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PAPER

Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan

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BACKGROUND: The increased health risks associated with obesity have been found to occur in Asians at lower body mass indices (BMIs). To determine the optimal cut-off values for overweight or obesity in Taiwan, we examined the relationships between four anthropometric indices and cardiovascular risk factors.
METHODS: The data were collected from four health-screening centers from 1998 to 2000 in Taiwan. Included were 55 563 subjects (26 359 men and 29 204 women, mean age = 37.3 ± 10.9 and 37.0 ± 11.1 y, respectively). None had known major systemic diseases or were taking medication. Individual body weight, height, waist circumference (WC), and a series of tests related to cardiovascular risk (blood pressure, fasting plasma glucose, triglycerides, total cholesterol, low- and high-density lipoprotein cholesterol) were assessed and their relationships were examined. Receiver operating characteristic (ROC) analysis was used to find out the optimal cut-off values of various anthropometric indices to predict hypertension, diabetes mellitus and dyslipidemia.
RESULTS: Of the four anthropometric indices we studied, waist-to-height ratio (WHtR) in women was found to have the largest areas under the ROC curve (women = 0.755, 95% CI 0.748 – 0.763) relative to at least one risk factor (ie hypertension or diabetes or dyslipidemia). The optimal cut-off values for overweight or obesity from our study in men and women showed that BMIs of 23.6 and 22.1 kg/m^2, WCs of 80.5 and 71.5 cm, waist-to-hip ratios (WHpR) of 0.85 and 0.76, and WHtR of 0.48 and 0.45, respectively, may be more appropriate in Taiwan.
CONCLUSIONS: WHtR may be a better indicator for screening overweight- or obesity-related CVD risk factors than the other three indexes (BMI, WC and WHpR) in Taiwan. Our study also supported the hypothesis that the cut-off values using BMI and WC to define obesity should be much lower in Taiwan than in Western countries.
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Keywords: obesity; ROC curve; cardiovascular risk factors; anthropometric indices; Taiwan

Introduction

The prevalence of obesity and its related medical consequences are increasing in many countries.[1–3] Obesity has now become a major global problem. Obesity has been found to increase the risk of morbidities and mortalities, including cardiovascular disease (CVD), diabetes, gallbladder disease, respiratory disease, cancer, arthritis and gout.[4–8] For example, CVD mortality is about three-fold higher among obese men and women, and about 21 and 28% of CVD mortality in men and women, respectively, could be attributed to being overweight.[7,8] Central distribution of body fat, which suggests excessive deposition of intra-abdominal fat, is also found to be one of the important predictors of CVD risk.[9–11]

Obesity is defined as a condition where there is an excess of body fat. Of the ways to measure total body fat and its distributions,[12–15] anthropometric measurements still play an important role in clinical practice. Body mass index (BMI) is often used to reflect total body fat amount, while waist

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circumference (WC), waist-to-hip ratio (WHpR) or waist-to-height ratio (WHtR) is used as a surrogate of body fat centralization.[16–19] These measurements have been shown to be associated with CVD risk factors such as hypertension, dyslipidemia, diabetes, etc in all ethnic groups studied.[20–23] The best index of obesity that is predictive for CVD risk, however, still remains controversial.

Most studies examining the risk of adverse health associated with obesity have been based on data from Europe or the United States. Little data is available from the Asia-Pacific region. It has been demonstrated that the increased risks associated with obesity occur at lower BMIs in Asians, and that these populations are predisposed to visceral or abdominal obesity.[24–26] Therefore, WHO proposes lower BMI values to define overweight and obesity in people living in the Asia-Pacific region.[27] In this study, we examined four anthropometric indices (BMI, WC, WHpR and WHtR) and three CVD risk factors (hypertension, diabetes mellitus and dyslipidemia) and used receiver operating characteristic (ROC) analysis to find the optimal cut-off values of these anthropometric indices for overweight or obesity in Taiwan.

Subjects and methods

From 1998 to 2000 in Taiwan, the data was collected from four nationwide health-screening centers. Our study included 55 563 'healthy' subjects (26 359 men and 29 204 women, mean age = 37.3 ± 10.9 and 37.0 ± 11.1 y, respectively), without any previous systemic diseases or medications related to body weight change or affecting blood pressure, glucose and lipid levels (such as DM, HTN, dyslipidemia or thyroid diseases and their related medications), from a total of 225 513 persons screened. In addition, people whose body weight had changed by more than 5% within 3 months were also excluded. The population structure in our study was similar to national data on adults published by our government.[24] The anthropometric and metabolic variables of the study population and the prevalence of newly diagnosed CVD risk factors are shown in Table 1. Trained staff measured height, waist and hip circumference (measured to nearest 0.1 cm) and weight (measured to the nearest 0.1 kg). Waist circumference was taken midway between the inferior margin of the last rib and the crest of the ilium in a horizontal plane. Hip circumference was taken as the distance around the pelvis at the point of maximal protrusion of the buttocks. BMI was calculated as weight (kg) divided by height squared (m^2). WHpR and WHtR were also calculated. The same staff measured blood pressure (BP) in the right arm using an appropriately sized cuff and a standard mercury sphygmomanometer. The systolic BP was determined by the onset of the 'tapping' Korotkoff sounds (K1). The fifth Korotkoff sound (K5), or the disappearance of Korotkoff sounds, was used to define diastolic BP. A venous blood sample was taken after a 12 h fast for measuring plasma glucose, triglycerides, total cholesterol, low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol. These assays were performed on a HITACHI 7150. Hypertension was defined as a systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg. Type 2 diabetes mellitus was defined as fasting plasma glucose ≥ 7.0 mmol. Dyslipidemia was defined as plasma total cholesterol ≥ 6.21 mmol and/or fasting triglycerides ≥ 2.26 mmol and/or LDL cholesterol ≥ 4.14 mmol and/or HDL-cholesterol < 0.91 mmol and/or total cholesterol/HDL-cholesterol ratio ≥ 5. Those in the 'risk' group had at least one CVD risk factor (defined as hypertension, diabetes and/or dyslipidemia) assigned to them. This study was approved by the Ethics Committee of National Taiwan University Hospital and MJ Health Screening Center.

Table 1 Anthropometric indices and cardiovascular risk factors in both sexes (mean ± s.d.)

Variables	*Men (n = 26 359)*	*Women (n = 29 204)*
Age (y)	37.3 ± 10.9	37.0 ± 11.1
Height (cm)	169.8 ± 6.1	157.5 ± 5.6
Weight (kg)	67.8 ± 10.3	53.8 ± 8.2
BMI (kg/m^2)	23.5 ± 3.1	21.7 ± 3.2
WC (cm)	80.5 ± 8.6	70.2 ± 7.7
HIP (cm)	94.5 ± 6.0	92.8 ± 6.1
WHpR	0.85 ± 0.06	0.75 ± 0.05
WHtR	0.48 ± 0.05	0.45 ± 0.05
Systolic BP (mmHg)	119.8 ± 14.4	112.5 ± 15.8
Diastolic BP (mmHg)	73.6 ± 10.2	68.4 ± 10.2
Glucose (mmol/l)	5.4 ± 0.71	5.2 ± 0.66
TCHO (mmol/l)	5.1 ± 0.92	4.9 ± 0.90
TG (mmol/l)	1.4 ± 0.75	1.0 ± 0.53
HDL (mmol/l)	1.2 ± 0.31	1.5 ± 0.35
LDL (mmol/l)	3.3 ± 0.83	3.0 ± 0.80
TCHO/HDL	4.58 ± 1.36	3.55 ± 1.02
Hypertension (%)	11.8	7.1
Diabetes (%)	1.2	0.9
Dyslipidemia (%)	29.3	11.2
Risk (%)	37.0	16.6
BMI groups (%)		
23 – 24.9 kg/m^2	10.6	14.7
25 – 29.9 kg/m^2	14.1	12.3
≥ 30 kg/m^2	2.0	1.9

BMI, body mass index; WC, waist circumference; HIP, hip circumference; WHpR, waist-to-hip ratio; WHtR, waist-to-height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; glucose, fasting plasma glucose; TCHO, total cholesterol; TG, fasting triglycerides; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; risk, at least one CHD risk factor (hypertension or diabetes or dyslipidemia).

Statistical analysis

Results are presented as the mean ± s.d., or as a percentage, where appropriate. BMI, WC, WHpR and WHtR were used to predict the prevalence of hypertension, diabetes and dyslipidemia. We used the receiver operating characteristic (ROC) analysis[28–31] to compare their predictive validity, and to find out their optimal cut-off values. ROC curves were plotted using measures of sensitivity and specificity based on various anthropometric cut-off values. The ROC curves demonstrated the overall discriminatory power of a diagnostic test over the whole range of testing values. A better test shows its curve skewed closer to the upper left corner.[32] The area under the curve (AUC) is a measure of the diagnostic power of a test. A perfect test will have an AUC of 1.0 and an AUC = 0.5 means the test performs no better than chance. Sensitivity and specificity of the anthropometric measurements have been calculated at all possible cut-off points to find the optimal cut-off value. The optimal sensitivity and specificity were the values yielding maximum sums from the ROC curves. Odds ratios were calculated as the ratios of having ‘at least one CVD risk factor’ prevalence relative to the one in the lowest BMI (< 18.5 kg/m^2) or WC (< 65 cm) in each gender. The relationships between BMI and WC *vs* odds ratio of having at least one CVD risk factor were assessed. Statistical analysis was performed using SPSS 10.0 for Windows on an IBM PC compatible computer.

Results

The areas under the ROC curves (AUCs) of various anthropometric indices and CVD risk factors are summarized in Table 2. AUCs of various anthropometric indices and the groups with at least one CVD risk factor were obtained for BMI — 0.690 in men, 0.721 in women; WC — 0.694 in men, 0.736 in women; WHpR — 0.680 in men, 0.723 in women; and WHtR — 0.702 in men, 0.755 in women. It seems that AUCs of 0.6 – 0.7 are considered poor and 0.7 – 0.8 are fair. Interestingly, AUCs were found to be always bigger for women. The cut-off values of various anthropometric indices found optimally to predict hypertension, diabetes mellitus, dyslipidemia or at least one CVD risk factor using the ROC analysis in both sexes are summarized in Tables 3 and 4. The sensitivity and specificity using overweight and obesity criteria proposed for the Asia-Pacific region[27] and obesity cut-off values by WHO[33] are also shown. The optimal BMI cut-off values for predicting hypertension, diabetes, dyslipidemia or at least one CVD risk factor varied from 23.6 to 24.5 kg/m^2 in men and 21.9 to 23.4 kg/m^2 in women. The optimal WC cut-off values varied from 80.5 to 84.5 cm in men and from 70.5 to 74.5 cm in women. The optimal WHpR cut-off values varied from 0.85 to 0.88 in men and from 0.76 to 0.79 in women. The optimal WHtR cut-off values varied from 0.48 to 0.50 in men and from 0.45 to 0.48 in women. In Figs 1 and 2, the increasing risk of having at one CVD risk factor was found to be associated with increasing BMI and WC in both genders.

Discussion

Most studies regarding the health risk of obesity are available from Europe or the United States. Increased risks related to obesity at lower BMIs have been found in Asians.[24,25] In addition, Asians are also predisposed to visceral or abdominal obesity.[26] Therefore, WHO recently proposed lower BMI values to define overweight and obesity in people of the Asia-Pacific region.[27] However, the cut-off values of overweight and obesity in people of these regions were only based on data from a few reports, predicated on either small-scale or cross-sectional studies. Our data was derived from a larger sample size, and the population structure in our study was similar to national data of the adults published by our government. More prospective or longitudinal epidemiological studies, however, are needed to determine the relative risk of developing these co-morbidities with obesity in the Asia-Pacific region.

Table 2 The areas under ROC curve (AUC) of various anthropometric indices and CVD risk factors (CVDs) in males (M) and females (F)

CVDs	*Sex*	*BMI* *AUC (95% CI)*	*WC* *AUC (95% CI)*	*WHpR* *AUC (95% CI)*	*WHtR* *AUC (95% CI)*
HTN	M	0.638 (0.628, 0.648)	0.649 (0.638, 0.659)	0.632 (0.621, 0.642)	0.658 (0.647, 0.668)
	F	0.731 (0.720, 0.742)	0.759 (0.748, 0.770)	0.753 (0.742, 0.764)	0.782 (0.772, 0.793)
DM	M	0.706 (0.678, 0.733)	0.745 (0.719, 0.770)	0.779 (0.755, 0.803)	0.769 (0.744, 0.793)
	F	0.815 (0.790, 0.839)	0.846 (0.823, 0.868)	0.857 (0.836, 0.878)	0.866 (0.845, 0.886)
TG	M	0.721 (0.713, 0.729)	0.733 (0.725, 0.741)	0.720 (0.712, 0.728)	0.735 (0.727, 0.743)
	F	0.783 (0.771, 0.796)	0.792 (0.779, 0.804)	0.776 (0.762, 0.790)	0.808 (0.796, 0.820)
TCHO	M	0.594 (0.584, 0.605)	0.617 (0.607, 0.627)	0.621 (0.611, 0.632)	0.630 (0.620, 0.640)
	F	0.640 (0.629, 0.651)	0.660 (0.649, 0.671)	0.655 (0.644, 0.667)	0.682 (0.671, 0.693)
LDL	M	0.589 (0.580, 0.599)	0.602 (0.593, 0.612)	0.601 (0.592, 0.610)	0.615 (0.606, 0.624)
	F	0.654 (0.643, 0.665)	0.663 (0.651, 0.674)	0.653 (0.642, 0.665)	0.683 (0.672, 0.694)
HDL	M	0.665 (0.657, 0.674)	0.648 (0.639, 0.656)	0.630 (0.622, 0.639)	0.646 (0.637, 0.654)
	F	0.706 (0.691, 0.721)	0.696 (0.681, 0.711)	0.670 (0.655, 0.686)	0.693 (0.678, 0.708)
TCHO/HDL	M	0.707 (0.701, 0.714)	0.703 (0.696, 0.709)	0.683 (0.676, 0.689)	0.705 (0.699, 0.712)
	F	0.750 (0.741, 0.759)	0.752 (0.743, 0.761)	0.726 (0.717, 0.736)	0.760 (0.751, 0.769)
Dyslipidemia	M	0.686 (0.679, 0.693)	0.687 (0.681, 0.694)	0.675 (0.668, 0.682)	0.694 (0.687, 0.700)
	F	0.702 (0.693, 0.712)	0.711 (0.702, 0.721)	0.697 (0.687, 0.706)	0.727 (0.718, 0.736)
Risk	M	0.690 (0.683, 0.696)	0.694 (0.687, 0.700)	0.680 (0.673, 0.687)	0.702 (0.696, 0.708)
	F	0.721 (0.713, 0.729)	0.736 (0.729, 0.744)	0.723 (0.715, 0.731)	0.755 (0.748, 0.763)

95% CI, 95% confidence interval; HTN, hypertension; DM, diabetes mellitus; TG, fasting triglycerides ≥ 2.26 mmol/l; TCHO, plasma total cholesterol ≥ 6.21 mmol/l; LDL, LDL-cholesterol ≥ 4.14 mmol/l; HDL, HDL-cholesterol < 0.91 mmol/l; TCHO/HDL, total cholesterol/HDL-cholesterol ratio ≥ 5; dyslipidemia, TCHO or LDL or HDL or TCHO/HDL; risk, at least one CVD risk factor (hypertension or diabetes or dyslipidemia).

Table 3 The optimal cut-off values, sensitivities and specificities for various anthropometric indices predictive of CVD risk factors in men

CVD risk factors		*BMI*			*WC*			*WHpR*			*WHtR*		
		Cut-off	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*
HTN	Optimal	23.9	60.24	60.15	81.5	62.71	58.41	0.86	59.51	59.33	0.48	61.43	61.41
	Asia 1	23.0	71.95	47.58	90	24.17	89.97						
	Asia 2	25.0	44.79	73.40									
	WHO	30.0	6.70	97.62	102	3.80	99.24						
DM	Optimal	24.5	65.64	65.64	84.5	67.18	69.62	0.88	70.50	71.20	0.50	69.94	69.78
	Asia 1	23.0	81.60	45.61	90	36.50	88.60						
	Asia 2	25.0	59.20	71.63									
	WHO	30.0	10.74	97.20	102	3.68	98.99						
TG	Optimal	24.2	66.23	66.18	82.5	69.41	65.14	0.87	66.54	66.21	0.49	67.14	67.06
	Asia 1	23.0	82.75	49.54	90	26.03	90.47						
	Asia 2	25.0	53.40	75.00									
	WHO	30.0	6.83	97.70	102	2.18	99.13						
CHO	Optimal	23.7	56.75	56.73	81.5	58.77	57.84	0.86	58.90	58.86	0.48	58.93	58.86
	Asia 1	23.0	66.45	46.81	90	18.03	89.12						
	Asia 2	25.0	37.67	72.42									
	WHO	30.0	4.61	97.33	102	1.99	99.08						
LDL	Optimal	23.7	55.98	56.03	81.5	55.87	57.87	0.86	57.36	56.55	0.48	58.00	57.89
	Asia 1	23.0	65.66	47.09	90	16.69	89.12						
	Asia 2	25.0	36.79	72.58									
	WHO	30.0	4.55	97.38	102	1.91	99.10						
HDL	Optimal	24.0	62.25	62.25	81.5	62.18	59.42	0.86	59.22	59.68	0.48	60.74	60.54
	Asia 1	23.0	74.44	49.10	90	20.40	89.98						
	Asia 2	25.0	47.20	74.83									
	WHO	30.0	6.07	97.72	102	1.77	99.09						
CHO/HDL	Optimal	23.7	64.73	64.74	81.5	63.14	65.92	0.86	63.77	63.32	0.48	65.06	64.88
	Asia 1	23.0	74.80	55.82	90	20.02	92.66						
	Asia 2	25.0	44.97	79.78									
	WHO	30.0	5.53	98.49	102	2.01	99.46						
Dyslipidemia	Optimal	23.7	63.43	63.35	81.5	63.24	63.85	0.86	62.65	63.14	0.48	63.90	63.96
	Asia 1	23.0	73.74	53.15	90	20.38	91.89						
	Asia 2	25.0	44.96	77.97									
	WHO	30.0	5.71	98.27	102	2.01	99.35						
Risk	Optimal	23.6	63.92	63.90	80.5	66.12	62.02	0.85	63.16	63.28	0.48	64.78	64.76
	Asia 1	23.0	72.14	55.49	90	20.09	93.21						
	Asia 2	25.0	43.44	79.87									
	WHO	30.0	5.40	98.58	102	1.97	99.49						

Asia 1 and Asia2, proposed overweight and obesity criteria for Asia-Pacific region; WHO, obesity criteria for Caucasians by WHO.

The four anthropometric indices (BMI, WC, WHpR and WHtR) have all been noted to be associated with several CVD risk factors.[16–22,34–35] In Hong Kong Chinese, Ko *et al*.[36] found that WHpR and WHtR were the main predictors for diabetes and hypertension, and all these four indexes were useful tools for detecting people with dyslipidemia. Nevertheless, some studies showed that WC was a better predictor of CVD risk factors.[18,34,37,38] Of the four anthropometric indices we studied, WHtR in women was found to have the largest areas under the ROC curve (women = 0.755, 95% CI 0.748–0.763) in relation to at least one CVD risk factor (ie hypertension or diabetes or dyslipidemia; Table 2). Our results suggested that WHtR was a better predictor of CVD risk factors, which was similar to other studies.[20–22,34,36]

Among the four anthropometric indices, BMI is closely related to the total amount of body fat[16,17] and now used to define the criteria of overweight or obesity. Both obesity-related morbidity and mortality risk have been shown to increase with increasing BMI in population study.[39,40] In our study, we also found that the increasing risk with at least one CVD risk factor was associated with increasing BMI in both genders (Figure 1). It is apparent that Asians have lower BMI than do Caucasians. Reeder *et al*[41] found, for example, that the mean BMIs in Canadian adults were 26.0 kg/m^2 for men and 25.0 kg/m^2 for women. In contrast, Ko *et al* found that the mean BMIs in Hong Kong Chinese adults were 23.4 kg/m^2 for men and 23.3 kg/m^2 for women.[22,36] In our study, the mean BMIs, 23.5 kg/m^2 for men and 21.7 kg/m^2 for women, respectively, were also much lower than the Caucasians' (Table 1). Furthermore, if we used the cut-off values of BMI equal to 30 kg/m^2 for obesity, 8–22.5% of Caucasians but only 0.5–8.8% of Asians would be considered obese.[2,27,42] Our study showed that only 2% of the Taiwanese adults (Table 1) would be defined to be obese and only less than 6% of them (Tables 3 and 4) would be screened out for one CVD risk factor if we used the cut-off

Table 4 The optimal cut-off values, sensitivities and specificities for various anthropometric indices predictive of CVD risk factors in women

CVD risk factors		*BMI*			*WC*			*WHpR*			*WHtR*		
		Cut-off	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*	*Cut-off*	*Sensitivity (%)*	*Specitivity (%)*
HTN	Optimal	22.5	68.43	68.35	72.5	68.38	71.32	0.77	68.91	68.95	0.46	71.59	71.80
	Asia 1	23.0	61.61	73.60	80	31.86	92.81						
	Asia 2	25.0	38.24	87.66									
	WHO	30.0	7.15	98.49	88	6.96	98.83						
DM	Optimal	23.4	75.10	75.16	74.5	77.82	76.99	0.79	78.60	78.64	0.48	79.77	79.85
	Asia 1	23.0	78.99	71.53	80	50.58	91.42						
	Asia 2	25.0	54.09	86.16									
	WHO	30.0	10.12	98.16	88	18.29	97.81						
TG	Optimal	22.9	71.67	71.65	72.5	74.61	70.04	0.77	70.69	70.90	0.47	73.53	73.52
	Asia 1	23.0	70.88	72.61	80	33.53	91.94						
	Asia 2	25.0	43.14	86.86									
	WHO	30.0	8.82	98.34	88	10.88	97.98						
CHO	Optimal	21.9	60.37	60.35	70.5	63.65	61.19	0.76	61.94	62.32	0.45	64.15	64.09
	Asia 1	23.0	46.66	72.68	80	19.90	92.03						
	Asia 2	25.0	25.55	86.83									
	WHO	30.0	4.03	98.28	88	6.40	98.04						
LDL	Optimal	21.9	61.30	61.25	70.5	63.44	61.20	0.76	62.12	61.65	0.45	64.06	64.06
	Asia 1	23.0	47.63	72.78	80	19.27	91.99						
	Asia 2	25.0	26.84	86.96									
	WHO	30.0	4.24	98.30	88	5.97	98.00						
HDL	Optimal	22.3	65.23	65.16	71.5	63.92	65.15	0.76	62.77	62.45	0.45	64.79	64.37
	Asia 1	23.0	58.03	72.27	80	23.71	91.65						
	Asia 2	25.0	35.29	86.67									
	WHO	30.0	6.32	98.26	88	6.32	97.83						
CHO/HDL	Optimal	22.4	68.94	68.88	71.5	70.53	67.62	0.77	66.84	66.95	0.46	69.41	69.41
	Asia 1	23.0	61.47	74.48	80	27.47	92.98						
	Asia 2	25.0	38.24	88.32									
	WHO	30.0	6.78	98.59	88	8.05	98.27						
Dyslipidemia	Optimal	22.1	64.89	64.93	71.5	64.59	67.62	0.76	65.32	64.84	0.45	67.22	67.56
	Asia 1	23.0	54.27	74.28	80	23.26	92.85						
	Asia 2	25.0	32.05	88.06									
	WHO	30.0	5.57	98.55	88	7.25	98.29						
Risk	Optimal	22.1	66.60	66.61	71.5	66.25	70.05	0.76	66.91	66.77	0.45	69.46	69.53
	Asia 1	23.0	55.77	76.44	80	24.97	94.24						
	Asia 2	25.0	33.13	89.58									
	WHO	30.0	5.73	98.85	88	8.10	98.82						

Asia 1 and Asia2, proposed overweight and obesity criteria for Asia-Pacific region; WHO, obesity criteria for Caucasians by WHO.

value of BMI equal to 30 kg/m^2 for obesity. In addition, the optimal cut-off values of BMIs for overweight or obesity from our study were found to be 23.6 kg/m^2 in men and 22.1 kg/m^2 in women, values which were similar in men but different in women to those of Ko *et al*.[36] As mentioned previously, Asians with lower BMIs have been found to be at increased risk for obesity.[24,25] Taken together, our study supported the conclusion that cut-off values using BMI to define obesity should be much lower in Taiwan than in Western countries. The increasing risk of having at one CVD risk factor was also found to be associated with increasing WC in both sexes (Figure 2). Similarly, optimal cut-off values using WC were 80.5 cm in men and 71.5 cm in women in our study. These values were apparently lower than the values for Caucasians (102 cm for men and 88 cm for women)[33] and for Asians (90 cm for men and 80 cm for women)[27] that have been previously recommended. In summary, further studies are needed to find out the appropriate cut-off values for overweight and obesity in the Asia-Pacific region.

Conclusions

Obesity is defined as an excess of body fat, but at what point does fat become excessive? In this report we have defined overweight or obesity as the level of various anthropometric indices associated with abnormal values of obesity-related CVD risk factors. It should be noted that the risk factors themselves are based on arbitrary cut-offs and do not necessarily indicate a clinical condition; everything could change if they were redefined. Thus the recommended cut-off values indicate levels of the anthropometric indices above which people are screened for CVD risk. The optimal cut-off values in our study suggested that BMIs of 23.6 kg/m^2 in men and 22.1 kg/m^2 in women, WCs of 80.5 cm in men and 71.5 cm in women, WHpRs of 0.85 in men and 0.76 in women, and a

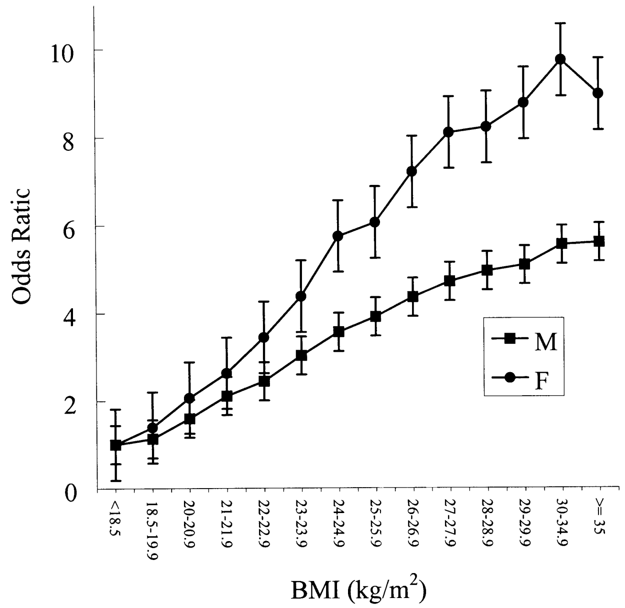

Figure 1 The relationship between body mass index (BMI) and the odds ratio of having at one CVD risk factor in both sexes (M, men; F, women). The increasing risk with at least one CVD risk factor was found to be associated with increasing BMI.

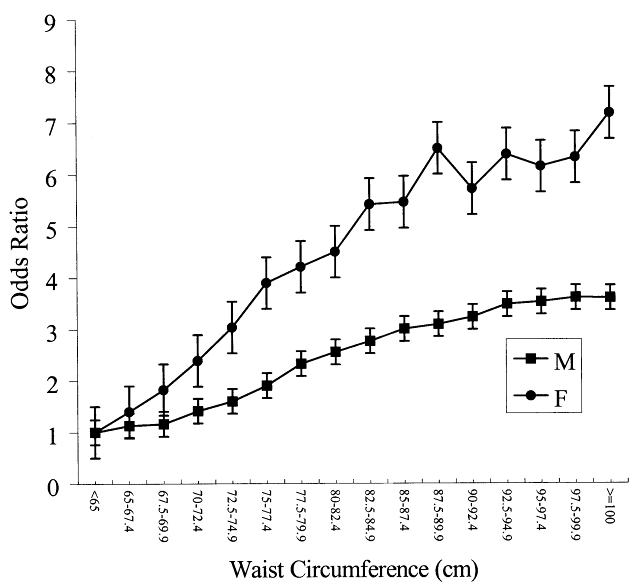

Figure 2 The relationship between waist circumference (WC) and the odds ratio of having at least one CVD risk factor in both sexes (M, men; F, women). The increasing risk with at least one CVD risk factor was found to be associated with increasing WC.

WHtR of 0.48 in men and 0.45 in women may be more appropriate for defining adult overweight or obesity in Taiwan. WHtR, especially for women, may be a better indicator for predicting obesity-related CVD risk factors than the other three indexes. Our study suggested that the cut-off values using BMI and WC to define obesity should be much lower in Taiwan than in Western countries.

References

1 Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults. The National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA* 1994; **272**: 205–211.
2 Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: Prevalence and trends, 1960–1994. *Int J Obes Relat Metab Disord* 1998; **22**: 39–47.
3 World Health Organization. *Obesity: preventing and managing the global epidemic*. WHO: Geneva, 1998.
4 Kopelman. Obesity as a medical problem. *Nature* 2000; **404**: 635–643.
5 Pi-Sunyer X. Health implications of obesity. *Am J Clin Nutr* 1991; **53**: 1595s–1603s.
6 Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. *Circulation* 1983; **67**: 968–977.
7 William BK, Ralph BD, Janet LC. Effect of weight on cardiovascular disease. *Am J Clin Nutr* 1996; **63**: 419s–422s.
8 Seidell JC, Verschu Ren WM, Van Leer EM, Kromhout D. Overweight, underweight, and mortality. A prospective study of 48,187 men and women. *Arch Intern Med* 1996; **156**: 958–963.
9 Björntorp P. Metabolic implications of body fat distribution. *Diabetes Care* 1991; **14**: 1132–1143.
10 Larsson B, Svardsud K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 y follow up of participants in the study of men born in 1913. *Br Med J* 1984; **288**: 1401–1404.
11 Kissebah AH, Vydelingum N, Murray R, Evans DJ, Hartz AJ, Kalkhoff RK, Adams PW. Relation of body fat distribution to metabolic complications of obesity. *J Clin Endocrinol Metab* 1982; **54**: 254–260.
12 Mazess RB, Barden HS, Bisek JP, Hanson J. Dual-energy X-ray absorptiometry for total body and regional bone mineral and soft tissue composition. *Am J Clin Nutr* 1990; **51**: 1106–1112.
13 Lukaski HC. Methods for the assessment of human body composition: Traditional and new. *Am J Clin Nutr* 1987; **46**: 537–556.
14 Friedl KE, Deluca JP, Marchitelli LJ, Vogel JA. Reliability of body-fat estimations from a four-compartment model by using density, body water, and bone mineral measurements. *Am J Clin Nutr* 1992; **55**: 764–770.
15 Kushner RF, Schoeller DA, Fjeld CR, Danford L. Is the impedance index (H^2/R) significant in predicting total body water. *Am J Clin Nutr* 1992; **56**: 835–839.
16 Gallagher D, Visser M, Sepulveda D, Pierson RN, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *Am J Epidemiol* 1996; **143**: 228–239.
17 Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta-analysis among different ethnic groups. *Int J Obes Relat Metab Disord* 1988; **22**: 1164–1171.
18 Pouliot MC, Despres JP, Lemieux S *et al*. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *Am J Cardiol* 1994; **73**: 460–468.
19 Després J-P, Prud'homme, Pouliot MC, Trembley A, Bouchard C. Estimation of deep abdominal adipose-tissue accumulation from siimple anthropometric measurements in men. *Am J Clin Nutr* 1991; **54**: 471–477.

20 Hsieh SD, Yoshinaga H. Abdominal fat distribution and coronary heart disease risk factors in men — waist/height ratio as a simple and useful predictor. *Int J Obes Relat Metab Disord* 1995; **19**: 585–589.
21 Hsieh SD, Yoshinaga H. Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. *Intern Med* 1995; **34**: 1147–1152.
22 Ko GTC, Chan JCN, Woo J, Lau E *et al*. Simple anthropometric indexes and cardiovascular risk factors in Chinese. *Int J Obes Relat Metab Disord* 1997; **21**: 995–1001.
23 Wang J, Thornton JC, Russell M, Burastero S, Heymsfield S Jr, Pierson RN. Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements. *Am J Clin Nutr* 1994; **60**: 23–28.
24 Deurenberg-Yap M, Yian TB, Kai CS, Deurenberg P, van Staveren WA. Manifestation of cardiovascular risk factors at low levels of body mass index and waist-to-hip ratio in Singaporean Chinese. *Asia Pacific J Clin Nutr* 1999; **8**: 177–183.
25 Hsieh SD, Yo Shinaga H, Muto T, Sakurai Y, Kosaka K. Health risks among Japanese men with moderate body mass index. *Int J Obes Relat Metab Disord* 2000; **24**: 358–362.
26 Wang J, Russell-Aulet M, Mazariegos M *et al*. Body fat by dual photon absorptiometry (DPA): comparisons with traditional methods in Asians, Blacks and Caucasians. *Am J Hum Biol* 1992; **4**: 501–510.
27 World Health Organization. *The Asia-Pacific perspective: redefining obesity and its treatment*. WHO: Geneva, 2000.
28 Department of Health. *Taiwan Public Health Report 1998–2000*. DOH: Taipei, 1998–2000.
29 van der Schouw YT, Verbeek ALM, Ruijs JHJ. ROC curves for the initial assessment of new diagnostic tests. *Fam Pract* 1992; **9**: 506–511.
30 Metz CE. Basic principles of ROC analysis. *Sem Nucl Med* 1978; **8**: 283–298.
31 Swets JA. The relative operating characteristics in psychology. *Science* 1973; **182**: 990–1000.
32 Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology* 1982; **143**: 29–36.
33 World Health Organization. *Obesity: preventing and managing the global epidemic*. eport of a WHO Consultation of Obesity, 3–5 June. WHO: Geneva, 1997.
34 Rissanen P, Hamalainen P, Vanninen E, Tenhunen-Eskelinen M, Uusitupa M. Relationship of metabolic variables to abdominal adiposity measures by different anthropometric measurements and dual-energy X-ray absorptiometry in obese middle-aged women. *Int J Obes Relat Metab Disord* 1997; **21**: 367–371.
35 Hodge AM, Dowse GK, Gareeboo H, Tuomilehto J, Alberti KGMM. Incidence, increasing prevalence, and predictors of change in obesity and fat distribution over 5 years in the rapidly developing population of Mauritus. *Int J Obes Relat Metab Disord* 1996; **20**: 137–146.
36 Ko GTC, Chan JCN, Cockram CS, Woo J. Prediction of hypertension, diabetes or albuminuria using simple anthropometric indexes in Hong Kong Chinese. *Int J Obes Relat Metab Disord* 1999; **23**: 1136–1142.
37 Han TS, van Leer EM, Seidell JC, Lean MEJ. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *Br Med J* 1995; **311**: 1401–1405.
38 Lean MEJ, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. *Br Med J* 1995; **311**: 158–161.
39 Kopelman. Obesity as a medical problem. *Nature* 2000; **404**: 635–643.
40 Pi-Sunyer X. Health implications of obesity. *Am J Clin Nutr* 1991; **53**: 1595s–1603s.
41 Reeder BA, Angel A, Ledoux M, Rabkin SW, Young TK, Sweet LE. Obesity and its relation to cardiovascular disease risk factors in Canadian adults. *Can Med Assoc J* 1992; **146**: 2009–2019.
42 Kim SM, Lee DJ. What is the best simple anthropometric indexes of abdominal visceral fat in obese patients? *J Korean Soc Study Obes* 1998; **7**: 157–168.