Original Article

Prevalence, Awareness, Treatment, Control and Risk Factors of Hypertension in the Guangxi Hei Yi Zhuang and Han Populations

Yin RUIXING[1)], Yao LIMEI[1)], Chen YUMING[1)], Yang DEZHAI[2)], Lin WEIXIONG[2)], Li MUYAN[2)], He FENGPING[3)], Wu JINZHEN[3)], Ye GUANGQING[4)], and Nong ZHENBIAO[4)]

Han is the largest nationality and Zhuang is the largest minority among the 56 nationalities in China. Geographically and linguistically, Zhuang can be classified into 43 ethnic subgroups, with the Hei Yi Zhuang Chinese, who live in Napo County bordering northeast Vietnam and comprise a population of 51,655, having the most conservative culture and customs (Hei Yi means "black-clothing" and the Hei Yi Zhuang revere and wear the color black). The determinants of hypertension and its risk factors in this population have not been well-defined. To obtain some of this information, a cross-sectional study of hypertension was carried out in 1,166 Hei Yi Zhuang Chinese (aged 7–84; mean, 44.00±17.54 years) and 1,018 Han Chinese controls (42.95±17.11; range, 6–89 years) in the same area. Information on demographic characteristics, health-related behaviors and lifestyle factors was collected by questionnaire. The overall prevalence rates of hypertension and isolated systolic hypertension in Hei Yi Zhuang were higher than those in Han (23.2% *vs.* 16.0% and 11.5% *vs.* 3.7%; $p<0.001$ for each). The levels of systolic blood pressure and pulse pressure in Hei Yi Zhuang were also higher than those in Han ($p<0.001$ for each). The prevalence of hypertension was positively correlated with triglycerides, male gender, and age in Hei Yi Zhuang, whereas it was positively correlated with total cholesterol, male gender, age, and alcohol consumption in Han. The rates of awareness, treatment and control in Hei Yi Zhuang were lower than those in Han (8.5% *vs.* 20.9%, 4.4% *vs.* 15.3%, and 1.9% *vs.* 10.4%; $p<0.001$ for each), which may have been due to unique geographical characteristics, unwholesome lifestyles, greater sodium intake, lower education levels, and genetic risk factors in the former group. (*Hypertens Res* 2006; 29: 423–432)

***Key Words*: hypertension, prevalence, awareness, treatment, risk factor**

Introduction

Hypertension is an emerging risk factor that causes more than 7 million premature deaths a year worldwide, and that is becoming more prevalent in developing countries. Hypertension can lead to coronary heart disease, stroke, congestive heart failure, renal insufficiency, and peripheral vascular disease (*1*). A recent cross-sectional study of China estimated that 129 million people aged 35–74 years have hypertension

From the [1)]Department of Cardiology, Institute of Cardiovascular Diseases, the First Affiliated Hospital, Guangxi Medical University, Nanning, P.R. China; [2)]Department of Molecular Biology, Guangxi Medical Scientific Research Center, Nanning, P.R. China; [3)]Clinical Science Experiment Center, the First Affiliated Hospital, Guangxi Medical University, Nanning, P.R. China; and [4)]the Health Bureau of Napo County, Guangxi Zhuang Autonomous Region, Baise, P.R. China.

This study was supported by the National Natural Science Foundation of P.R. China (No: 30360038 in 2004–2006).

Address for Reprints: Yin Ruixing, M.D., Department of Cardiology, Institute of Cardiovascular Diseases, Guangxi Medical University, 22 Shuangyong Road, Nanning 530021, Guangxi, P.R. China. E-mail: yinruixing@yahoo.com.cn

Received October 11, 2005; Accepted in revised form March 10, 2006.

Table 1. Demographic Characteristics, Health-Related Behaviors, Lifestyle Factors and Serum Lipid Levels between Hei Yi Zhuang and Han

Characteristics	Hei Yi Zhuang (n=1,166)	Han nationality (n=1,018)	t (χ^2)	p
Age (years)	44.00±17.54	42.95±17.11	1.4116	0.1582
Education level (years)	2.86±0.97	4.13±1.82	20.6978	0.0000
Physical activity (h/week)	39.25±13.75	38.61±14.47	1.0589	0.2898
Height (cm)	152.41±9.05	152.24±8.65	0.4470	0.6549
Weight (kg)	49.22±8.13	51.71±8.56	6.9660	0.0000
Body mass index (kg/m^2)	21.08±2.35	22.22±2.62	10.7186	0.0000
>24 kg/m^2 (n (%))	127 (10.9)	210 (20.6)	39.4848	0.0000
Waist circumference (cm)	72.16±6.77	73.72±7.54	5.0941	0.0000
Residential altitude (m)	949.86±87.19	814.67±121.29	30.1660	0.0000
Alcohol consumption (n (%))	608 (52.1)	468 (46.0)	8.2821	0.0040
(g wine/day)	337.38±252.96	353.63±128.08	1.2700	0.2044
Cigarette smoking (n (%))	343 (29.4)	276 (27.1)	1.4216	0.2326
(cigarettes/day)	21.08±8.99	22.39±9.30	1.7745	0.0765
Energy (kJ/day)	8,746.72±274.89	8,894.68±323.53	11.5539	0.0000
Fat (% of energy)	17.5±1.9	28.0±2.1	122.6558	0.0000
Carbohydrate (% of energy)	69.0±2.8	53.1±2.3	143.7258	0.0000
Protein (% of energy)	10.2±1.2	15.2±1.8	77.2145	0.0000
Alcohol (% of energy)	3.3±0.7	3.7±0.8	12.4623	0.0000
Carbohydrate (g/day)	368.67±18.37	283.55±16.49	113.2719	0.0000
Protein (g/day)	56.88±2.68	81.64±3.72	179.9916	0.0000
Animal (%)	15.1±1.3	23.8±1.6	140.1111	0.0000
Vegetal (%)	84.9±2.7	76.2±2.2	81.7987	0.0000
Total fat (g/day)	45.56±1.63	72.38±2.15	330.7780	0.0000
Saturated (g/day)	5.68±0.74	12.76±1.42	148.6934	0.0000
Monounsaturated (g/day)	10.81±1.27	28.85±1.87	266.4685	0.0000
Polyunsaturated (g/day)	23.38±1.16	26.46±1.37	56.8864	0.0000
Dietary cholesterol (mg/day)	176.82±102.25	197.44±115.73	4.4207	0.0000
Total dietary fiber (g/day)	8.76±3.59	6.69±2.37	15.6576	0.0000
Sodium intake (g/day)	8.83±3.78	6.47±2.71	16.5498	0.0000
Serum total cholesterol (mmol/l)	4.54±0.97	4.73±1.00	4.5010	0.0000
>5.17 mmol/l (n (%))	275 (23.6)	275 (27.0)	3.3914	0.0653
Triglyceride (mmol/l)	1.15±1.01	1.27±1.04	2.7317	0.0064
>1.70 mmol/l (n (%))	144 (12.3)	147 (14.4)	2.0560	0.1512
HDL-C (mmol/l)	2.11±0.50	1.99±0.46	5.8068	0.0000
>1.81 mmol/l (n (%))	824 (70.7)	646 (63.5)	12.8439	0.0003
LDL-C (mmol/l)	2.29±0.68	2.48±0.70	6.4251	0.0000
>3.20 mmol/l (n (%))	111 (9.5)	137 (13.5)	8.3734	0.0038
Apolipoprotein A1 (g/l)	1.44±0.14	1.43±0.15	1.6106	0.1074
<1.0 g/l (n (%))	10 (0.9)	9 (0.9)	0.0044	0.9469
Apolipoprotein B (g/l)	0.88±0.21	0.93±0.21	5.5507	0.0000
>1.14 g/l (n (%))	109 (9.3)	147 (14.4)	13.6178	0.0002
Apolipoprotein A1/ B	1.76±0.73	1.61±0.42	5.7744	0.0000
>2.50 (n (%))	75 (6.4)	24 (2.4)	20.8519	0.0000
Prevalence of hyperlipidemia (n (%))	349 (29.9)	248 (34.2)	8.4887	0.0036

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

(*2*). This represents the continuance of a trend of steep increase in both the prevalence and absolute number of persons with hypertension. Specifically, previous estimates found 30 million persons with hypertension in China in 1960, 59 million in 1980, and 94 million in 1990 (*3*). Although the exact causes and mechanisms of hypertension are not known,

Table 2. Blood Pressure Levels and the Prevalence of Hypertension between Hei Yi Zhuang and Han

Variables	Hei Yi Zhuang (n=1,166)	Han nationality (n=1,018)	t (χ^2)	p
SBP (mmHg)	124.01±18.64	120.90±16.06	4.1466	0.0000
SBP ≥140 mmHg (n (%))	134 (11.5)	38 (3.7)	45.1031	0.0000
DBP (mmHg)	75.85±11.17	76.26±10.12	0.8939	0.3715
DBP ≥90 mmHg (n (%))	36 (3.1)	42 (4.1)	1.7012	0.1914
SBP ≥140 and DBP ≥90 mmHg (n (%))	101 (8.7)	83 (8.2)	0.1824	0.6687
Pulse pressure (mmHg)	48.18±14.53	44.69±11.00	6.2565	0.0000
Hypertensive prevalence (n (%))	271 (23.2)	163 (16.0)	17.8425	0.0000
Awareness rate (n (%))	23 (8.5)	34 (20.9)	13.6552	0.0002
Treatment rate (n (%))	12 (4.4)	25 (15.3)	15.5330	0.0001
Control rate (n (%))	5 (1.9)	17 (10.4)	15.5865	0.0001

SBP, systolic blood pressure; DBP, diastolic blood pressure.

it is generally believed that both genetic factors (*4*, *5*) and environmental factors, such as higher sodium intake (*5*, *6*), cigarette smoking (*7*, *8*), and mental stress (*9*), are involved in determining the levels of blood pressure and the prevalence of hypertension.

There are 56 nationalities in China. Han is the largest nationality and Zhuang is the largest minority group. There are also forty-three ethnic subgroups of Zhuang. The Hei Yi Zhuang dwelling in Napo County (a county near Vietnam) of Guangxi is a special one of the subgroups. They hold that the color black is beautiful, and they generally wear black clothes. The population of Hei Yi Zhuang is 51,655. Because of the remoteness, continuous mountains, and difficult weather conditions in the region they inhabit, and because they only marry other members of their group, the special customs and culture of this nationality have been preserved (*10*). However, little is known about the genetic background and epidemiological data of hypertension in this population. Therefore, the present study was undertaken to compare the levels of blood pressure, the prevalence of hypertension, and the risk factors for hypertension between the Hei Yi Zhuang and Han populations.

Methods

Subjects

A total of 1,166 Hei Yi Zhuang Chinese were randomly selected from 7 villages in Napo County of the Guangxi Zhuang Autonomous Region of China. Napo is located in the southwest part of Guangxi and borders on northeast Vietnam (longitude: 105°31' to 106°5' E; latitude: 22°55' to 23°32' N). The altitude of the residential area is 460–1,080 m above mean sea level. The altitude of the mountain peak is 900–1,600 m, with a relative altitude of 200–500 m. The mean annual air temperature is 16.5–18.0°C (range, −4.4–35.0°C). The survey was conducted in December of 2003, with an average air temperature of 8.0–10.0°C. The ages of the subjects ranged 7–84 years, with an average age of 44.00±17.54 years. Among the total population of 51,655 Hei Yi Zhuang Chinese living in 82 villages in Napo County, the subjects accounted for 2.26%. At the same time, a total of 1,018 Han Chinese living in 9 villages in Napo County were also surveyed by the same method as controls. The mean age of the subjects was 42.95±17.11 years (range, 6–89 years). In the analysis, the participants with a history of heart attack or myocardial infarction, stroke, congestive heart failure, or diabetes mellitus were rejected. Some subjects were treated with antihypertensive drugs. The study protocol was approved by the First Affiliated Hospital, Faculty of Medicine, Guangxi Medical University, in accordance with the Helsinki Declaration of 1975 as revised in 1983, and all subjects gave informed consent. They were offered an honorarium for their participation.

Epidemiological Survey

The survey was carried out using internationally standardized methods, following a common protocol. Information on demographics (age, gender, and residential area), socioeconomic status (education level achieved, marital status, and annual household income), cigarette smoking, alcohol consumption, and physical activity was collected with a standardized questionnaire. The 24-h dietary recall method was used to determine the dietary intakes of each subject (*11*). 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 the food consumed. The intakes of macronutrients from the ingredients were determined by using the 2002 Chinese Food Composition Table (*12*). Physical activity was ascertained with the use of 10 questions designed to measure both leisure time and work activities. The alcohol information included questions about

the number of liangs (a liang is about 50 g) of rice wine, wine, beer, or liquor consumed during the preceding 12 months. At the physical examination, several anthropometric parameters, such as height, weight, waist circumference, and body mass index (BMI; in kg/m^2) were calculated. Sitting blood pressure was measured three times with the use of a mercury sphygmomanometer after an at least 5-min rest, and the average of the three measurements was used for the level of blood pressure. Systolic blood pressure (SBP) was determined by the first Korotkoff sound, and diastolic blood pressure (DBP) by the fifth Korotkoff sound. Blood pressure in adolescents was also measured with a cuff size suitable to the arm circumference (mercury sphygmomanometers).

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 3,000 rpm. The levels of total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) in samples were determined enzymatically using commercially available kits: Tcho-1, TG-LH (RANDOX Laboratories, Ltd., Antrim, UK), Cholestest N HDL, and Cholestest LDL (Daiichi Pure Chemicals Co., Ltd., Tokyo, Japan), respectively. Serum apolipoprotein (Apo) A1 and Apo B levels were measured by an immunoturbidimetric assay (RANDOX Laboratories, Ltd.). All determinations were performed with an autoanalyzer (Type 7170A; Hitachi, Ltd., Tokyo, Japan) in the Clinical Science Experiment Center of the First Affiliated Hospital, Guangxi Medical University.

Diagnostic Criteria

Hypertension was defined as an average SBP of 140 mmHg or greater and an average DBP of 90 mmHg or greater, and/or self-reported pharmacological treatment for hypertension within the 2 weeks prior to the interview. The subjects with only SBP ≥140 mmHg and DBP <90 mmHg were defined as having 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 normal values of serum TC, TG, LDL-C, and Apo B in our Clinical Science Experiment Center were 3.10–5.17, 0.56–1.70, 1.70–3.20 mmol/l and 0.63–1.14 g/l, respectively. Individuals with TC>5.17 mmol/l and/or TG>1.70 mmol/l were defined as hyperlipidemic (*10*). The subjects with BMI >24 kg/m^2 were diagnosed as overweight, and those with >28 kg/m^2 as obese (*13*).

Statistical Analysis

An excel databank was established for the data of all subjects. The measurement data are presented as the mean±SD. All analyses were performed with SPSS 10.0 software (SPSS Inc., Chicago, USA). Differences in parameters between the Hei Yi Zhuang and Han groups were tested by the Student's unpaired *t*-test. One-way analysis of variance (ANOVA) was performed to assess differences of three or more parameters. The enumeration data were expressed as percentages. The percentages were compared by the χ^2 test. In order to evaluate the association between the prevalence of hypertension and sex (female=0; male=1), age (<20=1; 20–29=2; 30–39=3; 40–49=4; 50–59=5; 60–69=6; 70–79=7; ≥80=8), BMI (≤24 kg/m^2=0; >24 kg/m^2=1), TC (≤5.17 mmol/l=0; >5.17 mmol/l=1), TG (≤1.70 mmol/l=0; >1.70 mmol/l=1), LDL-C (≤3.20 mmol/l=0; >3.20 mmol/l=1), Apo B (≤1.14 g/l=0; >1.14 g/l=1), alcohol consumption (nondrinkers=0; <250 g wine/day=1; 250–499 g/day=2; ≥500 g/day=3), cigarette smoking (nonsmokers=0; <10 cigarettes/day=1; 10–19 cigarettes/day=2; 20–39 cigarettes/day=3; ≥40 cigarettes/day=4), and nationality (Han=0; Hei Yi Zhuang=1), unconditional logistic regression analysis was also performed in the Hei Yi Zhuang, Han, and combined Hei Yi Zhuang + Han groups. A p value of less than 0.05 was considered significant.

Results

Demographic, Dietary and Lifestyle Factors

The demographic characteristics, health-related behaviors and lifestyle factors for the Hei Yi Zhuang and Han groups are shown in Table 1. The intakes of carbohydrates, dietary fiber, and table salt, and the ratio of alcohol consumption in Hei Yi Zhuang were higher than those in Han ($p<0.001$ to $p<0.01$), whereas the education level, waist circumference, body weight, and BMI, and the intakes of total energy, fat, protein, and dietary cholesterol in Han were higher than those in Hei Yi Zhuang ($p<0.001$ for all). There were no significant differences in the physical activity level, body height, amount of alcohol consumption, cigarette smoking, age and sex ratio between the two ethnic groups ($p>0.05$).

Levels of Blood Pressure and Prevalence of Hypertension

As shown in Table 2, the levels of SBP and pulse pressure in Hei Yi Zhuang were higher than those in Han ($p<0.001$ for each). But there was no significant difference of DBP levels between Hei Yi Zhuang and Han. The crude prevalence of hypertension in Hei Yi Zhuang was higher than that in Han

Table 3. Effects of Gender, BMI, Alcohol Consumption, Cigarette Smoking, and Age on Blood Pressure Levels between Hei Yi Zhuang and Han

Variables	*n*	SBP (mmHg)	DBP (mmHg)	PP (mmHg)
Hei Yi Zhuang				
Male	541	127.56±19.01	78.55±11.44	49.03±14.81
Female	625	120.93±17.77†††	73.51±10.38†††	47.44±14.26
BMI≤24 kg/m^2	1,039	124.02±18.88	75.68±11.19	48.36±14.70
BMI>24 kg/m^2	127	123.91±16.68	77.20±10.99	46.70±13.01
Nondrinker	558	121.59±18.93	73.39±10.74	48.22±14.99
Drinker	608	126.23±18.11†††	78.10±11.09†††	48.14±14.12
Nonsmoker	823	122.70±18.51	74.51±10.98	48.20±14.53
Smoker	343	127.14±18.62†††	79.05±10.98†††	48.13±14.55
Age (years)				
<20	98	111.11±13.25	68.21±9.50	43.00±10.51
20–29	156	118.74±13.21	74.21±10.38	44.57±10.84
30–39	255	119.27±14.49	75.31±9.44	43.96±11.03
40–49	177	120.96±13.46	77.72±10.36	43.30±10.00
50–59	196	127.19±18.89	77.81±11.37	49.39±14.16
60–69	196	134.87±22.78	77.75±12.69	57.12±18.12
70–79	76	135.46±20.24	75.67±12.23	59.79±16.21
≥80	12	141.00±26.50	81.17±13.23	59.83±20.22
F for 8 age subgroups	—	32.479	10.437	33.331
p for 8 age subgroups	—	<0.001	<0.001	<0.001
Han nationality				
Male	426	122.57±16.44***	78.38±10.80	44.27±11.11***
Female	592	119.70±15.68†	74.73±9.31*,†††	44.99±10.92***
BMI≤24 kg/m^2	808	120.24±16.19***	75.60±9.84	44.66±11.11***
BMI>24 kg/m^2	210	123.42±15.32†	78.79±10.78†	44.80±10.62
Nondrinker	550	118.80±16.05**	74.67±9.63	44.18±11.04***
Drinker	468	123.37±15.72†,**	78.13±10.38†	45.28±10.94***
Nonsmoker	742	120.00±16.20**	75.19±9.79	44.83±11.10***
Smoker	276	123.31±15.44†,**	79.14±10.43†	44.30±10.74***
Age (years)				
<20	85	110.38±12.84	68.81±7.94	41.56±9.07
20–29	183	115.75±11.89*	74.10±8.36	41.75±8.86**
30–39	230	117.72±12.71	75.13±8.23	42.72±9.59
40–49	173	120.65±14.26	77.08±9.65	43.57±9.59
50–59	149	125.15±16.85	79.28±10.92	45.87±11.54*
60–69	117	128.13±17.74**	78.91±11.27	49.22±11.48***
70–79	73	136.21±19.58	82.47±11.98***	53.74±14.76*
≥80	8	122.75±16.75	67.88±7.40*	54.87±14.25
F for 8 age subgroups	—	27.935	17.963	16.938
p for 8 age subgroups	—	<0.001	<0.001	<0.001

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure. *p<0.05, **p<0.01 and ***p<0.001 in comparison with same subgroup of Hei Yi Zhuang; $^{\dagger}p$<0.05, $^{\dagger\dagger}p$<0.01 and $^{\dagger\dagger\dagger}p$<0.001 in comparison with male, BMI≤24 kg/m^2, nondrinker, or nonsmoker of same nationality.

(23.2% *vs*. 16.0%, p<0.001), and the prevalence of isolated systolic hypertension was also higher than that in Han (11.5% *vs*. 3.7%, p<0.001). The rates of awareness, treatment and control in Hei Yi Zhuang were lower than those in Han (p<0.001 for all). The effects of gender, BMI, alcohol consumption, cigarette smoking, and age on blood pressure levels and the prevalence of hypertension in Hei Yi Zhuang and Han are shown in Tables 3 and 4.

Risk Factors of Hypertension

The results of multivariate logistic regression analysis

Table 4. Differences in the Effects of Gender, BMI, Alcohol Consumption, Cigarette Smoking, and Age on the Prevalence of Hypertension between Hei Yi Zhuang and Han

Variables	*n*	SBP ≥140 mmHg	DBP ≥90 mmHg	SBP ≥140 and DBP ≥90 mmHg	Prevalence of hypertension
Hei Yi Zhuang					
Male	541	66 (12.2)	29 (5.4)	70 (12.9)	165 (30.5)
Female	625	68 (10.9)	7 (1.1)†††	31 (5.0)†††	106 (17.0)†††
BMI≤24 kg/m^2	1,039	125 (12.0)	30 (2.9)	87 (8.4)	242 (23.3)
BMI>24 kg/m^2	127	9 (7.1)	6 (4.7)	14 (11.0)	29 (22.8)
Nondrinker	558	64 (11.5)	11 (2.0)	33 (5.9)	108 (19.4)
Drinker	608	70 (11.5)	25 (4.1)†	68 (11.2)††	163 (26.8)††
Nonsmoker	823	89 (10.8)	18 (2.2)	62 (7.5)	169 (20.5)
Smoker	343	45 (13.1)	18 (5.2)††	39 (11.4)†	102 (29.7)†††
Age (years)					
<20	98	1 (1.0)	1 (1.0)	0 (0.0)	2 (2.0)
20–29	156	8 (5.1)	8 (5.1)	2 (1.3)	18 (11.5)
30–39	255	15 (5.9)	7 (2.7)	13 (5.1)	35 (13.7)
40–49	177	8 (4.5)	10 (5.6)	17 (9.6)	35 (19.8)
50–59	196	30 (15.3)	6 (3.1)	20 (10.2)	56 (28.6)
60–69	196	50 (25.5)	4 (2.0)	34 (17.3)	88 (44.9)
70–79	76	22 (28.9)	0 (0.0)	10 (13.2)	32 (42.1)
≥80	12	0 (0.0)	0 (0.0)	5 (41.7)	5 (41.7)
χ^2 for 8 age subgroups	—	98.12	11.08	62.06	122.89
p for 8 age subgroups	—	<0.001	>0.05	<0.001	<0.001
Han nationality					
Male	426	16 (3.8)***	30 (7.0)	44 (10.3)	90 (21.1)***
Female	592	22 (3.7)***	12 (2.0)†††	39 (6.6)†	73 (12.3)*,†††
BMI≤24 kg/m^2	808	31 (3.8)***	29 (3.6)	60 (7.4)	120 (14.9)***
BMI>24 kg/m^2	210	7 (3.3)	13 (6.2)	23 (11.0)	43 (20.5)†
Nondrinker	550	18 (3.3)***	14 (2.5)	34 (6.2)	66 (12.0)***
Drinker	468	20 (4.3)***	28 (6.0)††	49 (10.5)†	97 (20.7)*,†††
Nonsmoker	742	26 (3.5)***	18 (2.4)	57 (7.7)	101 (13.6)***
Smoker	276	12 (4.3)***	24 (8.7)†††	26 (9.4)	62 (22.5)*,†††
Age (years)					
<20	85	2 (2.4)	0 (0.0)	0 (0.0)	2 (2.4)
20–29	183	3 (1.6)	6 (3.3)	5 (2.7)	14 (7.7)
30–39	230	6 (2.6)	6 (2.6)	7 (3.0)	19 (8.3)
40–49	173	2 (1.2)	12 (6.9)	11 (6.4)	25 (14.5)
50–59	149	8 (5.4)**	8 (5.4)	20 (13.4)	36 (24.2)
60–69	117	6 (5.1)***	8 (6.8)	19 (16.2)	33 (28.2)**
70–79	73	9 (12.3)*	2 (2.7)	21 (28.8)*	32 (43.8)
≥80	8	2 (25.0)	0 (0.0)	0 (0.0)	2 (25.0)
χ^2 for 8 age subgroups	—	33.51	12.24	81.37	94.69
p for 8 age subgroups	—	<0.001	>0.05	<0.001	<0.001

Data are *n* (%). SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure. *$p<0.05$, **$p<0.01$ and ***$p<0.001$ in comparison with same subgroup of Hei Yi Zhuang; $^{\dagger}p<0.05$, $^{\dagger\dagger}p<0.01$ and $^{\dagger\dagger\dagger}p<0.001$ in comparison with male, BMI≤24 kg/m^2, nondrinker, or nonsmoker of same nationality

revealed that the prevalence of hypertension was positively correlated with TC, TG, gender (male), age, alcohol consumption, and nationality (Hei Yi Zhuang) in the combined population of Hei Yi Zhuang and Han ($p<0.01$ for all); positively correlated with TC, gender (male), age, and alcohol consumption in Han ($p<0.01$ for all); and positively associated with TG, gender (male) and age in Hei Yi Zhuang ($p<0.001$ to $p<0.05$, Table 5). No significant association was detected between the prevalence of hypertension and each of BMI, LDL-C, Apo B, and cigarette smoking in either Hei Yi

Table 5. Risk Factors of Hypertension between Hei Yi Zhuang and Han

Population and risk factors	Regression coefficient	Standard error	Wald	*p*	Odds ratio
Han plus Hei Yi Zhuang					
Total cholesterol (mmol/l)	0.442	0.124	12.125	0.000	1.555
Triglyceride (mmol/l)	0.443	0.155	8.012	0.005	1.556
Age (years)	0.446	0.034	152.617	0.000	1.563
Gender	0.571	0.130	9.938	0.002	1.211
Alcohol intake (g wine/day)	0.201	0.061	8.384	0.004	1.234
Nationality	0.397	0.118	11.035	0.001	1.486
Han nationality					
Total cholesterol (mmol/l)	0.623	0.191	10.346	0.001	1.864
Age (years)	0.447	0.056	61.442	0.000	1.562
Gender	0.533	0.201	7.115	0.008	1.708
Alcohol intake (g wine/day)	0.268	0.095	7.594	0.006	1.307
Hei Yi Zhuang					
Triglyceride (mmol/l)	0.419	0.205	3.935	0.043	1.519
Age (years)	0.445	0.046	92.211	0.000	1.559
Gender	0.609	0.172	12.128	0.000	1.838

Zhuang or Han.

Blood Pressure Levels and Prevalence of Hypertension in Different Villages

We also found that there were significant differences of SBP, DBP, pulse pressure levels, and prevalence of hypertension among the 7 villages of Hei Yi Zhuang ($p<0.001$ to $p<0.05$), and among the 9 villages of Han ($p<0.001$ to $p<0.01$, Tables 6 and 7).

Discussion

Hypertension is a principal cause of mortality and morbidity in China, and is also one of the most important cardiovascular risk factors. It has been considered that there may be differences in blood pressure levels, the prevalence of hypertension, and the risk factors for hypertension among the various races and regions in China. The current study showed that the prevalence rates of hypertension and isolated systolic hypertension in Hei Yi Zhuang are higher than those in Han, and the levels of SBP and pulse pressure in Hei Yi Zhuang are also higher than those in Han. The possible contributing factors are as follows. 1) The vast majority of Hei Yi Zhuang people live in mountainous areas. The altitude of the residential area is 460–1,080 m above mean sea level. It has been found that as the altitude increases gradually, the reference value of whole blood contrast viscosity also increases gradually, and the correlation is quite clear (*14*). A recent study has shown that chronic hypoxia causes marked activation of the sympathetic nervous system in healthy humans and increased systemic arterial pressure, despite normalization of the arterial O_2 content with acclimatization (*15*). Increased secretion of catecholamine (*15*), vasopressin (*16*), and adrenocorticotropin (*17*) may promote the development of hypertension by the renin-angiotensin-aldosterone system (*18*). 2) For the Hei Yi Zhuang Chinese, corn is the main staple food throughout the year. The corn is generally ground into powder, then made into corn gruel or hoecake. There are three meals a day on non-farming days, and four meals on farming days. Table salt is the main flavoring, and thus the intake of sodium chloride is very high. Long-term increase in sodium intake is an important risk factor for hypertension (*5*, *6*). 3) Napo County has a south subtropics climate, a quick evaporation rate, and very dry and cold weather in winter, especially on the top of a mountain. Cold exposure has been shown to be a risk factor for hypertension (*19*). SBP and DBP have been shown to be increased in workers exposed to the cold. In a logistic regression analysis, the severity of cold exposure was found to be a significant variable affecting hypertension in cold-exposed workers (*19*). 4) Because corn is one of the only sources of income for Hei Yi Zhuang, it is not easy for adolescents to take time out from planting to attend junior high school. Thus the level of education is very low, and the knowledge of necessary health care is very poor.

Both gender and age affect the levels of blood pressure. Earlier studies have reported that the prevalence of hypertension was higher in males than in females, and the levels of blood pressure and prevalence of hypertension increased with age (*20*). The latter finding may be related to the increment of most cardiovascular risk factor levels with age. The present study also shows that the prevalence of hypertension is positively correlated with male gender and age in both nationalities. This may be related to the propensity for men to overwork and make unhealthy lifestyle choices (*21*). Job stress has been shown in prospective studies to have adverse

Table 6. Blood Pressure Levels in Different Villages between Hei Yi Zhuang and Han

Village (altitude (m))	*n*	SBP (mmHg)	DBP (mmHg)	PP (mmHg)
Hei Yi Zhuang				
Longhua (985)	343	122.40±16.96	75.24±11.05	47.16±13.33
Gonghe (953)	109	121.57±20.06	72.16±11.88	49.41±17.20
Guotao (878)	182	122.12±17.26	75.12±11.01	47.00±14.71
Tuanjie (1,045)	201	127.92±21.92	77.61±11.21	50.36±16.39
Yongan (975)	141	124.43±22.33	77.48±11.92	47.02±16.07
Nianyan (793)	80	122.37±13.07	75.74±9.26	46.64±10.08
Shanhe (1,020)	110	128.09±14.37	77.36±10.34	50.73±11.11
F value	—	3.565	4.020	2.244
p value	—	<0.01	<0.001	<0.05
Han nationality				
Yongle (890)	150	126.55±16.19	79.87±9.99	46.68±11.52
Zhemiao (1,015)	78	128.59±17.54	82.22±12.30	46.42±11.99
Dala (720)	72	121.53±15.51	79.36±10.36	42.31±9.42
Xiaoguola (768)	149	113.17±12.79	72.89±8.74	40.25±8.81
Longdi (660)	184	118.94±14.27	74.72±9.47	44.22±9.51
Nianyan (860)	70	117.97±16.79	75.23±11.73	43.23±14.20
Pohe (788)	13	121.54±13.29	75.69±9.38	45.85±12.05
Chaoqun (685)	86	121.57±14.37	74.77±7.86	46.80±10.74
Longping (946)	216	121.63±16.98	75.17±9.26	46.49±11.21
F value	—	10.302	10.599	5.862
p value	—	<0.001	<0.001	<0.001

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure.

effects on the development of hypertension and coronary artery disease, particularly in men (*9*). That is, SBP and DBP during the working day were greater in high job demand participants who were stress reactive than in other groups.

Overweight and obesity have become highly prevalent in Western countries and are rapidly reaching epidemic proportions in the developing world. 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 (*1*), increased cardiac load and peripheral vascular resistance. A previous study reported that the prevalence of hypertension was 2- to 6-fold higher in obese than in normal-weight individuals (*22*). In the same study, increases/decreases in BMI were significantly associated with increases/decreases in SBP and DBP, whereas there were no significant differences in BMI between genders or among age groups. The individuals with increased BMI were shown to be at increased risk for hypertension (*22*). In the present study, however, no significant association was found between the prevalence of hypertension and BMI in either Hei Yi Zhuang or Han. In our current study, the percentage of subjects with a BMI >24 kg/m^2 was only 10.9% in Hei Yi Zhuang and 20.6% in Han, suggesting that the effect of BMI on blood pressure was small in both nationalities. However, in the present study we found that the prevalence of hypertension was positively correlated with TG in Hei Yi Zhuang, and positively correlated with TC in Han (*23*).

Previous studies have revealed that alcohol in larger amounts (more than two portions a day) and cigarette smoking increase blood pressure and overall mortality (*7*, *8*, *24*). The mechanisms involved in the pressor effect of a moderate dose of alcohol primarily involve an increase in cardiac output and heart rate, although increased sympathetic nerve activity may also play a role (*25*). Cigarette smoking raises blood pressure, probably through the nicotine-induced release of norepinephrine from adrenergic nerve endings. When smokers quit, a trivial rise in blood pressure may occur, probably reflecting a gain in weight (*26*). In the same study, waist girth was shown to increase more in men who quit smoking than in male controls, and an increase in waist girth during follow-up was strongly predictive of incident hypertension. In the current manuscript, however, we found that the prevalence of hypertension was positively correlated with alcohol consumption only in Han, but not in Hei Yi Zhuang. The reason for this discrepancy is not clear. In our current study, we found that 95% of the alcohol drunk by Hei Yi Zhuang consists of corn wine and rum. The alcohol content of corn wine and rum is somewhat lower than that of other alcoholic beverages, and thus the alcohol intake of Hei Yi Zhuang may not be sufficient to influence the blood pressure. Conversely, a great deal of the wine drunk by Han is rice wine, which has a higher alcohol content. In the present study, there was no significant correlation between cigarette smoking and the prevalence of hypertension in either Hei Yi Zhuang or Han,

Table 7. Prevalence of Hypertension in Different Villages between Hei Yi Zhuang and Han

Village (altitude (m))	*n*	SBP ≥140 mmHg	DBP ≥90 mmHg	SBP ≥140 and DBP ≥90 mmHg	Prevalence of hypertension
Hei Yi Zhuang					
Longhua (985)	343	36 (10.5)	14 (4.1)	22 (6.4)	72 (21.0)
Gonghe (953)	109	14 (12.8)	2 (1.8)	6 (5.5)	22 (20.2)
Guotao (878)	182	19 (10.4)	3 (1.6)	13 (7.1)	35 (19.2)
Tuanjie (1,045)	201	30 (14.9)	5 (2.5)	27 (13.4)	62 (30.8)
Yongan (975)	141	17 (12.1)	7 (5.0)	17 (12.1)	41 (29.1)
Nianyan (793)	80	4 (5.0)	2 (2.5)	5 (6.3)	11 (13.8)
Shanhe (1,020)	110	14 (12.7)	3 (2.7)	11 (10.0)	28 (25.5)
χ^2 value	—	6.58	5.01	12.77	16.74
p value	—	>0.05	>0.05	<0.05	<0.05
Han nationality					
Yongle (890)	150	14 (9.3)	8 (5.3)	20 (13.3)	42 (28.0)
Zhemiao (1,015)	78	7 (9.0)	8 (10.3)	13 (16.7)	28 (35.9)
Dala (720)	72	1 (1.4)	0 (0.0)	10 (13.9)	11 (15.3)
Xiaoguola (768)	149	1 (0.7)	9 (6.0)	3 (2.0)	13 (8.7)
Longdi (660)	184	2 (1.1)	7 (3.8)	10 (5.4)	19 (10.3)
Nianyan (860)	70	5 (7.1)	6 (8.6)	2 (2.9)	13 (18.6)
Pohe (788)	13	0 (0.0)	1 (7.7)	1 (7.7)	2 (15.4)
Chaoqun (685)	86	3 (3.5)	0 (0.0)	5 (5.8)	8 (9.3)
Longping (946)	216	5 (2.3)	3 (1.4)	19 (8.8)	27 (12.5)
χ^2 value	—	31.62	24.20	28.78	54.51
p value	—	<0.001	<0.01	<0.001	<0.001

Data are *n* (%). SBP, systolic blood pressure; DBP, diastolic blood pressure.

suggesting that cigarette smoking may not be the main risk factor affecting the blood pressure levels.

In the present study, we also found that there were differences of SBP, DBP, pulse pressure, and the prevalence of hypertension among the different Hei Yi Zhuang villages, as well as among the different Han villages, indicating that, in addition to the environmental factors, genetic factors might also be involved in the development of hypertension. Hei Yi Zhuang have exclusively married other Hei Yi Zhuang from time immemorial. This tradition of intra-national marriage has an absolute binding force for all Hei Yi Zhuang. They must comply consciously regardless of farming in home or employment at outside, also the first marriage or remarriage. Of course, the intra-national marriages of Hei Yi Zhuang are not consanguineous marriages. Hei Yi Zhuang Chinese can not intermarry with direct descendant and the collateral kin in seven generations. Therefore, the hereditary characteristics and phenotypes of candidate hypertension-susceptibility genes in Hei Yi Zhuang may be different from those in Han. Genetic variants in elements of the renin-angiotensin-aldosterone system, namely the angiotensin-converting enzyme, aldosterone synthase, and angiotensin II type 1 receptor genes, have been associated with risk of hypertension in some populations. In addition, gene-gene interactions may be important causative factors in a complex disease such as young-onset essential hypertension (*4*, *5*). But this remains to be conclusively determined.

The rates of awareness, treatment, and control in our country were 35.6%, 17.1% and 4.1% in urban districts and 13.9%, 5.4% and 1.2% in rural areas in the population aged 15 years and above in 1991 (*27*); 42.6%, 31.1% and 6.0% in subjects aged 35–59 years in 1998 (*28*); and 44.7%, 28.2% and 8.1% in subjects aged 35–74 years in 2001 (*2*). The results of the current study show that the rates of awareness, treatment and control in Hei Yi Zhuang were lower than those in Han, and were also lower than those in the rural population of China. The reasons for the poor awareness, treatment and control of hypertension in Hei Yi Zhuang are likely multifactorial; however, a lack of public awareness and understanding of hypertension may contribute to the epidemic of uncontrolled hypertension in this population. Increasing public awareness of hypertension using public education and health provider strategies should be a high national health priority.

In conclusion, hypertension was found to be highly prevalent in Hei Yi Zhuang, and the rates of awareness, treatment and control of hypertension were lower in Hei Yi Zhuang than in Han Chinese. 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 national minority area of China.

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