro products were the subsidiary foods in Han Chinese. About 90 % of the beverages comprised rice wine with alcohol content of about 30 % (v/v). There were no significant differences in the age structure, the percentages of subjects who consumed alcohol or smoked cigarettes, or the ratio of men to women between the two ethnic groups ($P > 0·05$).

Prevalence of hyperlipidaemia in Bai Ku Yao and Han

As shown in Table 2, the prevalence of high TC (hypercholesterolaemia), LDL-C, apo B and apo A1:apo B ratio was lower in Bai Ku Yao than in Han ($P < 0·05$ to 0·001), whereas the prevalence of low HDL-C and apo A1 was higher in Bai Ku Yao than in Han ($P < 0·001$ for each). There was no significant difference in the prevalence of high TAG (hypertriacylglycerolaemia) between the two ethnic groups ($P > 0·05$). In the subjects with hypercholesterolaemia and hypertriacylglycerolaemia, there were thirty-six subjects in Bai Ku Yao (3·1 %) and eighty-three subjects in Han (7·1 %; $\chi^2 = 19·430$, $P < 0·001$) with both high TC and TAG. Thus, the prevalence of hyperlipidaemia in Bai Ku Yao and Han was 24·4 % (285/1170) *v.* 33·9 % (398/1173; $\chi^2 = 25·981$, $P < 0·001$).

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Table 1 Comparison of demographic, dietary and lifestyle characteristics between the Bai Ku Yao and Han populations

	Bai Ku Yao (*n* 1170)		Han Chinese (*n* 1173)			
Characteristic	Mean or *n*	SD or %	Mean or *n*	SD or %	t (χ^2)	P
Age (years)	37·5	16·7	38·3	16·8	1·120	0·263
Male/female	588/582		589/584		0·000	1·000
Education level (years)	4·4	3·7	6·5	3·7	13·492	0·000
Physical activity (h/week)	48·8	14·5	46·4	13·5	4·151	0·000
Height (cm)	152·7	7·2	155·0	8·1	7·297	0·000
Weight (kg)	50·5	7·1	53·3	8·8	8·430	0·000
BMI (kg/m^2)	21·7	2·4	22·2	2·9	4·574	0·000
>24 kg/m^2 [*n* and %]	178	15·2	246	21·0	13·104	0·000
Waist circumference (cm)	70·9	7·6	73·1	9·2	6·183	0·000
Systolic blood pressure (mmHg)	115·7	16·3	120·0	16·5	6·336	0·000
Diastolic blood pressure (mmHg)	74·1	9·4	75·9	10·4	4·278	0·000
Pulse pressure (mmHg)	41·6	12·0	44·2	11·2	5·403	0·000
Hypertension [*n* and %]	127	10·9	193	16·5	15·571	0·000
Alcohol consumption [*n* and %]	396	33·9	454	38·7	5·980	0·014
Cigarette smoking [*n* and %]	294	25·1	347	29·6	5·847	0·016
Energy (MJ/d)	8·85	0·37	8·99	0·39	8·761	0·000
Energy (kcal/d)	2114	88	2148	93	8·761	0·000
Fat (% of energy)	9·7	2·6	12·5	3·9	20·441	0·000
Carbohydrate (% of energy)	77·9	8·3	72·3	7·6	17·033	0·000
Protein (% of energy)	8·6	2·5	10·3	3·8	12·789	0·000
Alcohol (% of energy)	3·8	1·6	4·9	2·1	14·259	0·000
Carbohydrate (g/d)	412·0	17·2	388·3	15·3	35·255	0·000
Protein (g/d)	45·5	5·7	55·3	7·8	34·850	0·000
Animal (%)	26·8	3·2	34·6	4·3	49·799	0·000
Vegetal (%)	73·2	7·2	65·4	6·7	27·146	0·000
Total fat (g/d)	22·8	3·7	29·8	4·2	43·129	0·000
SFA (g/d)	5·7	2·2	9·2	3·3	30·735	0·000
MUFA (g/d)	7·2	2·9	9·7	5·6	13·571	0·000
PUFA (g/d)	9·9	3·9	10·9	4·7	5·810	0·000
Dietary cholesterol (mg/d)	179·4	102·8	198·8	108·5	4·427	0·000
Total dietary fibre (g/d)	9·4	3·1	7·8	2·7	13·582	0·000
Na intake (g/d)	7·2	2·4	7·8	2·6	5·898	0·000

Associations between general characteristics and hyperlipidaemia in Bai Ku Yao and Han

The associations of sex, BMI, hypertension, alcohol consumption, cigarette smoking and age with hyperlipidaemia in Bai Ku Yao and Han are also shown in Table 2. The prevalence of high TAG in both ethnic groups, high apo A1:apo B ratio in Bai Ku Yao, and low HDL-C and apo A1 in Bai Ku Yao was higher in males than females. The prevalence of high TC, TAG, LDL-C and apo B in both ethnic groups was higher in subjects with BMI > 24 kg/m^2 than those with BMI ≤ 24 kg/m^2. The prevalence of high TC, TAG and apo B in both ethnic groups was higher in drinkers than in non-drinkers. The prevalence of high apo B and apo A1:apo B ratio in Bai Ku Yao and high TAG in Han was higher in smokers than in non-smokers. There was also a significant difference in the prevalence of high TC, LDL-C and apo B, and of low HDL-C and apo A1 between age subgroups in both ethnic groups.

Risk factors for hyperlipidaemia in Bai Ku Yao and Han

The results of multiple logistic regression analysis are shown in Table 3. Hyperlipidaemia was positively correlated with BMI, waist circumference, total energy and total fat intakes, and negatively associated with physical activity and total dietary fibre intake, in Bai Ku Yao (P< 0·05 to 0·001). Hyperlipidaemia was positively associated with age, alcohol consumption, BMI, waist circumference, total energy and total fat intakes, and inversely correlated with physical activity and total dietary fibre intake, in Han (P< 0·05 to 0·001). There was no significant correlation between hyperlipidaemia and sex, education level, dietary cholesterol, cigarette smoking and hypertension in both ethnic groups (P> 0·05).

Comparison of hyperlipidaemia between Lihu and Baxu villages

The prevalence of hypertriacylglycerolaemia, low HDL-C and apo A1 in Bai Ku Yao was higher but the prevalence of hypercholesterolaemia was lower in subjects from Lihu village than from Baxu villages (P< 0·05 to 0·001). There was no significant difference in the prevalence of high apo B, apo A1:apo B ratio and hyperlipidaemia between the two villages (P> 0·05, Table 4).

Discussion

The present study shows that the prevalence of hypercholesterolaemia and hyperlipidaemia was lower in

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Table 2 Associations of demographic, dietary and lifestyle characteristics with the prevalence of hyperlipidaemia in the Bai Ku Yao and Han populations

		TC > 5·17 mmol/l		TAG > 1·70 mmol/l		HDL-C < 1·00 mmol/l		LDL-C > 3·20 mmol/l		Apo A1 < 1·0 g/l		Apo B > 1·14 g/l		Apo A1:apo B > 2·50	
Characteristic	*n*	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Bai Ku Yao	1170	145	12·4	176	15·0	61	5·2	151	12·9	267	22·8	68	5·8	84	7·2
Men	588	74	12·6	101	17·2	42	7·1	68	11·6	167	28·4	37	6·3	61	10·4
Women	582	71	12·2	75*	12·9	19**	3·3	83	14·3	100***	17·2	31	5·3	23***	4·0
BMI ≤ 24 kg/m^2	992	99	10·0	130	13·1	58	5·9	109	11·0	247	24·9	49	4·9	73	7·4
BMI > 24 kg/m^2	178	46***	25·8	46***	25·8	3*	1·7	42***	23·6	20***	11·2	19**	10·7	11	6·2
Normotensives	1043	118	11·3	150	14·4	58	5·7	123	11·8	256	24·5	57	5·5	70	6·7
Hypertensives	127	27***	21·3	26	20·5	3	2·4	28**	22·1	11***	8·7	11	8·7	14	11·0
Non-drinkers	774	72	9·3	98	12·7	54	7·0	90	11·6	226	29·2	36	4·7	27	3·5
Drinkers	396	73***	18·4	78**	19·7	7***	1·8	61	15·4	41***	10·4	32*	8·1	57***	14·4
Non-smokers	876	100	11·4	122	13·9	54	6·2	107	12·2	222	25·3	44	5·0	51	5·8
Smokers	294	45	15·3	54	18·4	7*	2·4	44	15·0	45***	15·3	24*	8·2	33**	11·2
Age (years)															
<20	185	2	1·1	32	17·3	28	15·1	2	1·1	95	51·4	0		7	3·8
20–29	261	20	7·7	36	13·8	20	7·7	25	9·6	90	34·5	9	3·5	11	4·2
30–39	239	28	11·7	41	17·2	6	2·5	29	12·1	31	13·0	18	7·5	19	8·0
40–49	210	42	20·0	34	16·2	0		42	20·0	20	9·5	16	7·6	22	10·5
50–59	139	30	21·6	15	10·8	2	1·4	32	23·0	17	12·2	13	9·4	12	8·6
60–69	83	13	15·7	9	10·8	5	6·0	13	15·7	10	12·1	8	9·6	9	10·8
≥70	53	10	18·9	9	17·0	0		8	15·1	4	7·6	4	7·6	4	7·6
χ^2 for 7 age subgroups	–	52·151		5·372		22·916‡		48·554		161·241		22·318		12·405	
P for 7 age subgroups	–	0·000		0·497		0·000‡		0·000		0·000		0·001		0·054	
Han Chinese	1173	307†††	26·2	174	14·8	18†††	1·5	191†	16·3	61†††	5·2	143†††	12·2	52††	4·4
Men	589	152†††	25·8	103	17·5	10†††	1·7	95†	16·1	35†††	5·9	71†††	12·1	25†††	4·2
Women	584	155†††	26·5	71*	12·2	8†	1·4	96	16·4	26†††	4·5	72†††	12·3	27	4·6
BMI ≤ 24 kg/m^2	927	197†††	21·3	105	11·3	15†††	1·6	120	13·0	58†††	6·3	88†††	9·5	47	5·1
BMI > 24 kg/m^2	246	110***,†††	44·7	69***	28·1	3	1·2	71***	28·9	3**,†††	1·2	55***,†††	22·4	5*,†	2·0
Normotensives	980	230†††	23·5	129	13·2	16†††	1·6	144	14·7	58†††	5·9	101†††	10·3	36††	3·7
Hypertensives	193	77***,†††	39·9	45***	23·3	2	1·0	47***	24·4	3*,†††	1·6	42***,†††	21·8	16**	8·3
Non-drinkers	719	166†††	23·1	93	12·9	16†††	2·2	124††	17·3	54†††	7·5	75†††	10·4	31	4·3
Drinkers	454	141***,†††	31·1	81*	17·8	2*	0·4	67	14·8	7***,†††	1·5	68*,††	15·0	21†††	4·6
Non-smokers	826	213†††	25·8	107	13·0	14†††	1·7	137†	16·6	49†††	5·9	100†††	12·1	33	4·0
Smokers	347	94†††	27·1	67**	19·3	4	1·2	54	15·6	12†††	3·5	43	12·4	19†††	5·5
Age (years)															
<20	180	11††	6·1	19	10·6	12††	6·7	9†	5·0	49†††	27·2	3	1·7	10	5·6
20–29	241	54†††	22·4	24	10·0	0†††		33	13·7	4†††	1·7	20†	8·3	6	2·5
30–39	251	61†††	24·3	46	18·3	5	2·0	33	13·2	6†††	2·4	27	10·8	10	4·0
40–49	208	79†††	38·0	41	19·7	0		51	24·5	1†††	0·5	38††	18·3	11†	5·3
50–59	139	52††	37·4	22	15·8	0		40	28·8	0†††		30††	21·6	7	5·0
60–69	85	29††	34·1	15	17·7	1	1·2	16	18·8	0††		11	12·9	5	5·9
≥70	69	21	30·4	7	10·1	0		9	13·0	1	1·5	14†	20·3	3	4·4
χ^2 for 7 age subgroups	–	67·235		15·325		6·046§		47·008		210·872		45·422		3·704	
P for 7 age subgroups	–	0·000		0·018		0·014§		0·000		0·000		0·000		0·717	

TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol.
*P < 0·05, **P < 0·01, ***P < 0·001 for comparison with men, BMI ≤ 24 kg/m^2, normotensive, non-drinkers or non-smokers of the same ethnic group.
†P < 0·05, ††P < 0·01, †††P < 0·001 for comparison with the same subgroup of Bai Ku Yao.
‡Values for the comparison of <20, 20–29 and 30–39 years age subgroups in Bai Ku Yao.
§Values for the comparison of <20 and 30–39 years age subgroups in Han Chinese.

Table 3 Comparison of the risk factors for hyperlipidaemia between the Bai Ku Yao and Han populations

Risk factor	Regression coefficient	SE	Wald	*P*	OR
Han plus Bai					
Ethnic group	0·386	0·096	16·221	0·000	1·471
Age	0·093	0·032	8·223	0·004	1·098
Physical activity	−0·221	0·105	9·265	0·003	1·212
Alcohol consumption	0·141	0·055	6·699	0·010	1·152
Waist circumference	0·835	0·134	41·558	0·000	2·323
BMI	0·915	0·115	62·937	0·000	2·498
Total energy	0·575	0·143	10·366	0·001	1·324
Total fat	0·551	0·135	17·997	0·000	1·676
Total dietary fibre	−0·443	0·131	12·158	0·000	1·574
Bai Ku Yao					
Physical activity	−0·198	0·093	6·753	0·016	1·301
Waist circumference	0·876	0·177	27·563	0·000	2·396
BMI	0·844	0·179	22·284	0·000	2·326
Total energy	0·631	0·184	12·536	0·000	1·975
Total fat	0·573	0·201	9·433	0·003	1·877
Total dietary fibre	−0·625	0·202	10·369	0·001	1·973
Han Chinese					
Age	0·136	0·043	10·131	0·001	1·146
Physical activity	−0·232	0·078	4·562	0·035	1·274
Alcohol consumption	0·145	0·072	4·020	0·045	1·156
Waist circumference	0·763	0·248	14·674	0·000	2·233
BMI	0·988	0·153	41·469	0·000	2·687
Total energy	0·552	0·215	7·823	0·007	1·824
Total fat	0·477	0·189	8·996	0·003	1·679
Total dietary fibre	−0·424	0·245	4·972	0·036	1·616

For the multiple logistic regression analysis, the data were recorded as follows: ethnic group: Bai Ku Yao = 0, Han = 1; sex: female = 0, male = 1; age (years): <20 = 1, 20–29 = 2, 30–39 = 3, 40–49 = 4, 50–59 = 5, 60–69 = 6, ≥70 = 7; BMI (kg/m^2): ≤24 = 0, >24 = 1; blood pressure: normotensive = 0, hypertensive = 1; alcohol consumption (g/d): non-drinkers = 0, <25 = 1, 25–49 = 2, 50–99 = 3, ≥100 = 4; cigarette smoking (cigarettes/d): non-smokers = 0, <10 = 1, 10–19 = 2, 20–39 = 3, ≥40 = 4.

Table 4 Comparison of hyperlipidaemia in Bai Ku Yao between Lihu and Baxu villages

		TC > 5·17 mmol/l		TAG > 1·70 mmol/l		HDL-C < 1·00 mmol/l		LDL-C > 3·20 mmol/l		Apo A1 < 1·0 g/l		Apo B > 1·14 g/l		Apo A1:apo B > 2.50		Hyperlipidaemia prevalence	
Village	*n*	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Lihu	602	59	9·8	114	18·9	40	6·6	60	10·0	181	30·1	30	5·0	44	7·3	158	26·3
Baxu	568	86	15·1	62	10·9	21	3·7	91	16·0	86	15·1	38	6·7	40	7·0	127	22·4
χ^2	–	7·676		14·714		5·137		9·530		36·965		1·555		0·031		2·396	
P	–	0·006		0·000		0·023		0·002		0·000		0·212		0·860		0·121	

TC, total cholesterol; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; hyperlipidaemia, TC > 5·17 mmol/l and/or TAG > ·70 mmol/l.

Bai Ku Yao than in Han. This discrepancy may mainly be attributed to the differences in dietary habits and lifestyle choices between the two ethnic groups. The staple and subsidiary foods are more favourable for lipid profiles in Bai Ku Yao than in Han. Corn contains abundant dietary fibre and high-quality plant protein[23]. Consumption of dietary fibre, specifically the soluble type such a pectins and guar gum, can result in a decrease of serum cholesterol levels in healthy and hyperlipidaemic subjects[24,25]. Plant protein can promote the transportation and excretion of free cholesterol. Corn oil is rich in PUFA and MUFA[26]. Suitable intakes of PUFA and MUFA can lower serum levels of cholesterol and LDL-C[26,27]. Soya protein intake is effective in reducing TC by 9·3%, LDL-C by 12·9% and TAG by 10·5%, and in increasing HDL-C by 2·4%. Furthermore, the changes in serum TC and LDL-C concentrations are directly related to the initial serum TC concentration[28]. The hypocholesterolaemic activity of buckwheat protein products is far stronger than that of soya protein isolate and corn[29]. Daily ingestion of 4 g caiapo (the extract of white-skinned sweet potato) for 6 weeks reduces TC and LDL-C in type 2 diabetic patients previously treated by diet alone[30]. The long-term beneficial effects of caiapo on plasma cholesterol levels are further confirmed in a recent report[31]. Studies have also demonstrated that pumpkin or pumpkinseed oil may be a useful therapy for hypercholesterolaemia by reducing oxidative stress and cholesterol levels[32]. The people of Bai Ku Yao are accustomed to drinking hempseed soup. There are more than twenty-nine fat-soluble constituents in hempseed, with fatty acid methyl esters making up 99·3%[33,34]. The main fatty acid components of hempseed oil are palmitic acid (8·4%), γ-linolenic acid (1·3%), linoleic acid (58·7%), linolenic acid (14·0%), oleic acid

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(10·1 %), stearic acid (3·8 %) and arachidic acid (1·0 %)[35]. A number of experimental and clinical studies have demonstrated that the beneficial effects of hempseed or hempseed oil on lipid profiles include decreasing the levels of TC, TAG and LDL-C, inhibiting lipid peroxidation, reducing the atherogenic index and increasing the levels of HDL-C[36–38]. The intake of animal fat, body weight and BMI were all lower in Bai Ku Yao than in Han. For nearly 50 years it has been widely accepted that high-fat diets, particularly those that contain large quantities of SFA, raise blood cholesterol concentrations and predispose individuals to CVD[39]. In addition, strict intra-ethnic marriages have been performed from time immemorial in the Bai Ku Yao. Therefore, the hereditary characteristics, genotypes and phenotypes of lipids in the Bai Ku Yao population may be different from those in Han Chinese. However, this still needs to be determined.

It is well documented that androgens induce disadvantageous effects on lipid profiles, whereas oestrogens are held to have opposite effects[40,41]. In the present study, we also showed that the prevalence of high TAG in both ethnic groups and low HDL-C and apo A1 in Bai Ku Yao was higher in males than in females. These discrepancies in dyslipidaemia between men and women might be partially attributable to the effects of gonadal hormones.

Epidemiological studies have provided abundant evidence that lipid levels are closely related with age[42,43]. In the present study, we showed that there was a significant difference in the prevalence of high TC, LDL-C and apo B, and low HDL-C and apo A1, for the age subgroups in both ethnic groups. This is consistent with previous studies. The exact mechanisms of age on hyperlipidaemia are not well known. They may due, in part, to the hereditary characteristics and ageing of the population.

The link between obesity and dyslipidaemia has been clearly documented[44,45]. Obesity not only induces dyslipidaemia, but also is directly associated with diabetes, hypertension and coronary artery disease. The current study also shows that the prevalence of high TC, TAG, LDL-C and apo B in both ethnic groups was higher in subjects with BMI $> 24\,kg/m^2$ than those with BMI ≤ 24 kg/m^2. This is in agreement with the findings of previous studies[44–46]. Dyslipidaemia in obesity may result from insulin resistance[47,48]. Insulin resistance can increase plasma NEFA concentrations and stimulate VLDL synthesis and release. At the same time, insulin resistance can also suppress lipoprotein lipase activity and increase plasma VLDL levels.

The association of hyperlipidaemia with hypertension is poorly understood. Studies have shown that the levels of TAG, VLDL cholesterol and apo E are higher and levels of apo AI, apo AII and apo CII are lower in untreated hypertensives than in controls[49]. TC and non-HDL-C levels increase significantly with increasing systolic or diastolic blood pressure in both sexes[50]. Some authors believe this relationship may be a kind of random phenomenon[51]. In the present study, we found that the prevalence of hypercholesterolaemia in both ethnic groups and hypertriacylglycerolaemia in Han was higher in hypertensives than in normotensives. These findings suggest that there may be a complicated interrelation between hyperlipidaemia and hypertension[52].

Both case–control and cohort studies have described a J- or U-shaped association between alcohol intake and CHD and between alcohol intake and mortality[53]. Although moderate alcohol consumption appears to be protective, heavy consumption of alcohol is associated with subclinical impairment of left ventricular function and occasionally results in overt cardiomyopathy. High alcohol intake and cigarette smoking have disadvantageous effects on lipid profiles. Smoking also disturbs lipoprotein metabolism by raising insulin resistance and lipid intolerance, and is implicated in the production of small dense LDL-C. In the present study, we showed that the prevalence of high TC, TAG and apo B in both ethnic groups was higher in drinkers than in non-drinkers. The prevalence of high apo B and apo A1:apo B ratio in Bai Ku Yao and high TAG in Han was higher in smokers than in non-smokers. These findings indicate that both alcohol consumption and cigarette smoking may be risk factors for hyperlipidaemia in the two populations.

In the present study, we also showed that the prevalence of high TAG, low HDL-C and apo A1 in Bai Ku Yao was higher, but the prevalence of high TC was lower, in subjects from Lihu village than from Baxu village. The reason for this discrepancy is not yet known. The customs and cultures in both villages are similar. One difference is the residential locus. The distance between the two villages is about 50 km. It is unclear whether geographical or other unknown factors might be involved in this discrepancy between the two villages.

Conclusion

The present study reveals that the prevalence of hypercholesterolaemia and hyperlipidaemia was lower in Bai Ku Yao than in Han. These differences between the two ethnic groups may result from different demographic characteristics, dietary patterns, lifestyle choices and physical activity level, as well as genetic background.

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analyses and drafted the manuscript; Y.D., L.S., P.S. and L.W. carried out the epidemiological survey and biochemical analyses; C.Y. carried out the epidemiological survey and helped to carry out biochemical analyses; F.Q. performed the statistical analyses; Y.H., T.J. and L.Y. carried out the epidemiological survey. All authors read and approved the final manuscript.

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