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Original Article

Prevalence of hypertension and its risk factors in the Chinese Mulao and Han populations

Xi-Jiang Hu[1], Rui-Xing Yin[1], Hui Li[2], Yuan-Lu Shi[3], Yi-Ming Wang[4], Mei-Fang Wei[3], Xing-Jiang Long[1], Dong-Feng Wu[1], Lynn Htet Htet Aung[1], Lin Miao[1]

[1]Department of Cardiology, Institute of Cardiovascular Diseases, The First Affiliated Hospital, Guangxi Medical University, Nanning 530021, Guangxi, People's Republic of China; [2]Clinical Laboratory of The Affiliated Cancer Hospital, Guangxi Medical University, Nanning 530021, Guangxi, People's Republic of China; [3]The Disease Control and Prevention Center, Luocheng Mulao Autonomous County, Luocheng 546400, Guangxi, People's Republic of China; [4]Department of Molecular Genetics, Medical Scientific Research Center, Guangxi Medical University, Nanning 530021, Guangxi, People's Republic of China

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Abstract: Mulao nationality is an isolated minority in China. Little is known about the prevalence of hypertension and its risk factors in this population. The aim of this study was to compare the difference in the prevalence of hypertension and its risk factors between the Mulao and Han populations. A cross-sectional study of hypertension in 1055 subjects of Mulao nationality and 969 participants of Han nationality aged 15-93 was conducted by a stratified randomized sampling. Information on demographics, diet, lifestyle, and physical activity was collected with standardized questionnaires. Blood pressure, serum lipids, and several anthropometric parameters were obtained from all subjects. The levels of systolic, diastolic, pulse pressure, and the overall prevalence of hypertension (39.91% *vs*. 32.40%) were higher in Mulao than in Han ($P < 0.01$ for all). The rates of awareness, treatment and control in Mulao and Han were 20.43% *vs*. 29.30% ($P < 0.01$), 13.78% *vs*. 22.61% ($P < 0.01$), and 2.85% *vs*. 6.69% ($P < 0.05$); respectively. Multivariate logistic regression analysis showed that the prevalence of hypertension was positively correlated with sex (male), total cholesterol, triglyceride, total fat, and sodium, and negatively associated with total dietary fiber in Han, whereas it was positively associated with age, body mass index, apolipoprotein B, total fat, and sodium, and negatively associated with total dietary fiber in Mulao ($P < 0.05$-0.001). The difference in the blood pressure levels and the prevalence of hypertension between the two ethnic groups might result from different education level, body mass index, hyperlipidemia, diet, lifestyle, and genetic background.

Keywords: Blood pressure, hypertension, prevalence, cross-sectional studies, risk factors, population

Introduction

Hypertension is a common health problem in China, with rising prevalence in recent decades [1]. The prevalence of hypertension in the adult population has quadrupled from 5% in 1959 to nearly 19% in 2002 [2]. The 2007-2008 China National Diabetes and Metabolic Disorders Study showed a total of 26.6% of Chinese adults aged 20 years and older had hypertension [3]. Other national cross-sectional surveys found that the adjusted prevalence of hypertension was 29.6% in Chinese mainland [4], and 34% in Macau [5]. Although the exact causes and mechanisms of hypertension remain unknown, it is generally believed that the levels of blood pressure and the prevalence of hypertension are determined by multiple environmental factors such as diet [6-8], more sodium intake [2, 9, 10], cigarette smoking [11, 12], mental work [13, 14], and physical inactivity [8, 15], as well as genetic factors [16, 17], and their interactions [18, 19]. In addition, there may be an ethnic difference in the prevalence of hypertension [8, 20-22].

There are 56 ethnic groups in China. Han is the largest group and Mulao is one of the 55 minorities with a population of 216,257 in 2010. The people of Mulao live in Guangxi Zhuang Autonomous Region, and approximately ninety percent of the people live in the Luocheng Mulao Autonomous County. Historical data trace the history of this ethnic minority

back to the Jin Dynasty (AD 265-420). It is believed that the Mulao people are the descendants of the ancient "Baiyue tribe" in southern China and ethnically related to the neighboring ethnic groups. In a previous study, Xu et al. [23] showed that the genetic relationship between Mulao nationality and other minorities in Guangxi was much closer than that between Mulao and Han or Uighur nationlity. To the best of our knowledge, however, the levels of blood pressure and the prevalence of hypertension in this population have not been reported previously. Therefore, the present study was undertaken to compare the differences in the prevalence of hypertension and its risk factors in the Chinese Mulao and Han populations from the same region.

Materials and methods

Subjects

A total of 1055 unrelated subjects of Mulao nationality and 969 participants of Han nationality aged 15-93 were randomly selected from our previous stratified randomized samples [24]. There were 504 males (47.77%) and 551 females (52.23%) in Mulao, and 450 men (46.44%) and 519 women (53.56%) in Han. All subjects were rural agricultural workers. The age of the subjects ranged from 15 to 93 (mean 54.89±14.97) years in Mulao, and 16 to 92 (mean 54.43±13.97) years in Han. Ages less than 40 years were 162 (15.36%) people in Mulao and 139 (14.34%) persons in Han; 40-49 years were 218 (20.66%) people in Mulao and 214 (22.08%) persons in Han; 50-59 years were 221 (20.95%) people in Mulao and 213 (21.98%) persons in Han; 60-69 years were 252 (23.89%) people in Mulao and 239 (24.66%) persons in Han; and 70 years and over were 202 (19.15%) people in Mulao and 164 (16.92%) persons in Han. 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. Some subjects were treated with antihypertensive drugs. The present study was approved by the Ethics Committee of the First Affiliated Hospital, Guangxi Medical University. Informed consent was obtained from all subjects.

Epidemiological survey

The survey was carried out using internationally standardized methods. Information on demographics, diet, and lifestyle was collected with standardized questionnaires. The dietary intakes of each subject were determined by the 24-h dietary recall method [25]. The intakes of macronutrients from the ingredients were calculated by using the 2002 Chinese Food Composition Table [26]. Physical activity was ascertained with the use of a modified version of the Harvard Alumni Physical Activity Questionnaire [27]. The alcohol information included questions about the number of grams of rice wine, wine, beer, or liquor consumed during the preceding 12 months. Current smoking was defined as more than one cigarette per day. Participants who reported having smoked ≥ 100 cigarettes during their lifetime were classified as current smokers if they currently smoked and former smokers if they did not. Body height, weight, waist circumference were measured, and body mass index (BMI, kg/m^2) were calculated. Sitting blood pressure was measured three times with the use of a mercury sphygmomanometer after the subject rested for 5 minutes, and the average of the three measurements was used for the blood pressure levels. Systolic blood pressure (SBP) was determined by the first Korotkoff sound, and diastolic blood pressure (DBP) by the fifth Korotkoff sound. Body weight was measured using a portable balance scale. Height was measured using a portable steel measuring device. Waist circumference was measured with a nonstretchable measuring tape.

Biochemical analysis

Venous blood samples were obtained from all subjects after an overnight fast. Serum levels of total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were determined enzymatically using commercially available kits (RANDOX Laboratories Ltd., Ardmore, Diamond Road, Crumlin Co. Antrim, United Kingdom, BT29 4QY; or Daiichi Pure Chemicals Co., Ltd., Tokyo, Japan), respectively. Serum apolipoprotein (Apo) A1 and ApoB levels were measured by an immunoturbidimetric assay (RANDOX Laboratories Ltd.). All determinations were performed with an autoanalyzer

Table 1. Comparison of the general characteristics between the Mulao and Han populations

Characteristics	Mulao (n = 1055)	Han (n = 969)	t (χ^2)	p
Age (years)	54.89±14.97	54.43±13.97	0.713	0.476
Male/female	504/551	450/519	0.360	0.548
Education level (years)	4.62±3.57	6.48±3.73	11.461	0.000
Physical activity (h/week)	46.63±8.62	44.82±7.68	4.971	0.000
Height (cm)	155.33±8.11	153.27±8.27	5.655	0.000
Weight (kg)	53.33±9.59	52.60±8.84	1.776	0.076
Body mass index (kg/m^2)	23.03±3.16	22.33±2.94	5.147	0.000
> 24 kg/m^2 [n (%)]	266 (25.21)	230 (23.74)	0.596	0.440
Waist circumference (cm)	76.95±8.91	75.08±8.01	4.950	0.000
Alcohol consumption [n (%)]	258 (24.46)	377 (38.91)	48.991	0.000
Cigarette smoking [n (%)]	271 (25.69)	302 (31.17)	7.471	0.006
Energy (kJ/day)	9023.28±402.63	8924.62±388.45	5.601	0.000
Carbohydrate (g/day)	424.23±22.68	394.61±16.32	33.467	0.000
Protein (g/day)	52.86±6.27	48.63±7.28	14.037	0.000
Total fat (g/day)	30.26±3.64	24.68±4.65	30.187	0.000
Dietary cholesterol (mg/day)	202.65±90.53	168.58±98.49	8.109	0.000
Total dietary fiber (g/day)	9.68±3.24	8.08±2.82	11.805	0.000
Sodium intake (g/day)	9.25±3.23	7.87±2.56	10.591	0.000
Serum total cholesterol (mmol/l)	5.06±1.15	4.92±0.97	2.947	0.003
Triglyceride (mmol/l)	1.41±1.10	1.34±0.98	1.507	0.132
HDL-C (mmol/l)	1.75±0.45	1.91±0.47	7.823	0.000
LDL-C (mmol/l)	2.98±0.88	2.73±0.79	6.704	0.000
Apolipoprotein A1 (g/l)	1.33±0.40	1.42±0.22	6.196	0.000
Apolipoprotein B (g/l)	1.01±0.58	0.91±0.22	5.044	0.000
Apolipoprotein (Apo) A1/ApoB	1.57±0.90	1.64±0.50	2.137	0.033
Prevalence of hyperlipidemia [n (%)]	551 (52.23)	441 (45.51)	9.118	0.003

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

(Type 7170A; Hitachi Ltd., Tokyo, Japan) in our Clinical Science Experiment Center [24].

Diagnostic criteria

Hypertension was defined as an average SBP of 140 mmHg or greater and/or an average DBP of 90 mmHg or greater, and/or self-reported pharmacological treatment for hypertension within the 2 weeks prior to the interview [18, 19]. The subjects with only SBP ≥ 140 mmHg and DBP < 90 mmHg were defined as isolated systolic hypertension. Awareness of hypertension was defined as a self-report of any prior diagnosis of hypertension by a health care professional. Treatment of hypertension was defined as a self-reported use of pharmacological medication for the management of high blood pressure within the 2 weeks preceding the participant's interview. Control of hypertension was defined as having an average SBP less than 140 mmHg and an average DBP less than 90 mmHg in the context of pharmacological treatment of hypertension. The individuals with TC > 5.17 mmol/L and/or TG > 1.70 mmol/L were defined as hyperlipidemic [24]. Normal weight, overweight and obesity were defined as a BMI < 24, 24 to 28, and > 28 kg/m^2, respectively [19, 28].

Statistical analysis

The measurement data are presented as mean ± SD. All analyses were performed with SPSS 11.5 (SPSS Inc., Chicago, Illinois). Differences in mean values were assessed using analysis of covariance (ANCOVA) and the Student's unpaired t test. Sex, age, BMI, hyperlipidemia, alcohol consumption, cigarette smoking were included in the statistical models as covariates.

Table 2. Blood pressure levels and the prevalence of hypertension between the Mulao and Han populations

Variable	Mulao (n = 1055)	Han (n = 969)	t (χ^2)	P
SBP (mmHg)	131.71±22.45	128.06±18.69	3.956	0.001
SBP ≥ 140 mmHg [n (%)]	133 (12.61)	86 (8.88)	7.288	0.007
DBP (mmHg)	81.84±11.76	80.41±11.08	2.809	0.005
DBP ≥ 90 mmHg [n (%)]	76 (7.20)	68 (7.02)	0.027	0.871
SBP ≥ 140 and ≥ 90 mmHg [n (%)]	212 (20.09)	160 (16.51)	4.322	0.038
Pulse pressure (mmHg)	49.87±17.05	47.65±13.70	3.211	0.001
Prevalence of hypertension [n (%)]	421 (39.91)	314 (32.40)	12.287	0.001
Awareness rate [n (%)]	86 (20.43)	92 (29.30)	7.713	0.006
Treatment rate [n (%)]	58 (13.78)	71 (22.61)	9.701	0.002
Control rate [n (%)]	12 (2.85)	21 (6.69)	6.177	0.013

SBP, systolic blood pressure; DBP, diastolic blood pressure; SBP ≥ 140 mmHg, isolated systolic hypertension.

The enumeration data were expressed as percentage. The difference in percentage was tested by the Chi-square test. In order to evaluate the risk factors for hypertension, unconditional logistic regression analysis was also performed in combined population of Mulao and Han, Mulao, and Han; respectively. The backward multiple logistic regression method was used to select the risk factors significantly associated with hypertension. Total intake of each nutrient was summed over all foods consumed. The Matlab 5.0 software was used for processing these procedures by the method of multiplication of matrix [29]. A P value of less than 0.05 was considered statistically significant.

Results

General characteristics between the Mulao and Han populations

The demographic, dietary, lifestyle characteristics and serum lipid levels between the Mulao and Han populations are list in **Table 1**. The levels of physical activity, height, BMI and waist circumference; the intakes of macronutrients; the concentrations of serum TC, LDL-C and ApoB; and the prevalence of hyperlipidemia were higher in Mulao than in Han (P < 0.01-0.001), whereas the levels of education, serum HDL-C and ApoA1, the ratio of ApoA1 to ApoB, and the percentage of subjects who consumed alcohol or smoked cigarettes were lower in Mulao than in Han (P < 0.01-0.001). There were no significant differences in the levels of age, weight, serum TG, and sex structure between the two ethnic groups (P > 0.05 for all).

Blood pressure levels and the prevalence of hypertension

The levels of SBP, DBP, and pulse pressure (PP) were significantly higher in Mulao than in Han (P < 0.01 for all). The overall prevalence of hypertension was also significantly higher in Mulao than in Han (39.91% *vs*. 32.40%, P < 0.01, **Table 2**).

Awareness, treatment, and control of hypertension

Of 421 subjects with hypertension in Mulao, 20.43% were aware of their high blood pressure, 13.78% were treated, and 2.85% were controlled, whereas the rates of awareness, treatment and control in Han were 29.30% (P < 0.01), 22.61% (P < 0.01), and 6.69% (P < 0.05, **Table 2**), respectively.

Sex, BMI, hyperlipidemia, alcohol, smoking, and age on blood pressure levels

The effects of sex, BMI, alcohol consumption, cigarette smoking, and age on blood pressure levels between Mulao and Han are shown in **Table 3**. For the Mulao population, the levels of DBP were higher in males than in females (P < 0.001); the levels of SBP, DBP and PP were higher in the subjects with a BMI > 24 kg/m^2 than a BMI ≤ 24 kg/m^2 (P < 0.05-0.001); the levels of SBP, DBP and PP were higher in subjects with hyperlipidemia than without hyperlip-

Table 3. Effects of sex, BMI, hyperlipidemia, alcohol consumption, cigarette smoking, and age on blood pressure levels between the Mulao and Han populations

Variable	*n*	SBP (mmHg)	DBP (mmHg)	PP (mmHg)
Mulao				
Male	504	132.57±21.99	83.41±12.04	49.16±16.11
Female	551	130.93±22.85	80.41±11.33^{c}	50.52±17.86
BMI ≤ 24 (kg/m^2)	789	129.65±22.08	80.54±11.57	49.11±16.59
BMI > 24 (kg/m^2)	266	137.82±22.47^{c}	85.71±11.50^{c}	52.12±18.19^{a}
Non-hyperlipidemia	504	128.01±21.40	80.33±11.12	47.67±16.68
Hyperlipidemia	551	135.11±22.86^{c}	83.23±12.17^{c}	51.88±17.15^{c}
Nondrinker	797	130.74±22.45	81.07±11.52	49.68±17.34
Drinker	258	134.71±22.21^{a}	84.24±12.20^{c}	50.47±16.80
Nonsmoker	784	131.98±22.74	81.49±11.65	50.48±17.44
Smoker	271	130.94±21.61	82.86±12.04	48.09±15.76^{a}
Age				
< 40	162	118.04±13.83	77.29±9.97	40.75±10.78
40-49	218	126.16±18.66	81.06±10.77	45.11±13.87
50-59	221	131.71±21.42	82.59±11.82	49.12±15.35
60-69	252	137.16±22.60	83.29±12.32	53.88±17.74
≥ 70	202	141.87±25.46	83.72±12.41	58.15±19.78
F for 5 age subgroups	–	36.816	9.040	33.586
P for 5 age subgroups	–	0.000	0.000	0.000
Han				
Male	450	130.50±18.79	82.08±11.26	48.43±14.32
Female	519	125.94±18.35^{c,z}	78.96±10.72^{c,x}	46.98±13.11^{z}
BMI ≤ 24 (kg/m^2)	739	126.97±18.74^{x}	79.45±10.88	47.51±13.99^{x}
BMI > 24 (kg/m^2)	230	131.57±18.10^{c,z}	83.50±11.17^{c,x}	48.12±12.73^{y}
Non-hyperlipidemia	528	125.28±18.03^{x}	78.79±10.64^{x}	46.49±13.14
Hyperlipidemia	441	131.38±18.94^{c,y}	82.34±11.29^{c}	49.04±14.22^{b,y}
Nondrinker	592	127.42±19.62^{y}	80.07±11.07	47.37±14.47^{y}
Drinker	377	129.07±17.09^{z}	80.94±11.10^{z}	48.10±12.38
Nonsmoker	667	127.12±18.46^{z}	79.81±10.93^{y}	47.29±13.36^{z}
Smoker	302	130.14±19.05^{a}	81.72±11.30^{a}	48.45±14.41
Age				
< 40	139	128.95±16.50^{z}	86.96±10.42^{z}	42.06±11.86
40-49	214	126.96±18.42	78.76±10.49^{x}	48.21±14.58^{x}
50-59	213	126.27±18.39^{z}	78.82±10.77^{z}	47.45±12.38
60-69	239	127.74±19.70^{z}	78.90±10.86^{z}	48.84±13.93^{z}
≥ 70	164	131.54±19.34^{z}	81.26±11.06^{x}	50.21±14.09^{z}
F for 5 age subgroups	–	2.202	18.343	7.999
P for 5 age subgroups	–	0.067	0.000	0.000

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; $^{a}P < 0.05$, $^{b}P < 0.01$ and $^{c}P < 0.001$ in comparison with male, BMI ≤ 24 (kg/m^2), non-hyperlipidemia, nondrinker, or nonsmoker of the same ethnic group; $^{x}P < 0.05$, $^{y}P < 0.01$ and $^{z}P < 0.001$ in comparison with the same subgroup of Mulao.

idemia ($P < 0.001$ for all); the levels of SBP and DBP were higher in drinkers than in nondrinkers ($P < 0.05$ for each); the levels of PP were lower in smokers than in nonsmokers ($P < 0.05$); and the levels of SBP, DBP and PP were increased with increasing age.

For the Han population, the levels of SBP and DBP were higher in males than in females ($P < 0.001$ for each); the levels of SBP and DBP were higher in the subjects with a BMI > 24 kg/m^2 than a BMI ≤ 24 kg/m^2 ($P < 0.001$ for each); the levels of SBP, DBP and PP were higher in

Table 4. Effects of gender, BMI, alcohol consumption, cigarette smoking, and age on the prevalence of hypertension between the Mulao and Han populations

Variables	*n*	SBP ≥ 140 mmHg	DBP ≥ 90 mmHg	SBP ≥ 140 and DBP ≥ 90 mmHg	Prevalence of hypertension
Mulao					
Male	504	64 (12.70)	41 (8.13)	111 (22.02)	216 (42.86)
Female	551	69 (12.52)	35 (6.35)	101 (18.33)	205 (37.21)
BMI ≤ 24 (kg/m^2)	789	95 (12.04)	43 (5.45)	137 (17.36)	275 (34.85)
BMI > 24 (kg/m^2)	266	38 (14.29)	33 (12.41)^c	75 (28.20)^c	146 (54.89)^c
Non-hyperlipidemia	504	60 (11.90)	38 (7.54)	70 (13.89)	168 (33.33)
Hyperlipidemia	551	73 (13.25)	38 (6.90)	142 (25.77)^c	253 (45.92)^c
Nondrinker	797	99 (12.42)	51 (6.40)	154 (19.32)	304 (38.14)
Drinker	258	34 (13.18)	25 (9.69)	58 (22.48)	117 (45.35)^a
Nonsmoker	784	104 (13.27)	53 (6.76)	154 (19.64)	311 (39.67)
Smoker	271	29 (10.70)	23 (8.49)	58 (21.40)	110 (40.59)
Age					
< 40	162	4 (2.47)	14 (8.64)	6 (3.70)	24 (14.81)
40-49	218	12 (5.51)	19 (8.72)	31 (14.22)	62 (28.44)
50-59	221	27 (12.22)	12 (5.43)	47 (21.27)	86 (38.91)
60-69	252	47 (18.65)	19 (7.54)	67 (26.59)	133 (52.78)
≥ 70	202	43 (21.29)	12 (5.94)	61 (30.20)	116 (57.43)
χ^2 for 5 age subgroups	–	47.293	2.812	51.438	97.836
P for 5 age subgroups	–	0.000	0.059	0.000	0.000
Han					
Male	450	41 (9.11)	43 (9.56)	88 (19.56)	172 (38.22)
Female	519	45 (8.67)^x	25 (4.82)^b	72 (13.87)^{a,x}	142 (27.36)^{c,z}
BMI ≤ 24 (kg/m^2)	739	70 (9.47)	46 (6.22)	104 (14.07)	220 (29.77)^x
BMI > 24 (kg/m^2)	230	16 (6.96)^y	22 (9.56)	56 (24.35)^c	94 (40.87)^{c,y}
Non-hyperlipidemia	528	44 (8.33)	24 (4.55)^x	68 (12.88)	136 (25.76)^y
Hyperlipidemia	441	42 (9.52)	44 (9.98)^b	92 (20.86)^c	178 (40.36)^c
Nondrinker	592	55 (9.29)	38 (6.42)	93 (15.71)	186 (31.42)^y
Drinker	377	31 (8.22)^x	30 (7.96)	67 (17.77)	128 (33.95)^y
Nonsmoker	667	55 (8.25)^y	35 (5.25)	108 (16.19)	198 (29.69)^z
Smoker	302	31 (10.26)	33 (10.93)^b	52 (17.22)	116 (38.41)^b
Age					
< 40	139	6 (4.32)	31 (22.30)^z	26 (18.71)^z	63 (45.32)^z
40-49	214	23 (10.75)^x	14 (6.54)	26 (12.15)	63 (29.44)
50-59	213	16 (7.51)	9 (4.23)	31 (14.55)	56 (26.29)^y
60-69	239	20 (8.37)^z	10 (4.18)	41 (17.15)^x	71 (29.71)^z
≥ 70	164	21 (12.80)^x	4 (2.44)	36 (21.95)	61 (37.20)^z
χ^2 for 5 age subgroups	–	8.197	60.595	7.623	17.597
P for 5 age subgroups	–	0.085	0.000	0.106	0.002

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; $^aP < 0.05$, $^bP < 0.01$ and $^cP < 0.001$ in comparison with male, BMI ≤ 24 (kg/m^2), non-hyperlipidemia, nondrinker, or nonsmoker of the same ethnic group; $^xP < 0.05$, $^yP < 0.01$ and $^zP < 0.001$ in comparison with the same subgroup of Mulao.

subjects with hyperlipidemia than without hyperlipidemia ($P < 0.01$-0.001); the levels of SBP and DBP were higher in smokers than in nonsmokers ($P < 0.05$ for each); and the levels of SBP and DBP were high in age subgroup of < 40 year old.

Table 5. Comparison of the risk factors for hypertension between the Mulao and Han populations

Populations	Risk factors	Regression coefficient	Standard error	Wald	*P*	OR
Han plus Mulao	Ethnic group	0.269	0.103	6.848	0.009	1.309
	Sex	0.231	0.104	4.970	0.026	1.260
	Age	0.233	0.039	36.242	0.000	1.263
	Body mass index	0.631	0.118	28.720	0.000	1.879
	Total cholesterol	0.404	0.106	14.681	0.000	1.198
	Triglyceride	0.430	0.129	11.030	0.001	1.537
	Total fat	0.445	0.150	8.136	0.004	1.581
	Sodium intake	0.356	0.127	11.126	0.001	1.481
	Total dietary fiber	-0.322	0.134	8.012	0.005	1.469
Han	Sex	0.417	0.152	7.542	0.006	1.517
	Total cholesterol	0.526	0.155	11.512	0.001	1.692
	Triglyceride	0.753	0.186	16.384	0.000	2.123
	Total fat	0.438	0.128	12.213	0.000	1.582
	Sodium intake	0.313	0.079	8.798	0.003	1.338
	Total dietary fiber	-0.385	0.148	5.143	0.022	1.598
Mulao	Age	0.509	0.057	80.617	0.000	1.664
	Body mass index	0.909	0.162	31.348	0.000	2.483
	Apolipoprotein B	0.372	0.172	4.688	0.030	1.450
	Total fat	0.428	0.213	4.977	0.025	1.478
	Sodium intake	0.388	0.095	7.788	0.005	1.389
	Total dietary fiber	-0.403	0.133	10.146	0.002	1.712

For the multiple logistic regression analysis, the data were recorded as follows: ethnic group: Mulao = 0, Han = 1; sex: female = 0, male = 1; age (year): < 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; TG (mmol/L): ≤ 1.70 = 0, > 1.70 = 1; alcohol consumption (g/day): nondrinkers = 0, < 25 = 1, 25-49 = 2, 50-99 = 3, ≥ 100 = 4; cigarette smoking (cigarettes/day): nonsmokers = 0, < 10 = 1, 10-19 = 2, 20-39 = 3, ≥ 40 = 4.

Sex, BMI, hyperlipidemia, alcohol, smoking, and age on the prevalence of hypertension

The effects of sex, BMI, alcohol consumption, cigarette smoking, and age on the prevalence of hypertension between the two ethnic groups are shown in **Table 4**. For the Mulao population, the prevalence of hypertension was higher in subjects with a BMI > 24 kg/m^2 than a BMI ≤ 24 kg/m^2 ($P < 0.001$), in subjects with hyperlipidemia than without hyperlipidemia ($P < 0.001$), and in drinkers than in nondrinkers ($P < 0.05$).

For the Han population, the prevalence of hypertension was higher in males than in females ($P < 0.001$), in subjects with a BMI > 24 kg/m^2 than a BMI ≤ 24 kg/m^2 ($P < 0.001$), in subjects with hyperlipidemia than without hyperlipidemia ($P < 0.001$), and in smokers than in nonsmokers ($P < 0.01$).

Risk factors for hypertension

Multivariate logistic regression analysis revealed that the prevalence of hypertension was positively correlated with sex (male), TC, TG, total fat, and sodium, and negatively associated with total dietary fiber in Han ($P < 0.05$-0.001), whereas it was positively associated with age, BMI, ApoB, total fat, and sodium, and negatively associated with total dietary fiber in Mulao ($P < 0.05$-0.001, **Table 5**).

Discussion

Hypertension is one of the most important and modifiable risk factors for cardiovascular disease, and is also a principal cause of mortality and morbidity in China. Over the past 40 years, rapid economic growth and associated socioeconomic changes have resulted in the emergence of numerous chronic, non-communicable diseases, including hypertension. The results of the present study showed that the levels of SBP, DBP and PP, and the overall prevalence of hypertension were higher in Mulao than in Han. But the rates of awareness, treatment and control were lower in Mulao than in Han. These differences in the blood pressure levels and the prevalence of hypertension bet-

ween the two ethnic groups might result from different education level, BMI, hyperlipidemia, diet, lifestyle, and genetic background.

In the present study, we showed that the educational level was significantly lower in Mulao than in Han. A lack of public awareness and understanding of hypertension and hypertensive complications may contribute to the epidemic of uncontrolled hypertension in the Mulao population [8]. These results also underscore the urgent need for developing a good blood pressure education program to coordinate the efforts in detection, prevention, and treatment of hypertension in the rural areas of China.

The BMI level in this study was significantly higher in Mulao than in Han. The levels of SBP and DBP, and the prevalence of hypertension were higher in the subjects with a BMI > 24 kg/m^2 than a BMI ≤ 24 kg/m^2 in both ethnic groups. The relationship between obesity and hypertension is well recognized. Overweight and obesity increase the risk of elevated blood pressure. Obesity can also cause metabolic syndrome [30], increase cardiac load and peripheral vascular resistance. A previous study showed that the prevalence of hypertension was 2- to 6-fold higher in obese than in normal-weight individuals [31]. In the same study, increases/decreases in BMI were significantly associated with increases/decreases in SBP and DBP [31].

Serum lipid metabolism and blood pressure regulation have been associated in several cross-sectional studies [32, 33]. Previous hyperlipidemia may be one of the causes of future hypertension [34, 35]. Higher levels of plasma TC, non-HDL-C, and the TC/HDL-C ratio were independently associated with a subsequent increased risk of incident hypertension in apparently healthy men. Elevated lipid levels appeared to predate the onset of hypertension by years [36, 37]. In the present study, we also showed that the prevalence of hyperlipidemia was significantly higher in Mulao than in Han. The levels of SBP and DBP, and the prevalence of hypertension were higher in the subjects with hyperlipidemia than in those without hyperlipidemia in both ethnic groups. These results suggest that early treatment of hyperlipidemia may be able to prevent or delay the occurrence of hypertension.

The intakes of total energy, total fat, dietary cholesterol, and sodium were higher in Mulao than in Han. Multivariate logistic regression analysis showed that the prevalence of hypertension was positively correlated with total fat and sodium in both ethnic groups. Long-term high saturated fat diet is an important risk factor for obesity, dyslipidemia, atherosclerosis, and hypertension [38, 39]. Dietary salt intake has impact on blood pressure levels in the general population [2, 9, 10]. A population-based epidemiological study from Turkey showed that the Turkish population consumes a large amount of salt (18.01 g/day). Salt intake was higher in obese participants, rural residents, participants with lower education levels and elderly. Salt intake was positively correlated with SBP and DBP. Each 100 mmol/day of salt intake resulted in 5.8 and 3.8 mmHg increase in SBP and DBP, respectively. Salt intake was also significantly correlated with SBP in normal weight individuals [10]. Thus, effort in sodium restriction may be therefore crucial in the treatment of hypertension as part of national and global health policies.

Available evidence indicates that alcohol in larger amounts (more than two portions a day) and cigarette smoking increase blood pressure and overall mortality [11, 12, 40]. A previous meta-analysis of 15 randomized controlled trials showed that decreased alcohol consumption was associated with reduction of SBP and DBP by 3.31 and 2.04 mmHg, respectively, which was similar in normotensives and hypertensives [40]. In the present study, however, we showed that the percentage of subjects who consumed alcohol or smoked cigarettes was lower in Mulao than in Han. But the levels of SBP and DBP, and the prevalence of hypertension in Mulao but not in Han were higher in drinkers than in nondrinkers. The levels of SBP and DBP, and the prevalence of hypertension in Han but not in Mulao were higher in smokers than in nonsmokers. These discrepancies may result from different kinds of wine and cigarette. In this study, 90% of the wine drunk by Mulao was rum or local wine, in which the alcohol content is low, and 95% of the cigarettes smoked by them were natural tobacco leaves, which the toxin content may be different. Tobacco smoke is a complex mixture of over 4,000 chemical constituents. There are many toxins in cigarette smoke such as nico-

tine, cadmium, carbon monoxide, and reactive oxygen species that might contribute to the cardiovascular toxicity [18]. In contrast, a great deal of the wine drunk by Han was rice wine, in which the alcohol content is high, and 95% of the cigarettes smoked by them were commercially available cigarettes.

In addition to the environmental factors, genetic variants might also be involved in the development of hypertension. Intra-ethnic marriages were popular in Mulao. Thus, the hereditary characteristics and phenotypes of some candidate hypertension-susceptibility genes in Mulao may be different from those in Han. In several previous studies, we showed that the genetic polymorphisms of some lipid metabolism-related genes in the Mulao population were different from those in Han Chinese [41-45]. But this remains to be conclusively determined.

Conclusion

The prevalence of hypertension was found to be significantly higher in the Mulao than in the Han populations, but the rates of awareness, treatment and control of hypertension were significantly lower in Mulao than in Han. These results underscore the urgent need for developing a high blood pressure education program to coordinate the effort of detection, prevention, and treatment of hypertension in the Chinese minority areas.

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Disclosure of conflict of interest

None.

Address correspondence to: Rui-Xing Yin, Department of Cardiology, Institute of Cardiovascular Diseases, The First Affiliated Hospital, Guangxi Medical University, 22 Shuangyong Road, Nanning 530021, Guangxi, China. Tel: +86-771-5358832; Fax: +86-771-5353342; E-mail: yinruixing@163.com

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