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Original Article

Serum lipid profiles, the prevalence of dyslipidemia and the risk factors in two isolated Chinese minorities

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Abstract: Both Jing and Mulao nationalities are the isolated minorities in China. Little is known about the prevalence of dyslipidemia between the two ethnic groups. Therefore, the aim of this study was to compare the differences in serum lipid profiles, the prevalence of dyslipidemia and their risk factors between the Jing and Mulao populations. A cross-sectional study of dyslipidemia was conducted in Dongxing city, Guangxi, China, during Dec 2011 and Jan 2012. A total of 1254 subjects of Jing and 1251 participants of Mulao were surveyed by a stratified randomized sampling. Information on demography, diet and lifestyle was collected with standardized questionnaire. Serum lipid levels were detected using the commercially available kits. The levels of low-density lipoprotein cholesterol (LDL-C), apolipoprotein (Apo) A1, and the ratio of ApoA1 to ApoB were lower but the levels of ApoB were higher in Jing than in Mulao ($P < 0.001$ for all). The prevalence of hypertriglyceridemia (32.38% *vs*. 24.38%), high ApoB (35.25% *vs*. 15.35%) and low ApoA1/ApoB ratio (22.65% *vs*. 16.87%) was higher and low high-density lipoprotein cholesterol (0.48% *vs*. 2.16%), high LDL-C (17.54% *vs*. 40.53%) and low ApoA1 (5.98% *vs*. 11.43%) was lower in Jing than in Mulao ($P < 0.001$ for all). The risk factors for serum lipid parameters and hyperlipidemia were different between the two ethnic groups. Serum lipid profiles, the prevalence of dyslipidemia and their risk factors are different between the Jing and Mulao populations. These differences may result from the combined effects of different diet, lifestyle, and genetic factors.

Keywords: Lipids, apolipoproteins, dyslipidemia, prevalence, risk factors

Introduction

Dyslipidemia is one of the most important risk factors for coronary artery disease (CAD). With the improvement of people's living standard and the change of lifestyle, the prevalence of dyslipidemia in China has been increased significantly according to the Chinese Residents of Nutrition and Health Survey in 2002 [1]. The results showed that the prevalence of dyslipidemia had been 18.6%, and there were about 160 million peoples with dyslipidemia. Dyslipidemia, one of the components of the metabolic syndrome, is closely related with obesity, type 2 diabetes, hypertension, CAD, and stroke [2]. The prevalence of dyslipidemia may be different among diverse racial/ethnic groups [3].

There are fifty-six nationalities in China. Both Jing and Mulao nationalities are the peculiar and isolated minorities in Guangxi. Jing nationality, the only oceanic nation in China, is a very small minority of coastal fisheries with population of 22,517 who live in compact communities primarily in the three islands of Wanwei, Wutou and Shanxin in Dongxing city, Guangxi, near the Sino-Vietnamese border. About 1511, their ancestors emigrated from Vietnam to China and first settled on the three uninhabited

lands. Mulao is one of the mountain minorities with population of 207,352 according to the China's fifth national census in 2000. Approximately ninety percent of Mulao people are dwelling in the Luocheng Mulao Autonomous County, Guangxi. Historical data can trace the history of this ethnic minority back to the Jin Dynasty (AD 265-420). The special customs and culture including their intra-ethnic marriages, dietary habits, lifestyle and genetic background are different between the two minorities, but little is known about the differences in serum lipid profiles and their risk factors between the two ethnic groups. Therefore, the aim of this study was to compare the serum lipid profiles, the prevalence of dyslipidemia and their risk factors between the Jing and Mulao populations.

Material and methods

Study population

The participants of this study were randomly selected from our previous stratified randomized samples. Previous stratified randomized sampling in Jing nationality was conducted in Dongxing city, Guangxi, China, during Dec 2011 and Jan 2012. First, teams (resident communities; inhabitants) were selected randomly from the three islands (villages). Then, sexes and age subgroups in each team were separated for the survey. Finally, the sampled resident sections were determined from the local population registers. A total of 1800 subjects were asked to participate in the study and 1674 subjects actually participated. The response rate was 93%. A total of 52 persons (3.1%) with a history and/or evidence of other diseases were excluded from the samples. The sampling of the Mulao population was also done by the same method. The present study included 1254 subjects of Jing (accounted for 5.57% of the total Jing population) and 1251 participants of Mulao. The subjects of Jing nationality consisted of 678 (54.07%) males and 576 (45.93%) females, aged from 35 to 92 years, with a mean age of 57.64±13.10 years. The participants of Mulao nationality consisted of 680 (54.37%) males and 571 (45.64%) females, aged from 35 to 93 years, with a mean age of 57.53±13.05 years. The participants with a history or evidence of hepatic, renal, thyroid diseases, and heart attack or myocardial infarction, stroke, congestive heart failure, diabetes mellitus or fasting blood glucose ≥ 7.0 mmol/L determined by glucose meter have been excluded. 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 and the Human Subjects Institutional Review Board of Guangxi Medical University. Informed consent was obtained from all subjects. Written informed consent was obtained from each participant.

Epidemiological survey

The survey was carried out using internationally standardized methods [4]. The information on demographics, medical history, dietary habits, lifestyle, education level, and physical activity was obtained with a standard questionnaire. The 24 h dietary recall method was used to determine the dietary intake of each subject. 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 well trained physician. The intakes of macronutrients from the ingredients were determined using the 2002 Chinese Food Composition Table [5]. The physical examination included the measurements of several parameters such as body height, weight, waist circumference, etc., and body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. Sitting blood pressure was measured three times using a mercury sphygmomanometer after the subject had rested for 5 min, and the average of the three measurements was used as the blood pressure level. Systolic blood pressure was determined by the first Korotkoff sound, and diastolic blood pressure by the fifth Korotkoff sound.

Determination of serum lipid parameters

A blood sample was obtained after an overnight fast. The levels of total cholesterol (TC) and triglyceride (TG) were determined enzymatically using commercially available kits (RANDOX Laboratories Ltd., Ardmore, Antrim, UK). The levels of high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were detected using standard enzymatic methods (Daiichi Pure Chemicals Co., Ltd., Tokyo, Japan). Serum apolipoprotein A1 (ApoA1)

Table 1. General characteristics, serum lipid profiles, and the prevalence of dyslipidemia between the Jing and Mulao populations

Parameter	Jing (*n* = 1254)	Mulao (n = 1251)	*t* (x^2)	P
Age (years)	57.64±13.10	57.53±13.05	0.014	0.989
Male/female	678/576	680/571	0.021	0.884
Education level (years)	4.81±3.46	4.62±3.97	1.277	0.202
Physical activity (h/week)	42.47±8.08	45.31±8.89	-8.367	< 0.001
Height (cm)	158.30±7.95	153.86±7.81	8.656	< 0.001
Weight (kg)	58.80±10.05	53.69±9.49	13.066	< 0.001
Body mass index (kg/m^2)	23.39±3.17	22.12±3.16	10.005	< 0.001
> 24 kg/m^2 [*n* (%)]	467 (37.24)	322 (21.17)	38.395	< 0.001
Waist circumference (cm)	80.35±9.35	76.01±8.85	11.940	< 0.001
Alcohol consumption [*n* (%)]	201 (16.03)	354 (28.00)	54.655	< 0.001
Cigarette smoking [*n* (%)]	235 (18.64)	345 (27.58)	27.492	< 0.001
Energy (kcal/day)	2112.36±92.50	2181.32±96.51	-18.275	< 0.001
Carbohydrate (g/day)	396.08±21.72	418.35±23.79	-24.468	< 0.001
Protein (g/day)	51.76±7.45	49.33±7.17	8.317	< 0.001
Total fat (g/day)	28.11±5.76	29.38±4.52	-6.138	< 0.001
Dietary cholesterol (mg/day)	199.24±97.38	203.79±99.31	1.159	0.247
Total dietary fiber (g/day)	8.33±3.48	9.88±4.26	9.974	< 0.001
Systolic blood pressure (mmHg)	131.37±21.42	132.79±23.19	-1.593	0.111
Diastolic blood pressure (mmHg)	80.05±10.57	82.35±12.22	-5.036	< 0.001
Pulse pressure (mmHg)	51.16±17.39	50.44±17.19	1.035	0.301
Prevalence of hypertension [*n* (%)]	468 (37.32)	534 (42.69)	7.511	0.006
Total cholesterol (TC, mmol/L)	5.15±0.89	5.21±1.29	-1.427	0.154
TC > 5.17 mmol/L [*n* (%)]	569 (45.37)	614 (49.08)	3.451	0.063
Triglyceride (TG, mmol/L)	1.67±0.89	1.62±2.20	0.722	0.471
TG > 1.70 mmol/L [*n* (%)]	406 (32.38)	305 (24.38)	19.697	< 0.001
HDL-C (mmol/L)	1.79±0.44	1.77±0.44	1.136	0.256
HDL-C < 0.91 mmol/L [*n* (%)]	6 (0.48)	27 (2.16)	13.593	< 0.001
LDL-C (mmol/L)	2.84±0.43	3.04±0.91	-7.213	< 0.001
LDL-C > 3.20 mmol/L [*n* (%)]	220 (17.54)	507 (40.53)	160.597	< 0.001
Apolipoprotein A1 (ApoA1, g/L)	1.30±0.23	1.36±0.40	-4.621	< 0.001
ApoA1 < 1.00 g/L [*n* (%)]	75 (5.98)	143 (11.43)	24.412	< 0.001
Apolipoprotein B (ApoB, g/L)	1.07±0.25	1.00±0.55	4.178	< 0.001
ApoB > 1.14 g/L [*n* (%)]	442 (35.25)	192 (15.35)	131.185	< 0.001
ApoA1/ApoB	1.28±0.37	1.56±0.69	-12.649	< 0.001
ApoA1/ApoB < 1.00 [*n* (%)]	284 (22.65)	211 (16.87)	13.200	< 0.001
Prevalence of hyperlipidemia [*n* (%)]	759 (60.53)	719 (57.47)	2.412	0.120

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; Hypercholesterolaemia, TC > 5.17 mmol/L; Hypertriacylglycerolaemia, TG > 1.70 mmol/L; Hyperlipidemia, TC > 5.17 mmol/L and/or TG > 1.70 mmol/L.

and ApoB levels were measured by an immunoturbidimetric assay (RANDOX Laboratories Ltd.).

Diagnostic criteria

The normal range of serum TC, TG, HDL-C, LDL-C, ApoA1, ApoB levels, and the ApoA1/ApoB ratio was 3.10-5.17, 0.56-1.70, 0.91-1.81, 2.70-3.20 mmol/L, 1.00-1.76, 0.63-1.14 g/L, and 1.00-2.50; respectively. The subjects with TC > 5.17 mmol/L and/or TG > 1.70 mmol/L were defined as hyperlipidemia [5].

Statistical analyses

Quantitative variables were represented as mean ± standard deviation (serum TG levels

Table 2. Serum lipid levels according to sex, BMI, blood pressure, drinking, smoking and age between the Jing and Mulao populations

Parameter	n	TC (mmol/L)	TG (mmol/L)	HDL-C (mmol/L)	LDL-C (mmol/L)	ApoA1 (g/L)	ApoB (g/L)	ApoA1/ApoB
Jing								
Male	678	5.08±0.80	1.50 (1.16)	1.74±0.45	2.81±0.37	1.29±0.23	1.08±0.23	1.27±0.40
Female	576	5.23±0.98**	1.40 (1.14)	1.84±0.42***	2.86±0.48	1.31±0.24	1.07±0.26	1.29±0.34
BMI ≤ 24 (kg/m^2)	787	5.08±0.87	1.33 (1.06)	1.87±0.44	2.81±0.41	1.33±0.21	1.03±0.24	1.36±0.39
BMI > 24 (kg/m^2)	467	5.26±0.91**	1.66 (1.29)***	1.64±0.40***	2.88±0.46*	1.26±0.27***	1.14±0.25***	1.15±0.31***
Normotensive	786	5.11±0.90	1.36 (1.08)	1.81±0.47	2.82±0.44	1.31±0.24	1.06±0.24	1.30±0.39
Hypertensive	468	5.21±0.85	1.53 (1.22)***	1.74±0.39**	2.87±0.40*	1.29±0.22	1.09±0.25	1.25±0.34*
Nondrinker	1053	5.13±0.92	1.44 (1.14)	1.76±0.43	2.84±0.44	1.30±0.24	1.08±0.25	1.26±0.35
Drinker	201	5.26±0.71	1.49 (1.16)	1.92±0.46***	2.84±0.34	1.34±0.22**	1.06±0.25	1.36±0.45**
Nonsmoker	1019	5.15±0.90	1.44 (1.12)	1.79±0.41	2.84±0.44	1.30±0.23	1.08±0.25	1.27±0.34
Smoker	235	5.13±0.85	1.44 (1.17)	1.78±0.55	2.83±0.38	1.30±0.23	1.06±0.23	1.32±0.50
Age ≤ 40 year	130	4.56±0.80	1.23 (1.00)	1.63±0.40	2.58±0.41	1.24±0.19	0.99±0.25	1.35±0.46
40~year	307	4.96±0.78	1.35 (1.10)	1.78±0.45	2.79±0.40	1.29±0.20	1.05±0.22	1.29±0.36
50~year	297	5.33±0.91	1.43 (1.14)	1.81±0.43	2.93±0.46	1.32±0.24	1.10±0.24	1.24±0.30
60~year	263	5.36±0.89	1.55 (1.19)	1.82±0.43	2.92±039	1.30±0.21	1.07±0.23	1.27±0.37
70~year	224	5.20±0.86	1.49 (1.21)	1.80±0.47	2.83±0.40	1.35±0.33	1.10±0.27	1.30±0.42
≥ 80 year	33	5.56±0.81	1.41 (1.29)	1.83±0.43	2.96±0.34	1.28±0.24	1.12±0.27	1.12±0.27
F for 6 age subgroups	-	23.044	1.184	3.970	16.970	3.813	5.951	2.878
P for 6 age subgroups	-	< 0.001	0.315	< 0.001	< 0.001	0.002	< 0.001	0.014
Mulao								
Male	680	5.31±1.34^{c}	1.18 (0.84)^{c}	1.76±0.46	3.02±0.88^{c}	1.38±0.42^{c}	1.05±0.60	1.52±0.67^{c}
Female	571	5.10±1.20^{**,a}	1.08 (0.84)^{***,c}	1.77±0.42^{c}	3.08±0.94^{c}	1.34±0.37	0.95±0.47^{**c}	1.60±0.72^{*c}
BMI ≤ 24 (kg/m^2)	929	5.13±1.06	1.06 (0.82)^{c}	1.87±0.44	3.00±0.85^{c}	1.38±0.41^{b}	0.96±0.48^{c}	1.62±0.72^{c}
BMI > 24 (kg/m^2)	322	5.44±1.77**	1.45 (0.95)^{***,c}	1.61±0.39***	3.18±1.06^{*,c}	1.31±0.37^{*,a}	1.13±0.69***	1.38±0.57^{***,c}
Normotensive	717	5.17±1.32	1.05 (0.81)^{c}	1.78±0.42	3.02±0.85^{c}	1.37±0.38^{c}	0.96±0.48^{c}	1.30±0.39
Hypertensive	534	5.26±1.23	1.27 (0.88)^{***,c}	1.74±0.39	3.09±0.99^{c}	1.36±0.42^{b}	1.05±0.62**	1.50±0.69^{*,c}
Nondrinker	897	5.15±1.15	1.12 (0.85)^{c}	1.73±0.41^{a}	3.10±0.90^{c}	1.32±0.37	1.00±0.54^{c}	1.53±0.67^{c}
Drinker	354	5.38±1.63**	1.14 (0.82)^{c}	1.87±0.50***	2.90±0.94^{***,c}	1.47±0.44^{***,b}	1.02±0.56^{c}	1.65±0.72^{**,c}
Nonsmoker	906	5.18±1.32	1.13 (0.84)^{c}	1.76±0.42^{a}	3.06±0.91^{c}	1.36±0.39	1.00±0.55^{a}	1.56±0.71^{c}
Smoker	345	5.29±1.20	1.10 (0.83)^{c}	1.78±0.55	3.01±0.91	1.38±0.41	1.00±0.53	1.57±0.63^{c}
Age ≤ 40 year	141	5.13±1.23^{c}	1.13 (0.82)	1.77±0.47^{b}	2.96±0.99^{c}	1.43±0.36^{c}	1.00±0.68	1.69±0.67^{c}
40~year	298	5.09±1.81	1.07 (0.78)^{c}	1.69±0.44^{b}	2.92±1.00^{a}	1.31±0.45	1-02±0.65	1.57±0.91^{c}
50~year	303	5.37±1.02	1.17 (0.83)^{c}	1.79±0.40	3.22±0.84^{c}	1.41±0.35^{c}	0.96±0.33^{c}	1.59±0.57^{c}
60~year	251	5.26±1.08	1.11 (0.85)^{c}	1.82±0.48	3.03±0.85	1.38±0.40^{b}	1.07±0.58	1.48±0.60^{c}
70~year	227	5.21±1.03	1.12 (0.88)^{c}	1.79±0.41	3.08±0.89^{c}	1.33±0.39	0.99±0.51^{b}	1.50±0.63^{c}
≥ 80 year	31	4.09±0.87^{b}	0.94 (0.80)^{c}	1.67±0.56	2.78±0.64	0.86±0.27	0.86±0.27^{c}	1.58±0.45^{c}
F for 6 age subgroups	-	5.054	2.047	3.181	4.431	3.697	1.655	2.125
P for 6 age subgroups	-	< 0.001	0.070	0.007	< 0.001	0.003	0.143	0.060

TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; ApoA1, apolipoprotein A1; ApoB, apolipoprotein B; ApoA1/ApoB, the ratio of apolipoprotein A1 to apolipoprotein B; BMI, body mass index. *P < 0.05, **P < 0.01 and ***P < 0.001 in comparison with male, BMI ≤ 24 kg/m^2, normotensive, nondrinking, or nonsmoker of the same ethnic group; ^{a}P < 0.05, ^{b}P < 0.01 and ^{c}P < 0.001 in comparison with the same subgroup of Jing. The values of TG were presented as median (inter-quartile range).

were represented as medians and inter-quartile ranges). Comparisons of mean values of general characteristics between Jing and Mulao were performed by Student's unpaired *t*-test. Comparisons of serum lipid levels between the two ethnic groups or two subgroups were tested by analysis of covariance (ANCOVA). Sex, age, weight, body height, BMI, alcohol consumption, cigarette smoking, blood pressure, and age were adjusted for the statistical analysis. Qualitative variables were expressed as percentages, the difference between the two ethnic groups was tested by the Chi-square test. The association of serum lipid levels and several environmental factors was tested by multivariable linear regression analysis. To evaluate the association of hyperlipidemia and several environmental factors, unconditional

logistic regression analysis was also performed in a combined population of Jing and Mulao, Jing, and Mulao; respectively. A *P* value of less than 0.05 was considered statistically significant.

Results

Population characteristics

The general characteristics of Jing and Mulao are presented in **Table 1**. The levels of body height, weight, BMI, waist circumference and the intake of protein were higher in Jing than in Mulao ($P < 0.001$ for all), whereas the intensity of physical activity, the intakes of energy, carbohydrate, total fat, total dietary fiber, the levels of diastolic blood pressure and the prevalence of hypertension, and the rates of drinking and smoking were lower in Jing than in Mulao ($P < 0.01$ for all).

Serum lipid levels and the prevalence of dyslipidemia

The levels of LDL-C, ApoA1, and the ratio of ApoA1 to ApoB were lower but the levels of ApoB were higher in Jing than in Mulao ($P < 0.001$ for all). The abnormal rates of HDL-C, LDL-C and ApoA1 were lower and the abnormal rates of TG, ApoB and ApoA1/ApoB ratio were higher in Jing than in Mulao ($P < 0.001$ for all; **Table 1**). The prevalence of hypercholesterolemia, hypertriglyceridemia and hyperlipidemia between Jing and Mulao was 45.37% *vs*. 49.08% ($P > 0.05$), 32.38% *vs*. 24.38% ($P < 0.001$) and 60.53% *vs*. 57.47% ($P > 0.05$); respectively.

Sex, BMI, blood pressure, alcohol, smoking, age and serum lipid levels

For the Jing population, the levels of TC and HDL-C were higher in females than in males; TC, TG, LDL-C and ApoB were higher and HDL-C, ApoA1 and the ratio of ApoA1 to ApoB were lower in subjects with a BMI > 24 kg/m^2 than those with a BMI ≤ 24 kg/m^2; TG and LDL-C were higher and HDL-C and the ratio of ApoA1 to ApoB were lower in hypertensives than in normotensives; and HDL-C, ApoA1 and the ratio of ApoA1 to ApoB were higher in drinkers than in nondrinkers ($P < 0.05$-0.001; **Table 2**).

For the Mulao population, the levels of TC, TG and ApoB were lower and the ratio of ApoA1 to ApoB was higher in females than in males; TC, TG, LDL-C and ApoB were higher and HDL-C, ApoA1 and the ratio of ApoA1 to ApoB were lower in subjects with a BMI > 24 kg/m^2 than those with a BMI ≤ 24 kg/m^2; TG, ApoB and the ratio of ApoA1 to ApoB were higher in hypertensives than in normotensives; and TC, HDL-C, ApoA1 and the ratio of ApoA1 to ApoB were higher and LDL-C was lower in drinkers than in nondrinkers ($P < 0.05$-0.001; **Table 2**).

The levels of TC (female and ≥ 80 year), TG (all subgroups but not ≤ 40 year), HDL-C (female, nondrinker, nonsmoker, and 40~ year) and ApoB (female, BMI ≤ 24 kg/m^2, normotensive, nondrinker, drinker, nonsmoker, 50~, 70~, and ≥ 80 year) were lower and the levels of TC (male and ≤ 40 year), HDL-C (≤ 40 year), LDL-C (all subgroups but not 60~ and ≥ 80 year), ApoA1 (male, BMI ≤ 24 kg/m^2, BMI > 24 kg/m^2, normotensive, hypertensive, drinker, ≤ 40, 50~, and 60~ year), and the ratio of ApoA1 to ApoB (all subgroups but not normotensive) were higher in Mulao than in Jing corresponding subgroups ($P < 0.05$-0.001; **Table 2**).

Risk factors for serum lipid parameters

The risk factors for serum lipid parameters between the two ethnic groups are listed in **Table 3**. Serum lipid parameters were correlated with sex, age, alcohol consumption, cigarette smoking, height, weight, BMI, waist circumference, and blood pressure in both ethnic groups ($P < 0.05$-0.001), but the risk factors were different between the Jing and Mulao populations.

Risk factors for hyperlipidemia

The prevalence of hyperlipidemia was associated with age, waist circumference, BMI, and the intakes of total energy and total dietary fiber in Jing, whereas it was correlated with age, sex, cigarette smoking, systolic blood pressure, and the intakes of total energy, total fat and total dietary fiber in Mulao ($P < 0.05$-0.001; **Table 4**).

Discussion

The present study showed that the serum lipid profiles and the prevalence of dyslipidemia were different between the Jing and Mulao populations. The levels of LDL-C, ApoA1, and the ratio of ApoA1 to ApoB were lower but the levels

Table 3. Related risk factors for serum lipid parameters between the Jing and Mulao populations

Lipid	Risk factor	Unstandardized coefficient	Std. error	Standardized coefficient	*t*	*P*
Jing and Mulao						
TC	Age	0.007	0.002	0.087	4.200	< 0.001
	Alcohol consumption	0.117	0.037	0.066	3.112	0.002
	Weight	-0.011	0.004	-0.102	-2.663	0.008
	Diastolic blood pressure	0.005	0.002	0.047	2.300	0.022
	Body mass index	0.060	0.013	0.174	4.664	< 0.001
TG	Age	-0.010	0.003	0.082	-3.716	< 0.001
	Height	-0.022	0.006	-0.106	-3.847	< 0.001
	Gender	-0.354	0.096	-0.105	-3.693	< 0.001
	Waist circumference	0.041	0.004	0.227	10.818	< 0.001
	Systolic blood pressure	0.005	0.002	0.062	2.933	0.003
HDL-C	Alcohol consumption	0.152	0.014	0.217	10.695	< 0.001
	Weight	-0.007	0.002	-0.171	-4.194	< 0.001
	Ethnic group	-0.094	0.017	-0.107	-5.434	< 0.001
	Gender	0.096	0.023	0.109	4.161	< 0.001
	Height	0.005	0.002	0.092	3.040	< 0.001
	Waist circumference	-0.010	0.002	-0.217	-0.620	< 0.001
LDL-C	Weight	-0.007	0.003	-0.104	-2.882	0.004
	Age	0.003	0.001	0.047	2.290	0.022
	Ethnic group	0.211	0.030	0.147	7.315	< 0.001
	Body mass index	0.039	0.008	0174	4.958	< 0.001
ApoA1	Alcohol consumption	0.080	0.010	0.152	7.768	< 0.001
	Systolic blood pressure	0.001	0.000	0.093	3.612	< 0.001
	Diastolic blood pressure	-0.002	0.001	-0.058	-2.191	0.029
	Waist circumference	-0.005	0.001	-0.142	-6.799	< 0.001
	Ethnic group	0.040	0.013	0.060	2.974	0.003
ApoB	Systolic blood pressure	0.003	0.000	0.149	5.747	< 0.001
	Ethnic group	-0.035	0.017	-0.042	-2.045	0.041
	Gender	-0.051	0.018	-0.060	-2.783	0.005
	Waist circumference	0.007	0.001	0.157	7.475	< 0.001
	Diastolic blood pressure	-0.003	0.001	-0.079	-2.556	0.011
ApoA1/ApoB	Age	-0.003	0.001	-0.068	-3.330	0.001
	Alcohol consumption	0.105	0.019	0.115	5.624	< 0.001
	Ethnic group	0.217	0.022	0.189	9.646	< 0.001
	Gender	0.075	0.030	0.065	2.478	0.013
	Height	0.004	0.002	0.060	1.967	0.049
	Weight	-0.005	0.002	-0.093	-2.270	0.023
	Waist circumference	-0.011	0.002	-0.178	-5.213	< 0.001
Jing						
TC	Gender	0.277	0.056	0.155	4.972	< 0.001
	Age	0.019	0.002	0.287	9.682	< 0.001
	Cigarette smoking	0.061	0.035	0.076	2.441	0.015
	Alcohol consumption	0.106	0.034	0.091	3.138	0.002
	Systolic blood pressure	-0.008	0.002	-0.197	-5.324	< 0.001
	Diastolic blood pressure	0.017	0.003	0.202	5.830	< 0.001
	Body mass index	0.047	0.014	0.169	3.321	0.001
TG	Gender	-2.243	0.065	-0.138	-3.737	< 0.001

	Age	-0.004	0.002	-0.060	-2.091	0.037
	Cigarette smoking	0.154	0.023	0.196	6.703	< 0.001
	Height	-0.033	0.005	-0.293	-7.208	< 0.001
	Waist circumference	0.045	0.005	0.4482	8.819	< 0.001
	Diastolic blood pressure	0.008	0.002	0.099	3.701-	< 0.001
HDL-C	Gender	0.145	0.024	0.164	6.109	< 0.001
	Age	0.004	0.001	0.110	4.005	< 0.001
	Alcohol consumption	0.145	0.015	0.251	9.409	< 0.001
	Waist circumference	-0.018	0.001	-0.372	-13.999	< 0.001
	Diastolic blood pressure	0.004	0.001	0.090	2.756	0.006
	Systolic blood pressure	-0.002	0.001	-0.090	2.756	0.006
LDL-C	Gender	0.085	0.026	0.099	3.223	0.001
	Age	0.006	0.001	0.186	6.111	< 0.001
	Cigarette smoking	0.031	0.012	0.082	2.590	0.010
	Diastolic blood pressure	0.005	0.001	0.134	3.790	< 0.001
ApoA1	Alcohol consumption	0.051	0.009	0.167	5.928	< 0.001
	Age	0.001	0.001	0.064	2.256	0.024
	Weight	-0.018	0.008	-0.782	-2.413	0.016
ApoB	Age	0.003	0.001	0.141	4.917	< 0.001
	Height	-0.004	0.001	-0.117	-2.873	0.004
	Weight	0.004	0.002	0.177	2.585	0.010
	Waist circumference	0.003	0.002	0.130	2.270	0.023
ApoA1/ApoB	Age	-0.002	0.001	-0.078	-2.802	0.005
	Alcohol consumption	0.063	0.013	0.129	-4.380	< 0.001
	Height	0.004	0.002	0.091	2.234	0.026
	Weight	-0.011	0.002	-0.291	-4.380	< 0.001
Mulao						
TC	Gender	-0.165	0.074	-0.064	-2.233	0.026
	Waist circumference	0.016	0.004	0.107	3.649	< 0.001
	Systolic blood pressure	0.006	0.002	0.115	2.957	0.003
TG	Age	-0.011	0.005	-0.066	-2.173	0.030
	Alcohol consumption	0.725	0.144	0.149	5.022	< 0.001
	Height	-0.124	0.055	-0.444	-2.243	0.025
	Weight	0.176	0.079	0.760	2.229	0.026
	Waist circumference	0.043	0.011	0.173	4.068	< 0.001
	Systolic blood pressure	0.009	0.004	0.099	2.648	0.014
	Body mass index	-0.406	0.191	-0.585	-2.131	0.033
HDL-C	Cigarette smoking	-0.023	0.011	-0.065	-2.117	0.034
	Alcohol consumption	0.205	0.031	0.208	6.675	<0.001
	Height	0.005	0.002	0.082	2.235	0.026
	Weight	-0.011	0.002	-0.241	-4.891	< 0.001
	Waist circumference	-0.006	0.002	-0.116	-2.786	0.005
LDL-C	Alcohol consumption	-2.222	0.056	-0.110	-3.939	< 0.001
	Body mass index	0.040	0.008	0.137	4.845	< 0.001
ApoA1	Age	-0.003	0.001	-0.084	-2.837	0.005
	Alcohol consumption	0.157	0.025	0.178	6.388	< 0.001
	Waist circumference	-0.005	0.001	-0.116	-4.067	< 0.001
	Systolic blood pressure	0.002	0.001	0.144	3.577	< 0.001
	Diastolic blood pressure	-0.003	0.001	-0.102	-2.612	0.009

ApoB	Gender	-0.129	0.037	-0.118	-3.456	0.001
	Age	-0.004	0.001	-0.090	-3-014	0.003
	Alcohol consumption	-0.088	0.041	-0.073	-2.165	0.031
	Waist circumference	0.008	0.002	0.124	4.283	< 0.001
	Systolic blood pressure	0.006	0.001	0.268	6.622	< 0.001
	Diastolic blood pressure	-0.008	0.002	-0.177	-4.545	< 0.001
ApoA1/ApoB	Gender	0.140	0.047	0.101	2.982	0.003
	Age	-0.004	0.001	-0.076	-2.724	0.007
	Alcohol consumption	0.233	0.051	0.152	4.555	0.001
	Waist circumference	-0.016	0.002	-0.205	-7.320	< 0.001

TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; ApoA1, apolipoprotein A1; ApoB, apolipoprotein B; ApoA1/ApoB, the ratio of apolipoprotein A1 to apolipoprotein B.

Table 4. Related risk factors for hyperlipidemia between the Jing and Mulao populations

Population	Risk factor	Regression coefficient	Standard error	Wald	*P* value	Odds ratio	95% Confidence interval
Jing and Mulao	Age	0.077	0.031	6.171	0.013	1.080	1.016-1.148
	Waist circumference	0.607	0.137	19.534	< 0.001	1.834	1.402-2.400
	Body mass index	0.253	0.108	5.450	0.020	1.288	1.041-1.593
	Alcohol consumption	0.285	0.101	7.899	0.005	1.330	1.090-1.622
	Diastolic blood pressure	0.242	0.097	6.196	0.013	1.274	1.053-1.541
	Total energy	0.553	0.164	10.234	0.001	1.372	1.196-2.428
	Total fat	0.546	0.138	13.131	< 0.001	1.571	1.137-2.346
	Total dietary fiber	-0.244	0.103	5.418	0.021	1.278	1.055-1.671
Jing	Age	0.252	0.046	29.675	< 0.001	1.286	1.175-1.408
	Waist circumference	0.783	0.187	17.585	< 0.001	2.188	1.518-3.156
	Body mass index	0.321	0.158	4.103	0.043	1.378	1.010-1.880
	Total energy	0.431	0.193	7.842	0.005	1.713	1.138-1.998
	Total dietary fiber	-0.258	0.086	6.222	0.011	1.435	1.042-1.976
Mulao	Age	-0.120	0.045	7.067	0.008	0.887	0.811-0.969
	Sex	-0.643	0.144	19.820	< 0.001	0.526	0.396-0.698
	Cigarette smoking	-0.430	0.161	7.170	0.007	0.651	0.475-0.891
	Systolic blood pressure	0.407	0.128	10.163	0.001	1.502	1.170-1.928
	Total energy	0.601	0.174	11.546	< 0.001	1.868	1.047-2.353
	Total fat	0.564	0.191	9.468	0.002	1.637	1.206-2.273
	Total dietary fiber	-0.286	0.110	6.459	0.009	1.715	1.148-2.336

Ethnic group (Jing = 0; Mulao = 1), gender (male = 0; female = 1), age (< 40 = 1; 40~ = 2; 50~ = 3; 60~ = 4; 70~ = 5; and > 80 = 6), BMI (≤ 24 kg/m^2 = 0; > 24 kg/m^2 = 1), waist circumference [< 90 (male)/85 (female) cm = 0; ≥ 90 (male)/85 (female) cm = 1), systolic blood pressure (< 140 mmHg = 0; ≥ 140 mmHg = 1), diastolic blood pressure (< 90 mmHg = 0; ≥ 90 mmHg = 1), hypertension (normotensive = 0; hypertensive = 1), alcohol consumption (nondrinker = 0; drinker = 1), cigarette smoking (nonsmoker = 0; smoker = 1).

of ApoB were higher in Jing than in Mulao. The prevalence of hypertriglyceridemia, high ApoB and low ApoA1/ApoB ratio was higher and low HDL-C, high LDL-C and low ApoA1 was lower in Jing than in Mulao. Multivariable linear regression and unconditional logistic regression analyses revealed that the risk factors for serum lipid parameters and hyperlipidemia were also different between the two ethnic groups. It is well recognized that dyslipidemia is a complex trait caused by multiple environmental and genetic factors and their interactions [5-7]. The differences in serum lipid profiles and the prevalence of dyslipidemia between the Jing and

Mulao populations may result from different dietary habits, lifestyle and genetic background.

Jing nationality is the only oceanic ethnic minority in China. They make living by fishing, and the economic condition is relatively good. They mainly eat fish and shrimp and like to use fish sauce as a kind of seasoning which is one of the local characteristics and also known as the "catfish sauce". Marin fish contains a lot of polyunsaturated fatty acids (PUFAs) that are mainly omega-3 fatty acids which main ingredient is eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). A number of studies showed that omega-3 fatty acids can reduce the generation of TG in liver and increase the excrement of TG and lower serum TG levels. It also can lower TC, LDL-C levels and increase HDL-C levels [8]. In addition, numerous studies reported that omega-3 fatty acids could improve insulin resistance [9], hypertension and hyperglycemia [10]. It is benefit for people eating fish rich in PUFAs for long-term to reduce LDL-C levels while reducing sclerosis of arterial congee appearance to reduce the death of coronary heart disease, acute myocardial infarction [11]. American Heart Association recommends coronary heart disease patients to acquire omega-3 PUFAs 1 g daily, and people without coronary heart disease eat fish, especially fatty fish at least twice a week.

The great majority of the Mulao people live in the mountain area. Rice and corn are the staple food all year. With the improvement of their living standard and the change of lifestyle, the intake of animal (pig) fat was more in Mulao than in Jing nationalities. The people of Mulao nationality like to eat cold foods along with acidic and spicy dishes, so bean soy sauce and pickled vegetables are among their most popular dishes. Some research showed that soluble dietary fiber absorbed a large number of bile acid, preventing cholesterol into blood and increasing its excretion, thereby increasing the conversion rate of cholesterol to lower serum cholesterol levels [12]. They also like to use animal oil to cook foods and eat fat meat, animal offal, brain ridge and pith which contain abundant saturated fatty acid. For nearly 50 years it has been widely accepted that high-fat diets, particularly those that contain large quantities of saturated fatty acids, raise blood cholesterol concentrations and predispose individuals to cardiovascular disease [13]. Moreover, these high calorie diets that contain high saturated fatty acid, high fat and high cholesterol may stimulate the synthesis of blood cholesterol and elevate blood lipid concentrations.

The relationship between obesity and dyslipidemia has been clearly documented. The typical dyslipidemia of obesity consists of increased TG and free fatty acids, decreased HDL-C with HDL dysfunction and normal or slightly increased LDL-C with increased small dense LDL [14]. The concentrations of serum ApoB are also often increased, partly due to the hepatic overproduction of ApoB containing lipoproteins [15]. In the present study, we showed that the mean values of BMI and waist circumference were higher in Jing than in Mulao, the levels of ApoB and the prevalence of hypertriglyceridemia were also higher in Jing than in Mulao. Hypertriglyceridemia in obesity may be the major cause of the other lipid abnormalities since it will lead to delayed clearance of the TG-rich lipoproteins [16] and formation of small dense LDL [16, 17]. Lipolysis of TG-rich lipoproteins is further impaired in obesity by reduced mRNA expression levels of lipoprotein lipase (LPL) in adipose tissue [18] and reduced LPL activity in skeletal muscle [19]. Hypertriglyceridemia further induces an increased exchange of cholesterol esters and TG between VLDL and HDL and LDL by cholesterylester-transfer-protein. In addition, hepatic lipase removes TG and phospholipids from LDL for the final formation of TG-depleted small dense LDL.

Several observational studies and meta-analyses have consistently shown that moderate drinking when taken on a regular basis can increase TG, HDL-C and lower LDL-C levels, and protect against cardiovascular disease and death [20], but heavy drinking could reduce HDL-C level and constitute a severe risk condition [21]. In the current study, we showed that the percentages of subjects who consumed alcohol were higher in Mulao than in Jing, but the people of Mulao like to drink their homemade "Chongyang wine", a kind of glutinous rice wine. Its alcohol content is low, but rich in a variety of amino acids, glucose, vitamins and minerals. In addition, there are many wild grapes, V. quinquangularis (Vitis louchengensis W.T. Wang, ined), these fruits are used to make

wine by local people. Conversely, the people of Jing drink rice wine on the market, with a higher content of alcohol. The effect of different kinds of alcoholic beverage on the lipid profiles is not well unknown, but some investigators have suggested that certain types of alcohol, e.g., wine, may be more protective than others. Ruidavets et al. [22] found that wine was positively associated with HDL-C, and beer was positively associated with HDL-C in men and with TG in men and women. Choudhury et al. [23] also showed serum TG levels were significantly lower in those who drank beer. The effects of alcohol intake on LDL-C appear to vary by specific patient types or patterns of alcohol intake, and perhaps by population and sex. A study in older Italian subjects (65-84 years old) found that alcohol intake increased serum LDL-C levels [24]. Another study in Turks also found increases in LDL-C, as well as in ApoB and TG, with alcohol in men, while women decreased TG and no change in LDL-C or ApoB with alcohol [25].

Some studies have proven that cigarette smoking has negative influences on the lipid profiles, but the results are inconsistent. Rao et al. [26] showed that cigarettes smoking raised LDL-C and TC levels but lowered HDL-C levels. In the current study, we showed that the percentages of subjects who smoked cigarettes were higher in Mulao than in Jing, but there were no significant differences in serum lipid parameters between smokers and nonsmokers in the both ethnic groups. These results suggested that cigarette smoking may not be independent risk factors for serum lipid levels in these populations.

Epidemiological studies have provided abundant evidence that plasma/serum lipid levels are closely related to sex and age [27]. Our study also showed that sex and age distribution could influence serum lipid levels in both ethnic groups. The levels of TC and HDL-C in Jing, and LDL-C and the ratio of ApoA1 to ApoB in Mulao were higher in females than in males. The levels of TC, TG and ApoB in Mulao were lower in females than in males. Sex differences in serum lipid profiles might result from different general characteristics such as BMI, waist circumference, alcohol consumption, dietary habits, exercise, and sex hormones. A meta-analysis demonstrated that testosterone decreased TC, TG, and HDL-C levels, but increased LDL-C levels [28]. Estrogen is negatively correlated with serum TC, TG, and LDL-C levels, and positively correlated with HDL-C levels. Postmenopausal estrogen levels drop and subsequent changes in serum lipid levels could lead to cardiovascular events rising [29].

Both dyslipidemia and hypertension are the components of the metabolic syndrome. Blood pressure and plasma/serum lipid levels have been consistently related in several previous studies [30]. In the present study, we showed that the levels of TG and LDL-C in Jing were higher and HDL-C and the ratio of ApoA1 to ApoB were lower; and the levels of TG, ApoB and the ratio of ApoA1 to ApoB in Mulao were higher in hypertensives than in normotensives. These findings suggest that dyslipidemia and hypertension may have many common risk factors.

Serum lipid levels are also influenced by genetic factors [5, 7]. Several genetic polymorphisms were related to serum lipid levels [5, 7]. The genetic background of Jing and Mulao is different. Therefore, we guess that some lipid-related genetic polymorphisms may be different between the two ethnic groups, but it still needs to be determined.

Study limitations

There are several limitations in this study. First, the sample size is small. Second, a 24 h dietary recall may be inaccurate when diets are highly variable. Third, it is well known that both estrogen and menopause can influence serum lipid levels. In the present study, however, we did not distinguish the premenopausal and postmenopausal women in the both ethnic groups because of the relatively small samples. Finally, it is clearly established that serum lipid levels are regulated by multiple environmental and genetic factors, and their interactions [5-7]. Although we have detected the effect of several risk factors on serum lipid levels in this study, there are still many unmeasured environmental and genetic factors and their interactions.

Conclusions

Serum lipid profiles, the prevalence of dyslipidemia, and their risk factors were different between the Jing and Mulao populations. These

differences between the two minorities may result from the combined effects of different diets, lifestyle as well as genetic background.

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Disclosure of conflict of interest

None.

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