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Prevalence and Risk Factors Associated with Prehypertension among Young and Middle-Aged Health Check-Up Population in Guangzhou

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ABSTRACT

Objective: To provide basic information and theories for prehypertension early intervention, a systematic analysis of the epidemic status and risk factors among young and middle-aged was carried out here. **Methods:** This study relied on the data bank of a health check-up population of a class a tertiary general hospital in Guangdong province in 2015. Total 9540 young and middle-aged adults were enrolled, and 733 people were included to find out the effect with lifestyle in these crowd. Principal Components Analysis (PCA) of Factor (FA) was used to identify dietary patterns. The logistic regression model was used to find the risk factors of prehypertension. **Results:** Among 9540 young and middle-aged cases, the incidence of prehypertension was 36.6%. Moreover, the average age, proportion of male gender, overweight, FBG (fasting blood glucose), dyslipidemia, and hyperuricemia were significantly higher in the prehypertension group than in the optimal BP group. Multivariate logistic regression analysis indicated that age, total cholesterol, triglycerides, uric acid, body mass index and HR (heart rate) were risk factors, and female was a protective factor for prehypertension. Among 733 cases, the incidence of prehypertension was 35.1%. The proportion of smoking, drinking, physical workers, moderate and severe physical activity, and the intake of meat, dietary energy were significantly higher in the prehypertension group than in the optimal BP group. Dietary patterns included “meat model”, “spice model”, “main vegeTables model” and “high protein model”. Multivariate logistic regression analysis indicated that age, drinking were risk factors for prehypertension, while dietary milk intake, dietary magnesium intake were protective factors. Conclusions: Prehypertension is highly prevalent in Guangzhou. However, education about effective lifestyle modifications as an alcohol limit, increasing the intake of dairy products, and magnesium may intervene in the development of prehypertension. But how to develop targeted interventions for such groups need to be further explored. The present study would lay the theoretical foundation and basic data for the next step.

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1. Introduction

The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) proposed a new blood pressure (BP) category, including120~139mmHg systolic BP (SBP) or 80~89mmHg diastolic BP (DBP), designated as 'prehypertension'(PHTN) in 2003 [1]. This proposal was based, at least in part, on a meta-analysis of 61 prospective studies, which indicated that mortality from ischemic heart disease and stroke in individuals aged 40 to 89 years increases in a log-linear relationship with BP, from levels as low as 115mmHg systolic and 75mmHg diastolic[2]. PHTN is not only a caveat to developing overt HTN, but it is a major health risk on its own. Prehypertensives were repeatedly reported to be subjected to approximately double the risk of cardiovascular disease (CVD) independent of progression to HTN in addition to other cardiovascular complications. The prevalence of HTN is up to 30~50% worldwide, as well as in many districts of China [3-5]. It is known that in China the prevalence of hypertension is significantly higher in the northern area than in the southern area because of the colder climate and high sodium intake[6]. Such regional factors may also affect the prevalence of HTN. However, the prevalence of HTN in Guangdong Province, southern China has been rarely reported.

Recent researches showed that lifestyle changes had an important role in lowering blood pressure and preventing and treating HTN. Our previous analyses also showed that the influence factors of PHTN, including overweight, dyslipidemia and impaired glucose metabolism, which were related to lifestyle[7]. In other words, identifying differences in healthy lifestyle factors between those with normal BP and those with PHTN could help to target intervention efforts aimed at preventing further increases in BP. Considering that prehypertensive individuals are prone to progress into frank hypertension, and most of them present with clustering of other cardiovascular risk factors[8-10]. Healthcare professionals should recommend lifestyle changes early to subjects with PHTN. However, since the incidence of CVD increased across the whole range of PHTN, physicians should be aware of which subgroup of the population are at high risk for CVD and of steps that should be taken to treat modifiable risk factors in these people. At present, the study of PHTN in Guangzhou is common in community residents, but the epidemiological data of the young and middle-aged people is not comprehensive enough. Given the above situations, we conducted a cross-sectional study of a health check-up population of a class a tertiary general hospital in Guangdong province in 2015. In this study, the influence factors and status of PHTN in young and middle-aged check-up population were analyzed. The influence factors of HTN were explored to provide a theoretical basis for the further development of the prevention and treatment of PHTN.

2. Methods

2.1 Study Participants

We performed a cross-sectional study in Guangzhou, using health check-up population information. The information on health check-up population was collected in the Health Management Center of First Affiliated Hospital of Guangdong Pharmaceutical University. The center provided data for participants who enrolled in their health check-up programs conducted between January and December 2015.

Total 9540 young and middle-aged (18~44, young-aged; 45~59, middle-aged) participants, with complete data for the following characteristics, were included in this study: age, gender, smoking/drinking habits, height, weight, BP, fasting plasma glucose (FPG), total cholesterol (TC), triglycerides (TG), low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), blood urea nitrogen and serum uric acid (UA).

Using the simple random sampling method to estimate the minimum sample size: $N=Z_{\alpha}^{2}PQ/\delta^{2}$. N: sample number; P: estimated incidence of PHTN; Q: 1-P; $\alpha=0.05$, $Z_{\alpha}=1.96$; δ: Permissible error, $\delta=0.1P$. Combined with the results of previous studies and literature data, the sample size of the sample is estimated to be P equal to 35.0%, then N=713. The survey was a total of 874 questionnaires recovered, a waste of 141 copies, and valid questionnaires of 733, which were collected in a sample of 9540 young and middle-aged participants. The 733 participants were selected to analyze their demographic data, health status, and dietary status through questionnaires.

2.2 BP Measurement

Participants were asked to avoid caffeinated beverages, smoking, and exercise for at least 30min, and BP measurements were taken after the participants were allowed to rest quietly for at least 5min. Three BP measurements (2min between each) were obtained for each individual by trained nurses, who were part of the Health Management Center, with a mercury sphygmomanometer. The first and fifth Korotkoff sounds were recorded as SBP and DBP, respectively. During the measurements, the participants were seated with the arm supported at the level of the heart. The mean of three BP measurements was calculated and recorded.

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2.3 Grouping Criteria

The correlative risk factors estimated in our study included the following: (1) BP classification was based on the recommendations from the JNC 7 [1]. Optimal BP was defined as SBP <120mmHg and DBP <80mmHg. HTN was defined as SBP ≥140mmHg and/or DBP ≥90mmHg, or previously diagnosed as HTN and currently undergoing antihypertensive treatment. PHTN was defined if individuals were not undergoing antihypertensive treatment and had an SBP of 120–139mmHg and/or DBP of 80–89mmHg. Diabetes was diagnosed according to the criteria of the World Health Organization (WHO), 1999 [11], and American Diabetes Association (ADA), 2003 [12]. The criteria included a fasting plasma glucose (FPG) ≥7.0mmol/L (126 mg/dL) and/or being on medical treatment for diabetes with insulin or other antihyperglycemic agents. Impaired fasting glucose was defined as an FPG level between 6.1 and 7.0mmol/L. According to the criteria of China adult dyslipidemia prevention guidelines [13], 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. hyperuricemia was defined as UA ≥416μmol/L in men and 357μmol/L in women. (3) 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) [14].

2.4 Questionnaire Survey

The baseline survey was completed by in-person interview using a structured questionnaire designed to collect information on demographic characteristics, health status, and dietary status.

2.5 Definition of Correlative Risk Factors

Smokers were classified as those who reported having smoked at least 1 cigarette every day and still smoked more than 6 months. Passive smokers were defined as those who inhaled the smoke exhaled by the smoker for more than 15 minutes at least one day a week. Alcohol use was defined as one drink per day and still drank more than 6 months, and each alcohol intake was at least 30g. The calculation of alcohol intake: alcohol consumption * alcohol content * 80%= intake of alcohol. According to the mental and physical standards-based workers were divided into mental and physical-based workers. Work intensity was divided into easy, general, tension, and fatigue. Physical activity was defined as the daily physical activity and was divided into mild, moderate and severe.

2.6 Assessment of Dietary Intake

Dietary information was collected via an in-person interview using a validated food frequency questionnaire (FFQ) [15]. The FFQ included 36 food items. For each food item or food group, participants were asked how frequently (daily, weekly, monthly, yearly, or never) they consumed the food or food group, followed by a question on the amount of consumption in Liang (1 Liang=50g) per unit of time over the past 12 months. For seasonal food consumption (mainly fruits and vegeTables), an additional question about months of food consumption per year was asked. Total intake of nutrients, minerals, and vitamin was calculated using the China Food Composition Table and Chinese Dietary Reference Intakes in 2013.

2.7 Ethics Statement

This study has been reviewed, discussed, and approved by the Ethics Committee of the Guangdong Pharmaceutical University. All subjects provided written informed consent.

2.8 Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Science software release V.16.0 (SPSS Inc, Chicago, Illinois, USA). Continuous variables are presented as mean (SD) or median (IQR) as appropriate. Categorical variables are expressed as percentages. After testing for normality using the Kolmogorov-Smirnov test, continuous variables were compared using a t-test or the Mann-Whitney U test, and categorical variables were compared by χ^2 test or Fisher's exact test as appropriate. Using the FACTOR procedure in SAS V9.2 (SAS Institute, Cary, NC, USA), principal component analysis (PCA) was performed to identify the dietary patterns of the subjects. Multiple logistic regression analysis was performed to evaluate predictive factors for PHTN. Individuals with optimal BP were used as the reference group. A value of $p<0.05$ was considered statistically significant.

3. Results

3.1 Prevalence of PHTN

9540 cases (5750 men, 3790 women) were eventually analyzed. The proportions of optimal BP, PHTN, and HTN were 43.9% (4188 cases), 36.6% (3491 cases), and 19.5% (1861 cases), respectively. The prevalence of PHTN was higher in men than in women (40.5% vs30.7%, $p<0.001$). There was an increasing trend of PHTN prevalence associated with age in women, while the prevalence of PHTN

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in men was sTable with age (Table 1).

Table 1. Prevalence of PHTN and HTN by gender and age group

Age (Years)	n	Optimal BP(%)	PHTN (%)	HTN (%)
Male				
18~	272	45.6	45.2	9.2
25~	988	48.0	43.5	8.5
35~	1536	38.6	40.2	21.2
45~	2257	28.7	39.5	31.9
≥55	697	22.1	38.0	39.9
Total	5750	34.6	40.5	24.9
Female				
18~	145	79.3	20.0	0.7
25~	710	78.0	19.6	2.4
35~	1238	62.9	28.4	8.6
45~	1524	45.9	36.9	17.2
≥55	173	27.7	48.0	24.3
Total	3790	57.9	30.7	11.4
All				
18~	417	57.3	36.5	6.2
25~	1698	60.5	33.5	5.9
35~	2774	49.5	34.9	15.6
45~	3781	35.6	38.4	25.9
≥55	870	23.2	40.0	36.8
Total	9540	43.9	36.6	19.5

3.2 Risk Factors Clustering in Different Blood Pressure Statuses

The average age, proportion of male gender, IFG, dyslipidemia, hyperuricemia, overweight, obesity, levels of FPG, TC, TG, BMI, and UA were significantly higher in the PHTN and HTN groups than in the optimal BP group (all p<0.05). The proportions of obesity and level of LDL-C were also higher in the PHTN group than in the optimal BP group (all p<0.05); however, the differences were not significant in the PHTN group compared with that in the HTN group (Table 2).

Table 2. Cardiovascular Risk factors clustering in different blood pressure statuses

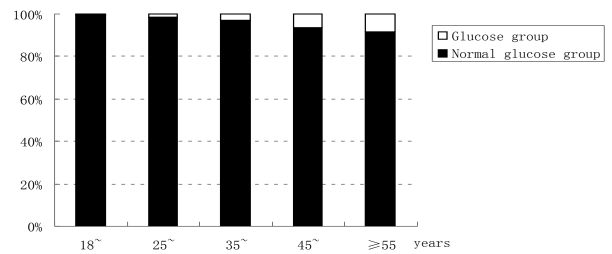
Items	Optimal BP（n=4188）	PHTN（n=3491）	HTN（n=1861）	Statistic（*F*-value）	*P*-value
Age (Years)	40.08±9.58	43.18±9.58*	47.36±7.65 #	409.648	<0.001
Male (n(%))	1992 (47.6)	2326 (66.6) *	1432 (76.9) #	557.472	<0.001
FPG (mmol /L)	4.64±0.71	4.83±0.96*	5.18±1.49 #	194.870	<0.001
IFG (n(%))	85（2.0）	149（4.3）	211（11.3）#	252.991	<0.001
TC (mmol /L)	4.92±0.91	5.18±0.95*	5.34±0.97 #	153.376	<0.001
TG (mmol /L)	1.38±1.11	1.82±1.44*	2.37±1.89 #	322.952	<0.001
HDLC (mmol /L)	1.47±0.26	1.42±0.25*	1.38±0.23 #	99.371	<0.001
LDLC (mmol /L)	2.83±0.75	2.95±0.81*	2.95±0.85	28.305	<0.001
dyslipidemia (n(%))	1360（32.5）	1740（49.8）*	1240(66.5）#	367.897	<0.001
UA（μmol/L）	331.37±86.85	368.09±92.60*	400.74±94.71 #	410.032	<0.001
Hyperuicaemia (n(%))	859(20.5）	1111（31.8）*	835（44.9）#	383.978	<0.001
BMI（kg/m^2）	22.21±2.98	23.98±3.19*	25.42±3.40 #	742.104	<0.001
Overweight (n(%))	921(22.0）	1293（37.0）*	853（45.8）#	234.578	<0.001
Obesity (n(%))	125（3.0）	356（10.2）*	368（19.8）#	436.237	<0.001
HR（times/min）	71.04±9.57	75.88±14.52	75.86±11.13	2.883	0.056

* versus optimal blood pressure p<0.05.

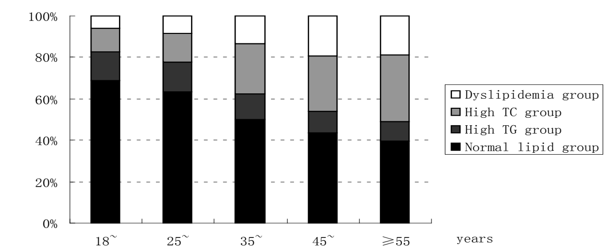
\# versus PHTN p<0.05.

3.3 Differences in Glucose and Lipid Metabolism, BMI, and Uric Acid by Age among Those with PHTN

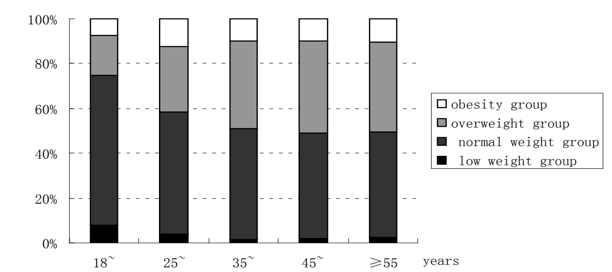
The proportion of IFG, Dyslipidemia, and overweight/obesity was increasing, while the proportion of hyperuricemia was decreasing with the increase of age among 3491 PHTN cases (all p<0.05, Figure 1).



(A)



(B)



(C)

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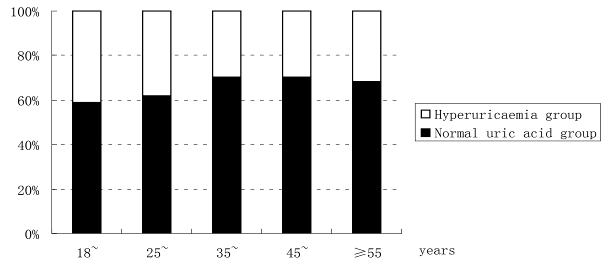

(D)

Figure 1. Differences in glucose (A) and lipid (B) metabolism, BMI (C), uric acid (D) by age among those with PHTN

3.4 Risk Factors Associated with PHTN

Multivariate logistic regression analysis showed that high BMI (overweight/obesity) was the most important risk factor for PHTN. Female gender, was a protective factor against PHTN, while age, total cholesterol , triglyceride, hyperuricemia, and heart rate were also significantly associated with PHTN.

Table 3. Univariate Analysis for Risk factors of PHTN

Items	χ^2-value	*P*-value	*OR*(95%*CI*)
Gender			
Male			1.000
Female	281.150	<0.001	0.454（0.414, 0.499）
Age（years）			
18~			1.000
≥45	165.091	<0.001	1.816（1.657, 1.989）
FBG（mmol/L）			
<6.1			1.000
≥6.1	32.292	<0.001	2.152（1.642, 2.820）
TC（mmol/L）	124.167	<0.001	
<5.18			1.000
5.18~	84.042	<0.001	1.593（1.441, 1.760）
≥6.22	69.135	<0.001	1.913（1.639, 2.233）
TG（mmol/L）	257.718	<0.001	
<1.70			1.000
1.70~	63.962	<0.001	1.749（1.524, 2.008）
≥2.26	228.834	<0.001	2.605（2.295, 2.957）
HDLC（mmol/L）			
≥0.91			1.000
<0.91	1.250	0.264	0.730（0.349, 1.525）
LDLC（mmol/L）	53.343	<0.001	
<3.37			1.000
3.37~	37.854	<0.001	1.443（1.283, 1.622）
≥4.14	21.725	<0.001	1.572（1.298, 1.903）
Hyperuicaemia			
Yes			1.000
No	127.775	<0.001	1.809（1.631, 2.006）
BMI（kg/m2）	498.696	<0.001	
18.5~			1.000
<18.5	48.634	<0.001	0.435（0.343, 0.553）
24.0~	240.526	<0.001	2.251（2.029, 2.496）
≥28.0	226.595	<0.001	4.566（3.692, 5.646）
HR	74.748	<0.001	
＜ 70			1.000
70 ～ 80	10.114	0.001	1.177（1.064, 1.301）
≥80	78.188	<0.001	1.765（1.555, 2.004）

Table 4. Multicariate logistic regression analysis for Risk factors of PHTN

Risk factors	*P*-value	*OR*	95%*CI*
Gender (men vs women)	0.0001	0.590	（0.530, 0.656）
Age (young vs middle aged)	0.0001	1.586	（1.430, 1.758）
TC	0.0034	1.201	（1.062, 1.358）
TG	0.0006	1.141	（1.058, 1.230）
Hyperuicaemia (yes vs no)	0.0002	1.259	（1.115, 1.421）
BMI	0.0001	1.844	（1.701, 2.000）
HR	0.0001	1.393	（1.302, 1.491）

3.5 Survey of Demographic Data among 733 Young and Middle-Aged Health Check-Up Cases

There were significant differences in the educational rate, marital status, and family income between different blood pressure group 733 young and middle-aged health check-up cases (all p<0.05, Table 5).

Table 5. The demographic data among 733 young and middle-aged health check-up cases

Characteristic	n	Optimal BP	PHTN	HTN	χ^2-value	*P*-value
Gender					13.974	0.001
Male	454（61.9）	170（49.9）	180（70.0）	104（77.0）		
Female	279（38.1）	171（50.1）	77（30.0）	31（23.0）		
Age group (years)					48.598	<0.001
18~	372（49.4）	210（61.6）	115（44.7）	37（27.4）		
≥45	361（50.6）	131（38.4）	142（55.3）	98（72.6）		

Account Types					2.929	0.231
Rural household	72（9.8）	33(9.8）	21（8.3）	19(14.3）		
Towns Account	661(90.2）	308(90.2）	236(91.7）	116（85.7）		
Educational level					15.503	0.004
Less than high school	72（9.8）	29（8.4）	24（9.4）	22(16.3）		
High school degree or equivalent	458(62.5）	201(59.1）	167(65.0）	92(68.4）		
More than high school	203(27.7）	111(32.5）	66（25.6）	21(15.3）		
marital status					25.697	<0.001
single	185(25.2）	104(30.4）	65（25.2）	8（6.1）		
Married / cohabiting	542(74.0）	234(68.8）	189(73.7）	127（93.9）		
Divorced / Separated	6（0.8）	3（0.8）	3（1.1）	0（0.0）		
Occupation					9.912	0.052
Institutions	532(72.6）	233(68.3）	194(75.6）	109（80.6）		
enterprise	191(26.1）	100(29.5）	61（23.7）	26(19.4）		
other	10（1.4）	8（2.2）	2（0.8）	0（0.0）		
Family income (yuan)					18.604	0.046
<2000	3（0.4）	2（0.5）	1（0.4）	0（0.0）		
2000~	249(34.0）	102(29.8）	93（35.0）	63(46.9）		
4000~	416(56.8）	213(62.6）	141(53.0）	61(44.9）		
>6000	65（8.8）	24（7.1）	31（11.7）	11（8.2）		
Total	733（100.0）	341（100.0）	257(100.0）	135（100.0）		

3.6 Survey of Health and Physical Activity among 733 Young and Middle-Aged Health Check-Up Cases

There were significant differences in the smoking rate, passive smoking, drinking, the nature of work, the degree of physical strength between different blood pressure groups among 733 young and middle-aged health check-up cases (all p<0.05, Table 6).

Table 6. The health and physical activity among 733 young and middle-aged health check-up cases

Characteristic	n	Optimal BP	PHTN	HTN	χ^2-value	P-value
Smoking status					9.983	0.007
no	443（60.4）	225（65.9）	145（56.4）	69（51.0）		
yes	290（39.6）	116（34.1）	112（43.6）	66（49.0）		
Passive smoking					21.319	0.002
no	118（16.1）	71（20.9）	32（12.4）	11（8.2）		
Less than one week	360（49.1）	166（48.8）	131（51.1）	61（44.9）		
One week to one month	54(7.4）	25（7.3）	20（7.9）	8（6.1）		
More than a month	201（27.4）	79（23.0）	74（28.6）	55（40.8）		
Alcohol use					23.914	<0.001
no	432（58.9）	232（67.8）	127（49.6）	69（51.0）		
yes	301（41.1）	110（32.2）	130（50.4）	66（49.0）		
Physical activity status					7.514	0.276
Inactive	214（29.2）	97（28.5）	70（27.4）	50（36.7）		
Not regularly active	363（49.5）	165（48.5）	130（50.4）	69（51.0）		
Sometimes active	134（18.3）	69（20.1）	47（18.4）	15（11.2）		
Regularly active	22(3.0）	10（3.0）	10（3.8）	1（1.0）		
Nature of the work					25.917	<0.001
Brain-based	278（37.9）	161（47.2）	84（32.7）	33（24.4）		
Mainly physical	455（62.1）	180（52.8）	173（67.3）	102(75.6）		
Intensity of work					6.591	0.360
Relaxed	11(1.5）	6（1.9）	2（0.8）	3（2.0）		
general	480（65.5）	212（62.3）	176（68.4）	94（69.4）		
tension	191（26.1）	99（28.7）	64（24.8）	26（19.4）		
Toil	51(7.0）	24（7.0）	15（6.0）	112(9.2）		
Physical extent					24.916	<0.001
light	94（12.8）	62（18.2）	25（9.4）	2（2.0）		
Moderate	502（68.5）	212（62.1）	188（73.3）	108(79.6）		
weight	137（18.7）	67（19.8）	44（17.3）	25（18.4）		
Sit time (hours)					6.143	0.407
<2	93(12.7）	37（10.8）	40（15.4）	17（12.2）		
2~	174（23.7）	88（25.7）	60（23.3）	23（17.3）		
4~	131（17.9）	61（17.9）	42（16.5）	29（21.4）		
>6	335（45.7）	155（45.5）	115（44.7）	66（49.0）		
Total	733（100.0）	341（100.0）	257（100.0）	135（100.0）		

3.7 Survey of Nutrients, Minerals and Vitamin Intake among 733 Young and Middle-Aged Health Check-Up Cases

Compared to the recommended value by Chinese residents balanced diet pagoda, the intake of meat, grains, and soy among 257 young and middle-aged PHTN cases were lightly more than the recommended value. The intake of dietary energy, dietary protein, fat, and carbohydrates was higher than the recommended values. Dietary phosphorus, potassium, sodium, zinc, copper, and manganese exceeded the recommended values. Vitamin A intake was lower than the dietary reference intakes (Table 7).

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Table 7. The Intake of Nutrients, Minerals and Vitamin among 733 Young and Middle-Aged Health Check-Up Cases

Dietary components	Optimal BP（n=341）	PHTN（n=257）	HTN（n=135）	*P*-value	RNIs/AIs
Nutrients					
Energy (kcal)	2438.7±773.8	2620.7±864.9*	2850.9±871.4	<0.001	2200
Carbohydrate (g)	352.1±150.5	382.6±163.0*	414.1±158.0	0.001	230~373
Protein (g)	112.3±40.5	102.0±49.2	97.1±44.9	0.013	66.9~99.8
Fat (g)	83.5±26.8	88.0±32.2	96.8±36.9 #	<0.001	56.9~78.3
cholesterol (g)	393.8±44.9	398.4±49.3	405.1±50.6	0.091	300~500
Fiber (g)	18.8±9.36	17.0±10.7	16.3±13.7	0.183	19.2~32.4
Carbohydrate (%)	56.74	57.39	57.32	0.722	
Protein (%)	15.66	15.32	15.65	0.535	
Fat (%)	31.69	31.08	31.27	0.656	
Minerals					
Calcium (g)	350.4±232.0	352.2±240.8	323.3±128.5	0.526	950.00
phosphorus (g)	929.4±327.4	989.4±326.6*	1022.0±316.4	0.013	702.50
Potassium (g)	2289.8±862.4	2468.1±994.5*	2675.4±892.9	<0.001	2000.0
Sodium (g)	1727.3±402.9	1769.7±345.4	1920.6±1275.2 #	0.015	1400.0
Magnesium (g)	321.6±95.2	301.5±105.4*	279.1±101.9	<0.001	322.50
iron (g)	12.9±5.8	12.5±7.1	11.9±6.7	0.279	13.00
zinc (g)	12.1±3.5	11.4±3.5*	10.4±3.8	<0.001	10.00
Selenium (g)	47.1±15.2	44.8±14.9*	41.1±16.1	<0.001	60.00
copper (g)	1.4±0.4	1.3±0.5*	1.1±0.5	<0.001	0.80
manganese (g)	5.4±1.9	5.2±1.8*	4.7±2.0	<0.001	4.50
Vitamin					
Vitamin A (μg, RE)	445.5±209.3	436.1±258.5	410.0±232.3	0.256	750.0
Vitamin E (mgα-RE)	13.3±11.3	13.4±4.9	13.7±3.7	0.882	14.00
Vitamin B1 (mg)	1.8±1.4	1.6±1.5*	1.3±2.0	0.006	1.30
Vitamin B2 (mg)	1.9±1.4	1.6±1.6*	1.3±1.4	0.003	1.30
Vitamin C (mg)	159.9±82.5	132.0±68.0*	122.3±75.9	0.019	100.0
niacin (mg)	9.1±10.3	7.0±8.5*	5.8±13.6 #	0.037	12.63

3.8 Dietary Pattern

It was presented that dietary patterns included “meat model”, “spice model”, “main vegeTables model” and “high protein model”.

Table 8. Rotated factor loading matrix

Items	factor 1	factor 2	factor 3	factor 4
Red meat	**0.71412**	0.24892	-0.01790	-0.10514
Plain boiled pork	**0.78560**	-0.03228	0.21550	-0.15544
oil	-0.20204	**0.64515**	-0.24710	0.03450
salt	0.08078	**0.72507**	-0.40996	0.07782
Sauce	-0.14635	**0.45135**	-0.15196	-0.06564
Meter	0.51350	-0.12688	**0.50277**	0.12276
surface	0.11389	-0.18066	**0.65901**	-0.00355
Other cereals	-0.07827	-0.09941	**0.54423**	0.03498
beans	-0.05615	-0.05798	-0.16311	0.35117
egg	0.16719	0.13672	0.01183	**0.50683**
milk	-0.10166	-0.01491	0.16137	**0.71506**
fruit	-0.15434	0.10916	-0.04551	**0.62409**
Fish and shrimp	0.17111	0.51432	0.04498	0.15538
vegeTables	0.43250	0.40162	-0.00272	-0.03967
Chicken	0.35030	-0.02455	0.48402	-0.03390
soy sauce	0.00240	0.00635	-0.01757	0.01450

3.9 Risk Factors Associated with PHTN Among 733 Young and Middle- Aged Health Check-Up Cases

Multicariate logistic regression analysis among 733 young and middle-aged health check-up cases revealed that age, drinking increased the risk of PHTN. But dietary milk intake and dietary magnesium intake were negative influencing factors for PHTN.

Table 9. Univariate Analysis of Risk Factors of PHTN

Items	χ^2-value	*P*-value	*OR*	95%*CI*
General status				
Gender	22.085	<0.001	0.450	（0.322, 0.629）
Age	13.213	<0.001	1.838	（1.322, 2.556）
Account Types	0.526	0.468	1.234	（0.699, 2.179）
Educational level	15.503	0.004	0.710	（0.381, 1.323）
Marital status	1.864	0.172	1.287	（0.895, 1.851）
Occupation	2.787	0.095	0.730	（0.504, 1.057）
Family income	3.065	0.080	0.729	（0.511, 1.039）
Smoking status	5.571	0.018	1.493	（1.070, 1.039）
Passive smoking	7.912	0.005	2.113	（1.250, 3.571）
Alcohol use	19.829	<0.001	2.128	（1.523, 2.973）
Physical activity status	0.043	0.835	0.950	（0.587, 1.538）
Nature of the work	4.164	0.041	1.579	（1.016, 2.454）
Intensity of work	1.334	0.248	0.803	（0.553, 1.166）
Physical extent	24.916	<0.001	2.313	（1.392, 3.842）
Sit time	2.040	0.153	0.648	（0.356, 1.177）
Food type				
Grain	15.692	0.001	1.002	（1.001, 1.003）
Peas and beans	0.141	0.707	0.999	（0.994, 1.004）
Livestock meat	6.231	0.013	1.003	（1.001, 1.006）

Fish and shrimp	0.022	0.881	1.000	（0.996, 1.003）
Eggs	2.063	0.151	0.999	（0.998, 1.000）
Dairy products	4.724	0.030	0.995	（0.993, 0.997）
VegeTables	2.198	0.138	1.000	（1.000, 1.000）
Fruits	1.630	0.202	0.999	（0.996, 1.001）
Fats and oils	1.635	0.201	1.009	（0.995, 1.023）
Salt	0.083	0.774	1.007	（0.960, 1.056）
Nutrients				
Energy	7.567	0.006	1.003	（1.001, 1.006）
Protein	1.726	0.189	0.088	（0.762, 1.012）
Fat	3.577	0.059	1.005	（1.002, 1.008）
Carbohydrate	5.812	0.016	1.003	（1.001, 1.005）
Cholesterol	1.513	0.219	1.002	（0.999, 1.005）
Fiber	0.515	0.473	1.005	（0.992, 1.017）
Minerals				
Calcium	0.009	0.926	1.000	（0.999, 1.001）
Phosphorus	5.018	0.025	1.002	（1.001, 1.003）
Potassium	5.625	0.018	1.004	（1.002, 1.006）
Sodium	2.387	0.122	1.000	（1.000, 1.001）
Magnesium	6.979	0.008	0.881	（0.752, 0.998）
Iron	1.257	0.262	0.996	（0.990, 1.002）
Zinc	9.978	0.042	0.916	（0.860, 0.976）
Selenium	8.169	0.044	0.920	（0.854, 0.990）
Copper	6.938	0.048	0.932	（0.880, 0.999）
Manganese	9.839	0.042	0.916	（0.832, 0.996）
Vitamin				
Vitamin A	1.749	0.186	0.930	（0.840, 1.051）
Vitamin E	0.052	0.820	1.000	（1.000, 1.000）
Vitamin B1	4.858	0.028	0.910	（0.822, 0.988）
Vitamin B2	4.750	0.029	0.910	（0.800, 0.990）
Vitamin C	1.692	0.193	1.000	（1.000, 1.001）
Niacin	2.174	0.140	0.920	（0.996, 1.025）
Dietary status				
Meat model	0.452	0.500	0.952	（0.802, 1.111）
Spice model	5.678	0.021	1.210	（1.032, 1.413）
Main vegeTables model	0.979	0.332	0.923	（0.790, 1.008）
High protein model	0.218	0.655	0.968	（0.820, 1.113）

Table 10. Multicariate Logistic Regression Analysis for Risk Factors of PHTN

Risk factors	*P*-value	*OR*	95%*CI*
age	0.0009	2.201	（1.379, 3.511）
Drinking	0.0006	1.982	（1.342, 2.927）
Milk and dairy products	0.0421	0.986	（0.950, 0.991）
magnesium	0.0427	0.978	（0.964, 0.992）

4. Discussion

In this study, we found that the prevalence of PHTN in Guangzhou, Guangdong Province, an economically developed district of southern China, was up to 36.6%. Many epidemiological studies have demonstrated that PHTN is an important public health problem. At the beginning of this century (2000–2001), a cross-sectional survey found that the prevalence of PHTN was 21.9% among Chinese participants aged between 35 and 74 years[4]. However, in other subsequent studies, the prevalence of PHTN was significantly higher than this ratio. In rural northeastern China, the prevalence of PHTN was 35.1% in men and 32.5% in women [16], and up to 40% in the whole population from urban areas of northeastern China [17], which may be associated with the cold climate and high sodium diet. The current study revealed that the overall prevalence of prehypertension in Guangzhou province was very similar to that in the urban areas of northeastern China [18], and significantly higher than that reported at the beginning of this century for the entire country [4]. The prevalence of PHTN in different countries and districts differs significantly and may be influenced by different factors. Logistic regression analysis revealed that dietary milk intake and dietary magnesium intake were negative influencing factors, while age, drinking, TC, TG, UA, BMI and HR increased the risk of PHTN.

In this study, the risk of prehypertension was about 1.8 times higher among subjects in the middle-aged group compared to the young-aged. We also analyzed that female was a protective factor for PHTN, and the prevalence of PHTN in men was stable with age, which suggested that men may be more easily prone to progress into frank HTN than women.

Further analysis showed that increased BMI was the most important risk factor for PHTN in our study. Therefore, our study suggests that although sodium intake is relatively low in the Guangdong Province in southern China [18], the prevalence of PHTN is almost as high as that in the northern area. With economic development and lifestyle changes, obesity/overweight has become a very important risk factor for increased BP. Many studies have documented that overweight/obesity can cause significant insulin resistance, which may play an important role in impaired glucose metabolism, dyslipidemia, and increased BP [19,20]. Meanwhile, clinical studies have shown that weight control can significantly lower BP [21]. These results indicated that lifestyle modifications, such as weight loss, may be effective in the long-term primary prevention of HTN.

In addition to the traditional risk factors, the results

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indicate that the effect of UA on BP may be increased throughout the entire PHTN range. Previous studies and our team have found that serum UA levels were significantly associated with PHTN [22,23]. UA can cause a proliferation of vascular smooth muscle cells and renal microvascular damage because of local inflammation and oxidative stress, finally leading to high BP [24,25]. Therefore, the mechanisms may be associated with inhibition of the nitric oxide pathway and activation of the renin-angiotensin system. And it needs to be investigated further. Besides, In this study, we also found that the proportion of hyperuricemia was decreasing with the increase of age among PHTN cases. It suggested that serum UA levels may be an important risk factor for young people. Previous findings strongly supported the synergistic pathogenic role of UA and obesity in HTN, which indicated diet is an important factor affecting the levels of UA[26]. Therefore, we emphasize the importance of lifestyle modification interventions for people with PHTN.

We explored that increasing the intake of dietary milk intake and dietary magnesium was the protective factor for PHTN through questionnaires. Dairy foods were rich in calcium. Currently, the impact of dietary calcium on blood pressure remains controversial. But the public generally considered that the level of calcium and blood pressure were negatively correlated, and increased dietary calcium can be effective in preventing blood pressure [27-29]. Magnesium may be used as calcium channel blockers to decrease the level of blood pressure. Chidambaram [30] found that the level of blood pressure that intake the lower magnesium intake was higher than those who intake the higher magnesium among the Indian inhabitants. A prospective cohort study showed that after 7.6 years of follow-up investigation and adjusting other factors, the risk of HTN and urinary magnesium was negatively correlated [31]. As for other influencing factors, it is consistent with other studies.

However, evidence for the treatment of prehypertension are still lacking, while lifestyle modifications remain the most important measure. At present, there are few kinds of researches on the influence of diet on blood pressure, and the current study is just to prove that lifestyle, especially diet, is closely related to the occurrence of prehypertension. Based on the results from the study, that alcohol intake, intake of dairy products, and intake of magnesium changes in intake of these products may be able to intervene in the development of HTN. However, the present study cannot provide reasonable dietary recommendations for the prehypertensive population. Further studies are needed to understand the underlying causes of the trends.

5. Limitations and Prospects

The present study has several methodological limitations. First, our data were based on community-based health check-up information, and not from a multistage stratified clustering sample. This may cause a bias in the prevalence of PHTN. Second, the determination of blood pressure was based on one-day measurement, which may result in misleading classifications of PHTN. But the blood pressure of 733 cases was accurately measured. Third, as the investigation time is short, food choices and the bias of memories contributed to the limitation of the findings oft the relationship of food consumption and PHTN. Our research team will conduct further study on interventions PHTN and pay attention to the above limitations.

6. Conclusion

This study showed that along with the economic development and lifestyle changes, PHTN was highly prevalent in Guangzhou. Our findings highlight there was an urgent need to educate both patients and health care providers of the importance of achieving the target of treatment in order to reduce morbidity and mortality due to PHTN and HTN.

Education about effective lifestyle modifications as an alcohol limit, increasing the intake of dairy products and magnesium can intervene in the development of PHTN, which would be of great benefit in controlling high blood pressure and preventing its complications. But how to develop targeted interventions for such groups need to be further explored. The present study also lays the theoretical foundation and basic data for the next step.

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Conflict of interest

The authors declare no conflict of interest.

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