Measures of overweight and obesity for elderly Taiwanese men and women: body mass index and waist circumference as predictors of cardiovascular disease risk factors

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ABSTRACT

This paper examines the relationship between body mass index (BMI) and waist circumference and cardiovascular disease (CVD) risk factors among the elderly Taiwanese using a national sample of men and women aged 54 and older. More than 47% of women and 34% of men are overweight or obese in the sample. The receiver operating characteristics (ROC) analyses demonstrate that waist circumference is a more sensitive predictor of CVD risk factors than BMI for both men and women. The optimal waist circumference cutoffs are 87 cm for men and 84 cm for women. There appears to be a moderate positive relationship between BMI and waist circumference and CVD risk factors, especially between BMI and waist circumference and hypertension. Further regression analysis is needed to determine this relationship. Similar to the West, the study provides evidence that BMI may not be a good indicator of obesity among elderly Chinese. Waist circumference is a useful predictor of obesity in elderly Chinese and the optimal cutoffs are lower than the WHO standard.

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Previous research on measures of obesity in the elderly

Like other developed societies, the prevalence of obesity has been increasing in Taiwan in the past decade, and it has become particularly high among the elderly population. In 1999 to 2000, among Taiwanese men and women aged 65 years or older, the prevalence of overweight and obesity by the WHO criteria were 32.9% and 5.25%, respectively (calculated based on data from Huang et al. 2005). Obesity has been associated with increased cardiovascular disease risk factors and metabolic syndrome among the elderly people in Taiwan (Huang et al. 2005), and has become a serious public health concern. Yet appropriate measurement of obesity for the elderly population has not been established.

The measure of obesity for the elderly people is a controversial issue. First, it is argued that body mass index (BMI), the most commonly used measure of obesity, may not be an effective measure of obesity for older adults who usually experience a decrease of height and lean tissue and an increase of abdominal fat (WHO Expert Subcommittee 1998). As a measure of overall and central obesity, waist circumference appears to be a better measure than BMI for the elderly people (Inelmen et al. 2003). Second, the World Health Organization (WHO) criteria for overweight (BMI>=25) and obesity (BMI>=30) may not be appropriate for elderly people of Chinese descent because the obesity-related mortality is lower for older people aged 65 and over in the West (Heiat et al. 2001; Heiat 2003). Third, the argument for lowering BMI and waist circumference[1] cutoffs for Asian populations adds another layer of uncertainty for measuring obesity in the elderly Chinese. Recent evidence indicates that lower BMI and waist circumference cutoffs are associated with

[1] WHO suggested that a waist circumference of 80 cm for women and 94 cm for men indicate high health risk and a waist circumference of 88 cm for women and 102 cm for men indicate higher risk (WHO 2000).

higher risk of cardiovascular disease (CVD) risk factors and metabolic syndrome among Asians than Caucasians (WHO/IASO/IOTF 2000). WHO recommended lower BMI (BMI>=23 for overweight and >=27.5 for obesity) action points for Asian population (WHO Expert Consultation 2004). The suggested WAIST CIRCUMFERENCE cutoffs for Asian population are 90 cm for men and 80 cm for women respectively (WHO/IASO/IOTF 2000). Emerging studies indicate that the suggested Asian standard seem to be more appropriate for Chinese populations (Ko et al. 1999; Ko et al. 2001; Zhou et al. 2002; Huang et al. 2002; Huang et al. 2005; Pan et al. 2004).

Studies on Western populations suggest that BMI is still a useful indicator of obesity-related mortality for the elderly, but the relationship between BMI and morbidity among the elderly is less clear. A recent systematic review (Heiat et al. 2001) showed that BMI is positively related to all-cause and CVD-mortality among elderly Caucasian men and women (>=65 years), but the optimal BMI cutoff is higher (BMI>=27) than the WHO criteria. In contrast, there is no relationship between BMI (>=25) and CVD risk factors among the elderly (Harris et al. 1993; 1997; Larson 1995) or only a weak association (Rimm et al. 1995). The relationship may be different for elderly men and women (Dey et al. 2002; 2003).

There is some evidence in the West that waist circumference might be a better predictor of mortality (Visscher et al. 2000; Folsom et al. 2000) and morbidity (Turcato et al. 2000) for elderly men and women, but there is no clear pattern of appropriate waist circumference cutoffs (Folsom et al. 2000; Dey et al. 2002; Dey and Lissner 2003; Wannamethee et al. 2005). Recent research suggests that the relationship between waist circumference and CVD risk factors may be different for elderly men and women. For instance, waist circumference is positively related to CVD risk factors for elderly men but not women (Dey et al. 2002; Dey and Lissner 2003). Others demonstrate

that waist circumference is positively related to CVD risk factors among elderly women (Folsom et al. 2000; Van Pelt et al. 2001).

Research on the relationship between BMI and waist circumference and health outcomes in elder Chinese is very limited. The few available studies indicate that BMI and waist circumference are related to CVD risk factors among elderly Chinese, but there is not enough evidence to draw any conclusion. Wildman et al. (2004) demonstrated a strong positive association between BMI (>=24) and waist circumference (>=80 cm) and CVD risk factors among middle-aged and older (age 35-74 years) men and women in mainland China. Woo et al. (2002) showed among elderly (>=70 years) Hong Kong Chinese that waist circumference is positively related to CVD risk factors in men and women, but BMI is only related to CVD risk factors in men. Huang et al. (2005) showed among elderly Taiwanese (>=65 years) that BMI (>=24) was positively associated with CVD risk factors and metabolic disorders in men, while the relationship was inconsistent for women. Despite the weaker relationship between obesity and CVD risk factors among the elderly, waist circumference (86-88 cm for men and 82-84 cm for women) is related to CVD risk factors to a greater extent than BMI in elderly men and women (Huang et al. 2002; 2005).

The current research

There is an urgent need to collect more evidence about the relationship between obesity and health outcomes among the elderly population, and especially among the elderly Chinese. This study examines the association between BMI and waist circumference and CVD risk factors among the elderly Taiwanese using a nationally representative sample of men and women aged 54 and over. The purpose of this paper is two fold: 1) to determine the most useful measures of obesity among elderly Taiwanese men and women; and 2) to identify cutoffs for BMI and waist circumference associated with increased CVD risks in elderly Taiwanese men and women. These

analyses provide evidence on the appropriateness of applying anthropometric measures in identifying CVD risks in an elderly Chinese population, and the usefulness of the standard cutoff values for BMI and waist circumference in predicting CVD risk factors for elderly Chinese. The examination will also provide further evidence on the ongoing discussion about the appropriateness of using age- and ethnic-specific definition of obesity.

Data and methods

Study Sample

The 2000 Social Environment and Biomarkers of Aging Study (SEBAS 2000) sample is a nationally representative sample of the elderly population aged 54 or older in Taiwan (Goldman and Weinstein 2003). Elderly respondents (71 and older in 2000) and urban residents were over-sampled. Respondents were interviewed in their homes between July and December, 2000. Several weeks after the interview, respondents who were willing and able collected 12-hour overnight urine samples, and received physical examinations in nearby hospitals the following morning. Among the 1,713 respondents selected for this study, a total of 1,497 provided interviews (a response rate of 92% among survivors), and 1,023 supplied biomarkers (68% of those interviewed). The research sample consists of 581 men and 427 women with biomarkers.

Anthropometric measures

BMI was classified into six groups to capture cutoffs for normal, overweight and obesity as suggested by both WHO criteria and WHO recommendations on Asian standards. These six groups are BMI<21, 21-22.9, 23-24.9, 25-27.4, 27.5-29.9, and 30 and over. BMI category does not include cutoff for underweight because there are few cases with BMI smaller than 18.5. Waist

circumference was grouped into six categories (<80, 80-83, 84-86, 87-89, 90-93, 94+) that capture WHO and Asian standards. In receiver operating characteristics (ROC) analysis, we used the same categories for waist circumference, but we created dichotomous variables for each BMI values.

Definition of cardiovascular risk factors

Three CVD risk factors were defined in the analysis: hypertension, Type-2 diabetes, and dyslipidemia. Hypertension was defined as having a systolic blood pressure >=140 mmHg, diastolic blood pressure >=90 mmHg, or the use of antihypertensive medication (Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, 1997). Type 2 diabetes mellitus was defined as a fasting plasma glucose of >=126 mg/dL, or current use of oral antidiabetic agents or insulin (WHO 1999). Dyslipidemia was defined as total cholesterol >=240 mg/dL, LDL-cholesterol >=160 mg/dL, HDL-cholesterol <40 mg/dL, or triglyceride >=200 mg/dL (National Cholesterol Education Program (NCEP) ATP III, 2001). The use of standard cutoff points for CVD risk factors allow us to make comparison with other studies.

Statistical methods

First, we presented descriptive statistics on measures of obesity and CVD risk factors for the total sample, and for men and women separately. The gender difference was measured using the Pearson χ^2 test. Second, cross-tabulations of BMI and waist circumference categories and CVD risk factors were presented for men and women. Third, we conducted ROC analysis to test the sensitivity and specificity of each BMI and waist circumference level for the detection of each CVD risk factors. The distance on the ROC curve of each BMI and waist circumference was calculated as the square root of $[(1\text{-sensitivity})^2 + (1\text{-specificity})^2]$. The area under the curve (AUC) is an

indicator of how well BMI and waist circumference can predict positive test outcome. AUC ranges from 0 to 1, with 0.5 indicating no predictive power and 1 indicating perfect power. We will use logistic regression to further determine the relationship between BMI and waist circumference and CVD risk factors.

Preliminary results

The data shows that the level of obesity is quite high among the elderly Taiwanese men and women aged 54 and older. In Table 1, according to WHO standard for BMI, 37.2 percent of women and 30.7 percent of men are overweight, 10.3 percent of women and 4.0 percent of men are obese. Women are more likely to be overweight and obese than men. Women are also more likely to have diabetes, high systolic blood pressure, high triacylglycerol and glucose levels than men (Table 2).

The bivariate analysis suggests that there is a positive association between obesity and CVD risk factors and the relationship is disease-specific. Figures 1 indicates a gradual increase in percentage of hypertension for men and women, diabetes and having more than two CVD risk factors in men with the increase of BMIs. Figure 3 shows that the increase in percentage of dyslipidemia and having more than two CVD risk factors in men, and diabetes and having more than two CVD risk factors in women with higher waist circumferences. However, we need to conduct further regression analysis to determine the seemingly positive relationship between obesity and CVD risk factors.

The ROC analyses demonstrate that optimal BMI cutoffs are 24 kg/m^2 for men and 25 kg/m^2 for women (Table 3), and the optimal waist circumference cutoffs are 87 cm for men and 84 cm for women (Table 4). However, the areas under the ROC curve indicate that waist circumference appears to be a more sensitive predictor of CVD risk factors for both men and women than BMI

(Table 5). Similar to what has been found among Western population, the study provides evidence that BMI may not be a good indicator of obesity among elderly Chinese. Waist circumference is a useful predictor of obesity in elderly Chinese and the optimal cutoffs are lower than the WHO standard.

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Table 1. Means and percent distributions of body mass index and waist circumference for men and women aged 54 to 91 years in Taiwan, SEBAS 2000

Variable	Men (N=581)	Women (N=427)[1]
	Mean (*s.d* .)	Mean (*s.d* .)
BMI (kg/m^2) (Mean and *s.d* .)	24.0 (3.4)	25.0 (3.8)**
WC (cm) (Mean and s.d.)	87.0 (9.1)	83.4 (9.6)
	Percentage (n)	Percentage (n)
BMI category by WHO standard		
Underweight (BMI<18.5)	4.8 (28)	2.6 (11)
Normal (18.5=<BMI<25)	60.4 (351)	49.9 (213)***
Overweight (25<=BMI<30)	30.7 (179)	37.2 (159)*
Obese (BMI>=30)	4.0 (23)	10.3 (44)***
BMI category by Asian standard		
Underweight (BMI<18.5)	4.8 (28)	2.6 (11)
Normal (18.5<=BMI<23)	33.7 (196)	28.6 (122)
Overweight (23<=BMI<27.5)	46.7 (271)	47.1 (201)
Obese (BMI>=27.5)	14.8 (86)	21.8 (93)**
Waist circumference category by WHO standard[2]		
Normal (<94 for men and <80 for women)	76.6 (445)	35.6 (152)
Risk level I (94-102 for men and 80-88 for women)	18.2 (106)	33.5 (143)
Risk level II (>=102 for men and >=88 for women)	5.2 (30)	30.9 (132)
Waist circumference category by Asian standard[2]		
Normal (<90 for men and <80 for women)	60.9 (354)	35.6 (152)
Risk level (>=90 for men and >=80 for women)	39.1 (227)	64.4 (275)

[1]The difference between men and women is at (*) .05 level, (**) at .01 level, and (***) .001 level of significance.

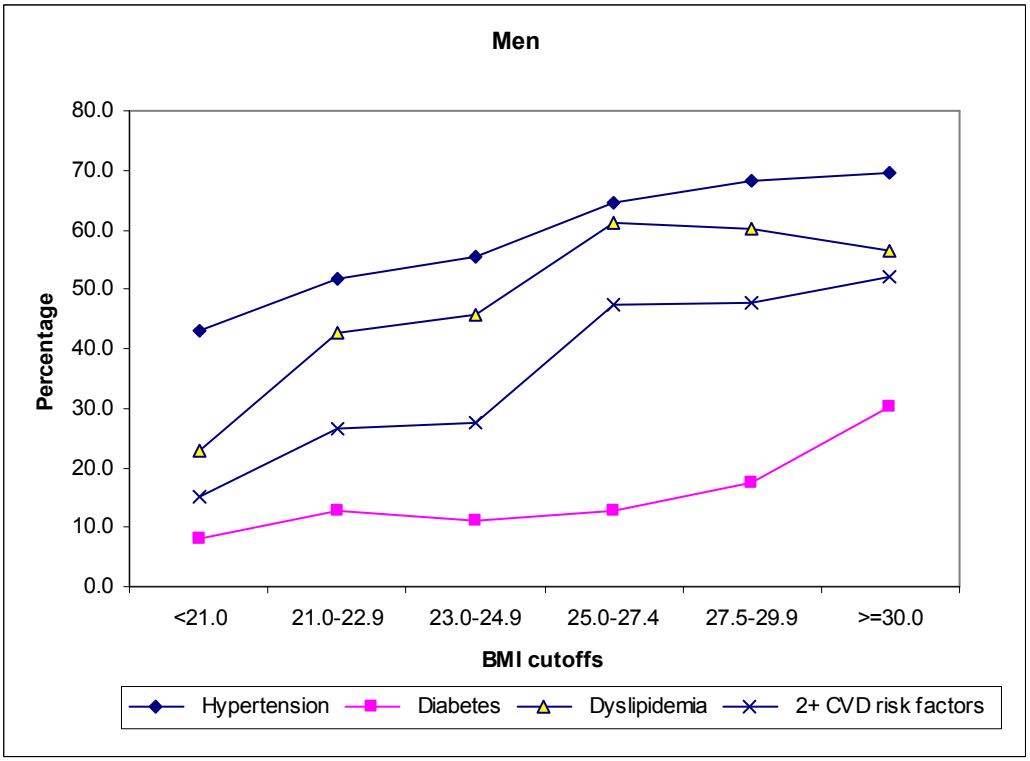
[2] Waist circumference cutoffs are sex-specific, so no comparison is made between men and women.

Table 2. Means and percent distributions of cardiovascular disease risk factors for men and women aged 54 to 91 years in Taiwan, SEBAS 2000

Variable	Men (N=581)	Women (N=427)[1]
	Mean (*s.d*.)	Mean (*s.d*.)
Age (years)	68.7 (8.4)	67.7 (8.6)
Systolic blood pressure (mm Hg)	137.5 (19.7)	140.0 (22.1)*
Diatolic blood pressure (mm Hg)	82.3 (11.1)	82.0 (11.3)
Total cholesterol (mg/dL)	194.1 (37.9)	209.4 (39.5)
HDL cholesterol (mg/dL)	47.0 (13.1)	51.9 (13.9)
LDL cholesterol (mg/dL)	124.5 (34.3)	132.0 (35.4)
Triacylglycerol (mg/dL)	113.2 (68.6)	128.0 (76.1)*
Glucose (mg/dL)	102.1 (27.2)	112.6 (43.7)***
	Percentage (n)	Percentage (n)
Hypertension	56.3 (327)	57.9 (248)
Diabetes	12.7 (74)	21.6 (92)***
Dyslipidemia	46.3 (269)	43.3 (185)
Two or more CVD risk factors	32.4 (188)	36.3 (155)

[1] The difference between men and women is at (*) .05 level, (**) at .01 level, and (***) .001 level of significance.

Figure 1. Percent distribution of cardiovascular disease risk factors by body mass index category for men and women aged 54 to 91 years in Taiwan, SEBAS 2000



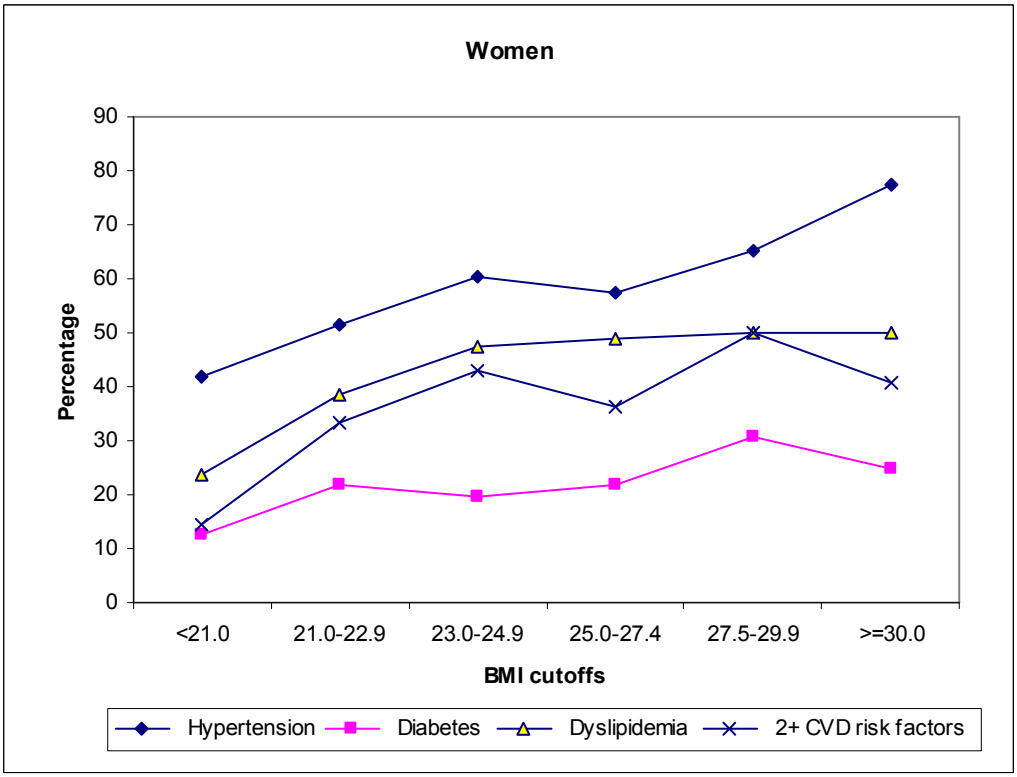
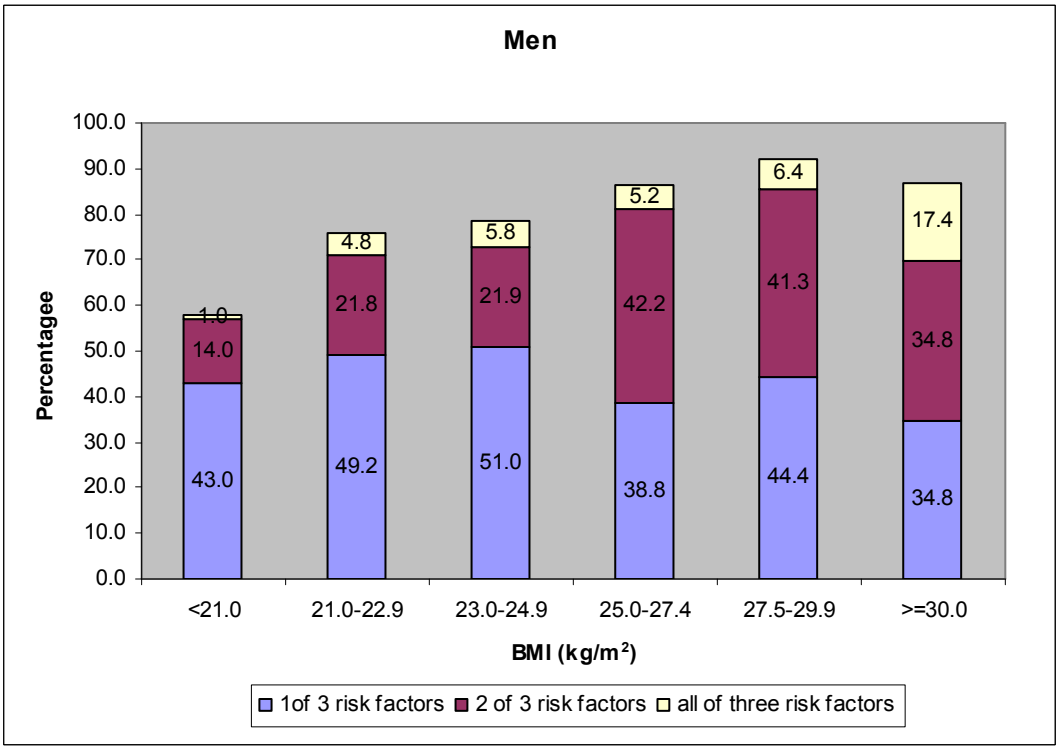


Figure 2. Percent distribution of one or more cardiovascular disease risk factors by body mass index category for men and women aged 54 to 91 years in Taiwan, SEBAS 2000



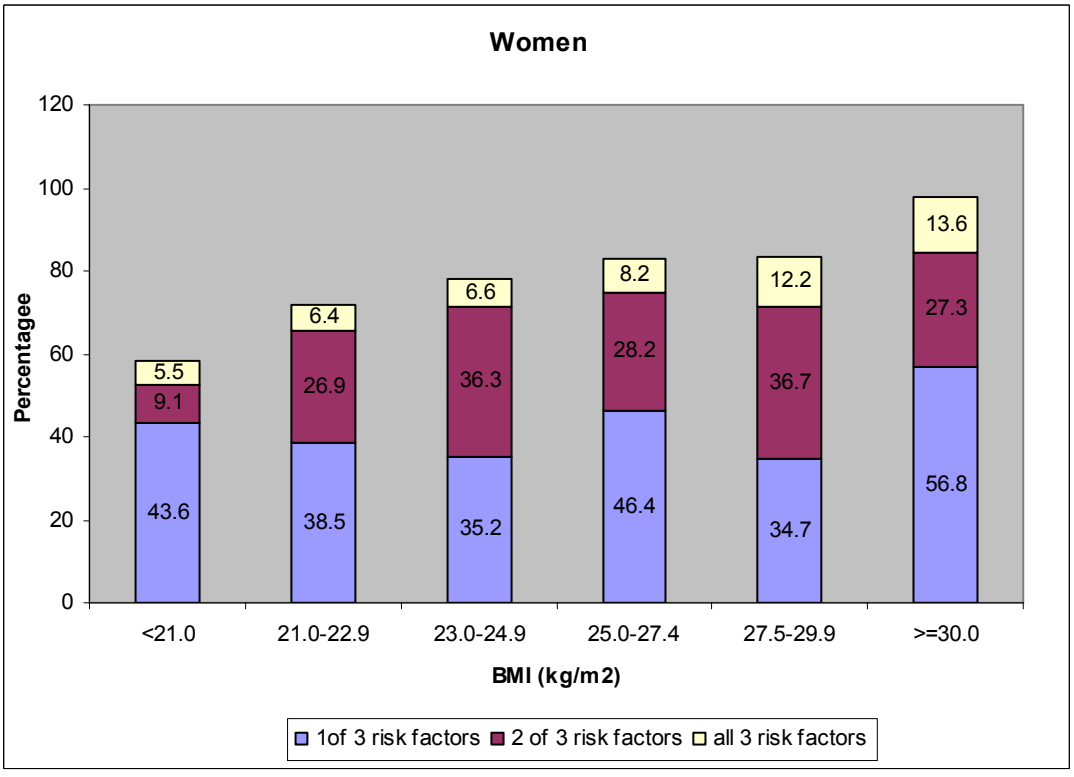
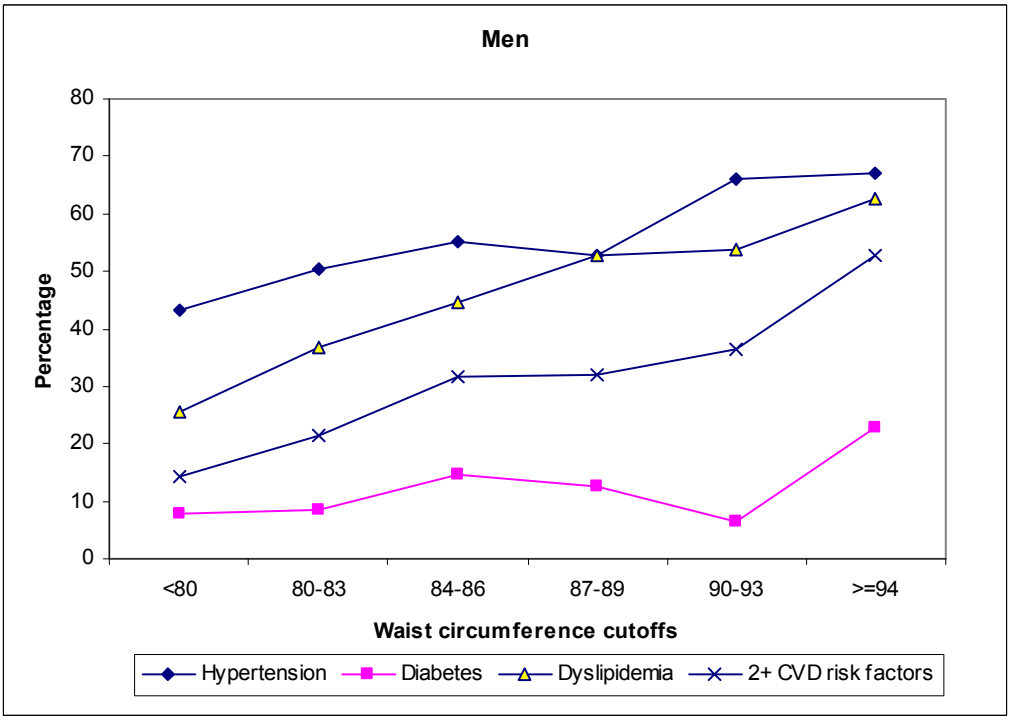


Table 3. Sensitivity, specificity, and distance on the receiver operating characteristics curve for body mass index cutoffs by cardiovascular disease risk factors for men and women aged 54 to 91 years in Taiwan, SEBAS 2000

			Hypertension			Diabetes			Dyslipidemia			>=2 Risk factors		
BMI (kg/m^2)	Percentile	n	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve
			%	%		%	%		%	%		%	%	
Men														
21	17.5	55	86.9	22.4	78.7	89.2	18.2	82.5	91.5	24.7	75.8	92.0	21.6	78.8
22	26.9	69	78.0	32.7	70.8	78.4	27.4	75.8	82.9	34.9	67.3	82.5	31.0	71.2
23	38.7	89	67.3	46.1	63.0	67.6	39.5	68.6	71.8	47.4	59.7	74.5	44.8	60.8
24	53.9	66	51.1	60.2	**63.0**	55.4	55.2	**63.2**	56.9	63.1	**56.7**	61.2	61.1	**54.9**
25	65.2	53	41.0	73.2	64.8	44.6	66.7	64.6	45.4	74.4	60.3	51.6	73.3	55.3
26	74.5	45	29.7	79.5	73.2	36.5	75.9	67.9	33.5	81.1	69.1	38.8	80.7	64.2
27	82.2	38	21.1	86.2	80.1	25.7	83.2	76.2	23.1	86.5	78.1	26.1	86.0	75.2
28	88.7	30	13.5	91.3	86.9	20.3	89.9	80.3	15.2	92.0	85.2	18.1	91.9	82.3
29	93.8	13	8.0	96.1	92.1	14.9	95.1	85.2	8.2	95.5	91.9	11.2	96.2	88.9
30	96.1	23	4.9	97.1	95.1	9.5	96.8	90.6	4.8	96.8	95.3	6.4	97.2	93.6
Women														
21	13.3	38	90.7	17.8	82.7	92.4	14.3	86	93.0	17.4	82.9	94.8	17.3	82.9
22	22.1	40	83.8	29.4	72.4	84.8	23.6	77.9	84.9	26.9	74.6	89.0	27.9	72.9
23	31.4	45	74.5	38.9	66.2	73.9	32.5	72.4	76.8	37.2	67.0	78.1	36.4	67.3
24	41.9	46	63.2	48.3	63.5	64.1	43.3	67.1	64.9	46.7	63.8	65.2	45.6	**64.6**
25	52.6	52	52.2	58.9	**63.0**	54.4	54.3	**64.6**	53.5	57.0	**63.3**	52.9	55.5	**64.8**
26	64.7	40	39.3	70.0	67.7	45.7	67.5	**63.3**	40.0	68.2	67.9	41.3	68.0	66.9
27	74.0	33	31.2	81.1	71.4	32.6	75.8	71.6	29.2	76.5	74.6	30.3	76.5	73.6
28	81.6	22	23.1	88.3	77.8	27.2	84.2	74.5	21.6	84.3	80.0	23.9	84.9	77.6
29	86.7	12	16.6	91.7	83.8	16.3	87.8	84.6	16.2	89.3	84.5	14.8	87.9	86.1
30	89.5	44	13.8	94.4	86.4	12.0	90.2	88.5	11.9	90.9	88.6	11.6	90.4	88.9

Figure 3. Percent distribution of cardiovascular disease risk factors by waist circumference category in men and women aged 54 to 91 years in Taiwan, SEBAS 2000



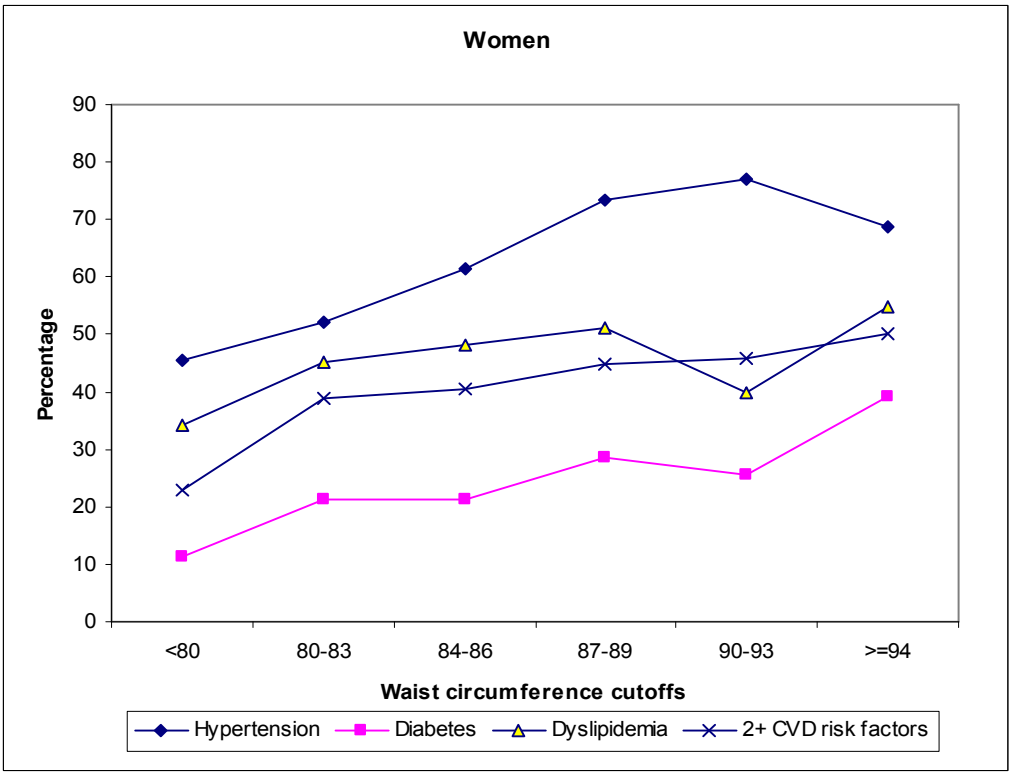
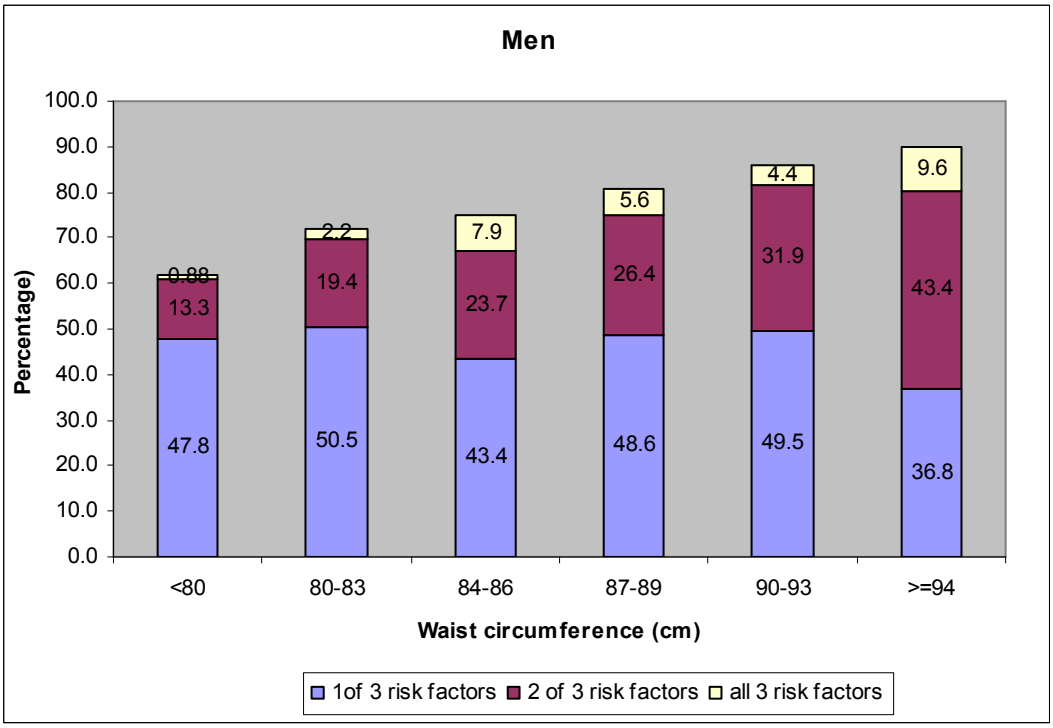


Figure 4. Percent distribution of one or more cardiovascular disease risk factors by waist circumference category in men and women aged 54 to 91 years in Taiwan, SEBAS 2000



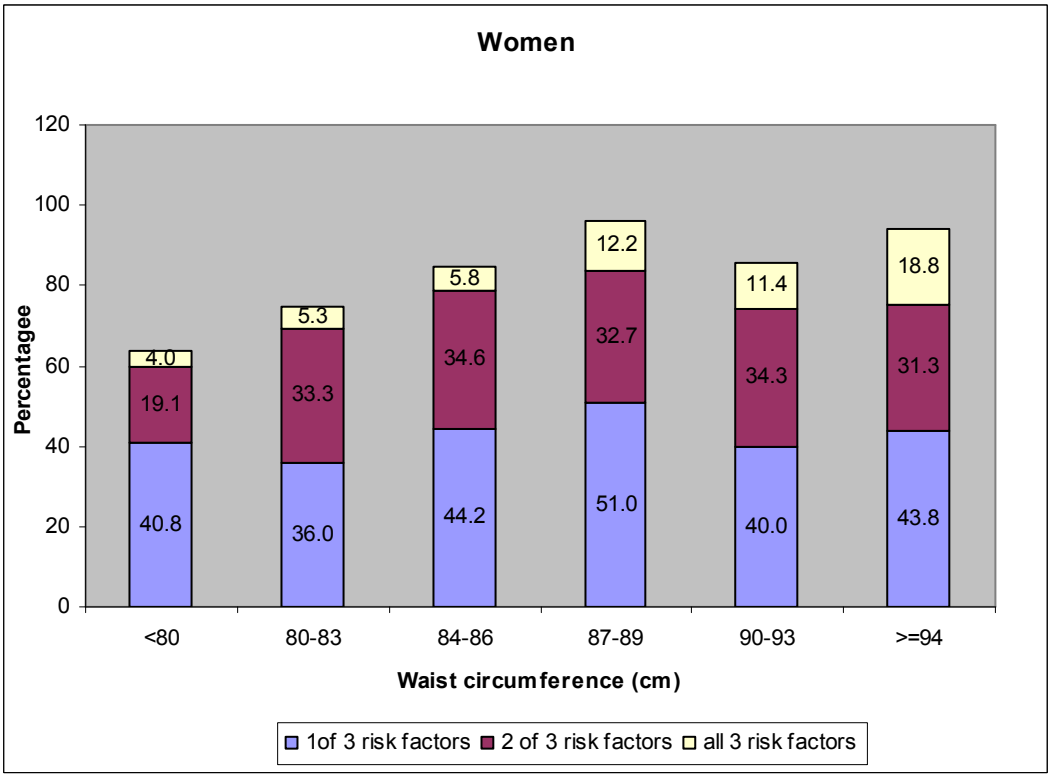


Table 4. Sensitivity, specificity, and distance on theon the receiver operating characteristics curve for waist circumference cutoffs by cardiovascular disease risk factors for men and women aged 54 to 91 years in Taiwan, SEBAS 2000

			Hypertension			Diabetes			Dyslipidemia			>=2 Risk factors		
Waist circum-ference (cm)	Percentile	n	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve	Sensi-tivity	Speci-ficity	Distance in ROC curve
			%	%		%	%		%	%		%	%	
Men														
80	19.4	93	85.0	25.2	76.3	87.8	20.5	80.4	89.2	26.9	73.9	91.5	24.7	75.8
84	35.5	76	70.6	43.3	63.9	77.0	37.3	66.8	76.6	45.8	59.0	80.9	43.3	59.8
87	48.5	72	57.8	56.7	**60.5**	62.2	50.1	**62.6**	63.9	59.3	**54.4**	68.1	56.5	**53.9**
90	60.9	91	46.2	70.1	61.6	50.0	62.5	62.5	49.8	70.2	58.4	55.9	69.0	53.9
94	76.6	136	27.8	82.3	74.3	41.9	79.3	61.7	31.6	83.7	70.3	38.3	83.7	63.8
Women														
80	35.6	75	72.1	46.1	60.7	81.5	40.3	62.5	71.9	41.3	65.1	77.4	43.0	37.6
84	53.2	52	56.3	66.1	**55.3**	64.1	57.9	**55.3**	53.5	58.3	**62.5**	58.7	59.9	**33.1**
87	65.3	49	43.3	77.2	61.1	52.2	70.2	56.3	40.0	69.4	67.4	45.2	71.3	38.3
90	76.8	35	28.7	84.4	73.0	37.0	80.6	65.9	26.5	79.3	76.4	31.0	81.3	51.1
94	85.0	64	17.8	88.9	83.0	27.2	88.4	73.7	18.9	88.0	82.0	20.7	88.2	64.3

Table 5. The areas under the ROC curve for cardiovascular disease risk factors in men and women aged 54 to 91 years in Taiwan, SEBAS 2000

		BMI	Waist circumference
CVD risk factors	Sex	AUC (95% *CI*)	AUC (95% *CI*)
Hypertension	Men	0.590 (0.543, 0.636)	0.599 (0.550, 0.642)
	Women	0.596 (0.542, 0.650)	**0.627 (0.570, 0.675)**
Diabetes	Men	0.580 (0.508, 0.652)	**0.610 (0.540, 0.679)**
	Women	0.571 (0.505, 0.637)	**0.652 (0.591, 0.714)**
Dyslipidemia	Men	**0.639 (0.594, 0.683)**	**0.649 (0.605, 0.693)**
	Women	0.582 (0.528, 0.635)	0.578 (0.521, 0.628)
2 + CVD risk factors	Men	**0.646 (0.601, 0.696)**	**0.673 (0.624, 0.715)**
	Women	0.588 (0.534, 0.642)	**0.624 (0.568, 0.675)**