ORIGINAL RESEARCH

Association of Body Fat Mass and Fat Distribution With the Incidence of Hypertension in a Population-Based Chinese Cohort: A 22-Year Follow-Up

Yongjie Chen, PhD; Xuan Liang, MS; Senshuang Zheng, MS; Yuan Wang, PhD; Wenli Lu, PhD

***Background*—**There have been few studies on the association between the incidence of hypertension and the presence and distribution of body fat. The aim of this article was to evaluate this association.

***Methods and Results*—**Data were obtained from the China Health Nutrition Survey, a 22-year cohort study of 12 907 participants. Body mass index and triceps skinfold thickness were used as markers of body fat, whereas waist circumference (WC) was used as a marker of fat distribution. Cox regression was used to examine the association of body mass index, WC, and skinfold thickness with the incidence of hypertension. The interval between the baseline and hypertension diagnosis was the time variable, and hypertension was the end event. The mean age and proportion of men and women were 38.29 and 38.03 years and 45.63% and 54.37%, respectively. Compared with normal WC, abdominal obesity was associated with hypertension ($P<0.001$; crude hazard ratio, 2.11; 95% confidence interval, 1.89–2.37). Similarly, overweight (crude hazard ratio, 1.75; 95% confidence interval, 1.64–1.87) and obesity (crude hazard ratio, 3.19; 95% confidence interval, 2.80–3.63) were risk factors for hypertension (all $P<0.001$). When stratified by sex, the results confirmed that WC and body mass index predicted the development of hypertension in both men and women but not skinfold thickness in women.

***Conclusions*—**Body mass index and WC were independent risk factors for hypertension, but skinfold thickness was a poor marker of body fat and could not be used to predict hypertension. **(*J Am Heart Assoc*. 2018;7:e007153. DOI: 10.1161/JAHA.117.007153.)**

Key Words: body mass index • China Health Nutrition Survey • incidence of hypertension • triceps skinfold thickness • waist circumference

Hypertension is a major public health problem worldwide and the greatest attributable risk factor for death.[1] As a major modifiable risk factor for cardiovascular disease, hypertension accounts for ≈45% of global cardiovascular disease morbidity and mortality,[2] which corresponds to ≈7 million deaths each year.[3–5] Overall, the prevalence of hypertension is ≈25% in adults, but this value is expected to increase to 29% by 2025.[6] In China, by contrast, the prevalence of hypertension increased in adults from 14.5% in 1991 to 34.0% in 2012.[7–10] Therefore, it is essential to investigate the factors that affect this rapidly growing prevalence.

It is well known that an epidemiological link exists between adiposity and hypertension.[11] Using the body mass index (BMI), many studies have reported that overweight and obesity are major independent risk factors for hypertension,[12–18] with ≈65% to 78% of adult hypertension cases being attributable to obesity at the population level.[19] Indeed, the prevalence of hypertension is reported to be 35% to 50% in overweight and obese adults, which is approximately double the reported prevalence of 23% in individuals of normal weight.[20] A limitation of BMI, however, is that it only measures weight relative to height, and it does not consider body fat distribution.[21] This is important because research has shown that not only fat quantity but also the location of specific adipose deposits are important for the development of hypertension.[22] In parallel to the increase in the prevalence of hypertension, China is currently experiencing a dramatic increase in the prevalence of overweight, obesity, and abdominal obesity.[23,24] Effective interventions are, therefore, needed to address these issues.

To date, few studies have investigated the relationship of body fat mass and fat distribution with the incidence of

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Received July 14, 2017; accepted December 8, 2017.

Clinical Perspective

What Is New?

- Body mass index and waist circumference, as the markers of body fat mass and fat distribution, respectively, were independent risk factors for hypertension in Chinese adults.
- Triceps skinfold thickness was a poor marker of body fat and unsuitable to be used as a predictor of hypertension.
- Body mass index and waist circumference should be used in combination when seeking to predict and screen for hypertension.

What Are the Clinical Implications?

- The results of this study suggest that body mass index and waist circumference should be used together in public health strategies, and with further investigation, these measures could form a simple and effective tool with broad applicability.
- The conclusion was consistent with other reports suggesting that general and abdominal obesity were important cardiovascular risk factors that drove adverse clinical events.
- Identifying the paracrine mediators linking body fat to the development of hypertension in future research might open new avenues for the prevention and management of hypertension.

hypertension, especially in Chinese adults, in whom there has been a dramatic shift in lifestyle and diet pattern over recent years. The present study focused on the relationship of skinfold thickness, BMI, and waist circumference (WC) with the incidence of hypertension using prospectively collected representative national data. The primary aim of this study was to evaluate the association of body fat mass and distribution with the incidence of hypertension to provide comprehensive evidence that could help improve the prevention, treatment, and control of hypertension.

Methods

The data, analytical methods, and study materials have been made available to other researchers involved in the Carolina Population Center (2011) and China Health and Nutrition Survey[25] for purposes of reproducing the results or replicating the procedure.

Study Design

Data were accessed from the China Health and Nutrition Survey (CHNS), which is an ongoing, open-cohort, international, collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health (formerly the National Institute of Nutrition and Food Safety) of the Chinese Center for Disease Control and Prevention. The CHNS was designed to examine the effects of health, nutrition, and family planning policies and programs implemented by national and local governments, as well as to see how the social and economic transformation of Chinese society has affected the health and nutritional status of its population. The CHNS covers 9 provinces that vary substantially in geography, economic development, public resources, and health indicators. A multistage random cluster process was used to create samples in each province. Counties in the 9 provinces were stratified by income (low, middle, and high), and a weighted sampling scheme was used to randomly select 4 counties per province. The first round of the CHNS was conducted in 1989, and it was subsequently performed in 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. A detailed description of the survey design and procedures has been published elsewhere.[26] This study was approved by the Institutional Review Board of the National Institute for Nutrition and Food Safety, China Center for Disease Control and Prevention, and University of North Carolina at Chapel Hill. All subjects provided informed consent.

Study Population

Data were obtained from all 9 waves of the CHNS conducted from 1989 to 2011, focusing on adults aged ≥18 years at baseline and for whom data existed on age, sex, and detailed physical examinations (eg, weight, height, WC, systolic blood pressure [BP], and diastolic BP). The following participants were excluded: participants who were pregnant or lactating at the time of the survey, those who had missing data or implausible outlying data (eg, weight >300 kg or <20 kg or WC <20 cm), those who had a systolic BP ≥140 mm Hg or a diastolic BP ≥90 mm Hg, those who used antihypertensive medications, or those who self-reported a diagnosis of hypertension at baseline. The flow diagram for the final cohort is summarized in Figure 1.

Measurement and Definition of Indicators

Weight, height, and WC were measured by trained healthcare workers following standardized protocols, as set by the World Health Organization. Weight was measured to the nearest 0.1 kg while wearing lightweight clothing using a calibrated beam scale, and height was measured to the nearest 0.1 cm without shoes using a portable stadiometer. BMI was calculated as weight (in kilograms) divided by the square of height (in meters). WC was measured at a point midway between the lowest rib and the iliac crest in a horizontal plane

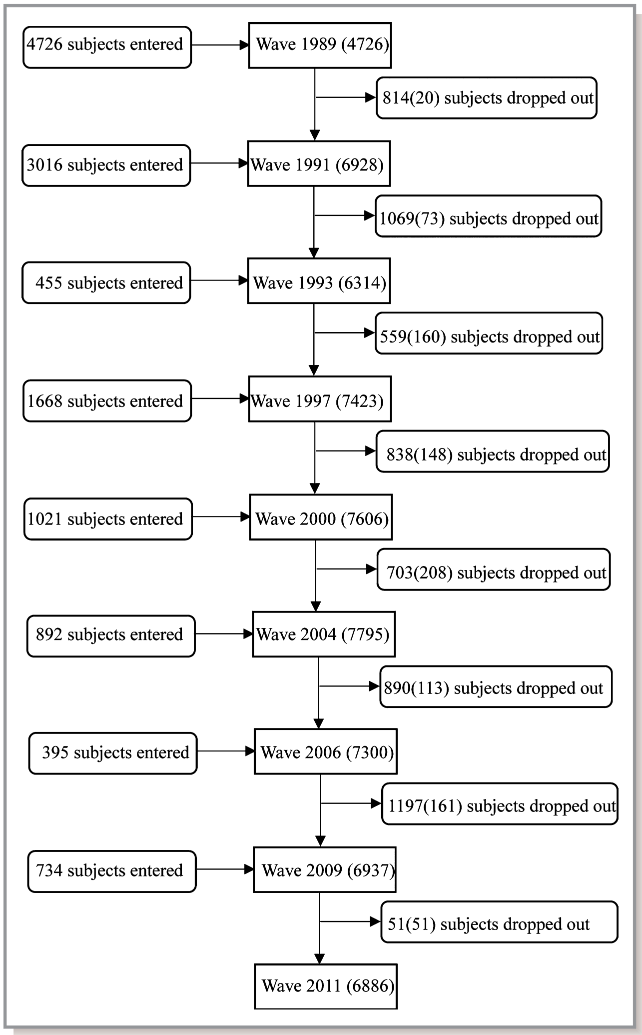

Figure 1. Flow diagram for cohort selection and censure. All subjects in the flow diagram were adults and eligible subjects. The number of subjects in the left box is the number of participants who entered in the wave. The number in the bracket in the center box is the number of participants who remained in the study in the wave. The number in the right box is the number of excluded participants after the wave, and the number in the bracket in the right box is the number of participants who died after the wave.

using nonelastic tape. Skinfold thickness was measured using skinfold calipers and recorded to the nearest 0.5 mm at the triceps on the right arms (between the tip of the olecranon process of the ulna and the acromion process of the scapula). Three measurements were obtained per subject for all indicators, and the mean measurement was used in the analysis.

BP measurements were obtained after rest for 10 minutes in the seated position, with 30-second intervals between cuff inflations, using standard mercury sphygmomanometers.[27] Care was taken to select the cuff size according to the participant's arm circumference. Systolic BP and diastolic BP were recorded as the points at which the first and fifth Korotkoff sounds appeared, respectively. The average of 3 measurements was used.

On the basis of the World Health Organization recommendations for Chinese people, overweight was defined as a BMI $\geq$23 kg/m^2 and obesity as a BMI $\geq$27.5 kg/m^2; in addition, abdominal obesity was defined by WC values $\geq$90 cm for men and $\geq$80 cm for women.[28] Hypertension was defined as systolic BP/diastolic BP $\geq$140/90 mm Hg, the use of hypertensive medications, or a self-reported diagnosis.[27,29] In this article, BMI and triceps skinfold thickness were used as the markers of body fat mass,[30,31] and WC was used as the marker of fat distribution.[32]

Statistical Analysis

Data are presented as medians (interquartile ranges) for continuous variables and as frequencies (percentages) for categorical variables. Baseline characteristics were compared between nonhypertension and hypertension groups by the Wilcoxon rank sum test and Z statistic for continuous variables and by the χ^2 test and χ^2 statistic for categorical variables. According to previous studies, there were significant differences in the relationship of total body fat and hypertension between men and women.[33,34] Therefore, Cox regressions were stratified by sex, with hypertension as the end event and the time interval between baseline and hypertension diagnosis as the time variable, and the χ^2 statistic was used to test the regression coefficients. The censored outcomes were from 2 groups: (1) those who were not diagnosed with hypertension until either dropout from the cohort or the end of the study (2011) and (2) those who were not diagnosed with hypertension until death before the end of the study. To correct for the competing risks of death attributable to hypertension, all models were adjusted for death. In the adjusted models, age, sex, current smoking, current drinking, physical activity, and nationality at baseline were adjusted. All analyses were conducted using SAS 9.4 (SAS Institute Inc, Cary, NC), and a 2-tailed $P\leq0.05$ was used to indicate statistical significance.

Results

Of the 12 907 subjects, 4307 experienced the end event and 8600 were censored. Compared with the nonhypertension group, age, WC, and BMI were greater in the hypertension group, but skinfold thickness was smaller. In addition, there were more men, smokers, drinkers, and Han nationals in the hypertension group than in the nonhypertension group, and the proportions of abdominal obesity, overweight, and general obesity were also greater (Table 1).

In models 1 to 3, skinfold thickness, WC, and BMI were entered into the Cox regression models separately. In model

Table 1. Characteristics of All Subjects at the Baseline Survey

Characteristics	All Subjects (12 907)	Subgroup Subjects: No Hypertension (8600)	Subgroup Subjects: Hypertension (4307)	*P* Value
Age, y*	35.10 (20.10)	32.10 (16.70)	41.50 (21.40)	<0.001
WC, cm*	77.00 (13.00)	75.00 (13.00)	80.00 (13.00)	<0.001
Skinfold thickness, mm*	11.33 (10.00)	11.67 (10.33)	11.00 (10.00)	<0.001
BMI, kg/m^2*	21.36 (3.53)	21.11 (3.33)	21.99 (3.83)	<0.001
Sex				<0.001
Male	5890 (45.63)	3672 (42.70)	2218 (51.50)	
Female	7017 (54.37)	4928 (57.30)	2089 (48.50)	
Smoke				<0.001
No	7977 (64.33)	5494 (67.88)	2483 (57.66)	
Yes	4423 (35.67)	2600 (32.12)	1823 (42.34)	
Drink				<0.001
No	7130 (57.50)	4943 (61.09)	2187 (50.78)	
Yes	5269 (42.50)	3149 (38.91)	2120 (49.22)	
Nationality				<0.001
Han	10 910 (84.53)	7119 (82.78)	3791 (88.02)	
Other	1997 (15.47)	1481 (17.22)	516 (11.98)	
Abdominal obesity				<0.001
No	3734 (73.53)	2859 (76.59)	875 (65.06)	
Yes	1344 (26.47)	874 (23.41)	470 (34.94)	
Obesity				<0.001
Normal	9236 (71.56)	6483 (75.38)	2753 (63.92)	
Overweight	3182 (24.65)	1884 (21.91)	1298 (30.14)	
Obesity	489 (3.79)	233 (2.71)	256 (5.94)	
Skinfold thickness				0.001
≤P25	3091 (27.04)	1982 (25.97)	1109 (29.18)	
P25–P50	3161 (27.65)	2110 (27.64)	1051 (27.66)	
P50–P75	2360 (20.64)	1614 (21.15)	746 (19.63)	
≥P75	2821 (24.67)	1927 (25.25)	894 (23.53)	

Data are reported as median (interquartile range) for continuous variables and frequencies (percentages) for categorical variables. BMI indicates body mass index; P25, percentile 25; P50, percentile 50; P75, percentile 75; and WC, waist circumference.
*These variables were analyzed using Wilcoxon rank sum test.

1, using a skinfold thickness ≤P25 as the reference, P25 (skinfold thickness = 7.33 mm) to P50 (skinfold thickness = 12.00 mm) was not a significant factor for the incidence of hypertension (*P*=0.066; crude hazard ratio [HR], 1.08; 95% confidence interval [CI], 1.00–1.18), but P50 to P75 (skinfold thickness = 17.33 mm) (*P*=0.002; crude HR, 1.16; 95% CI, 1.06–1.28) and ≥P75 (*P*<0.001; crude HR, 1.38; 95% CI, 1.26–1.51) were significant. Compared with normal WC, abdominal obesity was associated with the development of hypertension (*P*<0.001; crude HR, 2.11; 95% CI, 1.89–2.37). Similarly, compared with normal weight, overweight (crude HR, 1.75; 95% CI, 1.64–1.87) and obesity (crude HR, 3.19; 95% CI, 2.80–3.63) were risk factors for hypertension (both *P*<0.001).

When adjusting for age, sex, nationality, current smoking, current drinking, and physical activity, skinfold thickness was significant at the P25 to P50, P50 to P75, and ≥P75 quartiles (all *P*<0.001), and the results of WC and BMI were consistent with those obtained without adjusting for covariates (Table 2). When BMI and skinfold thickness were entered simultaneously into the model, the significance disappeared for skinfold thickness when not adjusting for covariates; however, the results were inverse when adjusting for covariates (*P*=0.026, *P*<0.001, and *P*<0.001, respectively). When skinfold thickness

Table 2. Effects of Body Fat and Fat Distribution on the Incidence of Hypertension From Cox Regression

Model	Crude Analysis			Adjusted Analysis*		
	Hazard Ratio	95% CI	*P* Value	Hazard Ratio	95% CI	*P* Value
Model 1†						
Skinfold thickness						
P25–P50	1.08	1.00–1.18	0.066	1.20	1.10–1.31	<0.001
P50–P75	1.16	1.06–1.28	0.002	1.43	1.30–1.58	<0.001
≥P75	1.38	1.26–1.51	<0.001	1.65	1.50–1.81	<0.001
Model 2†						
Abdominal obesity	2.11	1.89–2.37	<0.001	1.91	1.70–2.15	<0.001
Model 3†						
Overweight	1.75	1.64–1.87	<0.001	1.64	1.53–1.75	<0.001
Obesity	3.19	2.80–3.63	<0.001	2.63	2.31–3.00	<0.001
Model 4†						
Skinfold thickness						
P25–P50	0.95	0.81–1.12	0.545	1.11	1.01–1.21	0.026
P50–P75	0.89	0.74–1.06	0.179	1.22	1.10–1.35	<0.001
≥P75	1.03	0.87–1.21	0.725	1.27	1.15–1.41	<0.001
Overweight	2.09	1.85–2.37	<0.001	1.55	1.44–1.67	<0.001
Obesity	2.79	2.29–3.39	<0.001	2.30	2.00–2.64	<0.001
Model 5†						
Skinfold thickness						
P25–P50	1.00	0.85–1.17	0.951	1.11	0.94–1.30	0.214
P50–P75	0.96	0.81–1.14	0.638	1.27	1.06–1.52	0.009
≥P75	1.16	0.98–1.36	0.082	1.61	1.35–1.90	<0.001
Abdominal obesity	2.04	1.81–2.31	<0.001	1.72	1.52–1.95	<0.001

CI indicates confidence interval; P25, percentile 25; P50, percentile 50; and P75, percentile 75.
*In models 1 to 5, sex, age, smoking, drinking, nationality, and physical activity were adjusted for.
†In model 1, the skinfold thickness ≤P25 was taken as the reference. In model 2, the normal waist circumference was taken as the reference. In model 3, the normal weight was taken as the reference. In model 4, body mass index and skinfold thickness were entered into the model simultaneously. In model 5, waist circumference and skinfold thickness were entered into the model simultaneously.

and WC were analyzed together, the results were similar to those obtained using model 4. Whether adjusting for covariates or not, both BMI and WC were significant predictors of hypertension development (all $P<0.001$).

The results of the Cox regression stratified by sex are shown in Table 3. For men, skinfold thickness, WC, and BMI all significantly predicted hypertension (all $P<0.001$), and the results were comparable before and after adjusting for covariates. When skinfold thickness was analyzed with BMI or WC, all of them were significant predictors of hypertension.

In women, skinfold thickness ≥P75 was a risk factor for hypertension ($P<0.001$), but thicknesses in the P25 to P50 ($P=0.446$) and P50 to P75 ($P=0.485$) quartiles were not risk factors. When adjusting for covariates, a skinfold thickness of P50 to P75 appeared to significantly affect the incidence of hypertension ($P=0.006$; adjusted HR, 1.25; 95% CI, 1.06–1.46). The rest of the results were comparable before and after adjusting for covariates. When skinfold thickness was analyzed with BMI or WC together, BMI and WC were significant predictors of hypertension (all $P<0.001$), but skinfold thickness was not. Finally, the adjusted HR of abdominal obesity (1.89; 95% CI, 1.61–2.23) was less than the crude HR (2.79; 95% CI, 2.38–3.27). The survival curves for WC, BMI, and skinfold thickness by sex are shown in Figure 2.

Discussion

On the basis of a 22-year cohort study, the results from this study showed that BMI and WC significantly predicted the development of hypertension. Skinfold thickness was a significant risk factor for hypertension. However, only the ≥P75 quartile of skinfold thickness in the total sample and the

Table 3. Effects of Body Fat and Fat Distribution on the Incidence of Hypertension by Sex From Cox Regression

Model	Crude Analysis			Adjusted Analysis*		
	Hazard Ratio	95% CI	*P* Value	Hazard Ratio	95% CI	*P* Value
Men						
Model 1†						
Skinfold thickness						
P25–P50	1.35	1.21–1.50	<0.001	1.28	1.15–1.43	<0.001
P50–P75	1.62	1.41–1.86	<0.001	1.64	1.43–1.88	<0.001
≥P75	1.58	1.38–1.81	<0.001	1.57	1.38–1.80	<0.001
Model 2†						
Abdominal obesity	2.06	1.73–2.46	<0.001	1.82	1.52–2.17	<0.001
Model 3†						
Overweight	1.79	1.62–1.97	<0.001	1.61	1.46–1.77	<0.001
Obesity	2.97	2.42–3.64	<0.001	2.39	1.95–2.94	<0.001
Model 4†						
Skinfold thickness						
P25–P50	1.18	1.05–1.32	0.004	1.15	1.02–1.28	0.019
P50–P75	1.31	1.13–1.51	<0.001	1.36	1.18–1.58	<0.001
≥P75	1.29	1.12–1.48	<0.001	1.33	1.16–1.53	<0.001
Overweight	1.67	1.50–1.86	<0.001	1.51	1.36–1.69	<0.001
Obesity	2.44	1.97–3.03	<0.001	1.98	1.59–2.46	<0.001
Model 5†						
Skinfold thickness						
P25–P50	1.36	1.12–1.65	0.002	1.27	1.05–1.55	0.016
P50–P75	1.58	1.25–1.99	<0.001	1.58	1.25–2.00	<0.001
≥P75	1.88	1.51–2.33	<0.001	1.96	1.57–2.44	<0.001
Abdominal obesity	1.76	1.46–2.11	<0.001	1.54	1.28–1.86	<0.001
Women						
Model 1†						
Skinfold thickness						
P25–P50	0.94	0.81–1.10	0.446	1.07	0.91–1.24	0.424
P50–P75	1.06	0.91–1.24	0.485	1.25	1.06–1.46	0.006
≥P75	1.39	1.19–1.61	<0.001	1.60	1.37–1.86	<0.001
Model 2†						
Abdominal obesity	2.79	2.38–3.27	<0.001	1.89	1.61–2.23	<0.001
Model 3†						
Overweight	1.80	1.64–1.97	<0.001	1.68	1.53–1.84	<0.001
Obesity	3.57	3.02–4.22	<0.001	2.86	2.41–3.38	<0.001
Model 4†						
Skinfold thickness						
P25–P50	0.91	0.78–1.06	0.232	1.04	0.89–1.21	0.661
P50–P75	0.92	0.79–1.08	0.300	1.09	0.93–1.28	0.283
≥P75	0.97	0.83–1.14	0.727	1.17	0.99–1.38	0.058
Overweight	1.78	1.61–1.98	<0.001	1.59	1.43–1.77	<0.001
Obesity	3.37	2.79–4.06	<0.001	2.55	2.11–3.08	<0.001

Continued

Table 3. Continued

Model	Crude Analysis			Adjusted Analysis*		
	Hazard Ratio	95% CI	*P* Value	Hazard Ratio	95% CI	*P* Value
Model 5[†]						
Skinfold thickness						
P25–P50	0.79	0.59–1.05	0.105	0.75	0.56–1.01	0.058
P50–P75	0.79	0.59–1.06	0.109	0.81	0.60–1.09	0.162
≥P75	1.00	0.76–1.32	0.989	1.05	0.80–1.39	0.715
Abdominal obesity	2.64	2.23–3.12	<0.001	1.76	1.48–2.10	<0.001

CI indicates confidence interval; P25, percentile 25; P50, percentile 50; and P75, percentile 75.
*In models 1 to 5, sex, age, smoking, drinking, nationality, and physical activity were adjusted for.
[†]In model 1, the skinfold thickness ≤P25 was taken as the reference. In model 2, the normal waist circumference was taken as the reference. In model 3, the normal weight was taken as the reference. In model 4, body mass index and skinfold thickness were entered into the model simultaneously. In model 5, waist circumference and skinfold thickness were entered into the model simultaneously.

P50 to P75 and ≥P75 quartiles in the male sample remained significant when adjusting for covariates and analyzing BMI, WC, and skinfold thickness together. Therefore, skinfold thickness was poor and less powerful in predicting the incidence of hypertension.

In this study, WC was used as a marker of fat distribution and visceral adiposity. There is growing evidence that visceral adiposity is a pathological depot that accumulates when subcutaneous depots are overwhelmed or unavailable for storage.[11] Visceral fat is characterized by being more sensitive to lipolysis and by its ability to secrete higher amounts of inflammatory cytokines.[35] Although these are clearly unwanted and likely contributory effects, the exact mechanism underlying the association of visceral fat and hypertension remains unknown. It is possible that increased adipose tissue releases a variety of adipokines that are related to a decrease in the production and use of nitric oxide, which has important functions in the control of vascular tone and suppression of vascular smooth muscle cell proliferation. A decrease in the effect of nitric oxide has been associated with endothelial dysfunction and arterial hypertension.[36]

BMI, which reflects body fat mass, was shown to be an independent risk factor for hypertension, which was consistent with previous studies indicating an association between high body fat levels and hypertension.[37,38] BMI is easily measured and is a simple and effective tool for screening hypertension, making it suitable for use in comprehensive public health strategies. The prevalence of general obesity and abdominal obesity has been increasing significantly in China over recent years, and the burden of hypertension is expected to continue to increase. Therefore, the combined use of both BMI and WC is recommended when seeking to predict and screen for hypertension.

Because there are differences in ethnic and dietary patterns between countries, the prevalence and extent of obesity vary. Previous studies have reported that Asians have higher body fat levels than Western people with the same BMI.[39,40] Therefore, a specific BMI cutoff should be used to define overweight and obesity for a specified country. In this article, according to World Health Organization recommendations for Chinese people, ethnic-based cutoffs for BMI were used to define overweight and obesity. As a result, the selection bias was reduced, and the association of obesity and hypertension was more accurate.

Although sex affected the incidence of hypertension, BMI and WC remained the main determinants when the analyses were stratified by sex. Significant findings were observed for BMI and WC even after adjusting for covariates, suggesting that increases in these variables may precede the development of hypertension and play a role in its pathogenesis.[41] However, it was notable that triceps skinfold thickness showed a poor association with hypertension, especially when adjusting for covariates. Compared with BMI, skinfold thickness seemed to be a poor marker of body fat mass and a poor predictor of hypertension development.

Strengths and Limitations

This study relied on data from the CHNS, which followed a national and representative cohort study over 22 years. The results, therefore, provided strong evidence for the effects of BMI, WC, and skinfold thickness on the incidence of hypertension. However, the study has limitations that should be considered. The decision to exclude subjects with hypertension at baseline may have resulted in the selection of relatively healthy adults who were protected against the harmful effects of high BMI, WC, and skinfold thickness. This limitation should be examined in a dedicated study. Another limitation was that only triceps skinfold thickness was used as a measure of subcutaneous fat. Because there was a lack of skinfold thickness at the abdominal, suprailiac, subscapular, and thigh regions, the comprehensive subcutaneous fat was

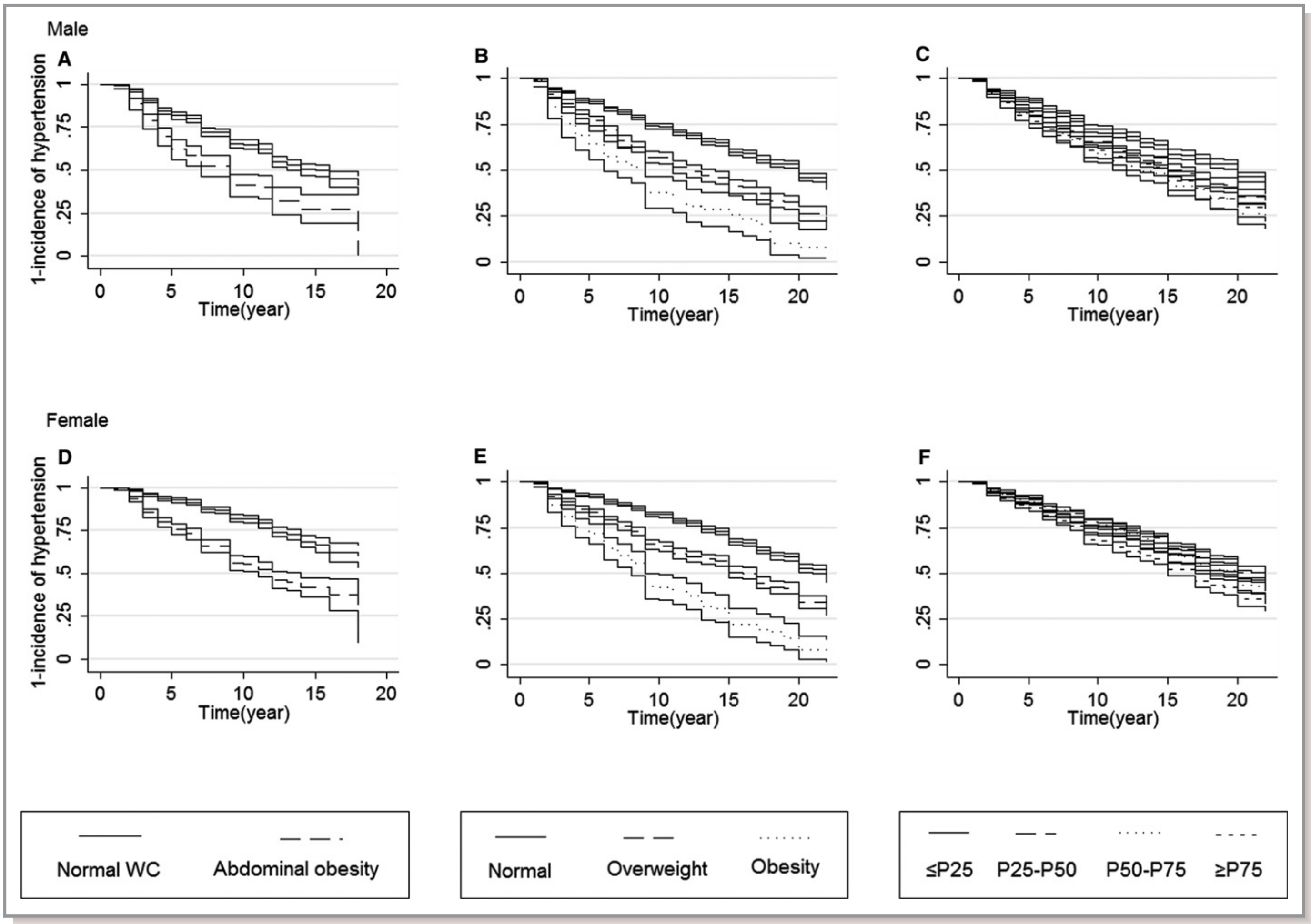

Figure 2. Body mass index (BMI), waist circumference (WC), and skinfold thickness survival curves for the incidence of hypertension by sex. Survival curves for men are shown for WC (A), BMI (B), and skinfold thickness (C). Survival curves for women are shown for WC (D), BMI (E), and skinfold thickness (F).

not calculated. The association of subcutaneous fat with hypertension needs to be examined in a future study. Compared with ambulatory BP, clinical BP shows a limited relationship with the average 24-hour daytime or nighttime BP values and is poor in grading hypertension severity and predicting cardiovascular risk. However, 24-hour BP is difficult to measure and assess in a population study, especially in a national survey. Given that ambulatory BP was not available in the CHNS, the clinical BP was used to define hypertension in this study.

In conclusion, BMI and WC, as markers of body fat mass and fat distribution, respectively, were independent risk factors for hypertension in Chinese adults. However, triceps skinfold thickness was a poor marker of body fat and unsuitable for use as a predictor of hypertension. BMI and WC should be used together in public health strategies, and with further investigation, these measures could form a simple and effective tool with broad applicability. The conclusion is consistent with other reports suggesting that general and abdominal obesity are important cardiovascular risk factors that drive adverse clinical events. Identifying the paracrine mediators linking body fat to the development of hypertension in future research might open new avenues for the prevention and management of hypertension.

Perspectives

On the basis of a 22-year cohort, this study confirmed that BMI and WC, but not triceps skinfold thickness, were independent risk factors for hypertension. Therefore, BMI and WC measurements are recommended to be used as simple and effective predictors of hypertension in public health strategies.

Acknowledgments

This research uses data from the China Health and Nutrition Survey (CHNS). We thank the National Institute of Nutrition and Food Safety, China Center for Disease Control and Prevention, Carolina Population Center, the University of North Carolina at Chapel Hill, the National Institutes of Health (NIH; R01-HD30880, DK056350, and R01-HD38700), and the Fogarty International Center, NIH, for financial support for the CHNS data collection and analysis files from 1989 to 2006 and both parties plus the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009 and future surveys.

Disclosures

None.

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Journal of the American Heart Association
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Yongjie Chen, Xuan Liang, Senshuang Zheng, Yuan Wang and Wenli Lu

J Am Heart Assoc. 2018;7:e007153; originally published March 16, 2018;
doi: 10.1161/JAHA.117.007153
The *Journal of the American Heart Association* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Online ISSN: 2047-9980