Int J Clin Exp Med 2015;8(9):16424-16433
www.ijcem.com /ISSN:1940-5901/IJCEM0012490

Original Article

Prevalence of prehypertension and associated risk factors among health check-up population in Guangzhou, China

Rui Wang[1], Xia Lu[1], Yan Hu[2], Tianhui You[1]

[1]*School of Nursing, Guangdong Pharmaceutical University, Guangzhou 510310, China;* [2]*Department of Medical Diagnostic Centre, The Sixth Affiliated Hospital, Sun Yat-Sen University, Guangzhou 510310, China*

Received July 6, 2015; Accepted September 6, 2015; Epub September 15, 2015; Published September 30, 2015

Abstract: The authors aimed to investigate the prevalence and risk factors of prehypertension among a cohort of patients presenting for a health check-up in Guangzhou. Using an age-and gender-stratified random sample method, 5170 urban adults aged 18-70 years undergoing health examination in Guangzhou were selected. Prehypertension was defined as systolic blood pressure (SBP) of 120-139 mmHg or diastolic blood pressure (DBP) of 80-89 mmHg. Overall prevalence of prehypertension in our study population was 35.15% (43.75% in men, 23.56% in women; P<0.05). Multivariate logistic regression analysis indicated that age (odds ratio [OR] =1.257), female (OR=0.437), fasting blood glucose (OR=1.514), total cholesterol (OR=1.241), triglycerides (OR=1.236), uric acid (OR=1.222), and body mass index (OR=1.778) were risk factors for prehypertension. The prevalence of prehypertension was reported to be higher among men in our study population in Guangzhou.

Keywords: Prehypertension, prevalence, health examination, risk factor

Introduction

Hypertension is a well-known risk factor for cardiovascular disease (CVD). According to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), prehypertension is defined as a systolic blood pressure (SBP) of 120-139 mmHg or a diastolic blood pressure (DBP) of 80-89 mmHg in adults [1]. Prehypertension has become a major public health concern due to its strong association with increased risk of hypertension and cardiovascular or cerebrovascular events. However, JNC-8 guidelines on hypertension do not focus on the concept of prehypertension [2, 3]. The presence of prehypertension predicts or indicates an increased risk of hypertension in the high-risk population. When compared with individuals with normal blood pressure, those with prehypertension have a 31% increased risk of coronary heart disease (CHD), 49% greater risk of stroke, and 44% greater risk of total cardiovascular events [4]. Moreover, prehypertension is often linked to target organ damage, such as early arteriosclerosis, small vascular damage, coronary artery calcification, vascular remodeling, and left ventricular hypertrophy [5-11]. Therefore, investigating the prevalence of prehypertension and related risk factors could help to prevent hypertension and CVD and end-organ damage.

The National Health and Nutrition Examination Survey of 1999-2006 indicated that the overall prevalence of prehypertension in healthy adults was 36.3% worldwide [12]. The reported prevalence of prehypertension was 31.6% in Korea [13] and more than 31.8% in Japan [14]. Prehypertension was noted in 50.6% of men and 35.9% of women in Israeli adults [15]. Non-Asian individuals appear more likely to be pre hypertensive than their Asian counterparts [16].

A survey conducted in 11 provinces of China among adults aged 35-64 years indicated that 32.2% of Chinese adults (34.2% in men, 30.2% in women) had prehypertension [17]. Another cross-sectional study showed that 40.5% urban

adults aged 18-74 years in northeastern China had prehypertension, with a prevalence of 47.7% in men and 33.6% in women [18]. Differences in the prevalence of prehypertension in different groups might be partly explained by the geographical and ethnic distribution of the population. Higher levels of fasting blood glucose (FBG), uric acid (UA), total cholesterol (TC), low density lipoprotein cholesterol (LDL-C), or triglyceride (TG) and larger waist circumference and body mass index (BMI; measure of weight in kilograms divided by the height in meters squared) have been considered to be potential risk factors of prehypertension [19].

Guangzhou, located in southern China, is representative of that region. With a gradual increase in the floating population, Guangzhou has become one of the most populous cities in China. Changed eating habits, an accelerated pace of work, and increased stress are thought to contribute to the increasing incidence of prehypertension and hypertension. However, scant data exists regarding the prevalence and risk factors associated with prehypertension in Guangzhou. The objective of the current study was to investigate the prevalence of prehypertension and potential risk factors associated with the progression of prehypertension among a representative cohort from Guangzhou.

Methods

Study design

This cross-sectional study was carried out in the hospitals of 11 districts of Guangzhou from November 1 to December 1, 2013. Using an age-and gender-stratified random sample method, subjects aged 18-70 years undergoing health check-up with complete information of the following characteristics were included in this study: demographic data, height, body weight, blood pressure, and TC, TG, LDL-C, HDL-C, FBG, and UA levels. Individuals with previous diagnosis of endocrine disease (Cushing syndrome, pheochromocytoma, hyperthyroidism, primary aldosteronism, etc.), chronic kidney disease (acute or chronic glomerulonephritis, pyelonephritis, renal artery stenosis, polycystic kidney, etc.), cardiovascular disease (aortic coarctation, congenital heart disease, severe aortic insufficiency, cardiomyopathy, etc.), secondary hypertension induced by drugs, and undefined tumors were excluded from the study. This study was approved by the Ethics Committee of the Guangdong Pharmaceutical University and informed written consent was obtained from all subjects.

Data collection

Information on demographic characteristics was collected using a standard questionnaire in a face-to-face interview. Trained research staff also recorded the data related to the diagnosis and treatment of hypertension. Weight and height were measured, and BMI was calculated. The waist circumference was taken at the level of the umbilicus by using a non-elastic tape. Information on gender, age, birth place, ethnic, occupation, marital status, cultural background, and economic status was collected.

Blood pressure measurement

SBP and DBP measurements were obtained for each subject by trained staff with a desktop mercury column sphygmomanometer. Blood pressure measurement procedure: (1) the mercury column was adjusted to zero position and the bubble within the mercury column was excluded; (2) the cuffs covered approximately half to two-thirds of the subject's arm; (3) the subjects were advised to avoid alcohol consumption, cigarette smoking, coffee, and tea for at least 60 min before their blood pressure measurements; (4) the blood pressure was measured three times at right brachial artery after seating for 5-10 min, and the time interval between the two consecutive blood pressure measurements was 2 min, and (5) finally, the average of 3 blood pressure measurement was calculated.

Blood samples and outcome measures

After fasting overnight for about an 8 hours, venous blood samples were obtained. The serum was isolated from the whole blood and was kept at -20°C until analysis. Serum levels of TC, TG, LDL-C, HDL-C, UA, and plasma FBG levels were measured with an automatic Biochemical Analyzer (Beckman-Coulter SYNCHRON LX20, USA).

Diagnostic criteria

The classifications of prehypertension, hypertension and the normal blood pressure were

Table 1. Prevalence of hypertension and prehypertension by gender and age groups

Items	Total population (%) (n=5170)	Normal blood pressure (%) (n=2551)	Prehypertension (%) (n=1817)	Hypertension (%) (n=802)	*P*-value#	*P*-value&
Gender						
Male	2967 (57.4%)	1123 (44.02%)	1298 (71.44%)	546 (68.08%)		
Female	2203 (42.6%)	1428 (55.98%)	519 (28.56%)	256 (31.92%)	0.000**	0.083
Age (Years)						
<25	556 (10.8%)	367 (16.30%)	175 (31.47%)	14 (1.75%)		
25~	1685 (32.6%)	1026 (40.22%)	567 (33.65%)	92 (11.47%)	0.163	0.016*
35~	1369 (26.5%)	714 (27.99%)	502 (36.67%)	153 (19.08%)	0.000**	0.000**
45~	803 (15.5%)	301 (11.80%)	292 (36.36%)	210 (26.18%)	0.000**	0.000**
55~	325 (6.3%)	86 (3.37%)	134 (41.23%)	105 (13.09%)	0.000**	0.000**
≥60	432 (8.4%)	57 (2.23%)	147 (34.02%)	228 (28.43%)	0.000**	0.000**

*P<0.05, **P<0.01; #Comparison between prehypertension and normal blood pressure; &Comparison between prehypertension and hypertension.

Table 2. Anthropometric characteristics of the study population

Items	Normal blood pressure (n=2551)	Prehypertension (n=1817)	Hypertension (n=802)	Statistic (F-value)	*P*-value
Age (years)	36.11±10.35	40.71±12.75	52.09±13.63	564.046	0.000**
SBP (mmHg)	108.35±7.78	127.23±6.23	148.23±13.63	7422.997	0.000**
DBP (mmHg)	67.85±6.43	79.84±6.08	93.01±8.92	4682.608	0.000**
FBG (mmol/L)	4.79±0.60	5.13±1.25	5.55±1.45	178.969	0.000**
TC (mmol/L)	5.09±0.98	5.41±1.03	5.65±1.08	111.091	0.000**
TG (mmol/L)	1.29±1.01	1.76±1.33	2.09±1.45	162.297	0.000**
HDL (mmol/L)	1.57±0.42	1.43±0.39	1.37±0.38	101.307	0.000**
LDL (mmol/L)	2.70±0.74	2.96±0.77	3.09±0.80	111.246	0.000**
UA (μmol/L)	347.19±92.69	396.37±96.79	411.37±104.01	209.679	0.000**
BMI (kg/m^2)	22.27±3.01	24.78±13.72	26.23±10.71	70.237	0.000**

SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; HDL, high-density lipoprotein; LDL, low-density lipoprotein; UA, uric acid; BMI, body mass index. Data is presented as mean ± SD. **P<0.01.

based on the JNC-7 guidelines [1]. Prehypertension was defined as a SBP of 120-139 mm Hg or a DBP 80-89 of mmHg. Hypertension was defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg, and also if the subject is on antihypertensive medication. Normal blood pressure was defined as subjects with SBP <120 mmHg and DBP <80 mmHg without having any antihypertensive medication. Diabetes was diagnosed according to the criteria of World Health Organization (WHO), 1999 [20] and American Diabetes Association (ADA), 2003 [21]. The criteria included a *fasting plasma glucose* (FPG) ≥7.0 mmol/L (126 mg/dL) and/or being on medical treatment for diabetes with insulin or other antihyperglycemic agents. Impaired fasting glucose was defined as a FPG level between 6.1 and 7.0 mmol/L. According to the criteria of China adult dyslipidemia prevention guidelines [22], dyslipidemia was defined as TG >1.7 mmol/L, TC ≥5.18 mmol/L, LDL-C ≥3.37 mmol/L, or HDL-C <0.91 mmol/L. The body mass index values were grouped into four categories in both males and females as low weight (BMI <18.5 kg/m^2), normal weight (BMI of 18.5 to 24.0 kg/m^2), overweight (BMI of 24.0 to 27.9 kg/m^2), and obesity (BMI ≥28.0 kg/m^2). Hyperuricemia was defined as serum UA level ≥416 μmol/L in men and ≥357 μmol/L in women.

Statistical analysis

The Statistical Analysis System (SAS) software (NORTH CAROLINA State University, USA) was used for all the statistical analyses. All the data

Table 3. Comparison of associated factors between different groups

Items	Normal blood pressure (n=2551)	Prehypertension (n=1817)	Hypertension (n=802)	OR (95% CI)	*P*-value#	OR (95% CI)	*P*-value&
Gender							
Male	1123	1298	546	1		1	
Female	1428	519	256	0.314 (0.277, 0.358)	0.000**	1.173 (0.979,1.404)	0.083
Age (years)							
<25	367	175	14	1		1	
25~	1026	567	92	1.159 (0.942, 1.426)	0.163	2.028 (1.127, 3.649)	0.016*
35~	714	502	153	1.474 (1.191, 1.825)	0.000**	3.810 (2.147, 3.616)	0.000**
45~	301	292	210	2.034 (1.598, 2.590)	0.000**	8.990 (5.071, 15.936)	0.000**
55~	86	134	105	3.268 (2.360, 4.523)	0.000**	9.795 (5.368, 17.871)	0.000**
≥60	57	147	228	5.408 (3.793, 7.713)	0.000**	19.388 (10.828, 34.714)	0.000**
BG (mmol/L)							
<6.1	2506	1701	668	1		1	
6.1~	27	64	61	3.492 (2.218, 5.499)	0.000**	2.427 (1.690, 3.486)	0.000**
≥7.0	18	52	73	4.256 (2.481, 7.300)	0.000**	3.575 (2.477, 5.159)	0.000**
TC(mmol/L)							
<1.04	0	0	0				
1.04~	1482	817	285	1		1	
5.18~	787	639	303	1.473 (1.287, 1.685)	0.000**	1.359 (1.122, 1.647)	0.002**
≥6.22	282	361	214	2.322 (1.944, 2.774)	0.000**	1.699 (1.369, 2.110)	0.000**
TG (mmol/L)							
<1.70	2078	1151	404	1		1	
1.70~	237	299	152	2.278 (1.893, 2.741)	0.000**	1.448 (1.156, 1.815)	0.001**
≥2.26	236	367	246	2.808 (2.348, 3.357)	0.000**	1.910 (1.568, 2.326)	0.000**
HDL (mmol/L)							
<0.91	75	106	68	1		1	
0.91~	127	160	74	0.891 (0.612, 1.299)	0.549	0.721 (0.478, 1.087)	0.118
1.04~	1167	955	452	0.579 (0.426, 0.788)	0.000**	0.738 (0.533, 1.021)	0.056
≥1.55	1182	596	208	0.357 (0.261, 0.487)	0.000**	0.544 (0.386, 0.767)	0.000**
LDL (mmol/L)							
<3.37	2142	1325	532	1		1	
3.37~	326	372	192	1.845 (1.566, 2.173)	0.000**	1.285 (1.051, 1.572)	0.014*
≥4.14	83	120	78	2.337 (1.752, 3.118)	0.000**	1.619 (1.197, 2.190)	0.002**
Hyperuricemia							
No	1839	992	372	1		1	
Yes	712	825	430	2.148 (1.893, 2.438)	0.000**	1.390 (1.176, 1.642)	0.000**
BMI (kg/m^2)							
<18.5	224	45	10	1		1	
18.5~	1637	794	219	2.414 (1.734, 3.362)	0.000**	1.241 (0.616, 2.503)	0.545
24.0~	607	738	385	6.052 (4.318, 8.483)	0.000**	2.348 (1.170, 4.709)	0.014*
≥28.0	81	239	186	14.688 (9.772, 22.08)	0.000**	3.502 (1.719, 7.134)	0.000**

FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; HDL, high-density lipoprotein; LDL, low-density lipoprotein; BMI, body mass index; OR, odd ratio; CI, confidence interval. *P<0.05, **P<0.01; #Comparison between prehypertension and normal blood pressure; &Comparison between prehypertension and hypertension.

were submitted into Epi Data software (Epi Data Association, Denmark). The categorical variables were expressed as the frequency and compared by using the chi-square test. The continuous variables were expressed as the mean ± standard deviation (SD) and examined using *t*-test and one-way analysis of variance (ANOVA) test. Unconditional multivariate logistic regression analysis was used to calculate the odds ratio (OR) with 95% confidence intervals (95% CI) for prehypertension. A *P*-value <0.05 was considered statistically significant.

Results

Prevalence of prehypertension and hypertension

A total of 5170 subjects (2967 men and 2203 women) aged 40.21±13.00 years were ulti-

Table 4. Category and description of the independent variables

Variable definition	Variable	Variable assignment
Y	Group	Normal BP=1; Prehypertension=2
X_1	Gender	Male=1; Female=2
X_2	Age (years)	<25=1; 25~ =2; 35~ =3; 45~ =4; 55~ =5; ≥55=6
X_3	FBG (mmol/L)	<6.1=1; 6.1~=2; ≥7.0=3
X_4	TC (mmol/L)	<5.18=1; ≥5.18=2
X_5	TG (mmol/L)	<1.7=1; ≥1.7=2
X_6	HDL-C (mmol/L)	<0.91=1; ≥0.91=2
X_7	LDL-C (mmol/L)	<3.37=1; ≥3.37=2
X_8	Hyperuricemia (μmol/L)	No=0; Yes=1
X_9	BMI (kg/m^2)	<18.5=1; 18.5~ =2; 24.0~ =3; ≥28.0=4

FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Table 5. Risk factors of prehypertension by unconditional binary stepwise logistic regression analysis

Variables	Regression coefficient	Standard error	Wald statistics	*P*-value	OR	95% CI
Constant terms	-2.4893	0.2548	95.4373	0.0001		
Gender (X_1)	-0.8281	0.0735	126.9313	0.0001	0.437	(0.378, 0.505)
Age (X_2)	0.2285	0.0309	54.8009	0.0001	1.257	(1.183, 1.335)
FBG (X_3)	0.4145	0.1289	10.3510	0.0013	1.514	(1.176, 1.949)
TC (X_4)	0.2157	0.0694	9.6735	0.0019	1.241	(1.083, 1.421)
TG (X_5)	0.2121	0.0812	6.8265	0.0090	1.236	(1.054, 1.449)
Hyperuricemia (X_8)	0.2002	0.0745	7.2149	0.0072	1.222	(1.056, 1.414)
BMI (X_9)	0.5756	0.0531	117.5653	0.0001	1.778	(1.602, 1.973)

FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; BMI, body mass index; OR, odds ratio; CI, confidence interval.

mately included in this study. Of those, 1817 (35.15%) subjects had hypertension including 1298 (43.75%) male and 519 (23.56%) female. A total of 2551 subjects had normal blood pressure. The prevalence of prehypertension was 41.23% among those aged 55 years to <60 years, 36.67% among those aged 35 years to <45 years, and 36.36% among those aged 45 years to <55 years. Detailed distribution of blood pressure is shown in **Table 1**.

Characteristics of prehypertensive subjects

As shown in **Table 2**, the age of prehypertensive subjects was 40.71±12.75 years which was significantly different compared to subjects with normal blood pressure (36.11±10.35 years) or hypertensive subjects (52.09±13.63 years). Total cholesterol, TG, LDL-C, FBG, UA levels and BMI were significantly higher and HDL-C levels were significantly lower in prehypertensive subjects than those with normal blood pressure individuals (all *P*-values <0.05).

Factors associated with the prehypertension by univariate analysis

The risk factors associated with prehypertension and hypertension in univariate analysis were presented in **Table 3**. The reference category was normal blood pressure. Gender, age, TC, TG, LDL-C, HDL-C, FBG, hyperuricemia, and BMI were associated with prehypertension in univariate analysis.

Predictors of prehypertension by multivariable unconditional logistic regression analysis

All significant factors in the univariate analysis were considered as independent variables and prehypertension and hypertension were considered as the dependent variables. We further

Table 6. Risk factors of prehypertension by unconditional binary stepwise logistic regression analysis after excluding gender

Variables	Regression coefficient	Standard error	Wald statistics	*P*-value	OR	95% CI
Constant terms	-4.2792	0.2064	429.6801	0.0001		
Age (X_2)	0.2106	0.0301	49.0994	0.0001	1.234	(1.164, 1.309)
FBG (X_3)	0.4290	0.1288	11.0840	0.0009	1.536	(1.193, 1.977)
TC (X_4)	0.3696	0.0789	21.9149	0.0001	1.447	(1.240, 1.689)
TG (X_5)	0.2570	0.0820	9.8234	0.0017	1.293	(1.101, 1.518)
Hyperuricemia (X_8)	0.3894	0.0719	29.3727	0.0001	1.476	(1.282, 1.699)
BMI (X_9)	0.6606	0.0523	159.2748	0.0001	1.936	(1.747, 2.145)

FBG, Fasting blood glucose; TC, total cholesterol; TG, triglycerides; BMI, body mass index; OR, odds ratio; CI, confidence interval.

performed a multivariable unconditional logistic regression analysis (**Table 4** presents the variables assignment). As shown in **Table 5**, male gender, age, FBG, TC, and TG levels, hyperuricemia, and BMI were significantly associated with prehypertension. Female gender was a protective factor against prehypertension (OR: 0.437; 95% CI: 0.378-0.505). After excluding gender from the analysis (**Table 6**), age ≥25 years, BMI ≥28.0 kg/m^2, TC ≥5.18 mmol/L, TG ≥1.7 mmol/L, FBG ≥6.1 mmol/L and hyperglycaemia were the main predictors of prehypertension. For each increased unit of the variables, prehypertension risk increased by 1.234 for age, 1.936 for FBG, 1.447 for TC, 1.293 for TG, 1.536 for hyperuricemia, and 1.476 for BMI.

Discussion

The current study revealed that the overall prevalence of prehypertension was 35.15% in Guangzhou urban adults undergoing health check-up. The prevalence of hypertension was 41.23% of the population already in the age group of 55-60 years. Higher prevalence of prehypertension was reported in male (43.75%) as compared to female (23.56%) subjects. Moreover, age, gender, hyperglycemia, TC, TG, hyperuricemia, and BMI were important risk factors for prehypertension in the population under investigation. For every 10 years increment in age, the risk of prehypertension increased 1.234 times. The risk of prehypertension was about 3 times higher among subjects in the age group of ≥55 years compared to those aged below 25 years.

The prevalence of prehypertension may be influenced by different factors, such as regional climate and lifestyle. The Control Hypertension and Other Risk Factors to Prevent Stroke with Nutrition Education in Urban Area of Northeast China (CHPSNE) study indicated that overall, 40.5% of urban Chinese adults had prehypertension in northeast China [18]. The prevalence of prehypertension was 44.1% in rural adults in Liaoning Province [23] and 38.39% in Mongolian populations of Inner Mongolia [24]. The prevalence of prehypertension was 35.8% in Taiwan [25], which was consistent with our study. Liaoning and Inner Mongolia represents the northern region of China. Higher prevalence of prehypertension in the northern population may be attributed to the lower annual average temperature and greater salt intake. In the eastern region of China, the prevalence of prehypertension was 37.1% in Shandong Province [26] and 45.9% in Zhejiang Province [27]. While in the western region of China, the prevalence of prehypertension was 34.24% (35.6% for male and 31.5% for female) [28].

The prevalence of prehypertension has been noted to be significantly higher in male individuals [16]. No significant difference in the prevalence of prehypertension was observed among different age groups in our study. In contrast with our study, Zhao et al. [29] suggested that the prevalence has decreased along with the age increment. These findings might be explained by the geographical factors.

The incidence of hypertension has increased steadily over the past two decades among Chinese adults, particularly in young adults, women, and rural residents [30]. Individuals with prehypertension have an increased risk of hypertension [31, 32]. An older age at baseline, male sex, Mongolian race, and being over-

weight or obese were the main predictors of progression to hypertension [33]. Presence of various risk factors altogether, contributes to the progression to hypertension from prehypertension.

In this study, individuals with prehypertension had higher TC, TG, LDL-C, FBG, UA levels and BMI than those with normal blood pressure. Overweight/abdominal obesity, waist circumference, hyperglycemia, dyslipidemia, male gender, older age, smoking, alcohol consumption, and hyperuricemia have been considered as risk factors of prehypertension [34]. These factors are also the key risk factors of carotid atherosclerosis and CVD or cerebrovascular diseases [35]. According to the univariate analysis, gender, age, TC, TG, LDL-C, HDL-C, FBG, hyperuricemia, and BMI were the risk factors for prehypertension. Multiple unconditional logistic regression analysis confirmed that age, male, TC, TG, hyperuricemia, diabetes and BMI were significantly associated with both prehypertension, while the female was a protective factor. High BMI was the strongest determinant predictor of prehypertension. This finding suggests that being overweight or obese has a statistically significant association with the development of prehypertension. Therefore, to prevent prehypertension, weight loss may be necessary for all individuals with high BMI.

Uric acid has not been listed as risk factor for CVD in hypertension guidelines 2010 [36]. Yet some studies found that a high serum UA level was an independent risk factor of prehypertension and the risk increased with the increment of serum UA level [37]. Our study also demonstrated that high UA level was significantly associated with prehypertension. However, the mechanisms underlying increased risk of prehypertension in individuals with hyperuricemia need to be investigated further. High density lipoprotein cholesterol is a strong independent predictor of cardiovascular events. Our study found that HDL-C was a risk factor for prehypertension in the univariate analysis but not in multiple logistic regression analysis. These negative findings might be explained by the HDL-C level not being fully representative of the HDL function [38].

The prevalence of prehypertension in Guangzhou urban adults was not lower than in other areas of China, and higher prevalence rate was found in male than female subjects. Although the JNC-8 guidelines do not specifically focus on the concept, prevention and treatment of prehypertension, we feel that the identification and management of prehypertension remains an important method of preventing the development of overt hypertension in China. Multiple risk factors contribute to the onset and development of prehypertension, including age, gender, hypercholesterolemia, hyperlipidemia, hyperuricemia, and higher BMI. Most of these risk factors of prehypertension are closely associated with lifestyle factors. Close attention should be paid to the identification of prehypertension even in the healthy population by doctors. Active management of blood pressure, timely and effective treatment of dyslipidemia, hyperuricemia or hyperglycaemia, lifestyle modifications, and increasing physical activity [39] may help to slow down the progression of prehypertension. Use of appropriate anti-hypertensive medication may be necessary in some prehypertensive individuals [40]. However, evidences for the treatment of prehypertension are still lacking [41], while lifestyle modifications remains the most important measure.

The present study has several methodological limitations. First, determination of blood pressure was based on one day measurement, which may result in misleading classifications of prehypertension. Second, the study was conducted in Guangzhou where most of the subjects were urban inhabitants, so the prevalence of prehypertension in the rural areas of southern China remains unrepresented. Moreover, this study included subjects who presented themselves for a health check-up, hence a selection bias cannot be excluded as individuals with low incomes were less likely to have participated in the health check-up. Third, we could not establish the cause-effect relationships because of the cross-sectional nature of this study. Finally, data regarding lifestyle factors including physical activity and dietary habits, especially salt intake, were not collected; such factors may influence the blood pressure level.

Conclusions

Prehypertension prevalence was higher among urban health check-up population in Guangzhou, China. The main determinants of prehy-

pertension in our population were BMI, hyperglycemia, TC level, and hyperuricemia. As all of these determinants are modifiable, early identification and management of prehypertension risk factors may help to slow down the progression of rising blood pressure. Most importantly, as prehypertension is usually asymptomatic and easily missed, increasing self-awareness of prehypertension is also a key prevention strategy.

Acknowledgements

This work was supported by Science and technology of Guangdong Province (2009B030-801314) and Medical Research Foundation of Guangdong Province (A2012306).

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Tianhui You, School of Nursing, Guangdong Pharmaceutical University, No. 68 Nanhua Street, Chigang Road, Haizhu District, Guangzhou 510310, China. Tel: 86-13802-991688; Fax: 020-34055935; E-mail: youth888cn@aliyun.com; Dr. Yan Hu, Department of Medical Diagnostic Centre, The Sixth Affiliated Hospital, Sun Yat-sen University, No. 17 Shougouling Road, Tianhe District, Guangzhou 510310, China. Tel: 86-13533044101; Fax: 020-38136901; E-mail: y.hu@zsyth.com

References

[1] Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr and Roccella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA 2003; 289: 2560-2572.

[2] Wang S, Wu H, Zhang Q, Xu J and Fan Y. Impact of baseline prehypertension on cardiovascular events and all-cause mortality in the general population: a meta-analysis of prospective cohort studies. Int J Cardiol 2013; 168: 4857-4860.

[3] Huang Y, Wang S, Cai X, Mai W, Hu Y, Tang H and Xu D. Prehypertension and incidence of cardiovascular disease: a meta-analysis. BMC Med 2013; 11: 177.

[4] Zhao D, Li CF, Wang W, Liu J, Zeng ZC, Wang WH, Sun JY and Wu ZS. The 10-year cardiovascular risk in a Chinese cohort aged 35-64 years with high normal blood pressure. Chin J Geriatr Heart Brain Vessel Dis 2006; 8: 730-733.

[5] Navarro-Gonzalez JF, Mora C, Muros M, Garcia J, Donate J and Cazana V. Relationship between inflammation and microalbuminuria in prehypertension. J Hum Hypertens 2013; 27: 119-125.

[6] Asmathulla S, Rajagovindan D, Sathyapriya V and Pai B. Prevalence of prehypertension and its relationship to cardiovascular disease risk factors in Puducherry. Indian J Physiol Pharmacol 2011; 55: 343-350.

[7] Celik T, Yuksel UC, Fici F, Celik M, Yaman H, Kilic S, Iyisoy A, Dell'oro R, Grassi G, Yokusoglu M and Mancia G. Vascular inflammation and aortic stiffness relate to early left ventricular diastolic dysfunction in prehypertension. Blood Press 2013; 22: 94-100.

[8] Pletcher MJ, Bibbins-Domingo K, Lewis CE, Wei GS, Sidney S, Carr JJ, Vittinghoff E, Mcculloch CE and Hulley SB. Prehypertension during young adulthood and coronary calcium later in life. Ann Intern Med 2008; 149: 91-99.

[9] King DE, Everett CJ, Mainous AG 3rd and Liszka HA. Long-term prognostic value of resting heart rate in subjects with prehypertension. Am J Hypertens 2006; 19: 796-800.

[10] Markus MR, Stritzke J, Lieb W, Mayer B, Luchner A, Doring A, Keil U, Hense HW and Schunkert H. Implications of persistent prehypertension for ageing-related changes in left ventricular geometry and function: the MONICA/KORA Augsburg study. J Hypertens 2008; 26: 2040-2049.

[11] Bajpai JK, A P S, A K A, A K D, Garg B, Goel A. Impact of prehypertension on left ventricular structure, function and geometry. J Clin Diagn Res 2014; 8: BC07-10.

[12] Gupta AK, Mcglone M, Greenway FL and Johnson WD. Prehypertension in disease-free adults: a marker for an adverse cardiometabolic risk profile. Hypertens Res 2010; 33: 905-910.

[13] Choi KM, Park HS, Han JH, Lee JS, Lee J, Ryu OH, Lee KW, Cho KH, Yoon D, Baik SH, Choi DS and Kim SM. Prevalence of prehypertension and hypertension in a Korean population: Korean National Health and Nutrition Survey 2001. J Hypertens 2006; 24: 1515-1521.

[14] Ishikawa Y, Ishikawa J, Ishikawa S, Kayaba K, Nakamura Y, Shimada K, Kajii E, Pickering TG and Kario K. Prevalence and determinants of prehypertension in a Japanese general population: the Jichi Medical School Cohort Study. Hypertens Res 2008; 31: 1323-1330.

[15] Grotto I, Grossman E, Huerta M and Sharabi Y. Prevalence of prehypertension and associated cardiovascular risk profiles among young

Israeli adults. Hypertension 2006; 48: 254-259.
[16] Guo X, Zheng L, Zhang X, Zou L, Li J, Sun Z, Hu J and Sun Y. The prevalence and heterogeneity of prehypertension: a meta-analysis and meta-regression of published literature worldwide. Cardiovasc J Afr 2012; 23: 44-50.
[17] Yu D, Huang J, Hu D, Chen J, Cao J, Li J and Gu D. Prevalence and risk factors of prehypertension among Chinese adults. J Cardiovasc Pharmacol 2008; 52: 363-368.
[18] Meng XJ, Dong GH, Wang D, Liu MM, Liu YQ, Zhao Y, Deng WW, Tian S, Meng X and Zhang HY. Epidemiology of prehypertension and associated risk factors in urban adults from 33 communities in China--the CHPSNE study. Circ J 2012; 76: 900-906.
[19] Isezuo SA, Sabir AA, Ohwovorilole AE and Fasanmade OA. Prevalence, associated factors and relationship between prehypertension and hypertension: a study of two ethnic African populations in Northern Nigeria. J Hum Hypertens 2011; 25: 224-230.
[20] Hosch W, Heye T, Schulz F, Lehrke S, Schlieter M, Giannitsis E, Kauczor HU, Katus HA and Korosoglou G. Image quality and radiation dose in 256-slice cardiac computed tomography: comparison of prospective versus retrospective image acquisition protocols. Eur J Radiol 2011; 80: 127-135.
[21] Genuth S, Alberti KG, Bennett P, Buse J, Defronzo R, Kahn R, Kitzmiller J, Knowler WC, Lebovitz H, Lernmark A, Nathan D, Palmer J, Rizza R, Saudek C, Shaw J, Steffes M, Stern M, Tuomilehto J and Zimmet P. Follow-up report on the diagnosis of diabetes mellitus. Diabetes Care 2003; 26: 3160-3167.
[22] The formulation of China adult dyslipidemia prevention guide joint committee. China adult dyslipidemia Prevention Guide. Chin J Cardiol 2007; 35: 390-413.
[23] Sun Z, Zheng L, Wei Y, Li J, Zhang X, Liu S, Xu C, Zhao F, Dong G, Hu D and Sun Y. The prevalence of prehypertension and hypertension among rural adults in Liaoning province of China. Clin Cardiol 2007; 30: 183-187.
[24] Li H, Xu T, Tong W, Liu Y, Zhao L and Zhang Y. Comparison of cardiovascular risk factors between prehypertension and hypertension in a Mongolian population, Inner Mongolia, China. Circ J 2008; 72: 1666-1673.
[25] Liu LK, Peng LN, Chen LK, Hwang SJ and Chiou ST. Prehypertension among middle-aged and elderly people in Taiwan: a five-year follow-up. J Atheroscler Thromb 2010; 17: 189-194.
[26] Chu J, Wang L, Xu A, Li Y, Wang H, Guo X, Lu Z, Zhang X, Zhang J, Ma J and Bi Z. Analysis on prevalence states and associated factors of hypertension and prehypertension among adults in Shandong province. Zhonghua Yu Fang Yi Xue Za Zhi 2014; 48: 12-17.
[27] Yu W, Yang L, Yan J, Zhang YF, Gao J, Fang SY, Xu XL, Luo JY and Tang XH. Study on the prevalence of prehypertension among residents living in the communities in Zhejiang. Zhonghua Liu Xing Bing Xue Za Zhi 2013; 34: 1059-1062.
[28] Zhang XL, Ma YT, Yang YN, Liu F, Xie X, Wang ZX, Ma X, Fu ZY, Li XM and Huang Y. Survey on the situation of normal blood pressure and prevalence and risk factors of prehypertension in Han, Uygur and Hazakh population of Xinjiang Uygur autonomous region. Zhonghua Xin Xue Guan Bing Za Zhi 2011; 39: 538-542.
[29] Zhao N, Zhao JB, Zhao YJ, Li JN, Liu XQ, Fu SY and Dong LX. Prevalence and risk factors associated with prehypertension in community residents of Haerbin. Chinese Journal of Disease Control Prevention 2012; 16: 280-284.
[30] Liang Y, Liu R, Du S and Qiu C. Trends in incidence of hypertension in Chinese adults, 1991-2009: the China Health and Nutrition Survey. Int J Cardiol 2014; 175: 96-101.
[31] Ferguson TS, Younger N, Tulloch-Reid MK, Lawrence-Wright MB, Forrester TE, Cooper RS, Van Den Broeck J and Wilks RJ. Progression from prehypertension to hypertension in a Jamaican cohort: incident hypertension and its predictors. West Indian Med J 2010; 59: 486-493.
[32] Selassie A, Wagner CS, Laken ML, Ferguson ML, Ferdinand KC and Egan BM. Progression is accelerated from prehypertension to hypertension in blacks. Hypertension 2011; 58: 579-587.
[33] Guo X, Zou L, Zhang X, Li J, Zheng L, Sun Z, Hu J, Wong ND and Sun Y. Prehypertension: a meta-analysis of the epidemiology, risk factors, and predictors of progression. Tex Heart Inst J 2011; 38: 643-652.
[34] Chockalingam A, Ganesan N, Venkatesan S, Gnanavelu G, Subramaniam T, Jaganathan V, Elangovan S, Alagesan R, Dorairajan S, Subramaniam A, Rafeeq K, Elangovan C and Rajendran V. Patterns and predictors of prehypertension among "healthy" urban adults in India. Angiology 2005; 56: 557-563.
[35] Riccioni G, De Santis A, Cerasa V, Menna V, Di Ilio C, Schiavone C, Ballone E and D'orazio N. Atherosclerotic plaque formation and risk factors. Int J Immunopathol Pharmacol 2003; 16: 25-31.
[36] Committee of Guidelines for prevention and treatment of hypertension of China. Guidelines for prevention and treatment of hypertension Chinese (2010 Revision). Chinese Journal of Hypertension 2011; 19: 701-743.
[37] Chen T, Li W, Hu B, Wang Y, Chen XR, Jia X and Sun Y. Serum uric acid and prehypertension. Chin J Hypertension 2008; 16: 688-691.

[38] Zhai ZL, Ma WH and Shen W. Research progress of correlation between high-density lipoprotein and atherosclerosis. Chinese General Practice 2013; 16: 4242-4245.
[39] Beck DT, Martin JS, Casey DP and Braith RW. Exercise training improves endothelial function in resistance arteries of young prehypertensives. J Hum Hypertens 2014; 28: 303-309.
[40] Luders S, Schrader J, Berger J, Unger T, Zidek W, Bohm M, Middeke M, Motz W, Lubcke C, Gansz A, Brokamp L, Schmieder RE, Trenkwalder P, Haller H and Dominiak P. The PHARAO study: prevention of hypertension with the angiotensin-converting enzyme inhibitor ramipril in patients with high-normal blood pressure: a prospective, randomized, controlled prevention trial of the German Hypertension League. J Hypertens 2008; 26: 1487-1496.
[41] Reed C, Kwatra SG, Brown K and Kwatra MM. Revisiting the prehypertension debate: increasing evidence for treatment yet randomized clinical trials are lacking. Blood Press 2013; 22: 340-343.