Association of diet and lifestyle with blood pressure in the Guangxi Hei Yi Zhuang and Han populations

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Abstract

Objective: To detect the association of diet and lifestyle with blood pressure in the Guangxi Hei Yi Zhuang and Han populations.

Design: A cross-sectional study of hypertension.

Setting: Both populations were from seven to nine villages in Napo County, Guangxi Zhuang Autonomous Region, China.

Subjects: A total of 1068 subjects of Hei Yi Zhuang and 933 participants of Han Chinese aged 20–89 years were surveyed by a stratified randomised cluster sampling.

Results: The levels of systolic blood pressure and pulse pressure were higher in Hei Yi Zhuang than in Han (125·20 (SD 18·62) *v.* 121·88 (SD 15·99) mmHg and 48·64 (SD 14·75) *v.* 44·98 (SD 11·12) mmHg, $P < 0·001$ for each, respectively). The prevalence of hypertension and isolated systolic hypertension was also higher in Hei Yi Zhuang than in Han (25·19 % *v.* 17·26 % and 12·45 % *v.* 3·86 %, $P < 0·001$ for each, respectively). Mean arterial pressure was positively correlated with gender, age, physical activity, TAG, alcohol consumption, cigarette smoking, total energy, total fat and salt intakes, and negatively associated with education level and total dietary fibre intake in Hei Yi Zhuang ($P < 0·05$–$0·001$), whereas it was positively associated with gender, age, physical activity, BMI, waist circumference, total cholesterol, alcohol consumption, cigarette smoking, total energy, total fat and salt intakes, and negatively associated with education level and total dietary fibre intake in Han ($P < 0·05$–$0·001$).

Conclusions: The differences in blood pressure levels and the prevalence of hypertension between the Hei Yi Zhuang and Han populations were associated with different dietary habits, lifestyle choices, education level, as well as geographical surroundings.

Hypertension is a principal cause of mortality and morbidity in China[1], and is also one of the most important cardiovascular risk factors all over the world[2]. A recent cross-sectional study in China estimated that 129 million people aged 35–74 years have hypertension[3]. Although the exact causes and mechanisms of hypertension are not well known, it is generally believed that genetic factors[4] as well as environmental factors, such as more sodium intake[5,6], cigarette smoking[7,8] and mental work[9,10], are involved in determining blood pressure levels and the prevalence of hypertension. In addition, the prevalence of hypertension in different races may also differ[11,12].

There are fifty-six ethnic groups in China. Han is the largest ethnic group and Zhuang is the largest minority. There are also forty-three ethnic subgroups of the Zhuang. Hei Yi Zhuang dwelling in Napo County (a county near Vietnam) of Guangxi is an isolated subgroup. They worship black colour, and they like to wear black garments and pants. Black colour has become the marking of Hei Yi Zhuang. The population size is 51 655. Because of isolation from the other ethnic groups, the special customs

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and cultures including their clothing, intra-ethnic marriages, dietary habits and lifestyle are still totally conserved to the present day[13]. Little is known about the association of diet and lifestyle with blood pressure in this population. We hypothesise that there may be significant differences in the dietary patterns, lifestyle and blood pressure levels between the two ethnic groups. Therefore, the present study was undertaken to detect the association of diet and lifestyle with blood pressure and the prevalence of hypertension in the Guangxi Hei Yi Zhuang and Han populations.

Methods

Populations

A total of 1068 subjects of Hei Yi Zhuang from seven villages in Napo County, Guangxi Zhuang Autonomous Region, China, were surveyed by a stratified randomised cluster sampling. The ages of the subjects ranged from 20 to 84 years, with an average age of 46·75 (SD 15·66) years. There were 487 (45·6%) males and 581 (54·4%) females. All of them were peasants. The numbers of subjects between the ages of 20–29, 30–39, 40–49, 50–59, 60–69 and ≥70 years were 156 (14·6%), 255 (23·8%), 177 (16·6%), 196 (18·4%), 196 (18·4%) and 88 (8·2%), respectively. They accounted for 2·1% of the total Hei Yi Zhuang population. During the same period, a total of 933 subjects of Han Chinese from nine villages in the same county were also surveyed by the same method. The mean age of the subjects was 45·46 (SD 15·76) years (range 20–89 years). There were 414 (44·4%) men and 519 (55·6%) women. These subjects were also peasants. The numbers of subjects between the ages of 20–29, 30–39, 40–49, 50–59, 60–69 and ≥70 years were 183 (19·6%), 230 (24·7%), 173 (18·5%), 149 (16·0%), 117 (12·5%) and 81 (8·7%), respectively. All study subjects were essentially healthy and had no evidence of any chronic illness, including hepatic, renal, thyroid, cardiac dysfunction or diabetes mellitus. Some subjects were treated with antihypertensive drugs, such as nifedipine (calcium channel blocker) and/or catopril (angiotensin converting enzyme inhibitor). The study was approved by our institutional ethics committee, and the study subjects gave informed consent to participate in the study.

Epidemiological survey

The survey was carried out using internationally standardised methods[14], following a common protocol. Information on demographics (age, gender, race/ethnicity and residential area), socio-economic status (education level achieved, marital status and annual household income), health-related behaviour (alcohol consumption, cigarette smoking and physical activity) and dietary intake was collected with standardised questionnaires. Dietary information of each subject was obtained using a 24 h dietary recall method[15]. 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. Quantitative estimate of cumulative nutrient intake per day in each food was based on food tables derived from the 2002 Chinese Food Composition Tables[16]. Overall physical activity was ascertained with the use of a modified version of the Harvard Alumni Physical Activity Questionnaire[17], which included questions about the number of hours per day (mean of a regular weekday and a regular weekend day) spent sleeping and in sedentary, light, moderate and vigorous activities; the interviewer ensured that the total time added up to 24 h. Current smoking was defined as more than one cigarette per day. Consumption of alcohol included questions about the number of liangs (about 50 g) of rice wine, wine, beer or liquor consumed during the preceding 12 months. The physical examination included blood pressure, height, weight and waist circumference. Blood pressure readings were taken with a standard mercury sphygmomanometer after at least 5 min of rest, while the subject was in a sitting position. The values used in the current analysis are means of three measurements taken by the same investigator at about 5 min intervals. Systolic blood pressure (SBP) was determined by the first Korotkoff sound, and diastolic blood pressure (DBP) by the fifth Korotkoff sound. Pulse pressure (PP) was calculated as the difference between SBP and DBP. Mean arterial pressure (MAP) was calculated as DBP plus one-third times PP[18]. Body weight (to the nearest 100 g on calibrated scales) and height (to the nearest 0·5 cm) were measured while the participants were wearing only light indoor clothing and no shoes. BMI was calculated as weight (kg) divided by height (m) squared. Waist circumference was measured with a non-stretchable measuring tape, at the level of the smallest area of the waist, to the nearest 0·1 cm.

Measurements of lipids and apolipoproteins

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

Diagnostic criteria

Hypertension was defined as an average SBP of 140 mmHg or greater and/or an average DBP of 90 mmHg or greater[19], 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 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 <140 mmHg and an average DBP <90 mmHg in the context of pharmacological treatment of hypertension. The normal values of serum total cholesterol, TAG, HDL-C, LDL-C, apo A1, apo B and the ratio of apo A1 to apo B in our Clinical Science Experiment Center were 3·10–5·17, 0·56–1·70, 0·91–1·81, 1·70–3·20 mmol/l, 1·00–1·76, 0·63–1·14 g/l and 1·00–2·50, respectively. Normal weight, overweight and obesity were defined as a BMI < 24, 24–28 and >28 kg/m², respectively[20].

Statistical analysis

The data were organised and analysed using EXCEL XP (Microsoft, Seattle, WA, USA) and SPSS for Windows version 11·5 (SPSS Inc., Chicago, IL, USA). Means and standard deviations (SD) as well as frequency distributions of participant characteristics were calculated. The difference of two parameters between Hei Yi Zhuang and Han was tested by Student's unpaired t-test. One-way ANOVA was performed to assess the differences of three and more parameters. Significant difference was then subjected to multiple comparison using the Newman–Keuls test. The difference of percentage was tested by the χ^2 tests. In order to evaluate the association between the MAP and ethnic group (Han = 0; Hei Yi Zhuang = 1), gender (female = 0; male = 1), age (year), education level (years), physical activity (h/week), BMI (kg/m² = 1), waist circumference (cm), total cholesterol (mmol/l), TAG (mmol/l), LDL-C (mmol/l), apo B (g/l), alcohol consumption (non-drinkers = 0; <25 g/d = 1; 25–49 g/d = 2; 50–99 g/d = 3; ≥100 g/d = 4), cigarette smoking (non-smokers = 0; <10 cigarettes/d = 1; 10–19 cigarettes/d = 2; 20–39 cigarettes/d = 3; ≥40 cigarettes/d = 4) and the intakes of total energy (kJ/d), total fat (g/d), dietary cholesterol (mg/d), total dietary fibre (g/d) and salt intake (g/d), unconditional logistic regression analysis were also performed in combined population of Hei Yi Zhuang and Han, Hei Yi Zhuang, and Han, respectively. The backward multiple logistic regression method was used to select the risk factors significantly associated with MAP. The total intake of each nutrient was summed over all foods consumed. Matlab5.0 software was used for the quantitative estimate of cumulative nutrient intake per day[21]. A P value of <0·05 was considered significant.

Results

General characteristics between Hei Yi Zhuang and Han

The demographic characteristics, dietary intake and other lifestyle factors between Hei Yi Zhuang and Han are shown in Table 1. The intakes of carbohydrate, total dietary fibre and salt, mean residential altitude, and the percentages of subjects who consumed alcohol in Hei Yi Zhuang were higher than those in Han ($P<0·05-0·001$), whereas the education level, body weight, BMI, waist circumference, and the intakes of total energy, total fat, protein and dietary cholesterol in Han were higher than those in Hei Yi Zhuang ($P< 0·001$ for all). There were no differences in physical activity level, body height, the percentages of subjects who smoked cigarettes and sex distribution between the two ethnic groups ($P> 0·05$).

Blood pressure levels and prevalence of hypertension

As shown in Table 1, the levels of SBP and PP in Hei Yi Zhuang were higher than those in Han ($P< 0·001$ for each), but there was no difference in DBP levels between Hei Yi Zhuang and Han ($P> 0·05$). The crude prevalence rates of hypertension and isolated systolic hypertension were also higher in Hei Yi Zhuang than in Han (25·19 % v. 17·26 % and 12·45 % v. 3·86 %, $P< 0·001$ for each, respectively).

Awareness, treatment and control of hypertension

Of the 269 subjects with hypertension in Hei Yi Zhuang, 8·55 % were aware of their high blood pressure, 4·46 % were treated and 1·86 % were controlled, whereas the rates of awareness, treatment and control in Han were 21·12 % ($P< 0·001$), 15·53 % ($P< 0·001$) and 10·56 % ($P< 0·001$), respectively (Table 1).

Association of demographic and lifestyle factors with blood pressure

The association of sex, age, BMI, alcohol consumption and cigarette smoking with blood pressure levels between Hei Yi Zhuang and Han is shown in Table 2. SBP, DBP and MAP in both Hei Yi Zhuang and Han were higher in men than in women ($P< 0·001$ for all), but there was no significant difference in PP between both sexes. SBP, DBP, PP and MAP increased progressively with age in both ethnic groups ($P< 0·01–0·001$). SBP levels in both ethnic groups were higher in drinkers than in non-drinkers ($P< 0·01$ for each). The levels of DBP and MAP in both ethnic groups were higher in drinkers than in non-drinkers, or in smokers than in non-smokers ($P< 0·001$ for all). In addition, the levels of DBP and MAP in Han were higher in drinkers than in non-drinkers ($P< 0·01$).

Table 1 General characteristics and blood pressure levels between the Hei Yi Zhuang and Han populations

Characteristic	Hei Yi Zhuang (*n* 1068)		Han Chinese (*n* 933)		$t (\chi^2)$	*P*
	Mean or *n*	SD or %	Mean or *n*	SD or %		
Age (years)	46·75	15·66	45·46	15·76	1·833	0·067
Male/female	487/581		414/519		0·303	0·582
Education level (years)	2·85	0·95	3·98	1·72	18·484	0·000
Physical activity (h/week)	39·48	13·22	38·76	13·45	1·206	0·228
Residential altitude (m)	9479·85	87·18	814·65	121·27	30·166	0·000
Height (cm)	153·18	7·96	152·66	8·17	1·440	0·150
Weight (kg)	49·98	7·37	52·42	7·99	7·103	0·000
BMI (kg/m²)	21·25	2·27	22·43	2·50	11·064	0·000
>24 kg/m²‡	123	11·52	202	21·65	37·591	0·000
Waist circumference (cm)	73·73	6·84	74·86	7·75	3·465	0·001
Alcohol consumption‡	592	55·43	466	49·95	6·011	0·014
Cigarette smoking‡	332	31·09	266	28·51	1·577	0·209
Energy (kJ/d)	8755·48	278·52	8890·72	325·75	10·011	0·000
Carbohydrate (g/d)	366·12	25·76	292·11	21·25	69·498	0·000
Protein (g/d)	52·30	5·78	79·67	7·87	89·377	0·000
Total fat (g/d)	39·52	5·67	61·38	6·85	78·076	0·000
Dietary cholesterol (mg/d)	176·33	105·47	195·67	116·25	3·901	0·000
Total dietary fibre (g/d)	8·87	3·44	6·72	2·54	15·712	0·000
Salt intake (g/d)	8·76	3·75	7·58	2·64	8·092	0·000
SBP (mmHg)	125·20	18·62	121·88	15·99	4·247	0·000
DBP (mmHg)	76·56	11·06	76·95	10·03	0·822	0·411
PP (mmHg)	48·64	14·75	44·98	11·12	6·196	0·000
Isolated SBP ≥ 140 mmHg‡	133	12·45	36	3·86	47·571	0·000
Isolated DBP ≥ 90 mmHg‡	35	3·28	42	4·50	2·018	0·155
Both SBP ≥ 140 and DBP ≥ 90 mmHg‡	101	9·46	83	8·90	0·188	0·664
Hypertension prevalence‡	269	25·19	161	17·26	18·566	0·000
Awareness rate‡	23	8·55	34	21·12	13·835	0·000
Treatment rate‡	12	4·46	25	15·53	15·686	0·000
Control rate‡	5	1·86	17	10·56	15·705	0·000

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure.
Data are presented as means and standard deviations or ‡as numbers of subjects and percentages.

Association of demographic and lifestyle factors with the prevalence of hypertension

The association of demographic and lifestyle factors with the prevalence of hypertension is shown in Table 3. The prevalence of hypertension in both ethnic groups was higher in males than in females, or in smokers than in non-smokers ($P < 0.01$ for all). In addition, the prevalence of hypertension in Han was higher in drinkers than in non-drinkers ($P < 0.01$).

Correlative factors for mean arterial pressure

Table 4 gives the results of multivariate logistic regression analysis. MAP was positively correlated with Hei Yi Zhuang, male, age, physical activity, BMI, waist circumference, total cholesterol, TAG, alcohol consumption, cigarette smoking, and total energy, total fat and salt intakes, and negatively associated with education level and total dietary fibre intake in a combined population of Hei Yi Zhuang and Han ($P < 0.05$–0.001). MAP was positively correlated with male, age, physical activity, TAG, alcohol consumption, cigarette smoking, and total energy, total fat and salt intakes, and negatively associated with education level and total dietary fibre intake in Hei Yi Zhuang ($P < 0.05$–0.001), whereas it was positively associated with male, age, physical activity, BMI, waist circumference, total cholesterol, alcohol consumption, cigarette smoking, and total energy, total fat and salt intakes, and negatively associated with education level and total dietary fibre intake in Han ($P < 0.05$–0.001). No association was observed between MAP and LDL-C, apo B or dietary cholesterol intake ($P > 0.05$).

Discussion

In the present study, we show that SBP and PP levels are higher in Hei Yi Zhuang than in Han. The prevalence of hypertension and isolated systolic hypertension is also higher in Hei Yi Zhuang than in Han. The disparity in blood pressure and the prevalence of hypertension between the two ethnic groups is multifactorial. The vast majority of Hei Yi Zhuang people reside in the mountainous areas. The mean residential altitude is higher than that in Han. 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 obvious[22,23]. A recent study has shown that chronic hypoxia causes marked activation of the sympathetic nervous system in healthy humans and increased SBP, despite normalisation of the arterial O_2 content with acclimatisation[24]. Increased secretion of

Table 2 Association of demographic characteristics and lifestyle factors with blood pressure levels between the Hei Yi Zhuang and Han populations

Variable	n	SBP (mmHg)		DBP (mmHg)		PP (mmHg)		MAP (mmHg)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hei Yi Zhuang									
Male	487	127·57	18·99	78·58	11·45	49·01	14·81	94·92	13·13
Female	581	120·93***	17·77	73·51***	10·38	47·44	14·26	89·32***	2·32
BMI ≤ 24 kg/m^2	945	125·34	18·84	76·49	11·06	48·86	14·97	92·78	13·02
BMI > 24 kg/m^2	123	124·07	16·80	77·11	11·15	46·95	12·99	92·76	12·07
Non-drinker	476	123·47	19·11	74·44	10·64	49·03	15·45	90·78	13·05
Drinker	592	126·59**	18·11	78·27***	11·11	48·33	14·18	94·38***	12·65
Non-smoker	736	124·08	18·61	75·29	10·88	48·79	14·82	91·55	12·85
Smoker	332	126·35	17·90	79·01***	10·91	47·34	14·84	94·79***	12·88
Age (years)									
20–29	156	118·74	13·21	74·21	10·38	44·57	10·84	89·07	10·61
30–39	255	119·27	14·49	75·31	9·44	43·96	11·03	89·96	10·24
40–49	177	120·96	13·46	77·72	10·36	43·30	10·00	92·15	10·18
50–59	196	127·19	18·89	77·81	11·37	49·39	14·16	94·27	12·77
60–69	196	134·87	22·78	77·75	12·69	57·12	18·12	96·79	15·41
≥70	88	136·22	21·11	76·42	12·44	59·80	16·68	96·35	14·56
F for six age subgroups	–	31·979		3·450		42·012		11·970	
P for six age subgroups	–	0·000		0·004		0·000		0·000	
Han Chinese									
Male	414	124·05††	16·06	79·51	10·44	44·63†††	11·21	94·39	10·83
Female	519	120·35***	15·77	75·16***,††	9·33	45·22††	11·05	90·23***	10·19
BMI ≤ 24 kg/m^2	730	121·34†††	16·10	76·34	9·70	45·02†††	11·26	91·35	10·48
BMI > 24 kg/m^2	203	123·72	15·48	79·06***	10·88	44·83	10·64	94·01**	10·76
Non-drinker	467	120·32††	16·08	75·75	9·51	44·63†††	11·30	90·63	10·41
Drinker	466	123·44**,††	15·75	78·15***	10·40	45·32†††	10·94	93·26***	10·67
Non-smoker	667	121·20††	16·10	75·96	9·70	45·26†††	11·24	91·05	10·47
Smoker	266	123·55*,†	15·60	79·40***	10·42	44·27†††	10·80	94·16***	10·25
Age (years)									
20–29	183	115·75†	11·89	74·10	8·36	41·75††	8·86	88·02	8·61
30–39	230	117·72	12·71	75·13	8·23	42·72	9·59	89·37	8·91
40–49	173	120·65	14·26	77·08	9·65	43·57	9·59	91·60	9·62
50–59	149	125·15	16·85	79·28	10·92	45·87†	11·54	94·57	11·23
60–69	117	128·13††	17·74	78·91	11·27	49·22†††	11·48	95·32	11·38
≥70	81	134·88	19·65	81·02	12·37	53·85	14·62	98·97	13·50
F for six age subgroups	–	27·722		10·122		21·585		20·737	
P for six age subgroups	–	0·000		0·000		0·000		0·000	

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure.
Mean values were significantly different from those of male, BMI ≤ 24 kg/m^2, non-drinker or non-smoker subgroups of the same ethnic group: *$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
Mean values were significantly different from those of Hei Yi Zhuang: †$P < 0·05$, ††$P < 0·01$, †††$P < 0·001$.

catecholamine[24,25], vasopressin[26] and adrenocorticotropin[27] may promote the development of hypertension by the renin–angiotensin–aldosterone system[28].

Corn gruel or hoecake is the staple food throughout the year in Hei Yi Zhuang. There are three meals a day on an ordinary day, and four meals on a farming day. Salt is the main flavouring. The intake of salt is very high. Long-term high salt intake is an important risk factor for hypertension[5]. Several large randomised trials and meta-analyses of trials have shown that a reduction in salt intake lowers blood pressure in hypertensive individuals[6,29].

The climate in Napo County is like the south subtropics. Evaporation is quick, and the weather is very dry and cold in winter at the mountain top. Cold exposure has been shown to be a risk factor for hypertension[30]. SBP and DBP were significantly higher in the cold-exposed workers. In logistic regression analysis, cold exposure severity was a significant variable affecting hypertension in cold-exposed workers[30].

Hei Yi Zhuang people reside in the infertile mountain area, which is 30% soil with 70% rock. The earnings derive mostly from planting corn and paddy. It is not easy for adolescents to go to junior high school. Thus, the education level is widespread lower, and the knowledge of necessary health care is very poor[11,31].

The association of sex and age with blood pressure has been extensively studied. Currently, it is believed that the prevalence of hypertension is higher in males than in females, and both blood pressure and the prevalence of hypertension increase with age[32,33]. The present study also shows that SBP and DBP are higher in men than in women in both ethnic groups. SBP, DBP, PP and MAP in both ethnic groups are all increased progressively with age. MAP is also positively correlated with male gender and age in both populations. This may relate to the overwork and unwholesome lifestyle in men[34]. Job stress has been shown in prospective studies to have adverse effects on the development of hypertension and

Table 3 Association of demographic characteristics and lifestyle factors with the prevalence of hypertension between the Hei Yi Zhuang and Han populations

Variable	n	SBP ≥ 140 mmHg		DBP ≥ 90 mmHg		SBP ≥ 140 and DBP ≥ 90 mmHg		Prevalence of hypertension	
		n	%	n	%	n	%	n	%
Hei Yi Zhuang									
Male	487	66	13·6	28	5·7	70	14·4	164	33·7
Female	581	67	11·5	7***	1·2	31***	5·3	105***	18·1
BMI ≤ 24 kg/m²	945	124	13·1	29	3·1	87	9·2	240	25·4
BMI > 24 kg/m²	123	9	7·3	6	4·9	14	11·4	29	23·6
Non-drinker	476	63	13·2	11	2·3	33	6·9	107	22·5
Drinker	592	70	11·8	24	4·1	68*	11·5	162	27·4
Non-smoker	736	88	12·0	17	2·3	62	8·4	167	22·7
Smoker	332	45	13·6	18**	5·4	39	11·7	102**	30·7
Age (years)									
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	88	22	25·0	0		15	17·1	37	42·1
χ^2 for six age subgroups	–	72·814		9·013		38·134		90·828	
P for six age subgroups	–	0·000		0·109		0·000		0·000	
Han Chinese									
Male	414	15†	3·6	30	7·2	44	10·6	89c	21·5
Female	519	21†††	4·0	12***	2·3	39	7·5	72**	13·9
BMI ≤ 24 kg/m²	730	29†††	4·0	29	4·0	60	8·2	118†††	16·2
BMI > 24 kg/m²	203	7	3·4	13	6·4	23	11·3	43	21·2
Non-drinker	467	16†††	3·4	14	3·0	34	7·3	64†††	13·7
Drinker	466	20†††	4·3	28*	6·0	49	10·5	97**,†	20·8
Non-smoker	667	24†††	3·6	18	2·7	57	8·5	99†††	14·8
Smoker	266	12†††	4·5	24***	9·0	26	9·8	62**,†	23·3
Age (years)									
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	81	11†	13·6	2	2·5	21a	25·9	34	42·0
χ^2 for six age subgroups	–	28·866		7·464		60·211		75·276	
P for six age subgroups	–	0·000		0·188		0·000		0·000	

SBP, systolic blood pressure; DBP, diastolic blood pressure.
Number of subjects was significantly different from those of male, BMI ≤ 24 kg/m², non-drinker or non-smoker subgroups of the same ethnic group: *$P < 0·05$, **$P < 0·01$, ***$P < 0·001$.
Number of subjects was significantly different from those of Hei Yi Zhuang: †$P < 0·05$, ††$P < 0·01$, †††$P < 0·001$.

coronary artery disease, particularly in men[9]. SBP and DBP during the working day were greater in high job demand participants who were stress reactive than in other groups[10].

Epidemiological studies have revealed that the prevalence of hypertension was 2- to 6-fold higher in obese than in normal weight populations[35,36]. An increase in BMI and a decrease in BMI were significantly associated with increased and decreased SBP and DBP, respectively[35]. In the present study, however, we fail to show an association of BMI and blood pressure in Hei Yi Zhuang. The reason for this discrepancy is unclear. In this study, the subjects with a BMI > 24 kg/m² were only 11·52 % in Hei Yi Zhuang, suggesting that the association of BMI and blood pressure is weak in this population. In a recent investigation, Biscevic[36] has shown that there was a higher correlation of blood pressure with waist circumference, than with BMI. In the present study, we also fail to show the association of MAP and waist circumference in Hei Yi Zhuang. However, our study shows that MAP was positively correlated with TAG in Hei Yi Zhuang, and was positively correlated with total cholesterol in Han[37]. The relationship between hypertension and hyperlipidaemia remains poorly understood. High blood pressure in patients with hyperlipidaemia may be a consequence of vascular endothelial dysfunction[34].

Alcohol in larger amounts increases blood pressure and overall mortality[7,8,38]. The mechanisms involved in the pressor effect of a moderate dose of alcohol primarily reflects an increase in cardiac output and heart rate, possibly a consequence of increased sympathetic nerve activity[39]. Alcohol also alters cell membranes, allowing more calcium to enter, perhaps by inhibition of intracellular sodium transport[40]. In the present study, we also show that SBP, DBP and MAP levels in both ethnic groups were higher in drinkers than in non-drinkers. MAP was also positively correlated with alcohol consumption in both ethnic groups. These results suggest that alcohol

Table 4 Correlative factors for mean arterial pressure between the Hei Yi Zhuang and Han populations

Ethnic groups/correlative factors	Regression coefficient (RC)	Standard error	Standardised RC	t	P
Hei plus Han					
Ethnic group	0·016	0·002	0·215	4·578	0·000
Sex	0·211	0·073	0·127	2·764	0·004
Age	0·009	0·003	0·174	3·774	0·000
Education level	−0·148	0·054	−0·121	−2·657	0·006
Physical activity	0·013	0·003	0·242	5·335	0·000
BMI	0·098	0·047	0·087	2·342	0·016
Waist circumference	0·023	0·012	0·095	2·225	0·023
Total cholesterol	0·099	0·034	0·079	2·293	0·017
TAG	0·002	0·001	0·113	2·258	0·019
Alcohol consumption	0·008	0·006	0·237	5·556	0·000
Cigarette smoking	0·007	0·004	0·112	2·138	0·031
Total energy	0·014	0·005	0·155	3·345	0·001
Total fat	0·003	0·002	0·214	4·841	0·000
Total dietary fibre	−0·177	0·054	−0·139	−3·321	0·001
Salt intake	0·002	0·003	0·188	4·162	0·000
Hei Yi Zhuang					
Sex	0·155	0·052	0·086	2·683	0·006
Age	0·013	0·003	0·187	6·112	0·000
Education level	−0·117	0·005	−0·193	−3·413	0·000
Physical activity	0·015	0·005	0·144	4·463	0·000
TAG	0·004	0·003	0·097	2·912	0·004
Alcohol consumption	0·008	0·002	0·163	4·893	0·000
Cigarette smoking	0·002	0·008	0·114	2·385	0·018
Total energy	0·012	0·002	0·163	4·822	0·000
Total fat	0·010	0·001	0·195	6·125	0·000
Total dietary fibre	−0·131	0·011	−0·112	−3·335	0·001
Salt intake	0·055	0·012	0·146	4·831	0·000
Han Chinese					
Sex	0·076	0·014	0·183	3·231	0·000
Age	0·014	0·003	0·201	4·324	0·000
Education level	−0·014	0·005	−0·118	−2·946	0·002
Physical activity	0·005	0·002	0·166	4·013	0·000
BMI	0·008	0·003	0·185	4·095	0·000
Waist circumference	0·036	0·012	0·145	3·513	0·000
Total cholesterol	0·005	0·004	0·099	2·113	0·031
Alcohol consumption	0·002	0·002	0·183	4·612	0·000
Cigarette smoking	0·068	0·025	0·097	2·287	0·022
Total energy	0·057	0·023	0·121	2·883	0·003
Total fat	0·015	0·004	0·215	5·176	0·000
Total dietary fibre	−0·034	0·008	−0·186	−4·554	0·000
Salt intake	0·007	0·003	0·145	2·736	0·005

consumption is a main risk factor for hypertension in both populations. The effect of different kinds of wine on blood pressure is not well known. In this study, 90 % of the wine consumed by Hei Yi Zhuang was corn wine and rum, in which the alcohol content is lower. On the contrary, a great deal of the wine consumed by Han is rice wine, in which the alcohol content is higher.

Cigarette smoking is a well-established cardiovascular risk factor. Cigarette smoking raises blood pressure, probably through the nicotine-induced release of nor-adrenaline from adrenergic nerve endings. In addition, smoking causes an acute and marked reduction in radial artery compliance[41]. When smokers quit, a trivial rise in blood pressure may occur, probably reflecting a gain in weight[42]. Waist girth increased more in men who quit smoking than in other men. An increase in waist girth during follow-up strongly predicted incident hypertension[43]. In our study, we show that DBP and MAP levels in both ethnic groups were higher in smokers than in non-smokers. MAP was also positively correlated with cigarette smoking in both ethnic groups, suggesting that cigarette smoking is another independent risk factor for hypertension in these populations.

The rates of awareness, treatment and control are important indices of hypertensive treatment and prognosis. The rates of awareness, treatment and control in our country were 44·7 %, 28·2 % and 8·1 %, respectively, in subjects aged 35–74 years in 2001[3,44]. The results of the present study show that the rates of awareness, treatment and control in Hei Yi Zhuang were significantly lower than those in Han, and were also significantly lower than those in the rural population of China. The reason for this status is likely multifactorial; however, a lack of public awareness and understanding of hypertension and its complications 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 is found to be highly prevalent in the Hei Yi Zhuang population, and the rates of awareness, treatment and control are relatively lower. These results underscore the urgent need for developing a high blood pressure education programme to coordinate the effort of detection, prevention and treatment of hypertension in the national minority area of China.

Acknowledgements

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