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PAPER

Four anthropometric indices and cardiovascular risk factors in Taiwan

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OBJECTIVE: To examine the relationships between four anthropometric measurements and cardiovascular risk factors in Taiwan.
DESIGN: The data was collected from four nationwide health screen centers in Taiwan from 1998 to 1999.
SUBJECTS: A total of 38 556 subjects: 18 280 men and 20 276 women, mean age = 37.0 ± 11.1 y. None had any known major systemic diseases or were currently on medication.
MEASUREMENTS: Individual body weight, height, waist circumference (WC), and cardiovascular risk factors (blood pressure, fasting plasma glucose, triglycerides, total cholesterol level, low-density and high-density-lipoprotein cholesterol level) were assessed and their relationships were examined.
RESULTS: In both sexes, with increasing body mass index (BMI), WC, WHpR (waist-to-hip ratio) and WHtR (waist-to-height ratio), there were significantly higher risks of hypertension, impaired fasting glucose, diabetes and dyslipidemia ($P < 0.001$) in almost all age groups. In the age groups older than 65, however, the relationships were statistically inconsistent.
CONCLUSIONS: In Taiwan, the four anthropometric indexes (BMI, WC, WHpR, WHtR) are closely related to cardiovascular risk factors.
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Keywords: anthropometric indices; cardiovascular risk factors; prevalence; odds ratio; Taiwan

Introduction

The prevalence of obesity is high and increasing in developed regions like Europe, the United States, and Oceania.[1–3] Obesity has been known to be associated with hypertension, diabetes, dyslipidemia and increased cardiovascular risk.[4–8] In addition, cardiovascular disease mortality is about 3-fold higher among obese men and women, and about 21 and 28% of cardiovascular disease 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 an important predictor of cardiovascular risk.[9–11]

Obesity is defined as a condition where there is an excess of body fat. Although there are several instruments to measure total body fat and its distribution,[12–15] anthropometric measurements still play an important role in clinical practice. The body mass index (BMI) is often used to reflect total body fat amounts while the waist circumference (WC), waist-to-hip ratio (WHpR), and waist-to-height ratio (WHtR) are used as surrogates for body fat centralization.[16–19] These measurements have been associated with cardiovascular risk factors, such as blood pressure, plasma lipid levels, and glucose concentrations across ethnic groups.[20–23] However, there are few reports and only small studies in the Asia-Pacific region. In this study, we examine the relationship between the four common anthropometric measurements and cardiovascular risk factors in Taiwan.

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Subjects and methods

The data was collected from four health screen centers in Taiwan from 1998 to 1999. A total of 38 556 'healthy' subjects (18 280 men and 20 276 women, mean age 37.0 ± 11.1 y), 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), out of a total 148 625 people were included in our study. 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 are shown in Table 1. Height, waist and hip circumferences (measured to the nearest 0.1 cm) and weight (measured to the nearest 0.1 kg) were measured by trained staff during one visit. Waist circumference was taken at the midway point between the inferior margin of the last rib and the crest of the ilium in a horizontal plane and measured to the nearest 0.1 cm. Hip circumference was taken around the pelvis at the point of maximal protrusion of the buttocks and measured to the nearest 0.1 cm. BMI was calculated as weight (kg) divided by height squared (m^2). In addition, WHpR and WHtR were also calculated. Blood pressure was measured in the right arm with an adequate cuff by the same staff using a standard mercury sphygmomanometer. The systolic BP was determined by the onset of the 'tapping' Korotkoff sound (K_1). The fifth Korotkoff sound (K_5), or the disappearance of Korotkoff sounds, defined the diastolic BP. A venous blood sample was taken after 12 h of fasting for measuring plasma glucose, triglycerides, total cholesterol (TCHO), low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol using an HITACHI 7150. Hypertension (HTN) was defined as a systolic BP $\geq$140 mmHg and/or diastolic BP $\geq$90 mmHg. Type 2 diabetes mellitus (DM) and impaired fasting glucose (IFG) were defined as fasting plasma glucose $\geq$7.0 mmol/l and 7.0 > plasma glucose $\geq$6.1mmol/l. The criteria for dyslipidemia-hypercholesterolemia, hypertriglyceridemia, elevated LDL cholesterol and abnormal HDL cholesterol were defined as total plasma cholesterol $\geq$6.2 mmol/l, triglycerides $\geq$2.3 mmol/l, LDL-cholesterol $\geq$4.1 mmol/l and HDL-cholesterol $<$0.9 mmol/l, respectively.

Statistical analysis

BMI was grouped according to the proposed criteria for the Asia-Pacific region, where being overweight is defined as BMI $\geq$23 kg/m^2 and obesity is defined as BMI $\geq$25 kg/m^2.[25] Waist circumference was grouped in men from 90 cm and in women from 80 cm to smaller sizes by 5 cm increments. WHpR and WHtR were grouped according to case numbers in quartiles. We analyzed the association between different anthropometric indices and disease prevalences, or actual plasma concentrations and blood pressure values by testing their trends. Odds ratios were calculated as the ratios of each cardiovascular risk factor prevalence relative to the one in the lowest anthropometric variables within the same sex and age groups. All the analyses were stratified into three groups according to age (20–39, 40–64 and $\geq$65 y). Statistical analysis was performed using SPSS for Windows (version 10.0) on an IBM PC compatible computer.

Results

In Table 2, there were statistically significant trends of increasing prevalence in cardiovascular risk factors, except

Table 1 Anthropometric indexes and metabolic factors in both sexes (mean ± s.d.)

	Men (n = 18 280)			*Women (n = 20 276)*		
Variables	*I (n = 12 038)*	*II (n = 5106)*	*III (n = 528)*	*I (n = 13 880)*	*II (n = 5911)*	*III (n = 485)*
Age (y)	31.11 ± 4.85	48.09 ± 6.89	69.79 ± 4.36	36.61 ± 4.95	48.99 ± 6.99	69.37 ± 4.21
Height (cm)	170.70 ± 5.79	167.79 ± 5.92	164.26 ± 5.88	158.51 ± 5.31	155.31 ± 5.23	151.56 ± 5.11
Weight (kg)	67.87 ± 10.63	67.63 ± 9.31	62.75 ± 9.25	52.78 ± 8.01	56.17 ± 8.05	54.61 ± 8.39
BMI (kg/m^2)	23.27 ± 3.25	24.0 ± 2.84	23.23 ± 2.98	21.00 ± 2.98	23.29 ± 3.15	23.74 ± 3.21
WC (cm)	79.07 ± 8.53	83.09 ± 8.02	83.82 ± 9.05	68.21 ± 6.74	74.08 ± 7.73	80.09 ± 8.73
Hip (cm)	94.22 ± 6.21	94.69 ± 5.62	93.64 ± 6.07	91.98 ± 6.00	94.74 ± 6.03	94.46 ± 6.71
WHpR	0.84 ± 0.05	0.88 ± 0.06	0.89 ± 0.06	0.74 ± 0.05	0.78 ± 0.06	0.85 ± 0.07
WHtR	0.46 ± 0.05	0.50 ± 0.05	0.51 ± 0.06	0.43 ± 0.04	0.48 ± 0.05	0.53 ± 0.06
SBP (mmHg)	118.7 ± 13.2	121.8 ± 16.1	132.8 ± 19.6	108.8 ± 12.3	120.3 ± 18.1	139.3 ± 19.6
DBP (mmHg)	72.8 ± 9.9	76.2 ± 10.7	75.6 ± 11.2	67.1 ± 9.4	72.8 ± 10.9	75.9 ± 11.4
Glucose (mmol/l)	5.26 ± 0.57	5.53 ± 0.97	5.61 ± 1.19	5.05 ± 0.43	5.37 ± 0.90	5.62 ± 0.95
TCHO (mmol/l)	5.05 ± 0.90	5.43 ± 0.92	5.41 ± 0.93	4.79 ± 0.81	5.37 ± 0.95	5.79 ± 1.00
TG (mmol/l)	1.33 ± 0.72	1.57 ± 0.80	1.34 ± 0.70	0.89 ± 0.43	1.18 ± 0.62	1.49 ± 0.70
HDL (mmol/l)	1.16 ± 0.30	1.17 ± 0.32	1.24 ± 0.36	1.43 ± 0.33	1.42 ± 0.36	1.40 ± 0.37
LDL (mmol/l)	3.28 ± 0.81	3.55 ± 0.83	3.56 ± 0.81	2.95 ± 0.72	3.40 ± 0.84	3.71 ± 0.91
BMI $\geq$25 kg/m^2	27.3%	34.8%	29.8%	9.3%	26.8%	30.1%
BMI $\geq$30 kg/m^2	3.2%	2.7%	0.7%	1.4%	3.3%	3.7%
WC $\geq$90 cm in men or $\geq$80 cm in women	11.4%	20.8%	26.9%	5.8%	22.1%	50.1%

Age groups: I, 20–39; II, 40–64; III, $\geq$65 y. BMI, body mass index; WC, waist 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.

for hypertension and hypercholesterolemia in women older than 65 y, according to different BMI groups. In men, the trends were similar in men except for those ≥ 65 y. There was no statistically significant relationship between elevated LDL cholesterol and BMI in men aged ≥ 40 y, which is shown in Table 4. As shown in Tables 3 and 5, in terms of actual plasma concentrations and blood pressure values, the increasing trends of various CVD risk factors with BMIs were also noted in both men and women aged less than 65 y. However, the associations showed inconsistent in both men and

Table 2 BMI groups and cardiovascular (CVD) risk factors in three age groups of women. BMI groups were defined by: 1, <18.5; 2, 18.5–22.9; 3, 23–24.9; 4, 25–29.9; 5, $\geq 30\,kg/m^2$

		BMI groups					
Age groups	*CVD risk factors (%)*	*1*	*2*	*3*	*4*	*5*	P *value*
I	HTN	1.3	1.9	2.7	5.4	15.2	<0.001
II	HTN	5.6	10.9	18.6	26.0	34.0	<0.001
III	HTN	53.3	44.4	51.8	48.4	72.2	0.156
I	IFG	0.5	0.8	1.1	3.6	8.6	<0.001
I	DM	0.0	0.1	0.2	0.9	0.0	
II	IFG	2.5	3.7	6.4	9.7	11.7	<0.001
II	DM	0.0	1.0	2.3	4.2	7.6	
III	IFG	6.7	8.0	13.9	10.9	27.8	<0.001
III	DM	0.0	1.1	5.8	10.2	22.2	
I	TG	0.2	1.0	3.5	8.6	13.1	<0.001
II	TG	0.5	4.3	9.8	12.3	19.3	<0.001
III	TG	0.0	9.1	21.9	16.4	22.2	0.008
I	TCHO	4.2	4.9	5.7	7.1	10.1	<0.001
II	TCHO	11.2	15.6	19.5	20.5	27.4	<0.001
III	TCHO	26.7	32.6	35.0	35.2	38.9	0.420
I	HDL	3.2	4.9	8.7	13.5	16.7	<0.001
II	HDL	1.0	3.5	8.4	10.9	14.7	<0.001
III	HDL	0.0	6.4	6.6	12.5	16.7	0.013
I	LDL	3.5	5.6	6.6	9.3	13.1	<0.001
II	LDL	8.1	15.0	18.8	20.8	25.4	<0.001
III	LDL	13.3	25.1	29.2	35.9	44.4	0.005

Table 3 BMI groups *vs* various prevalences of CVD risk factors BMI groups *vs* blood pressure values and actual plasma concentrations

		BMI groups					
Age groups	*CVD risk factors (mean + s.d.)*	*1*	*2*	*3*	*4*	*5*	P-*value*
I	SBP (mmHg)	106.98 ± 11.47	108.09 ± 11.92	110.16 ± 12.58	114.87 ± 13.41	121.67 ± 13.88	<0.0001
II		111.90 ± 13.72	116.34 ± 16.71	122.25 ± 17.76	126.22 ± 18.77	131.39 ± 20.24	<0.0001
III		136.13 ± 24.28	137.23 ± 18.40	138.41 ± 18.38	142.32 ± 21.35	148.39 ± 19.55	0.055
I	DBP (mmHg)	66.42 ± 9.16	66.68 ± 9.20	67.54 ± 9.44	69.90 ± 9.60	75.42 ± 10.62	<0.0001
II		69.38 ± 10.15	70.66 ± 10.34	73.54 ± 10.68	75.93 ± 11.21	78.71 ± 11.69	<0.0001
III		70.60 ± 11.22	74.59 ± 11.61	75.41 ± 10.87	77.42 ± 10.48	86.44 ± 12.27	<0.0001
I	Glucose (mmol/l)	4.96 ± 0.37	5.03 ± 0.42	5.12 ± 0.41	5.23 ± 0.56	5.30 ± 0.50	<0.0001
II		5.11 ± 0.39	5.25 ± 0.76	5.40 ± 0.89	5.57 ± 1.10	5.73 ± 1.10	<0.0001
III		5.34 ± 0.46	5.42 ± 0.63	5.67 ± 1.03	5.80 ± 1.16	6.19 ± 1.15	0.001
I	TG (mmol/l)	0.76 ± 0.27	0.85 ± 0.37	1.03 ± 0.51	1.28 ± 0.65	1.41 ± 0.64	<0.0001
II		0.81 ± 0.32	1.04 ± 0.52	1.26 ± 0.64	1.41 ± 0.69	1.58 ± 0.57	<0.0001
III		1.04 ± 0.39	1.30 ± 0.61	1.64 ± 0.73	1.65 ± 0.74	1.67 ± 0.61	0.032
I	TCHO (mmol/l)	4.70 ± 0.81	4.78 ± 0.80	4.82 ± 0.80	4.97 ± 0.87	5.01 ± 0.92	<0.0001
II		5.16 ± 0.81	5.30 ± 0.92	5.42 ± 0.94	5.46 ± 0.95	5.61 ± 1.31	<0.0001
III		5.50 ± 0.84	5.66 ± 0.94	5.90 ± 1.05	5.86 ± 1.02	6.06 ± 1.15	0.106
I	HDL (mmol/l)	1.54 ± 0.33	1.45 ± 0.32	1.31 ± 0.32	1.21 ± 0.28	1.14 ± 0.29	<0.0001
II		1.68 ± 0.39	1.50 ± 0.36	1.37 ± 0.35	1.30 ± 0.32	1.24 ± 0.31	<0.0001
III		1.67 ± 0.46	1.46 ± 0.38	1.39 ± 0.34	1.30 ± 0.35	1.29 ± 0.39	<0.0001
I	LDL (mmol/l)	2.82 ± 0.70	2.94 ± 0.71	3.04 ± 0.70	3.18 ± 0.78	3.22 ± 0.82	<0.0001
II		3.11 ± 0.70	3.32 ± 0.81	3.48 ± 0.82	3.51 ± 0.85	3.65 ± 1.24	<0.0001
III		3.35 ± 0.65	3.60 ± 0.83	3.76 ± 1.01	3.80 ± 0.91	4.01 ± 0.97	0.091

Table 4 BMI groups and cardiovascular (CVD) risk factors in three age groups of men. BMI groups were defined by: 1, <18.5; 2, 18.5–22.9; 3, 23–24.9; 4, 25–29.9; 5, $\geq 30\,kg/m^2$. BMI groups *vs* various prevalences of CVD risk factors

		BMI groups					
Age groups	*CVD risk factors (%)*	*1*	*2*	*3*	*4*	*5*	P-*value*
I	HTN	5.9	5.5	9.6	13.1	24.7	<0.001
II	HTN	5.7	12.8	17.0	24.1	35.5	<0.001
III	HTN	21.9	28.0	43.9	40.1	75.0	0.001
I	IFG	1.5	1.5	2.5	4.5	8.1	<0.001
I	DM	0.0	0.2	0.5	1.4	2.8	
II	IFG	4.1	6.4	8.7	10.7	17.0	<0.001
II	DM	0.8	1.3	2.0	5.1	9.2	
III	IFG	3.1	5.2	4.4	17.2	0.0	0.01
III	DM	3.1	4.3	6.1	3.8	25.0	
I	TG	0.6	4.4	14.1	24.8	34.6	<0.001
II	TG	3.3	10.9	19.8	29.4	38.3	<0.001
III	TG	0.0	8.2	12.3	17.2	25.0	<0.001
I	TCHO	4.2	7.4	12.5	15.8	21.0	<0.001
II	TCHO	10.6	18.9	20.0	20.4	37.6	<0.001
III	TCHO	21.9	14.2	19.3	21.0	25.0	0.186
I	HDL	6.5	12.6	20.4	32.3	41.4	<0.001
II	HDL	4.9	14.7	22.4	30.3	36.9	<0.001
III	HDL	3.1	10.3	21.9	29.3	0.0	<0.001
I	LDL	6.0	10.2	16.1	18.3	22.0	<0.001
II	LDL	13.8	21.6	22.8	21.0	31.2	0.185
III	LDL	21.9	15.5	22.8	22.3	50.0	0.097

Table 5 BMI groups *vs* blood pressure values and actual plasma concentrations

		BMI groups					
Age groups	*CVD risk factors (mean* $\pm$ *s.d.)*	*1*	*2*	*3*	*4*	*5*	P-*value*
I	SBP (mmHg)	114.50 ± 12.38	116.62 ± 12.49	119.15 ± 12.96	121.71 ± 13.28	127.52 ± 14.72	<0.0001
II		112.33 ± 14.80	118.84 ± 15.29	121.58 ± 15.58	125.24 ± 16.30	129.94 ± 17.52	<0.0001
III		128.39 ± 21.15	129.40 ± 19.72	136.01 ± 21.18	136.22 ± 17.18	136.50 ± 8.43	0.002
I	DBP (mmHg)	70.55 ± 9.88	71.18 ± 9.35	73.28 ± 9.77	75.20 ± 9.94	79.00 ± 10.83	<0.0001
II		70.45 ± 8.87	74.06 ± 10.04	75.98 ± 10.28	78.71 ± 11.10	81.97 ± 11.76	<0.0001
III		73.39 ± 11.78	73.82 ± 10.81	76.84 ± 11.22	77.66 ± 11.11	80.00 ± 14.02	0.005
I	Glucose (mmol/l)	5.10 ± 0.37	5.19 ± 0.50	5.28 ± 0.43	5.38 ± 0.71	5.52 ± 1.00	<0.0001
II		5.25 ± 0.50	5.40 ± 0.72	5.52 ± 0.90	5.69 ± 1.24	5.80 ± 0.98	<0.0001
III		5.38 ± 0.86	5.52 ± 0.89	5.72 ± 1.84	5.68 ± 1.04	6.09 ± 0.70	0.264
I	TG (mmol/l)	0.87 ± 0.34	1.09 ± 0.54	1.43 ± 0.70	1.70 ± 0.83	1.92 ± 0.87	<0.0001
II		0.94 ± 0.40	1.33 ± 0.71	1.62 ± 0.77	1.79 ± 0.84	2.05 ± 0.80	<0.0001
III		0.95 ± 0.35	1.22 ± 0.68	1.39 ± 0.67	1.57 ± 0.72	1.46 ± 0.77	<0.0001
I	TCHO (mmol/l)	4.61 ± 0.82	4.88 ± 0.86	5.18 ± 0.88	5.29 ± 0.91	5.40 ± 0.93	<0.0001
II		5.07 ± 0.83	5.39 ± 0.93	5.45 ± 0.91	5.45 ± 0.91	5.77 ± 0.89	<0.0001
III		5.38 ± 1.21	5.33 ± 0.86	5.55 ± 0.90	5.43 ± 0.99	6.28 ± 0.80	0.067
I	HDL (mmol/l)	1.35 ± 0.30	1.23 ± 0.30	1.13 ± 0.28	1.04 ± 0.26	0.97 ± 0.23	<0.0001
II		1.45 ± 0.38	1.27 ± 0.34	1.13 ± 0.29	1.07 ± 0.27	1.04 ± 0.24	<0.0001
III		1.49 ± 0.36	1.32 ± 0.36	1.21 ± 0.35	1.09 ± 0.29	1.22 ± 0.23	<0.0001
I	LDL (mmol/l)	2.86 ± 0.72	3.15 ± 0.78	3.40 ± 0.80	3.47 ± 0.82	3.55 ± 0.89	<0.0001
II		3.19 ± 0.77	3.51 ± 0.85	3.57 ± 0.83	3.56 ± 0.81	3.79 ± 0.81	<0.0001
III		3.47 ± 1.02	3.45 ± 0.74	3.71 ± 0.81	3.61 ± 0.84	4.38 ± 0.71	0.009

women aged greater than 65 y. In Tables 6 and 8, similarly, there were no statistically significant trends in hypercholesterolemia and elevated LDL cholesterol by different waist groups in both sexes ≥ 65 y. The associations between different waist circumference groups and actual values of various CVD risk factors were also shown to be inconsistent in both men and women aged greater than 65 y. In Figure 1, BMI and waist circumference groups were found to be closely related to the changes of odds ratios of DM and IFG across all age groups in both sexes. The risks of DM or IFG became significantly increased (2-fold greater) at lower BMI (23–24.9 kg/m^2) and WC groups (90 cm for men and 80 cm for

Table 6 Waist circumference groups and cardiovascular (CVD) risk factors in three age groups of women. Waist circumference groups were defined by: 1, <70; 2, 70–74.9; 3, 75–79.9; 4, ≥ 80 cm. Waist circumference groups *vs* various prevalences of CVD risk factors

		Waist circumference groups				
Age groups	*CVD risk factors (%)*	*1*	*2*	*3*	*4*	P-*value*
I	HTN	1.6	2.7	3.7	7.6	<0.001
II	HTN	8.4	13.4	21.4	29.2	<0.001
III	HTN	40.0	45.2	40.9	55.1	0.017
I	IFG	0.6	1.1	2.5	5.1	<0.001
I	DM	0.0	0.2	0.4	1.0	
II	IFG	2.5	5.2	6.6	11.1	<0.001
II	DM	0.6	0.8	2.8	6.1	
III	IFG	8.0	6.7	9.1	14.4	0.001
III	DM	0.0	3.8	4.5	7.8	
I	TG	0.6	2.5	5.1	10.0	<0.001
II	TG	2.2	6.5	10.2	15.2	<0.001
III	TG	4.0	9.6	21.6	16.9	0.011
I	TCHO	4.4	5.7	6.5	8.6	<0.001
II	TCHO	12.8	17.5	20.4	23.1	<0.001
III	TCHO	42.0	33.7	31.8	33.3	0.402
I	HDL	4.5	6.1	10.6	15.0	<0.001
II	HDL	2.6	5.6	8.4	12.0	<0.001
III	HDL	2.0	4.8	9.1	10.7	0.014
I	LDL	4.6	6.7	8.9	10.6	<0.001
II	LDL	12.4	17.0	20.3	22.1	<0.001
III	LDL	28.0	28.8	27.3	30.9	0.605

Table 7 Waist circumference groups *vs* blood pressure values and actual plasma concentrations

		Waist circumference groups				
Age groups	*CVD risk factors (mean* $\pm$ *s.d.)*	*1*	*2*	*3*	*4*	P-*value*
I	SBP (mmHg)	107.66 ± 11.70	109.53 ± 12.43	111.62 ± 13.25	115.64 ± 14.58	<0.0001
II		114.47 ± 15.48	119.13 ± 17.40	123.64 ± 18.38	127.71 ± 19.33	<0.0001
III		137.86 ± 16.97	135.66 ± 19.39	137.51 ± 21.49	141.83 ± 19.15	0.034
I	DBP (mmHg)	66.49 ± 9.17	67.41 ± 9.44	68.31 ± 9.55	70.70 ± 10.10	<0.0001
II		70.00 ± 10.11	72.01 ± 10.60	74.19 ± 10.91	76.49 ± 11.35	<0.0001
III		72.36 ± 5.35	75.38 ± 5.50	75.37 ± 5.63	77.20 ± 5.76	0.038
I	Glucose (mmol/l)	5.00 ± 0.37	5.09 ± 0.48	5.19 ± 0.59	5.26 ± 0.64	<0.0001
II		5.17 ± 0.49	5.29 ± 0.76	5.49 ± 1.04	5.69 ± 1.29	<0.0001
III		5.35 ± 0.47	5.50 ± 0.78	5.63 ± 1.15	5.76 ± 1.12	0.02
I	TG (mmol/l)	0.81 ± 0.37	0.98 ± 0.51	1.15 ± 0.70	1.38 ± 0.87	<0.0001
II		0.94 ± 0.45	1.18 ± 0.75	1.34 ± 0.79	1.59 ± 1.07	<0.0001
III		1.23 ± 1.18	1.40 ± 0.81	1.70 ± 1.09	1.80 ± 1.94	0.034
I	TCHO (mmol/l)	4.74 ± 0.80	4.84 ± 0.81	4.90 ± 0.85	5.01 ± 0.90	<0.0001
II		5.21 ± 0.88	5.36 ± 0.93	5.48 ± 0.96	5.55 ± 1.04	<0.0001
III		5.75 ± 1.06	5.70 ± 0.97	5.89 ± 1.08	5.84 ± 1.05	0.555
I	HDL (mmol/l)	1.49 ± 0.33	1.37 ± 0.31	1.28 ± 0.31	1.19 ± 0.30	<0.0001
II		1.55 ± 0.37	1.43 ± 0.35	1.36 ± 0.34	1.29 ± 0.32	<0.0001
III		1.57 ± 0.38	1.45 ± 0.36	1.40 ± 0.37	1.34 ± 0.36	0.001
I	LDL (mmol/l)	2.89 ± 0.70	3.03 ± 0.72	3.10 ± 0.75	3.20 ± 0.80	<0.0001
II		3.22 ± 0.77	3.40 ± 0.82	3.53 ± 0.83	3.56 ± 0.93	<0.0001
III		3.66 ± 0.87	3.67 ± 0.85	3.73 ± 0.96	3.72 ± 0.93	0.937

women). As shown in Figure 2, the trends in different WHpR groups were not statistically significant for women aged ≥ 65 y for CHD risk factors, except for DM or IFG, and only for hypercholesterolemia and elevated LDL cholesterol in men aged ≥ 65 y. In Figure 3, no significant trends by different WHtR groups were noted in hypertension, hypercholesterolemia and elevated LDL cholesterol in women ≥ 65 y, nor hypercholesterolemia and elevated LDL cholesterol in men aged ≥ 65 y. Among the above cardiovascular risk factors, only DM or IFG showed consis-

Table 8 Waist circumference groups and cardiovascular (CVD) risk factors in three age groups of men. Waist circumference groups were defined by 1, <80; 2, 80–84.9; 3, 85–89.9; 4, ≥ 90 cm. Waist circumference groups *vs* various prevalences of CVD risk factors

		Waist circumference groups				
Age groups	*CVD risk factors (%)*	*1*	*2*	*3*	*4*	P-*value*
I	HTN	5.8	10.2	11.9	18.0	<0.001
II	HTN	12.2	16.0	19.1	28.7	<0.001
III	HTN	30.8	27.4	39.4	42.1	0.013
I	IFG	1.4	2.8	3.7	7.0	<0.001
I	DM	0.2	0.8	1.1	1.8	
II	IFG	6.9	7.5	9.6	11.8	<0.001
II	DM	1.3	2.2	2.8	6.5	
III	IFG	4.7	7.1	7.3	14.5	0.002
III	DM	2.3	5.3	5.5	6.2	
I	TG	4.5	14.4	24.5	31.5	<0.001
II	TG	9.1	17.1	25.9	34.4	<0.001
III	TG	2.9	11.5	11.9	20.7	0.011
I	TCHO	7.0	13.3	15.6	19.4	<0.001
II	TCHO	17.4	18.4	21.1	24.8	<0.001
III	TCHO	15.1	17.7	15.6	22.8	0.118
I	HDL	13.0	22.6	29.5	35.4	<0.001
II	HDL	14.2	22.5	26.2	30.7	<0.001
III	HDL	6.4	16.8	23.9	27.6	0.014
I	LDL	10.0	16.4	18.0	21.1	<0.001
II	LDL	20.0	21.7	22.8	23.7	0.015
III	LDL	26.4	21.7	18.9	33.0	0.115

Table 9 Waist circumference groups *vs* blood pressure values and actual plasma concentrations

		Waist circumference groups				
Age groups	*CVD risk factors (mean* $\pm$ *s.d.)*	*1*	*2*	*3*	*4*	P-*value*
I	SBP (mmHg)	116.90 $\pm$ 12.55	119.21 $\pm$ 13.10	120.49 $\pm$ 13.48	123.88 $\pm$ 13.86	<0.0001
II		118.28 $\pm$ 15.38	120.90 $\pm$ 15.03	123.36 $\pm$ 15.84	126.88 $\pm$ 17.11	<0.0001
III		130.92 $\pm$ 21.20	128.53 $\pm$ 19.55	135.10 $\pm$ 19.87	136.54 $\pm$ 16.47	0.005
I	DBP (mmol/l)	71.27 $\pm$ 9.42	73.42 $\pm$ 9.83	74.70 $\pm$ 9.94	77.13 $\pm$ 10.25	<0.0001
II		73.76 $\pm$ 10.06	75.67 $\pm$ 10.36	77.25 $\pm$ 10.56	79.68 $\pm$ 11.25	<0.0001
III		74.36 $\pm$ 11.23	73.51 $\pm$ 10.09	76.90 $\pm$ 12.18	77.72 $\pm$ 10.75	0.005
I	Glucose (mmol/l)	5.18 $\pm$ 0.42	5.29 $\pm$ 0.59	5.35 $\pm$ 0.64	5.46 $\pm$ 0.88	<0.0001
II		5.40 $\pm$ 0.70	5.48 $\pm$ 0.85	5.58 $\pm$ 1.08	5.76 $\pm$ 1.28	<0.0001
III		5.44 $\pm$ 0.62	5.47 $\pm$ 0.89	5.74 $\pm$ 1.40	5.82 $\pm$ 1.63	0.009
I	TG (mmol/l)	1.09 $\pm$ 0.55	1.45 $\pm$ 0.70	1.68 $\pm$ 0.83	1.87 $\pm$ 0.85	<0.0001
II		1.26 $\pm$ 0.66	1.56 $\pm$ 0.76	1.73 $\pm$ 0.82	1.91 $\pm$ 0.85	<0.0001
III		1.07 $\pm$ 0.50	1.28 $\pm$ 0.73	1.40 $\pm$ 0.65	1.67 $\pm$ 0.76	<0.0001
I	TCHO (mmol/l)	4.87 $\pm$ 0.86	5.17 $\pm$ 0.87	5.30 $\pm$ 0.92	5.40 $\pm$ 0.94	<0.0001
II		5.34 $\pm$ 0.94	5.40 $\pm$ 0.89	5.48 $\pm$ 0.90	5.56 $\pm$ 0.93	<0.0001
III		5.35 $\pm$ 0.96	5.36 $\pm$ 0.90	5.41 $\pm$ 0.82	5.53 $\pm$ 1.01	0.313
I	HDL (mmol/l)	1.23 $\pm$ 0.30	1.11 $\pm$ 0.27	1.06 $\pm$ 0.25	1.02 $\pm$ 0.25	<0.0001
II		1.28 $\pm$ 0.35	1.14 $\pm$ 0.29	1.11 $\pm$ 0.28	1.07 $\pm$ 0.28	<0.0001
III		1.39 $\pm$ 0.38	1.24 $\pm$ 0.32	1.15 $\pm$ 0.31	1.13 $\pm$ 0.32	<0.0001
I	LDL (mmol/l)	3.14 $\pm$ 0.78	3.40 $\pm$ 0.79	3.47 $\pm$ 0.84	3.52 $\pm$ 0.86	<0.0001
II		3.48 $\pm$ 0.86	3.54 $\pm$ 0.81	3.58 $\pm$ 0.83	3.61 $\pm$ 0.83	<0.0001
III		3.47 $\pm$ 0.82	3.53 $\pm$ 0.81	3.62 $\pm$ 0.76	3.64 $\pm$ 0.82	0.238

tent trends in four anthropometric indices across different age groups.

Discussion

Most studies examining the risk of adverse health associated with obesity have been based on data from Europe or the United States. The increased risks associated with obesity have been shown to occur at lower BMIs in Asians, and these populations are predisposed to visceral or abdominal obesity.[26–28] Therefore, the WHO proposes a lower BMI value to define overweight and obesity in the Asia-Pacific region.[25] However, there are as yet a few reports, and small sample sizes of studies in Asia-Pacific region. Our study provides a

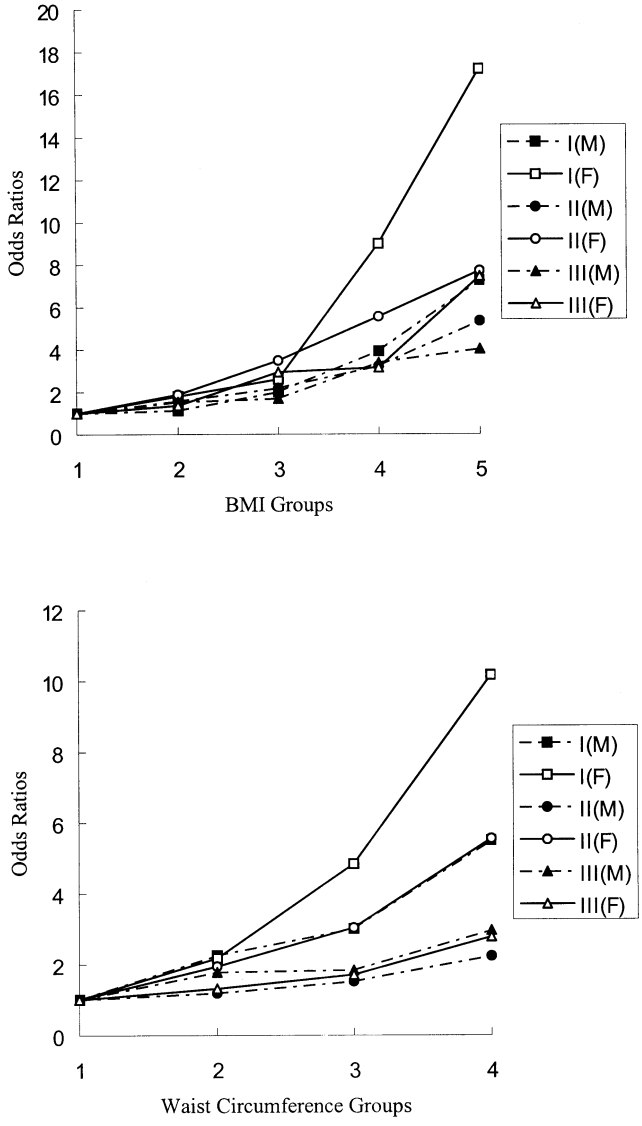

Figure 1 Different BMI or waist circumference groups *vs* IFG (impaired fasting glucose) and DM (type 2 diabetes mellitus) in three age groups of men and women. Age groups were defined by: 20–39, 40–64 and ≥65 y. BMI groups were defined by: 1, <18.5; 2, 18.5–22.9; 3, 23–24.9; 4, 25–29.9; 5, ≥30 kg/m^2. Waist circumference groups were defined by: 1, <70; 2, 70–74.9; 3, 75–79.9; 4, ≥80 cm for women; and 1, <80; 2, 80–84.9; 3, 85–89.9; 4, ≥90 cm for men. The results of statistics by testing for trends all showed consistently $P \leq 0.01$.

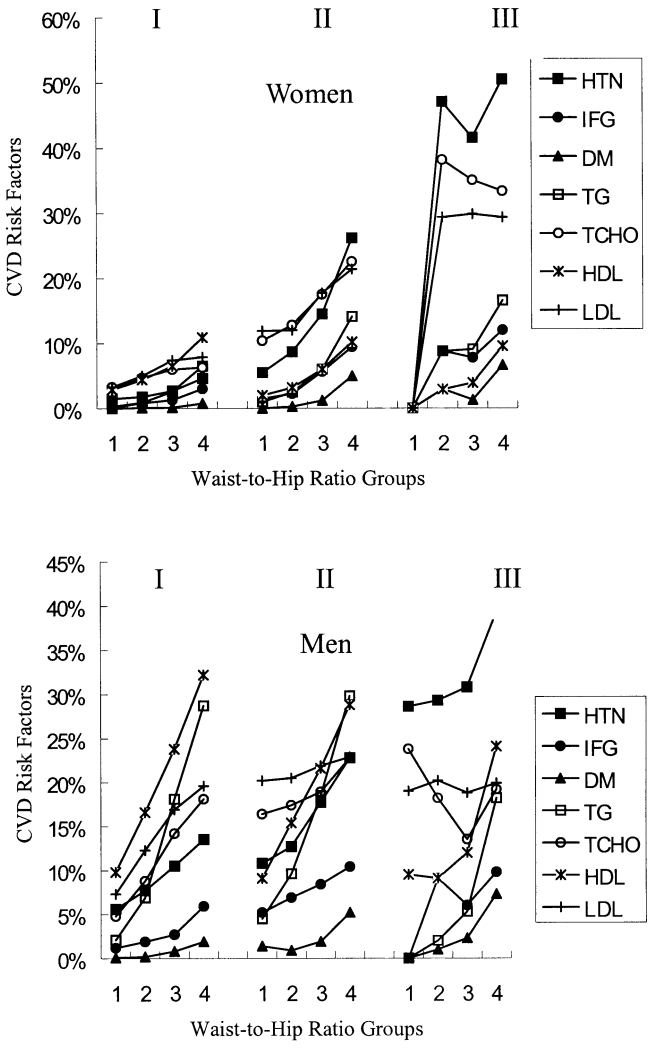

Figure 2 Waist-to-hip ratio groups *vs* CVD risk factors in three age groups of women and men. Waist-to-hip ratio groups were defined by: 1, <0.70; 2, 0.70–0.74; 3, 0.75–0.79; 4, ≥0.80 for women; and 1, <0.80; 2, 0.80–0.84; 3, 0.85–0.89; 4, ≥0.90 for men. The results of statistics by testing for trends showed *P*-value > 0.05: HTN, TG, TCHO, HDL, LDL in age group III for women and TCHO, LDL in age group III and LDL in age group II for men; others *P*-value ≤0.05.

larger sample size of data. Furthermore, our study implicates the relationships between the anthropomethric indices and the cumulative incidences[29] among 'healthy' people of cardiovascular risk factors. More prospective epidemiological studies, however, need to be performed to determine the relative risk of developing these co-morbiditites with obesity.

Obesity is characterized by an increased amount of body fat. BMI, WC, WHpR and WHtR have been accepted as simple anthropometric indexes for assessing body fat amount and distribution and are useful indices for providing important information to predict cardiovascular disease.[16,17,30] Ko *et al*[31] also found that WHpR and WHtR were the main predictors for DM and hypertension in working aged men and women. These four indices have been proven useful in predicting the probability of dyslipidemia. In our study, the four anthropometric indices were found to be closely related to cardiovascular disease, including hypertension, DM and dyslipidemia in both men and women aged 20–64 y. In the age groups older than 65, however, the

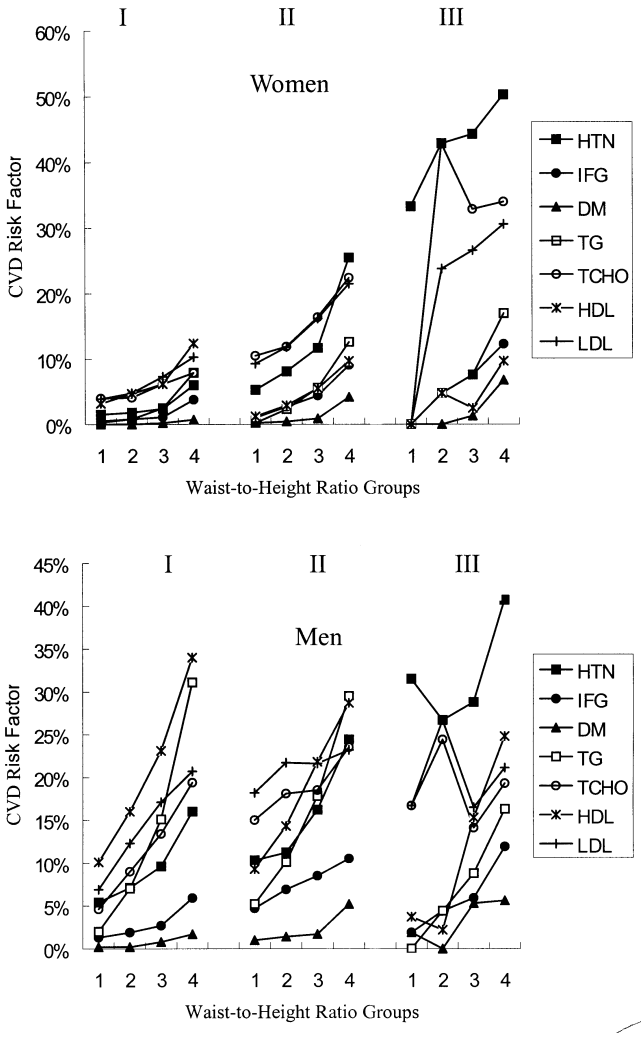

Figure 3 Waist-to-height ratio groups *vs* CVD risk factors in three age groups of women and men. Waist-to-height ratio groups were defined by: 1, <0.41; 2, 0.41–0.43; 3, 0.44–0.47; 4, ≥ 0.48 for women; and 1, <0.44; 2, 0.44–0.46; 3, 0.47–0.50: 4, ≥ 0.51 for men. The results of statistics by testing for trends showed *P*-value >0.05: HTN, TCHO, LDL in age group III and LDL in age group II for women and TCHO, LDL in age group III for men; others *P*-value ≤ 0.05.

relationships were statistically inconsistent for lipid abnormalities. This discrepancy may be due to the relatively smaller sample size of senior subjects in our study. In addition, our results showed that most cardiovascular risk factors, except hypercholesterolemia and elevated LDL cholesterol, were closely related to WC. Similarly, Turcato *et al*[32] found that waist and abdominal sagittal diameters the anthropometric indicators of fat distribution most closely related to cardiovascular risk factors in old age. Taken together, the relationship between cardiovascular risk factors and simple anthropometric indices in older subjects should be clarified in future research.

Central obesity, especially intra-abdominal fat accumulation, is known to be closely related to insulin resistance and its related disorders, including diabetes, hypertension and dyslipidemia.[33] There is now much data to confirm the importance of central adiposity as a cardiovascular risk factor.[10,11,18,20,21] Despite the close association between central adiposity and cardiovascular risks, there remains some controversy regarding the best anthropometric index for central adiposity. Some works have shown that WC is a better correlate of cardiovascular risk factors than WHpR.[18,34] Using computed tomographic scanning to measure adipose tissue, WC is found to be a better estimate of abdominal visceral adipose accumulation than WHtR and may be a better predictor of multiple cardiovascular risk factors than WHpR.[18,20] In our study, all four anthorpometric indices nevertheless provided useful information on cardiovascular risk factors, although at various degrees of importance.

In conclusion, the four anthropometric indices (BMI, WC, WHpR, WHtR) are closely related to the cardiovascular risk factors of Taiwanese people aged 20–64 y. The relationships, however, are statistically inconsistent for the elderly. Further studies must demonstrate for the importance of anthropometric measurements in more senior subjects.

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