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The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan

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The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan

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ABSTRACT

Objective: Obesity and hypertension (HTN) have become increasingly prevalent in Taiwan. People with obesity are more likely to have HTN. In this study, we evaluated the best obesity index for predicting HTN in middle-aged and elderly populations in Taiwan.

Design: Cross-sectional observational study.

Setting: Community-based investigation in Guishan township of northern Taiwan.

Participants: This study recruited 396 people from a northern Taiwan community for a cross-sectional study. Anthropometrics and blood pressure were measured by the annual health exam. The obesity indices included BMI, BF percentage and WC.

Outcome measures: Statistical analyses including Pearson's correlation, multiple logistic regression, and the area under ROC curves (AUC) between HTN and obesity indices were used in this study.

Results: Of the 396 people recruited, 200 had HTN. The age-adjusted Pearson's coefficients of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively. Multiple logistic regression on the HTN-related obesity indices showed that the odds ratio of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively. The AUC of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681, $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694, $p < 0.001$), respectively.

Conclusions: WC is a more reliable predictor for HTN in comparison to BMI and BF percentage. The effect of abdominal fat distribution on blood pressure is greater than that on total BF amount.

Keywords: Abdominal Fat, Elderly, Hypertension, Middle-Aged, Obesity Index

Strengths and limitations of this study:

- Waist circumference is a more reliable predictor for hypertension in comparison to BMI and body fat percentage.
- Abdominal fat distribution influences more on blood pressure than total body fat amount among middle-aged and elderly populations.
- Cross-sectional study can not effectively determine the causal relationship between obesity indices and hypertension.
- The number of participants in this study came from a relatively small community. Selection bias should be considered.

INTRODUCTION

The prevalence of obesity has increased progressively in Taiwan, particularly among the elderly. However, the precise definition of obesity in the elderly has yet to be developed [1]. Traditionally, body mass index (BMI), waist circumference (WC), and body fat (BF) percentage have been used to evaluate obesity. The cut-off values of these obesity indices have not been defined for the elderly population [1], because sarcopenia causes loss of muscle mass and fatty tissues increase with aging [2]. Aging and sarcopenia cause muscle loss and increase fat deposition, making BMI an inaccurate reference. Lower BMI in the elderly may not indicate the lower BF percentage, as it could be correlated with muscle loss coupled with relative BF increase.

The utility of different types of obesity indices has been discussed in the past. If the BF percentage by Dual-energy X-ray absorptiometry (DXA) is regarded as a gold standard, it would be hard to assess as the sensitivity and specificity of BMI vary with gender [3]. For older women, a BMI of 25 has the best sensitivity and specificity. For older men, a BMI of 27 is the most appropriate. Different obesity indices show different comorbidity risks. WC is more strongly associated with high risk of cardiovascular disease (CVD) than BMI among middle-aged and elderly persons in Taiwan [4]. BMI and WC are more positively correlated with insulin resistance than BF percentage [5].

Hypertension (HTN) is also a common problem among the elderly with increasing prevalence, with associated risks of cardiovascular disease, stroke, and chronic kidney disease [6]. It has different effects in different age groups. Isolated systolic HTN is predominant in the elderly [7]. There are many physiological changes related to the development of HTN in the elderly, such as arterial stiffness, widening pulse pressure, changes in renin and aldosterone levels, decreased renal salt excretion, declined renal function, changes in the autonomic nervous system sensitivity and function, and changes in endothelial function [8].

Obesity is a major risk factor for essential HTN [9]. The development of HTN caused by obesity can occur via multiple mechanisms: insulin resistance, adipokine alterations, inappropriate sympathetic nerve system and renin-angiotensin-aldosterone system activation, structural and functional abnormalities in the kidney, heart and vascular change, and immune maladaption [9 10]. Uric acid and incretin or dipeptidyl peptidase 4 activity alteration also contribute to the development of HTN in obesity [10]. Different obesity indices have different correlations with HTN. High levels of BMI and WC have increased the risks of HTN among rural Chinese women [11]. WC is more strongly associated with the development of HTN than BMI [12]. In another study, no significant difference in HTN prediction between BMI and WC was found [13]. Another similar study showed that the association of obesity indices with HTN in Chinese elderly differs by gender and age [14]. BMIs in men and hip circumferences in women showed a significant impact on the risk of HTN [14]. This study was designed to investigate the relationship between different obesity indices and HTN among middle-aged and elderly Taiwanese populations.

METHODS

Study design and study population

This is a cross-sectional, community-based study. We collected data from a community health promotion project of Linkou Chang Gung Memorial Hospital between February and August 2014. The project recruited 400 participants aged 50 years or older through poster promotion or notification from the community office. All participants completed a questionnaire including personal information and medical history during a face-to-face interview. Anthropometric measurements by trained research assistants or nurses were conducted under the supervision of a medical doctor. Exclusion criteria included: (1) Participants with coronary artery disease, cerebrovascular disease, peripheral artery disease, or heart failure; and (2) Participants with incomplete or missing data. Only 4 participants were excluded without measuring BF percentage. Finally, there were 396 participants enrolled in the analysis. The study was approved by Chang Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Anthropometric and laboratory measurements

Each participant was required to complete a questionnaire. The questionnaires were recorded by trained interviewers based on face-to-face interviews. Basic personal data included age, gender, systolic blood pressure (SBP), diastolic blood pressure (DBP), education level, history of HTN, diabetes, metabolic syndrome, and hyperlipidemia. Lifestyles included alcohol drinking, current smoking, and regular exercise. HTN was defined as SBP $\geqq$ 140mmHg or DBP $\geqq$ 90mmHg, or current use of antihypertensive medications, or history of HTN. Laboratory data included alanine aminotransferase (ALT), creatinine, fasting sugar, high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol, triglyceride, and uric acid. Each participant's blood pressure was measured on the right arm in sitting position using a standardized electronic sphygmomanometer. The participants rested for at least 5 minutes in seated position before the measurements, with their arms supported at the heart level. The obesity indices included BMI, BF percentage and WC. BF percentage was measured with an 8-contact electrode bioelectrical impedance analysis (BIA) device (Tanita BC-418, Tanita, Tokyo, Japan). BMI was calculated as weight / height^2 (kg/m^2). WC was measured at the level midway between the iliac crests and the lowest rib margin at minimal respiration in a standing position.

Statistical analysis

We expressed all continuous variables as mean and standard deviation, while categorical variables were expressed as numbers and percentages. In univariate analysis, independent T-test and Chi-square test were used to compare HTN and non-HTN subjects. Correlations were assessed with Pearson's correlation coefficient and the coefficient of determination (r^2) between different obesity indices and blood pressures. In multivariate analysis, binary logistic regression was used to adjust covariates. Receiver operating characteristic (ROC) curves were generated for BF percentage, WC, and BMI as predictors of HTN. The area under the ROC curve (AUC) and the optimal cut-off points for HTN prediction of BMI, WC, and BF percentage were determined by the largest sum of specificity and sensitivity. The analysis was performed with SPSS Statistics version 22 (IBM, SPSS Armonk, NY, IMM Corp).

RESULTS

A total of 396 participants were enrolled in the analysis, and 200 had HTN(SBP ≧ 140mmHg or DBP ≧ 90mmHg), with a prevalence of 50.5%. The average age was 64.44 years. There were no significant static differences in alcohol drinking, current smoking, ALT, total cholesterol, regular exercise, and dyslipidemia between people with and without HTN. People with HTN had higher level of BMI, WC, BF percentage, fasting sugar, triglyceride, uric acid, and creatinine with static significance (Table 1).

They also had a higher percentage of metabolic syndrome, diabetes, and hyperlipidemia, but lower LDL and HDL.

We analyzed the correlation between SBP and obesity indices. The age adjusted Pearson's coefficient of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively (Table 2, Figure 1). In addition, multiple logistic regression on the HTN-related obesity indices showed that the odds ratio of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively (Table 3).

Table 1 General characteristics of the study population according to HTN and non-HTN.

	HTN			
	Total	Yes	No	
Variables	(n=396)	(n=200)	(n=196)	p value
Age (year)	64.44 ± 8.46	65.63 ± 8.53	63.23 ± 8.23	0.005
SBP (mmHg)	129.61 ± 16.70	138.51 ± 15.92	120.53 ± 11.92	<0.001
DBP (mmHg)	77.10 ± 11.28	81.24 ± 11.74	72.88 ± 9.04	<0.001
BMI (kg/m^2)	24.55 ± 3.50	25.35 ± 3.83	23.73 ± 2.92	<0.001
BF percentage (%)	29.98 ± 8.41	30.92 ± 8.46	29.02 ± 8.27	0.025
WC (cm)	85.12 ± 9.66	87.52 ± 10.31	82.67 ± 8.28	<0.001
ALT (U/L)	22.67 ± 13.00	22.81 ± 12.66	22.53 ± 13.38	0.834
Creatinine (mg/dL)	0.77 ± 0.43	0.82 ± 0.42	0.72 ± 0.43	0.019
FPG (mg/dL)	96.31 ± 25.84	100.18 ± 29.85	92.36 ± 20.29	0.002
HDL-C (mg/dL)	54.29 ± 13.81	52.13 ± 13.91	56.49 ± 13.39	0.002
LDL-C (mg/dL)	118.54 ± 32.19	115.05 ± 30.87	122.11 ± 33.18	0.029
TC (mg/dL)	197.30 ± 35.80	194.29 ± 35.16	200.37 ± 36.28	0.091
TG (mg/dL)	122.68 ± 66.00	136.02 ± 74.02	109.08 ± 53.52	<0.001
Uric acid (mg/dL)	5.75 ± 1.40	5.94 ± 1.47	5.56 ± 1.31	0.007
Men, n(%)	140 (35.35%)	76 (38.00%)	64 (32.65%)	0.266
Alcohol drinking, n(%)	75 (18.94%)	36 (18.00%)	39 (19.90%)	0.630
Current smoking, n(%)	43 (10.86%)	24 (12.00%)	19 (9.69%)	0.461
Regular exercise, n(%)	325 (82.07%)	160 (80.00%)	165 (84.18%)	0.278
Education years, n(%)				0.294
≦ 6	205 (51.77%)	111 (55.50%)	94 (47.96%)	
7~12	157 (39.65%)	72 (36.00%)	85 (43.37%)	
> 12	34 (8.59%)	17 (8.50%)	17 (8.67%)	
Current single, n(%)	74 (18.69%)	49 (24.50%)	25 (12.76%)	0.003

Metabolic syndrome, n(%)	143	(36.11%)	108	(54.00%)	35	(17.86%)	<0.001
DM, n(%)	79	(19.95%)	51	(25.50%)	28	(14.29%)	0.005
Hyperlipidemia, n(%)	260	(65.66%)	137	(68.50%)	123	(62.76%)	0.229

Notes: Clinical characteristics are expressed as mean±SD for continuous variables and n(%) for categorical variables. P-value were derived from independent t-test for continuous variables and chi-square test for categorical variables.

Abbreviations: HTN, hypertension; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; BF, body fat; WC, waist circumference; ALT, alanine aminotransferase; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride; DM, diabetes mellitus.

Table 2 The correlation between SBP and obesity indices.

Variables	SBP (n=396)			
	Unadjusted		Adjusted for age	
	Pearson's coefficient	p value	Pearson's coefficient	p value
BMI (kg/m^2)	0.22	<0.001	0.23	<0.001
BF percentage (%)	0.13	0.01	0.14	0.01
WC (cm)	0.26	<0.001	0.26	<0.001

Abbreviations: SBP, systolic blood pressure; BMI, body mass index; BF, body fat; WC, waist circumference.

Finally, AUC of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681, $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694, $p < 0.001$), respectively (Figure 2). WC had the largest AUC for predicting HTN.

Table 3

Multiple logistic regression on the obesity indices related to the HTN among screened population (n=396).

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1[†]	1.15	(1.08-1.23)	<0.001	1.03	(1.00-1.05)	0.03	1.06	(1.03-1.08)	<0.001
Model 2[‡]	1.16	(1.09-1.24)	<0.001	1.08	(1.04-1.11)	<0.001	1.06	(1.03-1.09)	<0.001
Model 3[§]	1.15	(1.08-1.23)	<0.001	1.07	(1.03-1.11)	<0.001	1.06	(1.03-1.08)	<0.001

[†]Model 1: Unadjusted.

[‡]Model 2: Multiple logistic regression adjusted for age and sex.

[§]Model 3: Multiple logistic regression adjusted for factors in model 2 plus DM and Hyperlipidemia.

Abbreviations: BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; CI, confidence interval.

DISCUSSION

Our study revealed a positive correlation between all obesity indices and HTN. BMI, BF percentage, and WC were found to be associated with HTN or higher systolic pressure through independent T-test, Chi-square test, correlation analysis, and multivariate analysis. In the AUC, WC had the largest AUC for predicting HTN. Clinical adiposity indices, such as BMI and WC, were linked with HTN in review articles [15 16]. A Chinese study has shown that women with obesity defined by BMI or WC have an increased risk of developing HTN [11]. Another study on predicting HTN with different obesity indices has shown similar conclusions [12]. Compared with BMI, WC has a stronger association with HTN development [12].

A Korean study has shown a similar outcome to that of our study [17]. The central obesity index, WC, is better than BMI in predicting HTN in middle-aged Korean people [17]. The relationship between central obesity and HTN has also been mentioned in previous reviews [18 19]. Visceral obesity and leptin play a crucial role in the development of HTN in patients with obesity [18]. Fat is an important endocrine organ in patients with obesity. Adipokines, such as adiponectin, leptin and resistin, may result in arterial stiffness, and predispose to endothelial dysfunction and HTN [19].

Our study suggested that the optimal cut-off point for predicting HTN of BMI was 25.45 kg/m^2, for BF percentage was 35.15%, and for WC was 88.5cm. However, another study of younger population (40 to 59 years old) has suggested that the optimal BMI and WC cut-off values are 29.57 kg/m^2 and 90.5 cm [20]. Because age is also a risk factor for HTN, the cutoff point of BMI for elderly is lower. Similar to the results of the BMI-obesity literature review, other age-related studies have shown conflicting results [13]. A study in Nigeria has found that BMI and WC are both good predictors of HTN risk.

However, there was no significant difference between the AUC of BMI and WC [13]. In a Chinese rural cohort study, BMI was superior to WC for predicting incident HTN in both genders [21]. Another study among Chinese elderly has shown a gender difference in predicting HTN with obesity indices [14]. It shows that BMI is associated with a significant risk of developing HTN in men only [14]. Finally, a study has shown that the obesity indices prediction differed between genders [22]. The combination of BMI + WC can improve the measurement of HTN risk [22].

There were several limitations in our study. First, cross-sectional study can not effectively determine the causal relationship between obesity indices and HTN. Second, the number of participants in this study came from a relatively small community. Selection bias should be considered.

BMI, BF percentage, and WC were all positively associated with HTN with statistical significance. Of the three indices, WC was the most reliable predictor factor for HTN. Thus, there is a strong implication that abdominal fat distribution has more influences on blood pressure than total BF amount among middle-aged and elderly populations.

Authors' contributions Yen-An Lin was involved in writing of the manuscript. Ying-Jen Chen, Yu-Chung Tsao, Wei-Chung Yeh, Wen-Cheng Li and I-Shiang Tzeng provided opinions about the study designs and help collect data. Jau-Yuan Chen contributed conceived, designed and performed the experiments, collected and analyzed the data, revising it critically for important intellectual content and final approval of the version to be submitted.

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Competing interests None declared.

Ethics approval The study was approved by Chang-Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Data sharing statement No additional data are available.

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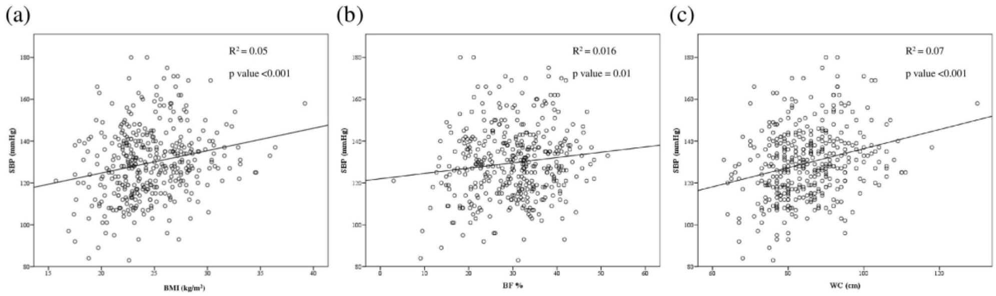
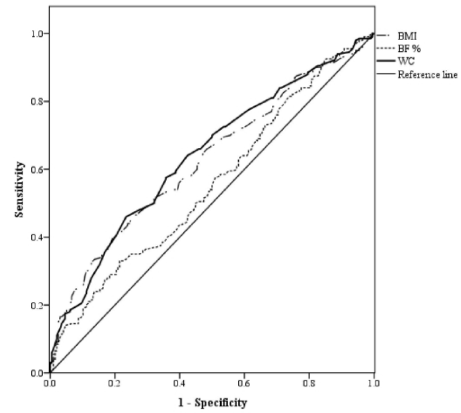


Figure 1 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP.

Figure 1 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP.

275x95mm (300 x 300 DPI)



Variables	AUC(95% CI)	p value	Cut-off point	Sensitivity	Specificity
BMI (kg/m^2)	0.626 (0.572-0.681)	<0.001	25.450	0.465	0.745
BF percentage (%)	0.556 (0.500-0.613)	0.052	35.150	0.330	0.786
WC (cm)	0.640 (0.586-0.694)	<0.001	88.500	0.460	0.765

Figure 2 ROC curves for obesity indices as predictors of HTN.

Figure 2 ROC curves for obesity indices as predictors of HTN.

275x190mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6,7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,10
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	9,12,13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9,12,13
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15,16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

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The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

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ABSTRACT

Objective: Obesity and hypertension (HTN) have become increasingly prevalent in Taiwan. People with obesity are more likely to have HTN. In this study, we evaluated the best obesity index for predicting HTN in middle-aged and elderly populations in Taiwan.

Design: Cross-sectional observational study.

Setting: Community-based investigation in Guishan township of northern Taiwan.

Participants: This study recruited 396 people from a northern Taiwan community for a cross-sectional study. Anthropometrics and blood pressure were measured by the annual health exam. The obesity indices included BMI, BF percentage and WC.

Outcome measures: Statistical analyses including Pearson's correlation, multiple logistic regression, and the area under ROC curves (AUC) between HTN and obesity indices were used in this study.

Results: Of the 396 people recruited, 200 had HTN. The age-adjusted Pearson's coefficients of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively. Multiple logistic regression on the HTN-related obesity indices showed that the odds ratio of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively. The AUC of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681, $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694, $p < 0.001$), respectively.

Conclusions: WC is a more reliable predictor for HTN in comparison to BMI and BF percentage. The effect of abdominal fat distribution on blood pressure is greater than that on total BF amount.

Keywords: Abdominal Fat, Elderly, Hypertension, Middle-Aged, Obesity Index

Strengths and limitations of this study:

- We conducted a community-based study and comprehensively collected various patient data from a health promotion project.
- Waist circumference is a more reliable predictor for hypertension in comparison to BMI and body fat percentage.
- Abdominal fat distribution influences more on blood pressure than total body fat amount among middle-aged and elderly populations.
- Cross-sectional study cannot effectively determine the causal relationship between obesity indices and hypertension.
- The number of participants in this study came from a relatively small community. Selection bias should be considered.

INTRODUCTION

The prevalence of obesity has increased progressively in Taiwan, particularly among the elderly. However, the precise definition of obesity in the elderly has yet to be developed [1]. Traditionally, body mass index (BMI), waist circumference (WC), and body fat (BF) percentage have been used to evaluate obesity. The cut-off values of these obesity indices have not been defined for the elderly population [1], because sarcopenia causes loss of muscle mass and fatty tissues increase with aging [2]. Aging and sarcopenia cause muscle loss and increase fat deposition, making BMI an inaccurate reference. Lower BMI in the elderly may not indicate the lower BF percentage, as it could be correlated with muscle loss coupled with relative BF increase.

The utility of different types of obesity indices has been discussed in the past. If the BF percentage by Dual-energy X-ray absorptiometry (DXA) is regarded as a gold standard, it would be hard to assess as the sensitivity and specificity of BMI vary with gender [3]. For older women, a BMI of 25 has the best sensitivity and specificity. For older men, a BMI of 27 is the most appropriate. Different obesity indices show different comorbidity risks. WC is more strongly associated with high risk of cardiovascular disease (CVD) than BMI among middle-aged and elderly persons in Taiwan [4,5]. BMI and WC are more positively correlated with insulin resistance than BF percentage [6].

Hypertension (HTN) is also a common problem among the elderly with increasing prevalence, with associated risks of cardiovascular disease, stroke, and chronic kidney disease [7]. It has different effects in different age groups. Isolated systolic HTN is predominant in the elderly [8]. There are many physiological changes related to the development of HTN in the elderly, such as arterial stiffness, widening pulse pressure, changes in renin and aldosterone levels, decreased renal salt excretion, declined renal function, changes in the autonomic nervous system sensitivity and function, and changes in endothelial function [9].

Obesity is a major risk factor for essential HTN [10-12]. The development of HTN caused by obesity can occur via multiple mechanisms: insulin resistance, adipokine alterations, inappropriate sympathetic nerve system and renin-angiotensin-aldosterone system activation, structural and functional abnormalities in the kidney, heart and vascular change, and immune maladaptation [10,13]. Uric acid and incretin or dipeptidyl peptidase 4 activity alteration also contribute to the development of HTN in obesity [13]. Different obesity indices have different correlations with HTN. High levels of BMI and WC have increased the risks of HTN among rural Chinese women [14,15]. WC is more strongly associated with the development of HTN than BMI [16]. In another study, no significant difference in HTN prediction between BMI and WC was found [17]. Another similar study showed that the association of obesity indices with HTN in Chinese elderly differs by gender and age [18]. BMIs in men and hip circumferences in women showed a significant impact on the risk of HTN [18]. Collectively, it appears that the relationship between various obesity indices and HTN has been relatively well established in the general population, but not in middle-aged and elderly population, an age group that has high risk of HTN. This study was designed to investigate the relationship between different obesity indices and HTN among middle-aged and elderly Taiwanese populations.

METHODS

Study design and study population

This is a cross-sectional, community-based study. We collected data from a community health promotion project of Linkou Chang Gung Memorial Hospital between February and August 2014. A total of 619 subjects aged 50 years or older through poster promotion or notification from the community office participated in this project. After exclusion, 400 subjects were eligible to be enrolled to this study. Four subjects were further excluded due to missing data (Figure 1).As a result, 396 participants were enrolled and all participants completed a questionnaire including personal information and medical history (Supplemental Information) during a face-to-face interview. Anthropometric measurements by trained research assistants or nurses were conducted under the supervision of a medical doctor. Exclusion criteria included: (1) Participants with coronary artery disease, cerebrovascular disease, peripheral artery disease, or heart failure; (2) Participants with secondary hypertension or medications which increase BP; and (3) Participants with incomplete or missing data. Only 4 participants were excluded without measuring BF percentage. Finally, there were 396 participants enrolled in the analysis. The study was approved by Chang Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Anthropometric and laboratory measurements

Each participant was required to complete a questionnaire. The questionnaires were recorded by trained interviewers based on face-to-face interviews. Basic personal data included age, gender, systolic blood pressure (SBP), diastolic blood pressure (DBP), education level, history of HTN, diabetes, metabolic syndrome, and hyperlipidemia. Lifestyles included alcohol drinking, current smoking, and regular exercise. HTN was defined as SBP ≧ 140mmHg or DBP ≧ 90mmHg, or current use of antihypertensive medications, or history of HTN. The definition of HTN was based upon the 2015 Guidelines of the Taiwan Society of Cardiology and the Taiwan Hypertension Society for the Management of Hypertension. Laboratory data included alanine aminotransferase (ALT), creatinine, fasting sugar, high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol, triglyceride, and uric acid. Each participant's blood pressure was measured on the right arm in sitting position using a standardized electronic sphygmomanometer (OMRON, model HEM-7130). The participants rested for at least 5 minutes in seated position before the measurements, with their arms supported at the heart level. We measured blood pressure in each subject for 3 times separated by an interval of 10 minutes, and calculated the mean value of these three readings. The obesity indices included BMI, BF percentage and WC. BF percentage was measured with an 8-contact electrode bioelectrical impedance analysis (BIA) device (Tanita BC-418, Tanita, Tokyo, Japan). BMI was calculated as weight / height^2 (kg/m^2). WC was measured at the level midway between the iliac crests and the lowest rib margin at minimal respiration in a standing position.

Statistical analysis

The minimum sample size for this study was calculated at the initial stage of the study. After previewing a relative smaller population, we found that the Non-HTN to HTN ratio was approximately 1:1. Considering 90% power, 95% confidence level, 0.30 as the exposure (obesity) rate among the Non-HTN, and a Non-HTN to HTN ratio of 1:1, we calculated that 308 participants were required to detect at least 2 odds ratio differences between these two study groups.

The normality of continuous variables was evaluated by the Kolmogorov-Smirnov test. We expressed all continuous variables as mean and standard deviation, while categorical variables were expressed as numbers and percentages. In univariate analysis, independent T-test and Chi-square test were used to compare HTN and non-HTN subjects. Correlations were assessed with Pearson's correlation coefficient and the coefficient of determination (r^2) between different obesity indices and blood pressures. In multivariate analysis, binary logistic regression was used to adjust covariates. Receiver operating characteristic (ROC) curves were generated for BF percentage, WC, and BMI as predictors of HTN. The area under the ROC curve (AUC) and the optimal cut-off points for HTN prediction of BMI, WC, and BF percentage were determined by the largest sum of specificity and sensitivity. The analysis was performed with SPSS Statistics version 22 (IBM, SPSS Armonk, NY, IMM Corp).

Patient and public involvement

No patient involved.

RESULTS

A total of 396 participants were enrolled in the analysis, and 200 had HTN(SBP ≧ 140mmHg or DBP ≧ 90mmHg), with a prevalence of 50.5%. The average age was 64.44 years. There were no significant static differences in alcohol drinking, current smoking, ALT, total cholesterol, regular exercise, and dyslipidemia between people with and without HTN. People with HTN had higher level of BMI, WC, BF percentage, fasting sugar, triglyceride, uric acid, and creatinine with static significance (Table 1). They also had a higher percentage of metabolic syndrome, diabetes, and hyperlipidemia, but lower LDL and HDL.

We analyzed the correlation between SBP and obesity indices. The age adjusted Pearson's coefficient of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively (Table 2, Figure 2). In addition, multiple

159 logistic regression on the HTN-related obesity indices showed that the odds ratio of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively (Table 3). Further multiple logistic regression analyses revealed that these obesity indices remained independent risk factors for HTN in the subgroup of participants with an age ≧ 65 years old (Table 4a) or with either sex (Table 4b and 4c). The odds ratio of BMI, BF percentage, and WC were 1.11 (95% CI = 1.00-1.22, p = 0.047), 1.06 (95% CI = 1.01-1.12, p = 0.03), and 1.04 (95% CI = 1.00-1.08, p = 0.04), respectively, in the subgroup of participants with an age ≧ 65 years old (Table 4a). The odds ratio of BMI, BF percentage, and WC were 1.19 (95% CI = 1.06-1.33, p = 0.002), 1.11 (95% CI = 1.03-1.19, p = 0.003), and 1.08 (95% CI = 1.03-1.12, p = 0.01), respectively, in the subgroup of male participants (Table 4b). The odds ratio of BMI, BF percentage, and WC were 1.13 (95% CI = 1.04-1.23, p = 0.003), 1.06 (95% CI = 1.01-1.10, p = 0.01), and 1.04 (95% CI = 1.01-1.08, p = 0.01), respectively, in the subgroup of female participants (Table 4c).

Table 1 General characteristics of the study population according to HTN and non-HTN.

		HTN		
	Total	Yes	No	
Variables	(n=396)	(n=200)	(n=196)	p value
Age (year)	64.44 ± 8.46	65.63 ± 8.53	63.23 ± 8.23	0.005
SBP (mmHg)	129.61 ± 16.70	138.51 ± 15.92	120.53 ± 11.92	<0.001
DBP (mmHg)	77.10 ± 11.28	81.24 ± 11.74	72.88 ± 9.04	<0.001
BMI (kg/m^2)	24.55 ± 3.50	25.35 ± 3.83	23.73 ± 2.92	<0.001
BF percentage (%)	29.98 ± 8.41	30.92 ± 8.46	29.02 ± 8.27	0.025

WC (cm)	85.12 ± 9.66	87.52 ± 10.31	82.67 ± 8.28	<0.001
ALT (U/L)	22.67 ± 13.00	22.81 ± 12.66	22.53 ± 13.38	0.834
Creatinine (mg/dL)	0.77 ± 0.43	0.82 ± 0.42	0.72 ± 0.43	0.019
FPG (mg/dL)	96.31 ± 25.84	100.18 ± 29.85	92.36 ± 20.29	0.002
HDL-C (mg/dL)	54.29 ± 13.81	52.13 ± 13.91	56.49 ± 13.39	0.002
LDL-C (mg/dL)	118.54 ± 32.19	115.05 ± 30.87	122.11 ± 33.18	0.029
TC (mg/dL)	197.30 ± 35.80	194.29 ± 35.16	200.37 ± 36.28	0.091
TG (mg/dL)	122.68 ± 66.00	136.02 ± 74.02	109.08 ± 53.52	<0.001
Uric acid (mg/dL)	5.75 ± 1.40	5.94 ± 1.47	5.56 ± 1.31	0.007
Men, n(%)	140 (35.35%)	76 (38.00%)	64 (32.65%)	0.266
Alcohol drinking, n(%)	75 (18.94%)	36 (18.00%)	39 (19.90%)	0.630
Current smoking, n(%)	43 (10.86%)	24 (12.00%)	19 (9.69%)	0.461
Regular exercise, n(%)	325 (82.07%)	160 (80.00%)	165 (84.18%)	0.278
Education years, n(%)				0.294
≦ 6	205 (51.77%)	111 (55.50%)	94 (47.96%)	
7~12	157 (39.65%)	72 (36.00%)	85 (43.37%)	
> 12	34 (8.59%)	17 (8.50%)	17 (8.67%)	
Current single, n(%)	74 (18.69%)	49 (24.50%)	25 (12.76%)	0.003
Metabolic syndrome, n(%)	143 (36.11%)	108 (54.00%)	35 (17.86%)	<0.001
DM, n(%)	79 (19.95%)	51 (25.50%)	28 (14.29%)	0.005
Hyperlipidemia, n(%)	260 (65.66%)	137 (68.50%)	123 (62.76%)	0.229

Notes: Clinical characteristics are expressed as mean±SD for continuous variables and n(%) for categorical variables. P-value were derived from independent t-test for continuous variables and chi-square test for categorical variables.

Abbreviations: HTN, hypertension; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; BF, body fat; WC, waist circumference; ALT, alanine aminotransferase; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, 183 triglyceride; DM, diabetes mellitus.

184 **Table 2** The correlation between SBP and obesity indices.

Variables	SBP (n=396)			
	Unadjusted		Adjusted for age	
	Pearson's coefficient	p value	Pearson's coefficient	p value
BMI (kg/m^2)	0.22	<0.001	0.23	<0.001
BF percentage (%)	0.13	0.01	0.14	0.01
WC (cm)	0.26	<0.001	0.26	<0.001

185 **Abbreviations:** SBP, systolic blood pressure; BMI, body mass index; BF, body
186 fat; WC, waist circumference.

187

188 Finally, AUC of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681,
189 $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694,
190 $p < 0.001$), respectively (Figure 3). WC had the largest AUC for predicting HTN.

Table 3

Multiple logistic regression on the obesity indices related to the HTN among screened population (n=396).

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.15	(1.08-1.23)	<0.001	1.03	(1.00-1.05)	0.03	1.06	(1.03-1.08)	<0.001
Model 2‡	1.16	(1.09-1.24)	<0.001	1.08	(1.04-1.11)	<0.001	1.06	(1.03-1.09)	<0.001
Model 3§	1.15	(1.08-1.23)	<0.001	1.07	(1.03-1.11)	<0.001	1.06	(1.03-1.08)	<0.001

†Model 1: Unadjusted.

‡Model 2: Multiple logistic regression adjusted for age and sex.

§Model 3: Multiple logistic regression adjusted for factors in model 2 plus DM and Hyperlipidemia.

Abbreviations: BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; CI, confidence interval.

Table 4

Subgroup analyses of the association of obesity indices and HTN according to age and gender.

(a) Age≧65 years old (n=166)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.09	(0.99-1.20)	0.06	1.04	(1.00-1.08)	0.04	1.03	(1.00-1.06)	0.08
Model 2‡	1.10	(1.00-1.21)	0.05	1.05	(1.00-1.11)	0.0497	1.04	(1.00-1.07)	0.04
Model 3§	1.11	(1.00-1.22)	0.047	1.06	(1.01-1.12)	0.03	1.04	(1.00-1.08)	0.04

(b) Male (n=140)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.17	(1.06-1.30)	0.002	1.10	(1.03-1.17)	0.004	1.07	(1.03-1.12)	<0.001
Model 2‡	1.08	(1.03-1.12)	<0.001	1.10	(1.03-1.17)	0.003	1.08	(1.03-1.12)	<0.001
Model 3§	1.19	(1.06-1.33)	0.002	1.11	(1.03-1.19)	0.003	1.08	(1.03-1.12)	0.001

(c) Female (n=256)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.14	(1.05-1.23)	0.001	1.06	(1.02-1.11)	0.004	1.05	(1.02-1.09)	0.001
Model 2‡	1.14	(1.05-1.23)	0.002	1.06	(1.02-1.11)	0.01	1.05	(1.01-1.08)	0.004
Model 3§	1.13	(1.04-1.23)	0.003	1.06	(1.01-1.10)	0.01	1.04	(1.01-1.08)	0.01

†Model 1: Unadjusted.

‡Model 2: Multiple logistic regression adjusted for age and sex.

§Model 3: Multiple logistic regression adjusted for factors in model 2 plus DM and Hyperlipidemia.

Abbreviations: BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; CI, confidence interval.

DISCUSSION

Our study revealed a positive correlation between all obesity indices and HTN. BMI, BF percentage, and WC were found to be associated with HTN or higher systolic pressure through independent T-test, Chi-square test, correlation analysis, and multivariate analysis. These obesity indices remained independent risk factors for HTN in the subgroup of participants with an age ≧ 65 years old (a population with a high expected prevalence of sarcopenia) or with either sex. In the AUC, WC had the largest AUC for predicting HTN. Clinical adiposity indices, such as BMI and WC, were linked with HTN in review articles [19,20]. A Chinese study has shown that women with obesity defined by BMI or WC have an increased risk of developing HTN [14]. Another study on predicting HTN with different obesity indices has shown similar conclusions [16]. Compared with BMI, WC has a stronger association with HTN development [16]. However, these previous observations were mainly from the general population. Thus, the novel findings of this study are the association between various obesity indices and HTN in middle-aged and elderly population, an age group that has high risk of HTN.

A Korean study has shown a similar outcome to that of our study [21]. The central obesity index, WC, is better than BMI in predicting HTN in middle-aged Korean people [21]. The relationship between central obesity and HTN has also been mentioned in previous reviews [22,23]. Visceral obesity and leptin play a crucial role in the development of HTN in patients with obesity [22]. Fat is an important endocrine organ in patients with obesity. Adipokines, such as adiponectin, leptin and resistin, may result in arterial stiffness, and predispose to endothelial dysfunction and HTN [23].

Our study suggested that the optimal cut-off point for predicting HTN of BMI was 25.45 kg/m^2, for BF percentage was 35.15%, and for WC was 88.5cm. However, another study of younger population (40 to 59 years old) has suggested that the optimal BMI and WC cut-off values are 29.57 kg/m^2 and 90.5 cm [24]. Because age is also a risk factor for HTN, the cutoff point of BMI for elderly is lower. Similar to the results of the BMI-obesity literature review, other age-related studies have shown conflicting results [17]. A study in Nigeria has found that BMI and WC are both good predictors of HTN risk. However, there was no significant difference between the AUC of BMI and WC [17]. In a Chinese rural cohort study, BMI was superior to WC for predicting incident HTN in both genders [25]. Another study among Chinese elderly has shown a gender difference in predicting HTN with obesity indices [18]. It shows that BMI is associated with a significant risk of developing HTN in men only [18]. Finally, a study has shown that the obesity indices prediction differed between genders [26]. The combination of BMI + WC can improve the measurement of HTN risk [26].

There were several limitations in our study. First, cross-sectional study cannot effectively determine the causal relationship between obesity indices and HTN. Second, the number of participants in this study came from a relatively small community. Selection bias should be considered. Third, our findings were obtained from community-based subjects and cannot be generalized to the whole middle-aged and elderly population in Taiwan. Fourth, we could not well define the stages of smoking/drinking or the regularity of exercise. This is because these items were included in the questionnaire used in your study, which was designed for community participants during health examination.

BMI, BF percentage, and WC were all positively associated with HTN with statistical significance. Of the three indices, WC was the most reliable predictor factor for HTN. Thus, there is a strong implication that abdominal fat distribution has more influences on blood pressure than total BF amount among middle-aged and elderly populations. Thus, our findings may provide valuable information for clinicians to alert subjects in this age group regarding the increased risk of HTN.

Authors' contributions Yen-An Lin was involved in writing of the manuscript. Ying-Jen Chen, Yu-Chung Tsao, Wei-Chung Yeh, Wen-Cheng Li and I-Shiang Tzeng provided opinions about the study designs and help collect data. Jau-Yuan Chen contributed conceived, designed and performed the experiments, collected and analyzed the data, revising it critically for important intellectual content and final approval of the version to be submitted.

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Competing interests None declared.

Ethics approval The study was approved by Chang-Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Data sharing statement No data are available.

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Figure Legends

Figure 1 Flowchart of the study

Figure 2 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP. BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

Figure 3 ROC curves for obesity indices as predictors of hypertension (HTN). BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

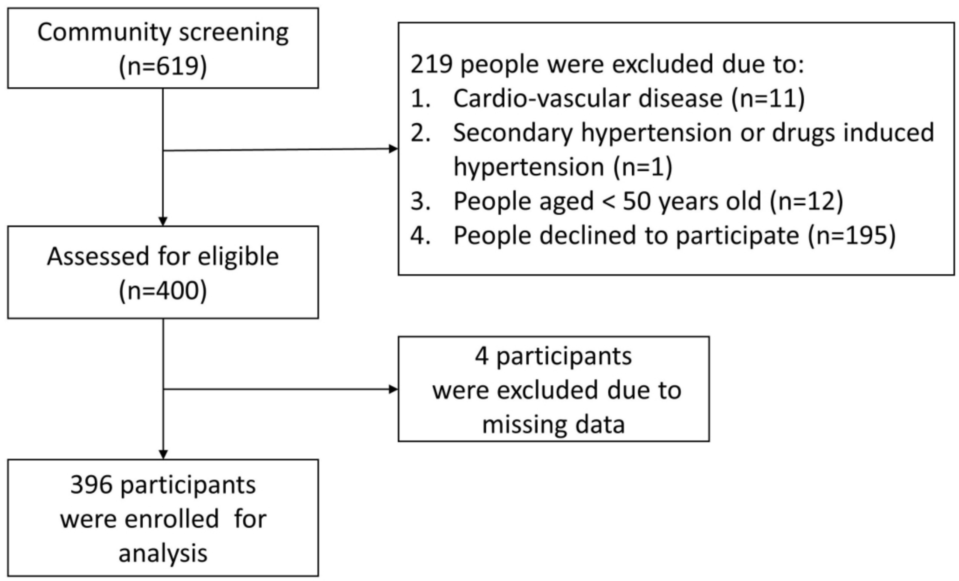

Figure 1 Flowchart of the study

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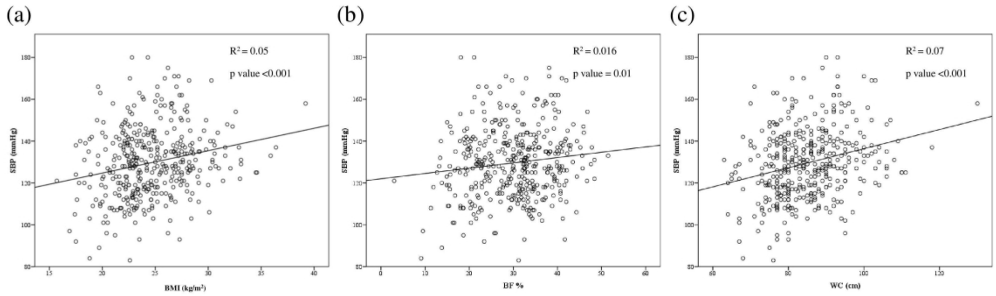
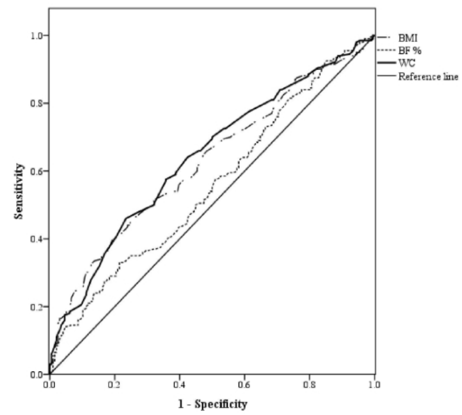


Figure 2 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP. BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

275x86mm (300 x 300 DPI)



Variables	AUC(95% CI)	p value	Cut-off point	Sensitivity	Specificity
BMI (kg/m^2)	0.626 (0.572-0.681)	<0.001	25.450	0.465	0.745
BF percentage (%)	0.556 (0.500-0.613)	0.052	35.150	0.330	0.786
WC (cm)	0.640 (0.586-0.694)	<0.001	88.500	0.460	0.765

Figure 3 ROC curves for obesity indices as predictors of hypertension (HTN). BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

275x178mm (300 x 300 DPI)

Supplemental Information

The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

Yen-An Lin, Ying-Jen Chen, Yu-Chung Tsao, Wei-Chung Yeh, Wen-Cheng Li, I-Shiang Tzeng, Jau-Yuan Chen

Table S1 Collinearity of obesity indices

Variables	BMI (kg/m^2)		BF percentage (%)		WC (cm)	
	r	p value	r	p value	r	p value
BMI (kg/m^2)	-	-	0.62	<0.001	0.80	<0.001
BF percentage (%)	0.62	<0.001	-	-	0.30	<0.001
WC (cm)	0.80	<0.001	0.30	<0.001	-	-

Abbreviations: BMI, body mass index; BF body fat percentage; WC, waist circumference.

※請接續下一頁※

This questionnaire was prepared in Chinese because it was designed for the survey of the Taiwanese people.

健康問卷

編號 ____________________ 收案時間 20_____/_____/_____

一、 基本資料

A.性別	① 男 ② 女
B.保險狀況	① 有，除健保外之________保(勞.漁.農.公.其他) ② 無
C.血型	① A ② B ③ O ④ AB ⑤ 不知道
D.婚姻狀況	① 未婚 ② 已婚 ③ 離婚或分居 ④ 鰥寡 婚姻年數________ 生育子女數________
E.教育程度	① 不識字 ② 小學程度 ③ 國中程度 ④ 高中程度 ⑤ 大專程度 ⑥ 研究所以上
F.宗教信仰	① 無 ② 一般民間信仰 ③ 道教 ④ 佛教 ⑤ 基督教 ⑥ 天主教 ⑦ 回教 ⑧ 其他______
G.父親氏族	① 台閩 ② 客家 ③ 原住民 ④ 外省籍，______省 ⑤ 其他_____
H.母親氏族	① 台閩 ② 客家 ③ 原住民 ④ 外省籍，______省 ⑤ 其他_____
I.居住成員 (可複選)	① 子女，共_____人 ② 孫子女，共_____人 ③ 配偶 ④ 獨居 ⑤ 媳婦 ⑥ 其他_____
J.經濟來源 (可複選)	① 父母 ② 子女 ③ 配偶 ④ 手足 ⑤ 政府 ⑥ 朋友 ⑦ 自己 ⑧ 其他________
K.自我照護	① 完全獨立 ② 需旁人協助 ③ 完全由旁人照顧
L.照顧者	① 自理 ② 父母 ③ 配偶 ④ 手足

※請繼續下一頁※

(可複選) ⑤ 子女 ⑥ 媳婦 ⑦ 看護 ⑧ 其他________

M.飲食習慣 ① 葷 ② 素 ③ 早素 ④ 其他______

N.基本生理
身高______公分 體重______公斤 腹圍______公分 心跳______次／分鐘
收縮壓______毫米汞柱 舒張壓______毫米汞柱 握力______Kg 行走______秒

O.病史（例：糖尿病、高血壓、高血脂）____

P.職業（請填代號）______ （若您已退休，請填您退休前的工作）

【行業】 0：農、林、漁、牧、狩獵業 1：礦業及土石採取業 2：製造業 3：水電燃氣業 4：營造業
5：商業 6：運輸、倉儲、及通信業 7：金融、保險、不動產、及工商服務業
8：公共行政社會服務及個人服務業 9：軍公教 10：其他 ________

二、 健康行為及用藥認知習慣

A.抽菸

(1) 您現在是否有抽菸的習慣？ ① 沒有 ② 有

B.喝酒

(1) 您現在是否有喝酒的習慣？ ① 沒有 ② 有

C.嚼檳榔

(1) 您現在是否有嚼檳榔的習慣？ ① 沒有 ② 有

D.活動量及飲食習慣

(1) 請問您一天有多少時間需要走動？

① 大部份時間坐著 ② 少於半天需要走動
③ 約半天時間需要走動 ④ 大部份時間需要走動

(2) 您活動時，需要搬重物嗎？

① 不需要 ② 很少 ③ 有時 ④ 經常需要 ⑤ 每天都要

(3) 您平均每星期運動幾次？______次

(4) 飲食習慣

※請繼續下一頁※

(4.1) 請問您認為中老年人每天都應該吃蔬菜、水果嗎？
① 是 ② 否 ③ 不知道

(4.2) 請問您認為中老年人每天都應該吃魚、肉、豆或蛋類食物嗎？
① 是 ② 否 ③ 不知道

(4.3) 食物好不好吃，比它是否有益健康來得重要？
① 是 ② 否 ③ 不知道

(4.4) 您常吃蔬菜或水果嗎？
① 幾乎每天吃 ② 每周三到五次 ③ 每周二次或以下

(4.5) 請問您是否常常三餐不定時、不定量？
① 很少或無 ② 每周三到五次 ③ 幾乎每天

E.藥物接觸

(1) 您是否長時間(一個月以上)服用**止痛-抗發炎類藥物**，包括針劑？
① 是 ② 否(請跳答(2))

(1.1) 您是否有經醫師診斷？ ① 是 ② 否

(1.2) 這幾天是否還持續吃藥？ ① 是 ② 否

(2) 您是否正在服用**高血壓藥物**？

① 是 (每天______次) ② 否(請跳答(3))

若是，則您從幾歲開始服藥？______歲

(2.1) 您是否曾經忘記服藥？ ① 是 ② 否

(2.2) 您認為不需要按時服用藥物嗎？ ① 是 ② 否

(2.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是 ② 否

(2.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是 ② 否

(2.5) 若您有未按時服高血壓藥的經驗，未按時服藥的原因為?(可複選)
① 感覺症狀改善 ② 我不相信藥物會讓病情改善 ③ 我不信任醫師
④ 服藥種類太多 ⑤ 醫師未向我解釋足夠的藥物資訊 ⑥ 副作用
⑦ 忘記 ⑧ 一天服藥次數太多或服藥時間複雜 ⑨ 接受其他療法(如中藥)
⑩ 其他________

※請繼續下一頁※

(3) 您是否正在服用**糖尿病藥物**，包括針劑？

① 是 (每天______次)　② 否　(請跳答(4))

若是，則您從幾歲開始服藥？______歲

(3.1) 您是否曾經忘記服藥？ ① 是　② 否

(3.2) 您認為不需要按時服用藥物嗎？ ① 是　② 否

(3.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是　② 否

(3.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是　② 否

(3.5) 若您有未按時服糖尿病藥的經驗，未按時服藥的原因為?(可複選)

① 感覺症狀改善　② 我不相信藥物會讓病情改善　③ 我不信任醫師
④ 服藥種類太多　⑤ 醫師未向我解釋足夠的藥物資訊　⑥ 副作用
⑦ 忘記　⑧ 一天服藥次數太多或服藥時間複雜　⑨ 接受其他療法(如中藥)
⑩ 其他________

(4) 您是否正在服用**降血脂藥物**，包括針劑？

① 是 (每天______次)　②否　(請跳答 F)

若是，則您從幾歲開始服藥？______歲

(4.1) 您是否曾經忘記服藥？ ① 是　② 否

(4.2) 您認為不需要按時服用藥物嗎？ ① 是　② 否

(4.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是　② 否

(4.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是　② 否

(4.5) 若您有未按時服降血脂藥物的經驗，未按時服藥的原因為?(可複選)

① 感覺症狀改善　② 我不相信藥物會讓病情改善　③ 我不信任醫師
④ 服藥種類太多　⑤ 醫師未向我解釋足夠的藥物資訊　⑥ 副作用
⑦ 忘記　⑧ 一天服藥次數太多或服藥時間複雜　⑨ 接受其他療法(如中藥)
⑩ 其他________

F.請問您是否曾吃補藥（燉補品）、中藥或喝補酒之習慣？

① 經常　② 偶爾　③ 未曾

G.請問您是否曾吃維他命等健康營養補充品？

① 經常　② 偶爾　③ 未曾

※請繼續下一頁※

H.您目前看病的科別有多少科？________科

(1) 承上，正在服用哪些疾病的藥物？________________________________(請填疾病名稱)

(2) 承上，若有您每日服藥________次，每日共吃________粒藥

(3) 承上，您吃的藥目前是否有剩？① 是，原因______________________ ② 否

I.用藥認知評值，您認為下列敘述是否正確？

（1） 服藥時可搭配茶或果汁來配藥。 ① 是 ② 否

（2） 為避免家中藥品變質，應全都放在冰箱保存。① 是 ② 否

（3） 如果忘記吃藥應在下一次吃兩倍的藥量，避免病情控制不好。 ① 是 ② 否

（4） 我到醫療院所看病時，不需要提醒醫師自己平時長期服用的藥物 ① 是 ② 否

（5） 隔壁林太太吃了有效的藥介紹給我，我可以買來吃吃看。① 是 ② 否

（6） 爲求方便我可以將藥袋包裝內的藥品集中處理，不用保留原包裝。 ① 是 ② 否

（7） 電台的藥品廣告有明星掛保證，一定沒問題，可安心使用。 ① 是 ② 否

（8） 藥袋上註明”飯後 ”服用，是指吃飽飯後任何時間都可以服藥。① 是 ② 否

（9） 藥品吃太多對身體不好，所以我可以自己覺得好一點就停藥或減量。 ① 是 ② 否

（10）我可把之前醫生開給我吃剩的藥留下來，下次症狀類似時，再拿出來吃。① 是 ② 否

三、 睡眠調查 (以下希望能夠瞭解您普遍的睡眠問題及情形)

(1) 下列問題是有關您過去一個月的睡眠習慣，您的答案應以一個月大部分日子裡最多的情形回答

(1.1) 過去一個月內，您通常多久才能睡著？

① 5 分鐘以內 ② 5 至 15 分鐘 ③ 15 至 30 分鐘

④ 30 分鐘至 1 小時 ⑤ 1 小時以上 ⑥ 整夜無法成眠

(1.2) 過去一個月內，您通常晚上實際約睡幾個小時？(並非您躺在床上的時間) ______小時

(2) 請問，過去一個月來，您對自己的睡眠品質滿不滿意？

① 非常滿意 ② 還算滿意 ③ 不太滿意

④ 非常不滿意 ⑤ 不知道/未回答

(3) 請問，過去一個月來，在**週一至週五**，您晚上睡覺的時間大概有幾個小時？

① 少於四小時 ② 5 小時 ③ 6 小時 ④ 7 小時

⑤ 8 小時 ⑥ 9 小時 ⑦ 10 小時以上 ⑧ 不知道/未回答

(4) 請問，過去一個月來，**周末假日**，您晚上睡覺的時間大概有幾個小時？

① 少於四小時 ② 5 小時 ③ 6 小時 ④ 7 小時

⑤ 8 小時 ⑥ 9 小時 ⑦ 10 小時以上 ⑧ 不知道/未回答

(5) 請問，過去一個月來，您「**不容易入睡**」的情形，平均一星期會有幾天？

※請繼續下一頁※

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤ 不知道/未回答

(6) 請問，過去一個月來，您「**半夜醒來，不容易再睡著**」的情形，平均一星期會有幾天？

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤ 不知道/未回答

(7) 請問，過去一個月來，您「**比預定時間早醒來/早起**」的情形，平均一星期會有幾天？

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤不知道/未回答

四、 成人免費健康檢查認知

(1) 請問您有沒有**曾經**利用過全民健保提供 40~64 歲民眾，免費三年一次健檢，65 歲以上免費每年一次的健檢服務？

① 有(請跳答第 3 題) ② 沒有

(2) 承上題，請問為什麼您**不曾利用**全民健保提供的免費成人健康檢查服務？【可複選】

① 不知道有這項服務 ② 不知道要去哪裡檢查／不知道哪裡有提供
③ 工作單位已提供，不需要 ④ 附近沒有可以提供此健檢服務之診所及醫院
⑤ 以為此健檢服務仍須付錢 ⑥ 此健檢服務項目太少，效果不好
⑦ 交通不便 ⑧ 沒空
⑨ 忘記要檢查 ⑩ 身體很好
⑪ 沒健保 ⑫ 其他【請寫出______________________________】

(3) 請問您知不知道全民健保有提供**每半年**洗牙一次的服務？

① 知道 ② 不知道

(3.1) 請問您平常有沒有**半年定期**給牙醫洗牙的習慣？

① 有 ② 沒有

(3.2) 請問您是否有每天刷牙的習慣？

① 是(每天______次) ② 否

(3.3) 請問您是否有每天使用牙線的習慣？

① 是 ② 否

(4) 您知不知道全民健保有提供 **30 歲以上**的婦女**每年**作一次子宮頸抹片檢查？

① 知道 ② 不知道

(5) 您知不知道全民健保有提供 **50 歲以上**民眾**每二年**一次大腸癌篩檢？

① 知道 ② 不知道

(6) 您知不知道全民健保有提供 **45 歲以上**婦女**每二年**一次乳癌篩檢？

① 知道 ② 不知道

※請繼續下一頁※

(7) 您知不知道全民健保有提供 30 **歲以上**抽菸、嚼檳榔民眾**每二年**一次口腔癌篩檢？

① 知道　② 不知道

※請繼續下一頁※

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6,7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,10
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	9,12,13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9,12,13
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15,16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

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- **Title**

The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

- **Short running title**

Obesity indices and hypertension

- **Author names and affiliations**

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ABSTRACT

Objective: Obesity and hypertension (HTN) have become increasingly prevalent in Taiwan. People with obesity are more likely to have HTN. In this study, we evaluated several anthropometric measurements for the prediction of HTN in middle-aged and elderly populations in Taiwan.

Design: Cross-sectional observational study.

Setting: Community-based investigation in Guishan Township of northern Taiwan.

Participants: A total of 396 people were recruited from a northern Taiwan community for a cross-sectional study. Anthropometrics and blood pressure were measured at the annual health exam. The obesity indices included BMI, BF percentage and WC.

Outcome measures: Statistical analyses, including Pearson's correlation, multiple logistic regression, and the area under ROC curves (AUCs) between HTN and anthropometric measurements, were used in this study.

Results: Of the 396 people recruited, 200 had HTN. The age-adjusted Pearson's coefficients of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively. Multiple logistic regression of the HTN-related obesity indices showed that the odds ratios of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively. The AUCs of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681, $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694, $p < 0.001$), respectively.

Conclusions: WC is a more reliable predictor of HTN than BMI or BF percentage. The effect of abdominal fat distribution on blood pressure is greater than that of total BF amount.

Keywords: Abdominal Fat, Elderly, Hypertension, Middle-Aged, Obesity Index

Strengths and limitations of this study:

- We conducted a community-based study and comprehensively collected various data from a health promotion project that may have clinical implications.
- This is the first study to explore the association between different obesity indices and hypertension in a middle-aged and elderly Taiwanese population.
- A cross-sectional study cannot effectively determine the causal relationship between obesity indices and hypertension.
- Our findings were obtained from community-based subjects and cannot be generalized to the whole middle-aged and elderly population in Taiwan.

INTRODUCTION

The prevalence of obesity has increased progressively in Taiwan, particularly among the elderly. However, the precise definition of obesity in the elderly has yet to be developed [1]. Traditionally, body mass index (BMI), waist circumference (WC), and body fat (BF) percentage have been used to evaluate obesity. The cut-off values of these obesity indices have not been defined for the elderly population [1] because sarcopenia causes loss of muscle mass and fatty tissues increase with aging [2]. Aging and sarcopenia cause muscle loss and increase fat deposition, making BMI an inaccurate reference. Lower BMI in the elderly may not indicate a lower BF percentage, as it could be correlated with muscle loss coupled with a relative BF increase.

The utility of different types of obesity indices has been discussed in the past. If the BF percentage determined by dual-energy X-ray absorptiometry (DXA) is regarded as a gold standard, it would be difficult to assess as the sensitivity and specificity of BMI, which vary by sex [3]. For older women, a BMI of 25 has the best sensitivity and specificity. For older men, a BMI of 27 is the most appropriate. Different obesity indices show different comorbidity risks. WC is more strongly associated with a high risk of cardiovascular disease (CVD) than BMI among middle-aged and elderly persons in Taiwan [4 5]. BMI and WC are more positively correlated with insulin resistance than BF percentage [6].

Hypertension (HTN) is also a common problem among the elderly population, with increasing prevalence, and is associated with the risks of cardiovascular disease, stroke, and chronic kidney disease [7]. HTN has different effects in different age groups. Isolated systolic HTN is predominant in the elderly [8]. There are many physiological changes related to the development of HTN in the elderly, such as arterial stiffness, increasing pulse pressure, changes in renin and aldosterone levels, decreased renal salt excretion, declined renal function, changes in the autonomic nervous system sensitivity and function, and changes in endothelial function [9].

Obesity is a major risk factor for essential HTN [10-12]. The development of HTN caused by obesity can occur via multiple mechanisms: insulin resistance, adipokine alterations, inappropriate sympathetic nerve function and renin-angiotensin-aldosterone system activation, structural and functional abnormalities in the kidney, heart and vascular changes, and immune maladaptation [10 13]. Uric acid and incretin or dipeptidyl peptidase 4 activity alteration also contribute to the development of HTN in the context of obesity [13]. Different obesity indices have different correlations with HTN. High levels of BMI and WC have increased the risk of HTN among rural Chinese women [14 15]. WC is more strongly associated with the development of HTN than BMI [16]. In another study, no significant difference in HTN prediction between BMI and WC was found [17]. Another similar study showed that the association of obesity indices with HTN in Chinese elderly individuals differed by sex and age [18]. BMI in men and hip circumference in women showed a significant impact on the risk of HTN [18]. Collectively, it appears that the relationship between various obesity indices and HTN has been relatively well established in the general population but not in the middle-aged and elderly population, an age group that has a high risk of HTN. This study was designed to investigate the relationship between different obesity indices and HTN among middle-aged and elderly Taiwanese individuals.

METHODS

Study design and study population

This is a cross-sectional, community-based study. We collected data from a community health promotion project of Linkou Chang Gung Memorial Hospital conducted between February and August 2014. A total of 619 subjects aged 50 years or older recruited through poster promotion or notification from the community office participated in this project. The recruitment posters were all placed in the community, and all participants were recruited from the community. After exclusion, 400 subjects were eligible to be enrolled in this study. Four participants were excluded because they had pacemaker implantations (Figure 1). As a result, 396 participants were enrolled, and all participants completed a questionnaire including personal information and medical history (Supplemental Information) during a face-to-face interview. Anthropometric measurements were conducted by trained research assistants or nurses under the supervision of a medical doctor. The exclusion criteria included the following: (1) participants with coronary artery disease, cerebrovascular disease, peripheral artery disease, or heart failure; (2) participants with secondary hypertension or medications that increase BP, such as licorice, oral contraceptives, steroids, NSAIDs, cocaine, amphetamines, erythropoietin, cyclosporin, tacrolimus, and anti-VEGF; and (3) participants with incomplete or missing data. Only 4 participants were excluded due to lack of BF percentage measurements. Finally, 396 participants were enrolled in the analysis. The study was approved by Chang Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Anthropometric and laboratory measurements

Each participant was required to complete a questionnaire. The questionnaires were completed by trained interviewers based on face-to-face interviews. Basic personal data included age, sex, systolic blood pressure (SBP), diastolic blood pressure (DBP), education level, history of HTN, diabetes, metabolic syndrome, and hyperlipidemia. Lifestyle factors included alcohol consumption, current smoking, and regular exercise. HTN was defined as SBP ≧ 140 mmHg or DBP ≧ 90 mmHg, current use of antihypertensive medications, or history of HTN. The definition of HTN was based upon the 2015 Guidelines of the Taiwan Society of Cardiology and the Taiwan Hypertension Society for the Management of Hypertension. Laboratory data included alanine aminotransferase (ALT), creatinine, fasting sugar, high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol, triglycerides, and uric acid. Each participant's blood pressure was measured on the right arm in a sitting position using a standardized electronic sphygmomanometer (OMRON, model HEM-7130). The participants rested for at least 5 minutes in a seated position before the measurements, with their arms supported at the heart level. We measured blood pressure in each subject 3 times, separated by an interval of 10 minutes to minimize random error and provide a more accurate basis for the estimation of blood pressure and calculated the mean value of these 3 readings. There was a warning light on our electronic sphygmomanometer for irregular heartbeat detection. We also performed physical examination for every participant, including manual auscultation, and there was no participant with an irregular heartbeat detected by the warning light or manual auscultation. The obesity indices included BMI, BF percentage and WC. The BF percentage was measured with an 8-contact electrode bioelectrical impedance analysis (BIA) device (Tanita BC-418, Tanita, Tokyo, Japan). BMI was calculated as weight / height^2 (kg/m^2). WC was measured at the level midway between the iliac crests and the lowest rib margin at minimal respiration in a standing position.

Statistical analysis

The minimum sample size for this study was calculated at the initial stage of the study. After previewing a relatively smaller population, we found that the non-HTN to HTN ratio was approximately 1:1. Considering 90% power, 95% confidence level, 0.30 as the exposure (obesity) rate among the non-HTN individuals, and a non-HTN to HTN ratio of 1:1, we calculated that 308 participants were required to detect at least 2 odds ratio differences between these two study groups.

The normality of continuous variables was evaluated by the Kolmogorov-Smirnov test. We express all continuous variables as the mean and standard deviation, while categorical variables are expressed as numbers and percentages. In univariate analysis, independent T-test and chi-square test were used to compare HTN and non-HTN subjects. Correlations were assessed with Pearson's correlation coefficient and the coefficient of determination (r^2) between different obesity indices and blood pressures. In multivariate analysis, binary logistic regression was used to adjust covariates. Receiver operating characteristic (ROC) curves were generated for BF percentage, WC, and BMI as predictors of HTN. The area under the ROC curve (AUC) and the optimal cut-off points for HTN prediction by BMI, WC, and BF percentage were determined by the largest sum of specificity and sensitivity. The analysis was performed with SPSS Statistics version 22 (IBM, SPSS Armonk, NY, IMM Corp).

Patient and public involvement

No patients were involved.

RESULTS

A total of 396 participants were enrolled in the analysis, and 200 had HTN (SBP

≧ 140 mmHg or DBP ≧ 90 mmHg), with a prevalence of 50.5%. The average age was 64.44 years. There were no significant static differences in alcohol consumption, current smoking, ALT, total cholesterol, regular exercise, or dyslipidemia between people with and without HTN. People with HTN had higher levels of BMI, WC, BF percentage, fasting sugar, triglycerides, uric acid, and creatinine with static significance (Table 1). They also had a higher prevalence of metabolic syndrome, diabetes, and hyperlipidemia but lower LDL and HDL levels.

We analyzed the correlation between SBP and obesity indices. The age-adjusted Pearson's coefficient of BMI, BF percentage, and WC were 0.23 ($p < 0.001$), 0.14 ($p = 0.01$), and 0.26 ($p < 0.001$), respectively (Table 2, Figure 2). In addition, multiple logistic regression of the HTN-related obesity indices showed that the odds ratio of BMI, BF percentage, and WC were 1.15 (95% CI = 1.08-1.23, $p < 0.001$), 1.07 (95% CI = 1.03-1.11, $p < 0.001$), and 1.06 (95% CI = 1.03-1.08, $p < 0.001$), respectively (Table 3). Further multiple logistic regression analyses revealed that these obesity indices remained independent risk factors for HTN in the subgroup of participants with an age ≧ 65 years old (Table 4a) and subgroups of either sex (Table 4b and 4c). The odds ratio of BMI, BF percentage, and WC were 1.11 (95% CI = 1.00-1.22, $p = 0.047$), 1.06 (95% CI = 1.01-1.12, $p = 0.03$), and 1.04 (95% CI = 1.00-1.08, $p = 0.04$), respectively, in the subgroup of participants with an age ≧ 65 years old (Table 4a). The odds ratio of BMI, BF percentage, and WC were 1.19 (95% CI = 1.06-1.33, $p = 0.002$), 1.11 (95% CI = 1.03-1.19, $p = 0.003$), and 1.08 (95% CI = 1.03-1.12, $p = 0.01$), respectively, in the subgroup of male participants (Table 4b). The odds ratio of BMI, BF percentage, and WC were 1.13 (95% CI = 1.04-1.23, $p = 0.003$), 1.06 (95% CI = 1.01-1.10, $p = 0.01$), and 1.04 (95% CI = 1.01-1.08, $p = 0.01$), respectively, in the subgroup of female participants (Table 4c).

Table 1 General characteristics of the study population according to HTN and non-HTN.

	HTN			
	Total	Yes	No	
Variables	(n=396)	(n=200)	(n=196)	p value
Age (year)	64.44 ± 8.46	65.63 ± 8.53	63.23 ± 8.23	0.005
SBP (mmHg)	129.61 ± 16.70	138.51 ± 15.92	120.53 ± 11.92	<0.001
DBP (mmHg)	77.10 ± 11.28	81.24 ± 11.74	72.88 ± 9.04	<0.001
BMI (kg/m^2)	24.55 ± 3.50	25.35 ± 3.83	23.73 ± 2.92	<0.001
BF percentage (%)	29.98 ± 8.41	30.92 ± 8.46	29.02 ± 8.27	0.025
WC (cm)	85.12 ± 9.66	87.52 ± 10.31	82.67 ± 8.28	<0.001
ALT (U/L)	22.67 ± 13.00	22.81 ± 12.66	22.53 ± 13.38	0.834
Creatinine (mg/dL)	0.77 ± 0.43	0.82 ± 0.42	0.72 ± 0.43	0.019
FPG (mg/dL)	96.31 ± 25.84	100.18 ± 29.85	92.36 ± 20.29	0.002
HDL-C (mg/dL)	54.29 ± 13.81	52.13 ± 13.91	56.49 ± 13.39	0.002
LDL-C (mg/dL)	118.54 ± 32.19	115.05 ± 30.87	122.11 ± 33.18	0.029
TC (mg/dL)	197.30 ± 35.80	194.29 ± 35.16	200.37 ± 36.28	0.091
TGs (mg/dL)	122.68 ± 66.00	136.02 ± 74.02	109.08 ± 53.52	<0.001
Uric acid (mg/dL)	5.75 ± 1.40	5.94 ± 1.47	5.56 ± 1.31	0.007
Men, n (%)	140 (35.35%)	76 (38.00%)	64 (32.65%)	0.266
Alcohol consumption, n (%)	75 (18.94%)	36 (18.00%)	39 (19.90%)	0.630
Current smoking, n (%)	43 (10.86%)	24 (12.00%)	19 (9.69%)	0.461
Regular exercise, n (%)	325 (82.07%)	160 (80.00%)	165 (84.18%)	0.278
Education years, n (%)				0.294
≦ 6	205 (51.77%)	111 (55.50%)	94 (47.96%)	
7~12	157 (39.65%)	72 (36.00%)	85 (43.37%)	
> 12	34 (8.59%)	17 (8.50%)	17 (8.67%)	
Current single, n (%)	74 (18.69%)	49 (24.50%)	25 (12.76%)	0.003

Metabolic syndrome, n (%)	143	(36.11%)	108	(54.00%)	35	(17.86%)	<0.001
DM, n (%)	79	(19.95%)	51	(25.50%)	28	(14.29%)	0.005
Hyperlipidemia, n (%)	260	(65.66%)	137	(68.50%)	123	(62.76%)	0.229

Notes: Clinical characteristics are expressed as the mean±SD for continuous variables and n (%) for categorical variables. P-values were derived from independent t-tests for continuous variables and chi-square tests for categorical variables.

Abbreviations: HTN, hypertension; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; BF, body fat; WC, waist circumference; ALT, alanine aminotransferase; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TGs, triglycerides; DM, diabetes mellitus.

Table 2 The correlation between SBP and obesity indices.

Variables	SBP (n=396)			
	Unadjusted		Adjusted for age	
	Pearson's coefficient	p value	Pearson's coefficient	p value
BMI (kg/m^2)	0.22	<0.001	0.23	<0.001
BF percentage (%)	0.13	0.01	0.14	0.01
WC (cm)	0.26	<0.001	0.26	<0.001

Abbreviations: SBP, systolic blood pressure; BMI, body mass index; BF, body fat; WC, waist circumference.

Finally, the AUCs of BMI, BF percentage, and WC were 0.626 (95% CI = 0.572-0.681, $p < 0.001$), 0.556 (95% CI = 0.500-0.613, $p = 0.052$), and 0.640 (95% CI = 0.586-0.694, $p < 0.001$), respectively (Figure 3). WC had the largest AUC for predicting HTN.

Table 3

Multiple logistic regression of the obesity indices related to HTN in the screened population (n=396).

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1[†]	1.15	(1.08-1.23)	<0.001	1.03	(1.00-1.05)	0.03	1.06	(1.03-1.08)	<0.001
Model 2[‡]	1.16	(1.09-1.24)	<0.001	1.08	(1.04-1.11)	<0.001	1.06	(1.03-1.09)	<0.001
Model 3[§]	1.15	(1.08-1.23)	<0.001	1.07	(1.03-1.11)	<0.001	1.06	(1.03-1.08)	<0.001

[†]Model 1: Unadjusted.

[‡]Model 2: Multiple logistic regression adjusted for age and sex.

[§]Model 3: Multiple logistic regression adjusted for factors in model 2 plus DM and hyperlipidemia.

Abbreviations: BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; CI, confidence interval.

Table 4

Subgroup analyses of the association of obesity indices with HTN according to age and sex.

(a) Age≧65 years old (n=166)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.09	(0.99-1.20)	0.06	1.04	(1.00-1.08)	0.04	1.03	(1.00-1.06)	0.08
Model 2‡	1.10	(1.00-1.21)	0.05	1.05	(1.00-1.11)	0.0497	1.04	(1.00-1.07)	0.04
Model 3§	1.11	(1.00-1.22)	0.047	1.06	(1.01-1.12)	0.03	1.04	(1.00-1.08)	0.04

(b) Male (n=140)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.17	(1.06-1.30)	0.002	1.10	(1.03-1.17)	0.004	1.07	(1.03-1.12)	<0.001
Model 2‡	1.08	(1.03-1.12)	<0.001	1.10	(1.03-1.17)	0.003	1.08	(1.03-1.12)	<0.001
Model 3§	1.19	(1.06-1.33)	0.002	1.11	(1.03-1.19)	0.003	1.08	(1.03-1.12)	0.001

(c) Female (n=256)

	BMI			BF percentage			Waist circumference		
	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value	Odds ratio	(95% CI)	p value
Model 1†	1.14	(1.05-1.23)	0.001	1.06	(1.02-1.11)	0.004	1.05	(1.02-1.09)	0.001
Model 2‡	1.14	(1.05-1.23)	0.002	1.06	(1.02-1.11)	0.01	1.05	(1.01-1.08)	0.004
Model 3§	1.13	(1.04-1.23)	0.003	1.06	(1.01-1.10)	0.01	1.04	(1.01-1.08)	0.01

†Model 1: Unadjusted.

‡Model 2: Multiple logistic regression adjusted for age and sex.

§Model 3: Multiple logistic regression adjusted for factors in model 2 plus DM and hyperlipidemia.

Abbreviations: BMI, body mass index; HTN, hypertension; DM, diabetes mellitus; CI, confidence interval.

DISCUSSION

Our study revealed a positive correlation between all obesity indices and HTN. BMI, BF percentage, and WC were found to be associated with HTN or higher systolic pressure through the independent T-test, chi-square test, correlation analysis, and multivariate analysis. These obesity indices remained independent risk factors for HTN in the subgroup of participants with an age ≧ 65 years old (a population with a high expected prevalence of sarcopenia) and subgroups of either sex. Regarding the AUC, WC had the largest AUC for predicting HTN. Clinical adiposity indices, such as BMI and WC, were linked with HTN in review articles [19 20]. A Chinese study showed that women with obesity defined by BMI or WC have an increased risk of developing HTN [14]. Another study on predicting HTN with different obesity indices reached a similar conclusion [16]. Compared with BMI, WC has a stronger association with HTN development [16]. However, these previous observations were mainly from the general population. Thus, the novel finding of this study is the association between various obesity indices and HTN in the middle-aged and elderly population, an age group that has a high risk of HTN.

A Korean study showed a similar outcome as that of our study [21]. The central obesity index, WC, is better than BMI for predicting HTN in middle-aged Korean people [21]. The relationship between central obesity and HTN has also been mentioned in previous reviews [22 23]. Visceral obesity and leptin play a crucial role in the development of HTN in patients with obesity [22]. Fat is an important endocrine organ in patients with obesity. Adipokines, such as adiponectin, leptin and resistin, may result in arterial stiffness and predispose individuals to endothelial dysfunction and HTN [23].

Our study suggested that the optimal cut-off point for predicting HTN with BMI was 25.45 kg/m^2, with BF percentage was 35.15%, and with WC was 88.5 cm. However, another study of a younger population (40 to 59 years old) suggested that the optimal BMI and WC cutoff values are 29.57 kg/m^2 and 90.5 cm [24]. Because age is also a risk factor for HTN, the cutoff point for BMI for elderly individuals is lower. Similar to the results of the BMI-obesity literature review, other age-related studies have shown conflicting results [17]. A study in Nigeria found that BMI and WC are both good predictors of HTN risk. However, there was no significant difference between the AUCs of BMI and WC [17]. In a Chinese rural cohort study, BMI was superior to WC for predicting incident HTN in both sexes [25]. Another study among Chinese elderly individuals showed a sex difference in predicting HTN with obesity indices [18]. The results showed that BMI is associated with a significant risk of developing HTN in men only [18]. Finally, a study showed that the obesity index predictions differed between sexes [26]. The combination of BMI + WC can improve the estimation of HTN risk [26].

There were several limitations in our study. First, a cross-sectional study cannot effectively determine the causal relationship between obesity indices and HTN. Second, the participants in this study came from a relatively small community, so selection bias should be considered. Third, our findings were obtained from community-based subjects and cannot be generalized to the whole middle-aged and elderly population in Taiwan. Fourth, we could not closely define the stages of smoking/alcohol consumption or the regularity of exercise. This is because these items were included in the questionnaire used in your study, which was designed for community participants during a health examination. Fifth, sarcopenia was not assessed in our study because hand grip and walking speed were not measured in our subjects in this project. The potential impact of sarcopenia may be an area for future work.

BMI, BF percentage, and WC were all positively associated with HTN with statistical significance. Of the three indices, WC was the most reliable predictor of HTN. Thus, there is a strong implication that abdominal fat distribution has more influence on blood pressure than total BF amount among middle-aged and elderly populations. Thus, our findings may provide valuable information for clinicians to alert subjects in this age group regarding the increased risk of HTN.

Authors' contributions Yen-An Lin was involved in writing of the manuscript. Ying-Jen Chen, Yu-Chung Tsao, Wei-Chung Yeh, Wen-Cheng Li and I-Shiang Tzeng provided opinions about the study designs and help collect data. Jau-Yuan Chen contributed conceived, designed and performed the experiments, collected and analyzed the data, revising it critically for important intellectual content and final approval of the version to be submitted.

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Competing interests None declared.

Ethics approval The study was approved by Chang-Gung Medical Foundation Institutional Review Board (102-2304B), and written informed consent was given by all the participants before enrollment.

Data sharing statement No data are available.

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Figure Legends

Figure 1 Flowchart of the study

Figure 2 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP. BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

Figure 3 ROC curves for obesity indices as predictors of hypertension (HTN). BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

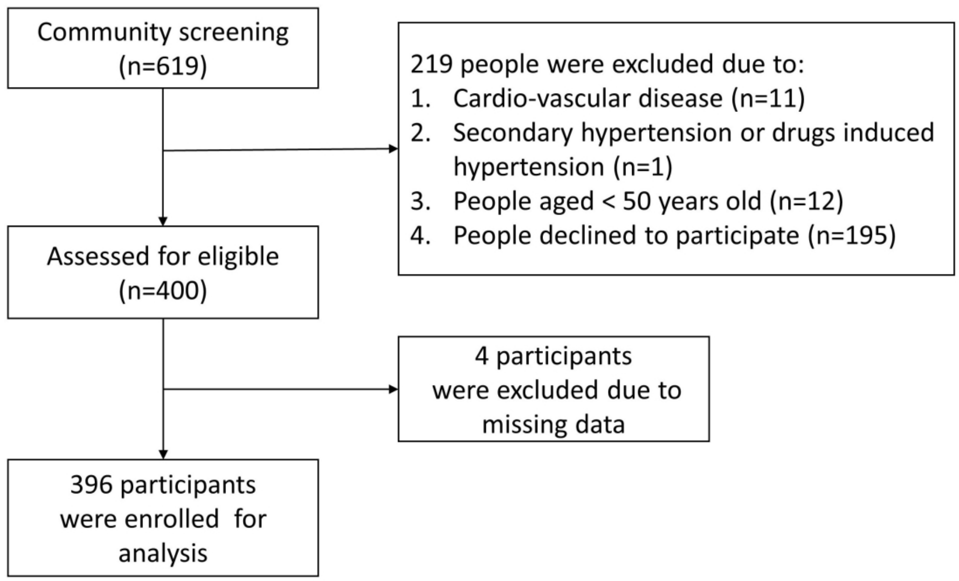


Figure 1 Flowchart of the study

222x138mm (300 x 300 DPI)

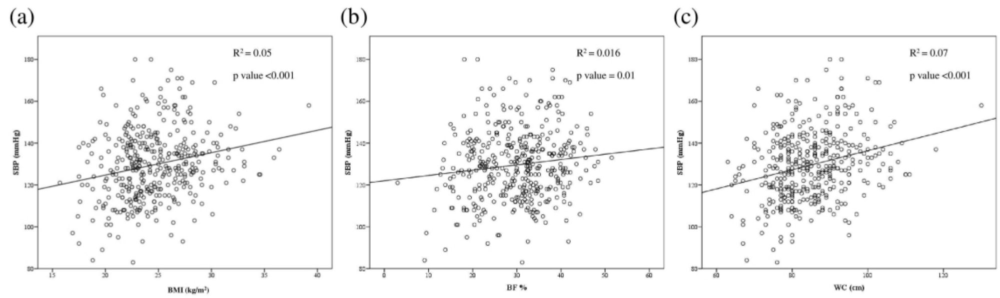
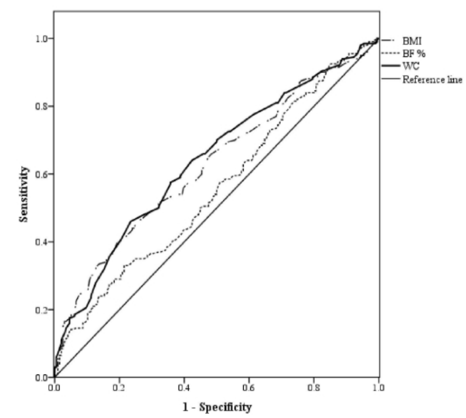


Figure 2 The correlation between (a) BMI and SBP, (b) BF% and SBP and (c) WC and SBP. BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

275x86mm (300 x 300 DPI)



Variables	AUC(95% CI)	p value	Cut-off point	Sensitivity	Specificity
BMI (kg/m^2)	0.626 (0.572-0.681)	<0.001	25.450	0.465	0.745
BF percentage (%)	0.556 (0.500-0.613)	0.052	35.150	0.330	0.786
WC (cm)	0.640 (0.586-0.694)	<0.001	88.500	0.460	0.765

Figure 3 ROC curves for obesity indices as predictors of hypertension (HTN). BMI, body mass index; SBP, systolic blood pressure; BF, body fat; WC, waist circumference.

275x178mm (300 x 300 DPI)

Supplemental Information

The relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study

Yen-An Lin, Ying-Jen Chen, Yu-Chung Tsao, Wei-Chung Yeh, Wen-Cheng Li, I-Shiang Tzeng, Jau-Yuan Chen

※請接續下一頁※

Table S1 Collinearity of obesity indices

Variables	BMI (kg/m^2)		BF percentage (%)		WC (cm)	
	r	p value	r	p value	r	p value
BMI (kg/m^2)	-	-	0.62	<0.001	0.80	<0.001
BF percentage (%)	0.62	<0.001	-	-	0.30	<0.001
WC (cm)	0.80	<0.001	0.30	<0.001	-	-

Abbreviations: BMI, body mass index; BF body fat percentage; WC, waist circumference.

This questionnaire was prepared in Chinese because it was designed for the survey of the Taiwanese people.

健康問卷

編號 ____________________ 收案時間 20_____/_____/_____

一、 基本資料

A.性別	① 男 ② 女
B.保險狀況	① 有，除健保外之________保(勞.漁.農.公.其他) ② 無
C.血型	① A ② B ③ O ④ AB ⑤ 不知道
D.婚姻狀況	① 未婚 ② 已婚 ③ 離婚或分居 ④ 鰥寡 婚姻年數________ 生育子女數________
E.教育程度	① 不識字 ② 小學程度 ③ 國中程度 ④ 高中程度 ⑤ 大專程度 ⑥ 研究所以上
F.宗教信仰	① 無 ② 一般民間信仰 ③ 道教 ④ 佛教 ⑤ 基督教 ⑥ 天主教 ⑦ 回教 ⑧ 其他______
G.父親氏族	① 台閩 ② 客家 ③ 原住民 ④ 外省籍，______省 ⑤ 其他_____
H.母親氏族	① 台閩 ② 客家 ③ 原住民 ④ 外省籍，______省 ⑤ 其他_____
I.居住成員 (可複選)	① 子女，共_____人 ② 孫子女，共_____人 ③ 配偶 ④ 獨居 ⑤ 媳婦 ⑥ 其他_____
J.經濟來源 (可複選)	① 父母 ② 子女 ③ 配偶 ④ 手足 ⑤ 政府 ⑥ 朋友 ⑦ 自己 ⑧ 其他________
K.自我照護	① 完全獨立 ② 需旁人協助 ③ 完全由旁人照顧
L.照顧者	① 自理 ② 父母 ③ 配偶 ④ 手足

※請繼續下一頁※

(可複選) ⑤ 子女 ⑥ 媳婦 ⑦ 看護 ⑧ 其他________

M.飲食習慣 ① 葷 ② 素 ③ 早素 ④ 其他______

N.基本生理 身高______公分 體重______公斤 腹圍______公分 心跳______次／分鐘
收縮壓______毫米汞柱 舒張壓______毫米汞柱 握力______Kg 行走______秒

O.病史（例：糖尿病、高血壓、高血脂）____

P.職業（請填代號）______ （若您已退休，請填您退休前的工作）

【行業】 0：農、林、漁、牧、狩獵業 1：礦業及土石採取業 2：製造業 3：水電燃氣業 4：營造業
5：商業 6：運輸、倉儲、及通信業 7：金融、保險、不動產、及工商服務業
8：公共行政社會服務及個人服務業 9：軍公教 10：其他 ________

二、 健康行為及用藥認知習慣

A.抽菸

(1) 您現在是否有抽菸的習慣？ ① 沒有 ② 有

B.喝酒

(1) 您現在是否有喝酒的習慣？ ① 沒有 ② 有

C.嚼檳榔

(1) 您現在是否有嚼檳榔的習慣？ ① 沒有 ② 有

D.活動量及飲食習慣

(1) 請問您一天有多少時間需要走動？

① 大部份時間坐著 ② 少於半天需要走動
③ 約半天時間需要走動 ④ 大部份時間需要走動

(2) 您活動時，需要搬重物嗎？

① 不需要 ② 很少 ③ 有時 ④ 經常需要 ⑤ 每天都要

(3) 您平均每星期運動幾次？______次

(4) 飲食習慣

※請繼續下一頁※

(4.1) 請問您認為中老年人每天都應該吃蔬菜、水果嗎？
① 是 ② 否 ③ 不知道

(4.2) 請問您認為中老年人每天都應該吃魚、肉、豆或蛋類食物嗎？
① 是 ② 否 ③ 不知道

(4.3) 食物好不好吃，比它是否有益健康來得重要？
① 是 ② 否 ③ 不知道

(4.4) 您常吃蔬菜或水果嗎？
① 幾乎每天吃 ② 每周三到五次 ③ 每周二次或以下

(4.5) 請問您是否常常三餐不定時、不定量？
① 很少或無 ② 每周三到五次 ③ 幾乎每天

E.藥物接觸

(1) 您是否長時間(一個月以上)服用**止痛-抗發炎類藥物**，包括針劑？
① 是 ② 否(請跳答(2))

(1.1) 您是否有經醫師診斷？ ① 是 ② 否

(1.2) 這幾天是否還持續吃藥？ ① 是 ② 否

(2) 您是否正在服用**高血壓藥物**？

① 是 (每天______次) ② 否(請跳答(3))

若是，則您從幾歲開始服藥？______歲

(2.1) 您是否曾經忘記服藥？ ① 是 ② 否

(2.2) 您認為不需要按時服用藥物嗎？ ① 是 ② 否

(2.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是 ② 否

(2.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是 ② 否

(2.5) 若您有未按時服高血壓藥的經驗，未按時服藥的原因為?(可複選)
① 感覺症狀改善 ② 我不相信藥物會讓病情改善 ③ 我不信任醫師
④ 服藥種類太多 ⑤ 醫師未向我解釋足夠的藥物資訊 ⑥ 副作用
⑦ 忘記 ⑧ 一天服藥次數太多或服藥時間複雜 ⑨ 接受其他療法(如中藥)
⑩ 其他________

※請繼續下一頁※

(3) 您是否正在服用**糖尿病藥物**，包括針劑？

① 是 (每天______次) ② 否 (請跳答(4))

若是，則您從幾歲開始服藥？______歲

(3.1) 您是否曾經忘記服藥？ ① 是 ② 否

(3.2) 您認為不需要按時服用藥物嗎？ ① 是 ② 否

(3.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是 ② 否

(3.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是 ② 否

(3.5) 若您有未按時服糖尿病藥的經驗，未按時服藥的原因為?(可複選)

① 感覺症狀改善 ② 我不相信藥物會讓病情改善 ③ 我不信任醫師
④ 服藥種類太多 ⑤ 醫師未向我解釋足夠的藥物資訊 ⑥ 副作用
⑦ 忘記 ⑧ 一天服藥次數太多或服藥時間複雜 ⑨ 接受其他療法(如中藥)
⑩ 其他________

(4) 您是否正在服用**降血脂藥物**，包括針劑？

① 是 (每天______次) ②否 (請跳答 F)

若是，則您從幾歲開始服藥？______歲

(4.1) 您是否曾經忘記服藥？ ① 是 ② 否

(4.2) 您認為不需要按時服用藥物嗎？ ① 是 ② 否

(4.3) 當您覺得症狀較好時，是否會自己停止服藥？ ① 是 ② 否

(4.4) 假如因服藥而覺得不舒服時，您是否會自己停止服藥？ ① 是 ② 否

(4.5) 若您有未按時服降血脂藥物的經驗，未按時服藥的原因為?(可複選)

① 感覺症狀改善 ② 我不相信藥物會讓病情改善 ③ 我不信任醫師
④ 服藥種類太多 ⑤ 醫師未向我解釋足夠的藥物資訊 ⑥ 副作用
⑦ 忘記 ⑧ 一天服藥次數太多或服藥時間複雜 ⑨ 接受其他療法(如中藥)
⑩ 其他________

F.請問您是否曾吃補藥（燉補品）、中藥或喝補酒之習慣？

① 經常 ② 偶爾 ③ 未曾

G.請問您是否曾吃維他命等健康營養補充品？

① 經常 ② 偶爾 ③ 未曾

※請繼續下一頁※

H.您目前看病的科別有多少科？________科

(1) 承上，正在服用哪些疾病的藥物？________________________________(請填疾病名稱)

(2) 承上，若有您每日服藥________次，每日共吃________粒藥

(3) 承上，您吃的藥目前是否有剩？① 是，原因______________________ ② 否

I.用藥認知評值，您認為下列敘述是否正確？

（1） 服藥時可搭配茶或果汁來配藥。 ① 是 ② 否

（2） 為避免家中藥品變質，應全都放在冰箱保存。① 是 ② 否

（3） 如果忘記吃藥應在下一次吃兩倍的藥量，避免病情控制不好。 ① 是 ② 否

（4） 我到醫療院所看病時，不需要提醒醫師自己平時長期服用的藥物 ① 是 ② 否

（5） 隔壁林太太吃了有效的藥介紹給我，我可以買來吃吃看。① 是 ② 否

（6） 爲求方便我可以將藥袋包裝內的藥品集中處理，不用保留原包裝。 ① 是 ② 否

（7） 電台的藥品廣告有明星掛保證，一定沒問題，可安心使用。 ① 是 ② 否

（8） 藥袋上註明"飯後 "服用，是指吃飽飯後任何時間都可以服藥。① 是 ② 否

（9） 藥品吃太多對身體不好，所以我可以自己覺得好一點就停藥或減量。 ① 是 ② 否

（10）我可把之前醫生開給我吃剩的藥留下來，下次症狀類似時，再拿出來吃。① 是 ② 否

三、 睡眠調查 (以下希望能夠瞭解您普遍的睡眠問題及情形)

(1) 下列問題是有關您過去一個月的睡眠習慣，您的答案應以一個月大部分日子裡最多的情形回答

(1.1) 過去一個月內，您通常多久才能睡著？

① 5 分鐘以內　② 5 至 15 分鐘　③ 15 至 30 分鐘

④ 30 分鐘至 1 小時　⑤ 1 小時以上　⑥ 整夜無法成眠

(1.2) 過去一個月內，您通常晚上實際約睡幾個小時？(並非您躺在床上的時間) ______小時

(2) 請問，過去一個月來，您對自己的睡眠品質滿不滿意？

① 非常滿意　② 還算滿意　③ 不太滿意

④ 非常不滿意　⑤ 不知道/未回答

(3) 請問，過去一個月來，在**週一至週五**，您晚上睡覺的時間大概有幾個小時？

① 少於四小時　② 5 小時　③ 6 小時　④ 7 小時

⑤ 8 小時　⑥ 9 小時　⑦ 10 小時以上　⑧ 不知道/未回答

(4) 請問，過去一個月來，**周末假日**，您晚上睡覺的時間大概有幾個小時？

① 少於四小時　② 5 小時　③ 6 小時　④ 7 小時

⑤ 8 小時　⑥ 9 小時　⑦ 10 小時以上　⑧ 不知道/未回答

(5) 請問，過去一個月來，您「**不容易入睡**」的情形，平均一星期會有幾天？

※請繼續下一頁※

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤ 不知道/未回答

(6) 請問，過去一個月來，您「**半夜醒來，不容易再睡著**」的情形，平均一星期會有幾天？

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤ 不知道/未回答

(7) 請問，過去一個月來，您「**比預定時間早醒來/早起**」的情形，平均一星期會有幾天？

① 少於 1 天 ② 1 至 3 天 ③ 4 至 5 天 ④ 6 至 7 天 ⑤不知道/未回答

四、 成人免費健康檢查認知

(1) 請問您有沒有**曾經**利用過全民健保提供 40~64 歲民眾，免費三年一次健檢，65 歲以上免費每年一次的健檢服務？

① 有(請跳答第 3 題) ② 沒有

(2) 承上題，請問為什麼您**不曾利用**全民健保提供的免費成人健康檢查服務？【可複選】

① 不知道有這項服務 ② 不知道要去哪裡檢查／不知道哪裡有提供
③ 工作單位已提供，不需要 ④ 附近沒有可以提供此健檢服務之診所及醫院
⑤ 以為此健檢服務仍須付錢 ⑥ 此健檢服務項目太少，效果不好
⑦ 交通不便 ⑧ 沒空
⑨ 忘記要檢查 ⑩ 身體很好
⑪ 沒健保 ⑫ 其他【請寫出____________________】

(3) 請問您知不知道全民健保有提供**每半年**洗牙一次的服務？

① 知道 ② 不知道

(3.1) 請問您平常有沒有**半年定期**給牙醫洗牙的習慣？

① 有 ② 沒有

(3.2) 請問您是否有每天刷牙的習慣？

① 是(每天______次) ② 否

(3.3) 請問您是否有每天使用牙線的習慣？

① 是 ② 否

(4) 您知不知道全民健保有提供 **30 歲以上**的婦女**每年**作一次子宮頸抹片檢查？

① 知道 ② 不知道

(5) 您知不知道全民健保有提供 **50 歲以上**民眾**每二年**一次大腸癌篩檢？

① 知道 ② 不知道

(6) 您知不知道全民健保有提供 **45 歲以上**婦女**每二年**一次乳癌篩檢？

① 知道 ② 不知道

※請繼續下一頁※

(7) 您知不知道全民健保有提供 30 **歲以上**抽菸、嚼檳榔民眾**每二年**一次口腔癌篩檢？

① 知道　　② 不知道

※請翻續下一頁※

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6,7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6,7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,10
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	9,12,13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9,12,13
		(*b*) Report category boundaries when continuous variables were categorized	8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12,13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15,16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.