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Cut-off Values for Anthropometric Variables That Confer Increased Risk of Type 2 Diabetes Mellitus and Hypertension in Iraq

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Background. Body mass index (BMI) is often used to reflect total body fat amount (general obesity), whereas waist circumference (WC), waist-to-hip ratio (WHpR) or waist-to height ratio (WHtR) is used as a surrogate of body fat centralization (central obesity). The purpose of the present study was to identify cut-offs for BMI and upper-body adiposity (WC, WHpR, and WHtR) that, associated with increased risk of type 2 DM and hypertension in Iraqi adults, would be consistent with overweight and central adiposity.

Methods. This was a community-based cross-sectional survey for establishing cut-off values for BMI and upper-body adiposity (WC, WHpR or WHtR) associated with increased risk of type 2 DM and hypertension from one district in Southern Iraq, Basrah (Abu-Al-khasib). The total number of persons involved was 12,986 (6693 men and 6293 women), aged 45.6 ± 15.7 years.

Results. The cut-off point in men associated with increased risk of type 2 DM and hypertension were BMI 25.4 and 24.9, WC 90 and 95 cm, WHpR 0.92 for both and WHtR 0.52 and 0.55, respectively. For women, the cut-off point associated with increased risk of type 2 DM and hypertension were BMI 26.1 and 26.5, WC 91 and 95 cm, WHpR 0.91 for both, and for WHtR 0.56 and 0.59, respectively. The best index for association with type 2 DM was WHpR with cut-off point of 0.92 for men and 0.91 for women. For hypertension, the best index is WHtR (with cut-off point of 0.55 for men and 0.59 for women), whereas the least reliable index was the BMI for both type 2 DM and hypertension.

Conclusions. Our finding showed that, in Iraqi adults, WHpR has the strongest association with type 2 DM and WHtR for hypertension.

Key Words: Anthropometric measurements, Diabetes, Hypertension, Iraq.

Introduction

Obesity is defined as a condition where there is an excess of body fat (1). Of the ways to measure total body fat and its distributions, anthropometric measurements still play an important role in clinical practice. Body mass index (BMI) is often used to reflect total body fat amount (general obesity), whereas waist circumference (WC), waist-to-hip ratio (WHpR) or waist-to height ratio (WHtR) is used as a surrogate of body fat centralization (central obesity) (2). These measurements have been shown to be associated with cardiovascular disease risk factors such as hypertension, dyslipidemia and diabetes in all ethnic groups studied (3,4).

The risk of hypertension is up to five times higher among obese people than among those of normal weight (5).

Numerous epidemiological studies have shown that obesity is an important risk factor for the development of type 2 diabetes mellitus (DM); indeed, it is arguable that obesity is the single most important risk factor for this condition (6,7).

BMI is the most commonly used measurement for assessing obesity in adults but has a lot of limitations because it does not distinguish overweight due to excess fat mass from overweight due to excess lean mass (8). Because of

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variations in body proportions, BMI may not correspond to the same body fat in different populations (4). Epidemiological studies have shown that the ideal BMI may differ for different populations (4). Furthermore, there is evidence that even individuals with a BMI within the ''normal'' range of 23–25 are at increased risk of diabetes, compared with individuals with a lower BMI (6,7).

The purpose of the present study was to identify cut-offs for BMI and upper-body adiposity (WC, WHpR, and WHtR) that associated with increased risk of type 2 DM and hypertension in Iraqi adults would be consistent with overweight and central adiposity.

Materials and Methods

This was a community-based cross-sectional survey for establishing of cut-off values for BMI and upper-body adiposity (WC, WHpR or WHtR) to predict type 2 DM and hypertension from one district in Southern Iraq, Basrah (Abu-al-khasib). The population of Basrah according to the last census is 1,570,664, distributed over an area of 19,070 km^2. The major districts are the Centre, Abu al-Khasib, Shatt al-Arab, al-Zubair, al-Madina, and al-Qurnah. The study used a multistage, stratified, clustered sampling. During vaccination program at home this study was conducted from January to April 2005. Informed consent was obtained from each participant before data collection.

WC was measured at the umbilical level from the horizontal plane in centimeters (cm), using a plastic anthropometric tape with the subjects standing and breathing normally by the same physician during the physical examination with a participant standing erect (9).

Standing height and weight measurements were completed with subjects wearing lightweight clothing and no shoes. Height was measured to the nearest cm and weight was measured to the nearest half kilogram (kg). BMI was calculated as body weight in kilograms divided by the squared value of body height in meters (kg/m^2). WHpR and WHtR were measured accordingly as ratio.

Three blood pressure measurements were obtained by physicians. The measurements were made with the participant in a sitting position after ≥5 min of rest. Hypertension was defined as self-reported use of antihypertensive medication within the past 2 weeks or an average systolic blood pressure ≥140 mmHg, an average diastolic blood pressure ≥90 mmHg, or both.

Type 2 DM was diagnosed according to the American Diabetes Association criteria of fasting plasma glucose value ≥126 mg/dL on two occasion or symptoms of diabetes and a casual plasma glucose ≥200 mg/dL (11.1 mmol/L) or history of diabetes (10).

Total number of persons involved (Table 1) was 12,986 persons (6693 men and 6293 women), aged 45.6 ± 15.7 years. All individuals were aged 18 years and older and women were not pregnant. There were 2055 persons with type 2 DM and 2249 with hypertension. Mean WC was 90.9 ± 14.2 and 92.6 ± 15.1 cm for men and women, respectively, whereas for hip it was 99.7 ± 10.3 and 103.4 ± 11.9 for men and women, respectively. Mean BMI for men was 25.5 ± 5.4 and 27.4 ± 7.7 for women.

Statistical Analysis

Data analyses were performed separately in men and women in the Iraqi population. All data were analyzed in 2006 by SPSS (version 9.0, SPSS Inc., Chicago, IL). Receiver operator characteristic (ROC) curve was used to assess the degree of association of BMI and upper-body adiposity (WC, WHpR, WHtR) with diabetes and hypertension. Custom code in Excel 2000 (Microsoft, Redmond, WA) was written by the authors to calculate further indices of association between those anthropometric variables with DM and hypertension. After plotting the true positive rate (sensitivity) against the false-positive rate (1—specificity), the Youden index was used for determining the appropriate cut-off points. Area under the ROC curves (AUC) (95% confidence intervals) for the identification of type 2 DM and hypertension by various obesity-related anthropometric indices was used.

Results

The optimal cut-off point for various obesity-related anthropometric indices associated with increased risk of type 2 DM and hypertension with corresponding specificity and sensitivity among men are shown in Table 2. The cut-off point in men for association with type 2 DM and hypertension were BMI 25.4 and 24.9, WC 90 and 95 cm, WHpR 0.92 for both, and for WHtR 0.52 and 0.55, respectively.

For women (Table 3), the cut-off point associated with increased risk of type 2 DM and hypertension were BMI 26.1 and 26.5, WC 91 and 95 cm, WHpR 0.91 for both, and for WHtR 0.56 and 0.59, respectively.

Table 1. Characteristics of the studied population

	Men (n = 6693)	Women (n = 6293)	Total (n = 12,986)
Age (years) mean ± SD	44.9 ± 16	46.5 ± 15.4	45.6 ± 15.7
Type 2 DM	1022	1033	2055
Hypertension	1055	1194	2249
WC (cm)	90.9 ± 14.23	92.6 ± 15.1	91.7 ± 14.6
Hip (cm)	99.7 ± 10.3	103.4 ± 11.9	101.5 ± 11.3
Weight (kg)	75.5 ± 17.2	70.1 ± 19.4	72.9 ± 18.5
Height (cm)	171.4 ± 6.9	159.7 ± 5.7	165.75 ± 8.42
WHpR	0.91 ± 0.85	0.89 ± 0.088	0.90 ± 0.086
WHtR	0.53 ± 0.083	0.58 ± 0.095	0.55 ± 0.092
BMI (kg/m^2)	25.6 ± 5.4	27.45 ± 7.7	26.5 ± 6.6

Table 2. Measurements of association between diabetes mellitus and hypertension with different anthropometric variables for men

	Diabetes mellitus				Hypertension			
Index	WC (cm)	BMI (kg/m^2)	WHpR	WHtR	WC (cm)	BMI (kg/m^2)	WHpR	WHtR
Cut-off value	90	25.4	0.92	0.52	95	24.9	0.92	0.55
Sensitivity	79.5%	66.0%	76.9%	82.2%	74.2%	78.1%	75.3%	75.6%
Specificity	49.4%	53.9%	60.5%	48.4%	64.3%	51.9%	60.4%	63.5%
False positive ratio	0.78	0.79	0.74	0.78	0.72	0.77	0.74	0.72
False negative ratio	0.07	0.10	0.06	0.06	0.07	0.07	0.07	0.07
Positive likelihood ratio	1.57	1.43	1.95	1.59	2.08	1.62	1.90	2.07
Negative likelihood ratio	0.41	0.63	0.38	0.37	0.40	0.42	0.41	0.38
Pre-test odds ratio	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19
Post-test odds ratio	0.28	0.26	0.35	0.29	0.39	0.30	0.36	0.39
Pre-test probability	15.3%	15.3%	15.3%	15.3%	15.8%	15.8%	15.8%	15.8%
Post-test probability	22.1%	20.5%	26.0%	22.3%	28.0%	23.3%	26.3%	27.9%

Further statistical variables were calculated to assess the degree of association between these anthropometric indices with type 2 DM and hypertension. The results supported the conclusions made by using the AUC as indicator for hypertension in women, although WHpR had the highest positive likelihood ratio among the anthropometric indices but ranks third in the negative likelihood ratio, which affects the overall strength of association with hypertension and places it third behind WHtR and WC.

Using AUC as indicator of the strength of association (Figures 1 and 2), the index with the strongest association with type 2 was WHpR with cut-off point of 0.92 for men and 0.91 for women DM (AUC = 0.74 for men and 0.73 for women), whereas the least reliable index was the BMI. For hypertension, the index with the strongest association was WHtR with cut-off point of 0.54 for men and 0.59 for women (AUC = 0.76 for men and 0.73 for women), whereas the least reliable index was again the BMI.

Discussion

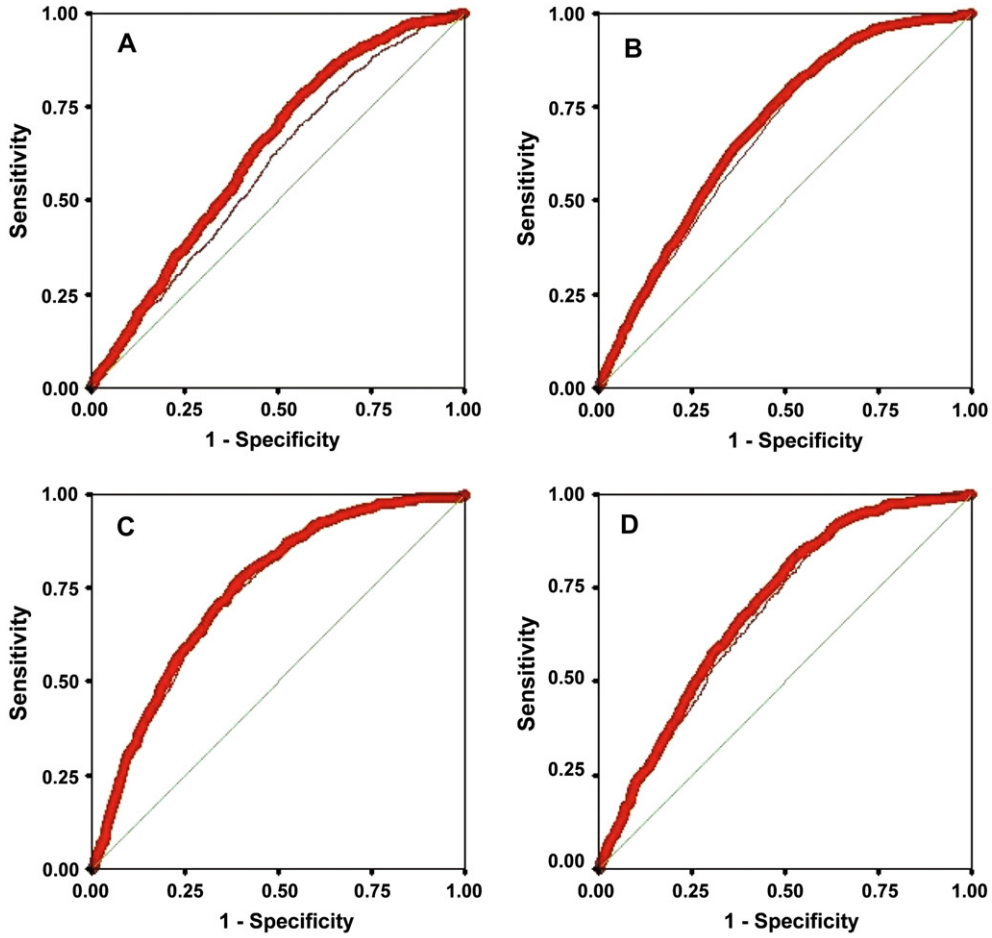
Our cut-off values of BMI for association with type 2 DM and hypertension were 25.4 and 24.9, respectively, in men and in women 26.1 and 26.5 for type 2 DM and hypertension, respectively, which is consistent with the current definitions of overweight (BMI ≥25) recommended by the World Health Organization (WHO) (11). These figures are also consistent with data from Western populations in the U.S. and Europe but higher than Asian populations. They give us clues that Arabs may have BMI measurements similar to those in the U.S. than those of Asian persons in Japan, China, and India (12,13). BMI in our study was the one with the weakest association with type 2 DM and hypertension. This is in contrast with a study on medical students in Crete, Greece, where BMI was the strongest predictor of hypertension (14).

WC cut-off point for association with type 2 DM and hypertension were 90 and 95 cm, respectively, for men and 91 and 95 cm, respectively, for women. These figures were different from the WHO criteria of central adiposity for women (waist circumference ≥94 cm for men and ≥80 cm for women) (11).

WHpR cut-off points were 0.92 for type 2 DM and hypertension in men and 0.91 in women for type 2 DM and hypertension. For WHtR, cut-off values were 0.52 and 0.55 for type 2 DM and hypertension in men, respectively, and 0.56 and 0.59 in women, respectively. WHtR could help to resolve debates about the use of different BMI

Table 3. Measurements of association between diabetes mellitus and hypertension with different anthropometric variables for women

	Diabetes mellitus				Hypertension			
Index	WC (cm)	BMI (kg/m^2)	WHpR	WHtR	WC (cm)	BMI (kg/m^2)	WHpR	WHtR
Cut-off value	91	26.1	0.91	0.56	95	26.5	0.91	0.59
Sensitivity	79.6%	66.3%	71.5%	82.6%	73.2%	71.7%	66.3%	78.6%
Specificity	47.2%	47.4%	63.4%	45.1%	58.4%	51.9%	63.3%	54.0%
False positive ratio	0.77	0.80	0.72	0.77	0.71	0.74	0.70	0.71
False negative ratio	0.08	0.12	0.08	0.07	0.10	0.11	0.11	0.09
Positive likelihood ratio	1.51	1.26	1.96	1.50	1.76	1.49	1.81	1.71
Negative likelihood ratio	0.43	0.71	0.45	0.39	0.46	0.55	0.53	0.40
Pre-test odds ratio	0.20	0.20	0.20	0.20	0.23	0.23	0.23	0.23
Post-test odds ratio	0.30	0.25	0.38	0.30	0.41	0.35	0.42	0.40
Pre-test probability	16.4%	16.4%	16.4%	16.4%	19.0%	19.0%	19.0%	19.0%
Post-test probability	22.8%	19.8%	27.8%	22.8%	29.2%	25.9%	29.8%	28.6%



E

Estimated AUC – Diabetes (95% CI)

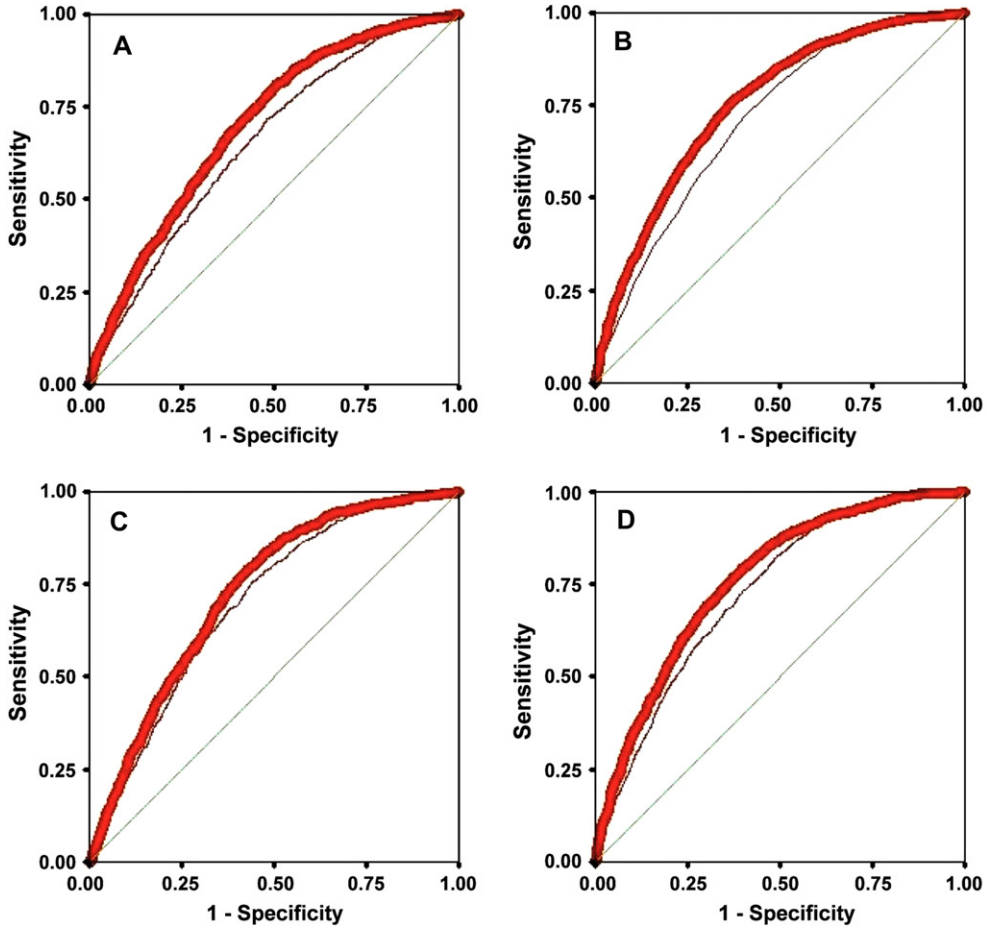
	Males	Females
BMI	0.63 (0.62–0.65)	0.59 (0.57–0.60)
WC	0.69 (0.67–0.71)	0.67 (0.65–0.69)
WHpR	0.74 (0.73–0.76)	0.73 (0.72–0.75)
WHtR	0.70 (0.68–0.71)	0.68 (0.66–0.69)

Figure 1. Comparison of the four anthropometric indices for the risk of type 2 DM. Indices include (A) body mass index (BMI), (B) waist circumference (WC), (C) waist/hip ratio (WHpR), (D) waist/height ratio (WHtR). The plots show ROC for males (bold curves) and female (light curves). The estimated area under ROC curves (which reflects the overall predictive accuracy) and their 95% confidence interval are shown in E.

boundary values for assessing health risks in different populations (15) and is independently and better associated with urinary albumin excretion rate than WC or WHpR in Chinese adult type 2 DM women but not men (16). Nevertheless, in India, Mamtani et al. found WC is a better predictor of central obesity and type 2 DM than WHpR (17).

For type 2 DM, the best indicator was WHpR, whereas for hypertension it was WHtR in this study. Sakurai et al. found that among four anthropometric variables of obesity—i.e., BMI, WC, WHpR, and WHtR—WC had the strongest association with blood pressure and the prevalence of hypertension in men and BMI had the strongest association with blood pressure and hypertension in women in Japan (18).

WHtR was the better predictor for coronary heart disease than WHpR in a Japanese mass epidemiological study (19) and in school children (20). In Tehranian adult women, WC is the best screening measure for cardiovascular risk factors, compared with BMI, WHpR and WHtR (21).



E

Estimated AUC – Hypertension (95% CI)

	Males	Females
BMI	0.70 (0.68–0.65)	0.65 (0.64–0.67)
WC	0.75 (0.47–0.77)	0.71 (0.70–0.73)
WHpR	0.73 (0.71–0.74)	0.70 (0.68–0.71)
WHtR	0.76 (0.76–0.78)	0.73 (0.71–0.74)

Figure 2. Comparison of the four anthropometric indices for the risk of hypertension. Indices include (A) body mass index (BMI), (B) waist circumference (WC), (C) waist/hip ratio (WHpR), (D) waist/height ratio (WHtR). The plots show ROC for males (bold curves) and female (light curves). The estimated area under ROC curves (which reflects the overall predictive accuracy) and their 95% confidence interval are shown in E.

In Thai adults, WC, WHpR and WHtR provided more consistent association with cardiovascular risk factors than BMI (22).

It is also noticeable that WC is almost as high as WHtR in strength of association with hypertension, but not type 2 DM, in both sexes, although BMI still does poorly. This suggests that the distribution of body fat, and not the total amount of body fat, is the factor with the strongest association with hypertension.

In conclusion, our findings showed that in Iraqi adults, WHpR is the single most important indicator for association with type 2 DM, whereas for hypertension, WHtR is the most important indicator. These indicators have a vital public health implication for developing countries (23). Both of theses diseases are the most important risk factors for cardiovascular disease. They offer the prospect of an extremely effective, simple, inexpensive and non-invasive means for a first-level screening for type 2 DM and hypertension.

References

1. Lukaski HC. Methods for the assessment of human body composition: traditional and new. Am J Clin Nutr 1987;46:537−556.
2. 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.
3. Ko GTC, Chan JCN, Woo J, Lau E, Yeung VTF, Chow CC, et al. Simple anthropometric indexes and cardiovascular risk factors in Chinese. Int J Obes Relat Metab Disord 1997;21:995−1001.
4. World Health Organization: WHO Recommendations: Obesity: Preventing and Managing the Global Epidemic. Geneva: WHO;2000. (Tech Rep Ser no. 894).
5. Wolf HK, Tuomilehto J, Kuulasmaa K, Domarkiene S, Cepaitis Z, Molarius A, et al. Blood pressure levels in the 41 populations of the WHO MONICA project. J Hum Hypertens 1997;11:733−742.
6. Chan JM, Stampfer MJ, Rimm EB, Willett WC, Colditz GA. Obesity fat distribution, and weight gain as risk factors for clinical diabetes in men. Diabetes Care 1994;17:961−969.
7. Colditz GA, Willet WC, Rotnitzky A, Manson JE. Weight gain as a risk factor for clinical diabetes mellitus in women. Ann Intern Med 1995;122:481−486.
8. Willett WC. Anthropometric measures and body composition. In: Willett WC, ed. Nutritional Epidemiology, 2nd ed. New York: Oxford University Press;1998. pp. 244−272.
9. Perissinotto E, Pisent C, Sergi G, Grigoletto F. ILSA Working Group (Italian Longitudinal Study on Ageing). Anthropometric measurements in the elderly: age and gender differences. Br J Nutr 2002;87: 177−186.
10. American Diabetic Association. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 2003:S5−S20.
11. WHO: Obesity: preventing and managing the global epidemic. Report of a WHO consultation of obesity. Geneva, WHO, 1997. Obes Res 1998;6:51S−210S.
12. 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.
13. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. Am J Clin Nutr 2004; 79:379−384.
14. Bertsias G, Mammas I, Linardakis M, Kafatos A. Overweight and obesity in relation to cardiovascular disease risk factors among medical students in Crete, Greece. BMC Public Health 2003;3:3 (Epub 2003 Jan 8).
15. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr 2005;56:303−307.
16. Tseng CH. Waist-to-height ratio is independently and better associated with urinary albumin excretion rate than waist circumference or waist-to-hip ratio in Chinese adult type 2 diabetic women but not men. Diabetes Care Sep 2005;28:2249−2251.
17. Mamtani MR, Kulkarni HR. Predictive performance of anthropometric indexes of central obesity for the risk of type 2 diabetes. Arch Med Res 2005;36:581−589.
18. Sakurai M, Miura K, Takamura T, Ota T, Ishizaki M, Morikawa Y, et al. Gender differences in the association between anthropometric indices of obesity and blood pressure in Japanese. Hypertens Res 2006; 29:75−80.
19. Hsieh SD, Muto T. The superiority of waist-to-height ratio as an anthropometric index to evaluate clustering of coronary risk factors among non-obese men and women. Prev Med 2005;40:216−220.
20. Hara M, Saitou E, Iwata F, Okada T, Harada K. Waist-to-height ratio is the best predictor of cardiovascular disease risk factors in Japanese schoolchildren. J Atheroscler Thromb 2002;9:127−132.
21. Esmaillzadeh A, Mirmiran P, Azizi F. Comparative evaluation of anthropometric measures to predict cardiovascular risk factors in Tehranian adult women. Public Health Nutr 2006;9:61−69.
22. Aekplakorn W, Kosulwat V, Suriyawongpaisal P. Obesity indices and cardiovascular risk factors in Thai adults. Int J Obesity (Lond) 2006;. Apr 18[Epub ahead of print].
23. Harris MI, Eastman RC. Early detection of undiagnosed diabetes: a US perspective. Diabetes Metab Res Rev 2000;16:230−236.