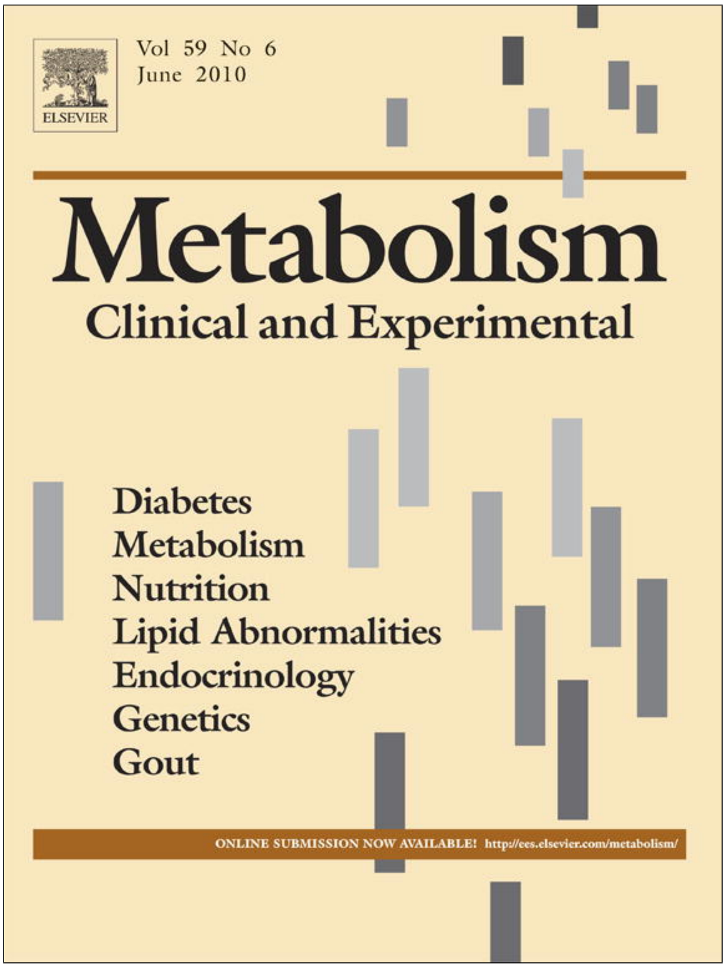
ELSEVIER
Vol 59 No 6
June 2010
Metabolism
Clinical and Experimental
Diabetes
Metabolism
Nutrition
Lipid Abnormalities
Endocrinology
Genetics
Gout
ONLINE SUBMISSION NOW AVAILABLE! http://ees.elsevier.com/metabolism/

Available online at www.sciencedirect.com
ScienceDirect
Metabolism Clinical and Experimental 59 (2010) 834 – 840
Metabolism
Clinical and Experimental
www.metabolismjournal.com

Urgency of reassessment of role of obesity indices for metabolic risks

Shiun Dong Hsieh[a,*], Margaret Ashwell[b], Takashi Muto[c], Hiroshi Tsuji[a], Yasuji Arase[a], Toshio Murase[d]

[a]Medical Center of Health Science, Toranomon Hospital, Tokyo 105-0001, Japan
[b]Ashwell Associates (Europe), Hertfordshire SG7 5PZ, UK
[c]Department of Public Health, Dokkyo Medical University School of Medicine, Tochigi 321-0293, Japan
[d]Okinaka Memorial Institute for Medical Research, Tokyo 105-8470, Japan

Received 28 July 2009; accepted 30 September 2009

Abstract

The definition of metabolic syndrome places emphasis on health care for persons at risk. However, whether an obesity index should be a mandatory component of the definition and whether obesity indices can identify metabolic risks satisfactorily require further exploration. Therefore, we investigated the effectiveness of various anthropometric obesity indices in identifying the clustering of 2 or more American Heart Association (AHA)/National Heart, Lung, and Blood Institute (NHLBI)/International Diabetes Federation (IDF)–defined metabolic risk factors (hypertension, hyperglycemia, hypertriglyceridemia, and low high-density lipoprotein cholesterol) for metabolic syndrome and those of other metabolic risk factors (high low-density lipoprotein cholesterol, hyperuricemia, high γ-glutamyltransferase, fatty liver) in 6141 men and 2137 women. The anthropometric indices were the following: (1) for both sexes—various levels of waist-to-height ratio (WHtR) including 0.5 and body mass index (BMI) of 23 and 25 kg/m^2; (2) for men and women individually—waist circumference (W) 90/80 cm (AHA/NHLBI/IDF for ethnic groups), W 85/90 cm (Japan Society for the Study of Obesity), and combined W and BMI: W 85/90 cm and/or BMI 25 kg/m^2 (Japanese government). The results showed the following: (1) The optimal value for WHtR was 0.5 for AHA/NHLBI/IDF-defined risk factors and approximately 0.5 for other risk factors in both sexes. (2) The sensitivities of various proposed obesity indices for identifying clustering of defined and other risk factors varied between 74.4% (WHtR 0.5) and 36.3% (BMI 25) and between 80.5% (WHtR 0.5) and 43.7% (BMI 25) in men, and varied between 65.6% (WHtR 0.5) and 16.8% (W 90 cm) and between 82.3% (WHtR 0.5) and 28.2% (W 90 cm) in women. Because the sensitivities of many anthropometric indices were very low, a reassessment of the effectiveness of obesity indices in evaluating metabolic risks and especially their suitability as a single mandatory component of metabolic syndrome is urgently needed. However, WHtR 0.5 provides a very useful algorithm for screening persons at risk.

1. Introduction

Body mass index (BMI), which was defined by the World Health Organization (WHO), has been used for many years as a global index for assessing obesity [1,2]. More recently, identifying metabolic syndrome has become more important than the simple assessment of obesity. In 2001, the Adult Treatment Panel III (ATP III) proposed a definition for metabolic syndrome as the presence of 3 or more of 5 metabolic risk factors, including large waist circumference [3]. In 2005, the International Diabetes Federation (IDF) also proposed a definition of metabolic syndrome, with large waist circumference as the single mandatory component. However, the cutoff values for waist circumference also varied for sexes, ethnic groups, and even countries [3,4]. In the same year, the American Heart Association (AHA)/National Heart, Lung, and Blood Institute (NHLBI) made a statement after minor revision of the definition of ATP III for the fasting glucose value [5]. In 2006, the IDF revised the cutoff value for the waist circumference of Japanese people from 85 to 90 cm in men and from 90 to 80 cm in women [6]; these were the same as those for South Asians, Chinese, and Asian Americans defined by AHA/NHLBI. However, the Japan Society for the Study of Obesity (JASSO) insists that waist circumferences of 85 cm in men and 90 cm in women

Conflicts of interest: none.

* Corresponding author. Tel.: +81 3 3588 1111; fax: +81 3 3560 7775.
E-mail address: hsiehsd@toranomon.gr.jp (S.D. Hsieh).

0026-0495/$ – see front matter © 2010 Elsevier Inc. All rights reserved.
doi:10.1016/j.metabol.2009.09.032

(corresponding to a visceral fat area of 100 cm^2) should continue to be used as the single essential component of metabolic syndrome for Japanese [7]. Recently, the Ministry of Health, Labour, and Welfare of Japan established special health checkups and interventions for metabolic syndrome that took effect in April 2008, with the combined criteria of waist circumferences and BMI as the single mandatory component of metabolic syndrome [8].

In 1995 and 1996, another anthropometric index, waist-to-height ratio (WHtR), was shown to be better associated with metabolic risk factors [9-12]. As an advantage of this index, the same cutoff value (0.5) can be applied to both men and women [9,10]. In the last few years, there has been an exponential increase in evidence from other investigators showing the superiority of WHtR as a predictor of metabolic risks, stroke, and chronic kidney disease based on studies in both adults and children [13-29]. We have previously proposed WHtR of 0.5 or greater as a more effective index than the various indices of BMI and waist circumference for screening defined metabolic risk factors of metabolic syndrome using the former definition by the ATP III [30]. However, we have not yet reported sensitivity and specificity for various levels of WHtR and their comparison with other proposed anthropometric indices including the recent proposal by the Japanese government in screening both defined and undefined metabolic risk factors of the recent definition of metabolic syndrome by AHA/NHLBI/IDF. Therefore, this index merits further evaluation.

Because obesity indices have been used as a single mandatory component of metabolic syndrome by the IDF and other institutions, individuals who have clustering of metabolic risk factors but whose anthropometric values do not exceed the cutoffs of obesity indices are underevaluated and may not receive the needed consultation. This is particularly a problem in light of government legislation requiring intervention for patients with metabolic syndrome [8]. In addition, the use of anthropometric indices and proposed cutoff values for the definition of metabolic syndrome is very complicated; and recommendations may even differ within the same country. We believe that both the care of persons at risk and the cost-effectiveness of such medical care can be substantially improved by a further exploration of the role of various obesity indices in screening of metabolic risks. Therefore, we evaluated the effectiveness of various anthropometric indices in screening defined and other metabolic risk factors, and considered whether the anthropometric index should be a mandatory or optional component of metabolic syndrome.

2. Methods

2.1. Study population

Routine health checkups are common in Japan because the Japanese government and companies encourage people to receive periodic examinations. The subjects in this study were 6141 men (49.5 ± 8.9 years old [mean ± SD], BMI from 14.7-37.5 kg/m^2) and 2137 women (51.9 ± 9.0 years old, BMI from 13.9-43.3 kg/m^2) who underwent such health checkups at the Medical Center of Health Science, Toranomon Hospital, Tokyo [13]. The research was approved by the institutional review committee for non-invasive study of human use.

2.2. Procedure and measurement

After an overnight fast, height and weight were measured. Waist circumference (W) was measured by the physician at the umbilical level with the subjects standing and breathing normally during physical examination [9,10]. Blood pressure was measured by hospital staff with the subjects in a sitting position. Plasma glucose, serum triglyceride, high-density lipoprotein (HDL) cholesterol, uric acid, and γ-glutamyl-transferase were measured by enzymatic methods using autoanalyzer (Labosbect; Hitachi, Tokyo, Japan). Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald equation, but excluding subjects with serum triglyceride of 400 mg/dL or greater [31]. Abdominal ultrasonography was performed using the SAA-250A device (Toshiba, Tokyo, Japan) by the experienced technician during the same morning, and the result was diagnosed later by the physician (specialist in ultrasonography). A total of 6061 men and 2073 women received this examination at the subject's option. The current histories of subjects receiving medication for metabolic risks were obtained at the time of examination.

2.3. Anthropometric indices

2.3.1. Classification of WHtR levels

For this study, WHtR values were classified arbitrarily around our previous proposed value, 0.5 [9,10], into the 5 following groups, considering simplicity and the ease of effective calculation: at least 0.44, at least 0.46, at least 0.48, at least 0.5, and at least 0.52 [9,10]. These groups were studied to determine the optimal cutoff value.

2.3.2. Definition of obesity-related anthropometric cutoff values used for metabolic syndrome

2.3.2.1. Men. (1) W at least 90 cm (AHA/NHLBI for Asian Americans [5] and IDF for South Asians, Chinese, and Japanese [6]), (2) W at least 85 cm (JASSO [7]), and (3) W at least 85 cm and/or BMI at least 25 kg/m^2 (Ministry of Health, Labour, and Welfare of Japan [8]).

2.3.2.2. Women. (1) W at least 80 cm (AHA/NHLBI for Asian Americans [5] and IDF for South Asians, Chinese, and Japanese [6]), (2) W at least 90 cm (JASSO [7]), and (3) W at least 90 cm and/or BMI at least 25 kg/m^2 (Ministry of Health, Labour, and Welfare of Japan [8]).

Table 1
Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various levels of WHtR

WHtR	≥0.44		≥0.46		≥0.48		≥0.5		≥0.52	
Risk factors	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Men										
≥1	96.0	15.2	90.6	28.1	80.5	43.7	65.4	63.5	45.7	80.8
≥2	98.4	10.6	95.1	20.7	87.8	35.1	74.4	53.4	54.5	71.9
Women										
≥1	87.4	33.4	77.4	51.2	62.9	67.0	48.8	79.7	36.0	89.2
≥2	95.5	27.1	89.9	42.9	77.0	58.5	65.6	72.4	52.0	83.0

2.3.2.3. Both men and women. (1) WHtR at least 0.5 (our proposal [9,10]), (2) BMI at least 23 kg/m^2 (WHO for Asians [2]), and (3) BMI at least 25 kg/m^2 (WHO [1]).

2.4. Definition of metabolic risk factors

2.4.1. AHA/NHLBI/IDF-defined metabolic risk components of metabolic syndrome [5,6]

(1) Hypertension: systolic blood pressure at least 130 mm Hg and/or diastolic blood pressure at least 85 mm Hg and/or currently receiving medication for hypertension. (2) Hyperglycemia: fasting plasma glucose at least 100 mg/dL and/or currently receiving medication for hyperglycemia. (3) Hypertriglyceridemia: serum triglyceride at least 150 mg/dL and/or currently receiving medication for hypertriglyceridemia. (4) Low HDL cholesterol: serum HDL cholesterol less than 40 mg/dL for men and less than 50 mg/dL for women.

2.4.2. Other metabolic risk factors

(1) High LDL cholesterol: serum LDL-cholesterol at least 140 mg/dL and/or currently receiving medication for hypercholesterolemia. (2) Hyperuricemia: serum uric acid greater than 7 mg/dL and and/or currently receiving medication for hyperuricemia. (3) High γ-glutamyltransferase: serum γ-glutamyltransferase greater than 109 IU/L. (4) Fatty liver: bright liver, increased liver echotexture compared with kidneys, vascular blurring, and deep attenuation as shown by ultrasonography [32].

2.5. Data analysis

Sensitivity was calculated as true positives over the sum of true positives and false negatives. Specificity was calculated as true negatives over the sum of true negatives and false positives. The optimal cutoff value was determined by the value that had the largest sum of sensitivity and specificity [17]. JMP software (SAS Institute, Cary, NC) was used in this analysis.

3. Results

3.1. Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various levels of WHtR in men and women

In men, the optimal cutoff value of WHtR for the identification of both 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors was 0.5. In women, the optimal value for the identification of 1 or more metabolic risk factors was 0.48; and that for the identification of clustering of 2 or more AHA/NHLBI/IDF-defined metabolic risk factors was 0.5 (Table 1).

3.2. Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various levels of WHtR in men and women

In men, the optimal value of WHtR for the identification of 1 or more other metabolic risk factors was 0.5; and that for the identification of clustering of 2 or more other metabolic risk factors was 0.5 to 0.52 (sum of sensitivity and specificity, 132.3∼133). In women, the optimal value for the identification of 1 or more other metabolic risk factors was 0.48; and that for the identification of clustering of 2 or more other metabolic risk factors was 0.5 to 0.52 (sum of sensitivity and specificity, 152.6∼152.8) (Table 2).

Table 2
Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various levels of WHtR

WHtR	≥0.44		≥0.46		≥0.48		≥0.5		≥0.52	
Risk factors	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Men										
≥1	97.8	15.2	93.4	27.4	84.3	43.7	69.2	62.8	49.3	80.4
≥2	99.4	9.7	97.3	19.3	92.0	33.4	80.5	51.8	62.0	71.0
Women										
≥1	88.8	32.5	78.2	49.2	64.9	65.5	50.1	78.2	35.8	86.9
≥2	98.9	25.2	97.2	40.5	90.1	56.2	82.3	70.3	71.3	81.5

Table 3
Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various proposed anthropometric indices in men

Risk factors	Our proposal WHtR ≥0.5		AHA/NHLBI for Asian Americans and IDF for South Asians, Chinese, and Japanese W ≥90 cm		JASSO W ≥85 cm		WHO for Asians BMI ≥23 kg/m^2		The Ministry of Health, Labour, and Welfare of Japan W ≥85 cm and/or BMI ≥25 kg/m^2 (parenthesis: BMI ≥25 kg/m^2 alone)	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
≥1	65.4	63.5	34.3	87.5	62.6	64.5	62.3	63.2	63.1 (29.7)	63.9 (90.1)
≥2	74.4	53.4	41.7	60.2	71.5	55.3	69.5	53.8	72.0 (36.3)	54.8 (83.4)

3.3. Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various proposed anthropometric indices in men

The optimal index for identification of both 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors among the various proposed indices was WHtR 0.5 in men. Waist-to-height ratio of 0.5 also showed the highest sensitivity (65.4 for 1 or more risk factors, 74.4 for 2 or more risk factors). Waist circumference of 85 cm and BMI 23 kg/m^2 had a slightly lower sensitivity (62.6 and 62.3 for 1 or more risk factors, 71.5 and 69.5 for 2 or more risk factors). The combined index of “W 85 cm and/or BMI 25 kg/m^2” was not much more sensitive than W 85 cm alone (63.1 for 1 or more risk factors, 72.0 for 2 or more risk factors). The sensitivities were much lower for both W 90 cm and BMI 25 kg/m^2 (34.3 and 29.7 for 1 or more risk factors, 41.7 and 36.3 for 2 or more risk factors) (Table 3).

3.4. Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various proposed anthropometric indices in men

The optimal index for identification of 1 or more other risk factors was WHtR 0.5. The sum of sensitivity and specificity for identification of 2 or more other risk factors was very close for the combined index of “W 85 cm and/or BMI 25 kg/m^2,” W 85 cm, and WHtR 0.5 (132.5∼132.3), indicating that these would be the optimal indices for identification of 2 or more other risk factors in men. On the other hand, among various proposed indices, the sensitivities for identification of both 1 or more and 2 or more other metabolic risk factors were highest for WHtR 0.5 in men (69.2 for 1 or more risk factors, 80.5 for 2 or more risk factors), followed by “W 85 cm and/or BMI 25 kg/m^2” and W 85 cm (67 and 66.4 for 1 or more risk factors, 78.9 and 78.3 for 2 or more risk factors). The sensitivities were much lower for both W 90 cm and BMI 25 kg/m^2 (37.1 and 32.8 for 1 or more risk factors, 49.8 and 43.7 for 2 or more risk factors) (Table 4).

3.5. Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various proposed anthropometric indices in women

The optimal index for identification of both 1 or more and clustering of 2 or more AHA/NHLBI/IDF-defined metabolic risk factors among the various proposed indices was WHtR 0.5 in women. In addition, WHtR 0.5 also showed the highest sensitivity (48.8 for 1 or more risk factors, 65.6 for clustering of 2 or more risk factors). Both W 80 cm and BMI 23 kg/m^2 showed lower sensitivity (39.1 and 39.1 for 1 or more risk factors, 54.7 and 54 for 2 or more risk factors). The sensitivities were much lower for both W 90 cm and BMI 25 kg/m^2 (10.2 and 20.2 for 1 or more risk factors, 16.8 and 32.7 for 2 or more risk factors). The combined index of “W 90 cm and/or BMI 25 kg/m^2” was not much more sensitive than BMI 25 kg/m^2 alone (21.4 for 1 or more risk factors, 33.9 for 2 or more risk factors) (Table 5).

Table 4
Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various proposed anthropometric indices in men

Risk factors	Our proposal WHtR ≥0.5		AHA/NHLBI for Asian Americans and IDF for South Asians, Chinese, and Japanese W ≥90 cm		JASSO W ≥85 cm		WHO for Asians BMI ≥23 kg/m^2		The Ministry of Health, Labour, and Welfare of Japan W ≥85 cm and/or BMI ≥25 kg/m^2 (parenthesis: BMI ≥25 kg/m^2 alone)	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
≥1	69.2	62.8	37.1	87.0	66.4	64.3	66.1	62.9	67.0 (32.8)	63.8 (90.6)
≥2	80.5	51.8	49.8	80.2	78.3	54.1	77.1	53.3	78.9 (43.7)	53.6 (83.5)

Table 5
Sensitivity and specificity for identification of 1 or more and 2 or more AHA/NHLBI/IDF-defined metabolic risk factors by various proposed anthropometric indices in women

Risk factors	Our proposal WHtR ≥0.5		AHA/NHLBI for Asian Americans and IDF for South Asians, Chinese, and Japanese W ≥80 cm		JASSO W ≥90 cm		WHO for Asians BMI ≥23 kg/m^2		The Ministry of Health, Labour, and Welfare of Japan W ≥90 cm and/or BMI ≥25 kg/m^2 (parenthesis: BMI ≥25 kg/m^2 alone)	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
≥1	48.8	79.7	39.1	84.4	10.2	98.7	39.1	83.1	21.4 (20.2)	93.8 (93.8)
≥2	65.6	72.4	54.7	78.8	16.8	96.7	54.0	77.8	33.9 (32.7)	90.7 (91.2)

3.6. Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various proposed anthropometric indices in women

The optimal index for the identification of both 1 or more and clustering of 2 or more other metabolic risk factors among the various proposed indices was WHtR 0.5 in women. In addition, WHtR 0.5 also showed highest sensitivity (50.1 for 1 or more risk factors, 82.3 for clustering of 2 or more risk factors). Both W 80 cm and BMI 23 kg/m^2 showed lower sensitivity (39.1 and 39.7 for 1 or more risk factors, 72.4 and 68.0 for 2 or more risk factors). The sensitivities were much lower for either W 90 cm or BMI 25 kg/m^2 (10.0 and 21.1 for 1 or more risk factors, 28.2 and 46.4 for 2 or more risk factors). The combined index of "W 90 cm and/or BMI 25 kg/m^2" was not much more sensitive than BMI 25 kg/m^2 alone (22.3 for 1 or more risk factors, 48.1 for 2 or more risk factors) (Table 6).

4. Discussion

In this study, the sensitivities of some of the proposed anthropometric indices in identification of clustering of both defined and other metabolic risk factors were very low (<50: BMI 25 for both men and women; AHA/NHLBI/IDF for men; JASSO and the Ministry of Health, Labour, and Welfare of Japan for women). Therefore, their suitability as a component of metabolic syndrome requires further study.

The optimal WHtR for identification of 2 or more AHA/NHLBI/IDF-defined and other metabolic risk factors in our current study was approximate 0.5 in both men and women, based on combined sensitivity, specificity, and simplicity. We found that, among various proposed indices of abdominal obesity, only WHtR 0.5 could identify more people with clustering of metabolic risk factors in both men and women, considering sensitivity and specificity. Our optimal WHtR value is very similar to those in other reports from Japan (0.49 for men) [11], Taiwan (0.48 for men and 0.45 for women) [14], Hong Kong (0.48 for both sexes) [17], and the United Kingdom (0.5 for children) [21] for identifying any or more metabolic risk factors under various definitions in their populations. Indeed, a recent meta-analysis has shown that WHtR may be a better indicator of metabolic risks than BMI, waist circumference, or waist-to-hip ratio [33].

Short people may have higher metabolic risks than taller people with a similar waist circumference [34]. We can speculate on the following 3 possible reasons for the better sensitivity of WHtR in identifying metabolic risk factors in both men and women: (1) The relative amount of central fat may be more closely associated with metabolic risks than the absolute amount of central fat, especially for people with moderate BMI. (2) Waist circumference adjusted by height may better reflect the different risk experienced by older and younger people. In particular, in Japan, younger people are generally taller than older people because of the improved nutritional environment in recent years. Thus, using the same cutoff value for waist circumference for all ages may overestimate the metabolic risk for younger people and underestimate the metabolic risk for older people. (3) Waist circumference

Table 6
Sensitivity and specificity for identification of 1 or more and 2 or more other metabolic risk factors by various proposed anthropometric indices in women

Risk factors	Our proposal WHtR ≥0.5		AHA/NHLBI for Asian Americans and IDF for South Asians, Chinese, and Japanese W ≥80 cm		JASSO W ≥90 cm		WHO for Asians BMI ≥23 kg/m^2		The Ministry of Health, Labour, and Welfare of Japan W ≥90 cm and/or BMI ≥25 kg/m^2 (parenthesis: BMI ≥25 kg/m^2 alone)	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
≥1	50.1	78.2	39.1	82.2	10.0	97.8	39.7	81.4	22.3 (21.1)	93.0 (93.2)
≥2	82.3	70.3	72.4	77.2	28.2	96.5	68.0	75.9	48.1 (46.4)	89.6 (90.1)

adjusted by height may better reflect the combined metabolic risks due to stature and girth. For example, shorter persons may be prone to metabolic risks and/or cardiovascular disease because of their poor nutritional state in intrauterine life or childhood.

The AHA/NHLBI/IDF initially defined metabolic syndrome using limited data. However, it has been reported that the recommendations issued in the ACC/AHA's current clinical practical guidelines were largely developed based on low levels of evidence or expert opinion. These findings highlight the need to improve the process of writing guidelines and to expand the evidence base from which clinical practical guidelines are derived [35]. The definitions of metabolic syndrome made by AHA/NHLBI/IDF; JASSO; and the Ministry of Health, Labour, and Welfare of Japan are other examples of this problem.

Because none of the presently proposed indices perfectly identifies people with clustering of metabolic risk factors, a reassessment of the effectiveness of the present indices and definitions in enhancing health promotion is urgently required. There may be individual differences in susceptibility to metabolic risks due to hereditary or other reasons that are not necessarily related to these anthropometric indices. From this viewpoint, we suggest that an anthropometric index should not be a mandatory component of metabolic syndrome; and we also support the use of the obesity index as one of the optional components of metabolic syndrome as proposed by AHA/NHLBI in recommending consultation to individuals who have clustering of metabolic risk factors but an anthropometric index less than the cutoff value because dietary treatment such as salt restriction, low cholesterol, low-purine diets, and appropriate alcohol and calorie intake in combination with exercise may be also effective. On the other hand, the sensitivities and specificities of some anthropometric indices for identifying clustering of metabolic risks were very close. The significance of differences requires further study.

However, in addition to other anthropometric indices, the potential of WHtR 0.5 as an optional component of metabolic syndrome and its global utilization as an obesity index in public health should not be neglected, considering its simplicity and effectiveness in screening both men and women with metabolic risk factors [36].

5. Issue for future research on role of obesity indices in metabolic syndrome and other health risks

(1) Why should the same cutoff value of BMI be used as a global obesity index for both sexes, but not waist circumference? (2) Should individual differences in height be ignored for the sake of simplicity? (3) Which has a higher correlation with metabolic risk, total amount of visceral fat or relative amount of visceral fat to stature, especially in subjects with moderate BMI? (4) Do people with the same amount of abdominal fat have the same threshold for metabolic risks, irrespective of hereditary, environmental, and other factors? (5) Why do some people with anthropometric values of obesity less than the cutoff values still have clustering of metabolic risks? (6) Why should anthropometric index of obesity be a mandatory component of metabolic syndrome? (7) Are there any discrepancies between BMI and waist circumference as parameters of metabolic risks and other health risks? Is a 90-cm waist size a meaningful criterion for women, considering the fact that women with a waist circumference greater than 90 cm defined by JASSO and the Ministry of Health, Labour, and Welfare of Japan can almost always be identified as overweight or obese from appearance without measuring their waist circumferences? It should be noted that, when attempting to establish an anthropometric index for metabolic risks, it is desirable to use an index that can also contribute to preventing other complications of obesity, such as the effect of weight itself on the joints.

References

[1] WHO. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. WHO technical report series; 2000. Ser 894.

[2] WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.

[3] Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486-97.

[4] George K, Alberti MM, Zimmet P, and the IDF Epidemiology Task Force Consensus Group. The metabolic syndrome. Lancet 2005; 366:1059-62.

[5] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome. An American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation 2005;112:2735-52.

[6] Alberti MM, Zimmet P, Shaw J. Metabolic syndrome-a new worldwide definition. A consensus statement from the International Diabetes Federation. Diabet Med 2006;23:469-80.

[7] The Examination Committee for Criteria for "Obesity Disease" in Japan, Japan Society for the Study of Obesity. New criteria for "obesity disease" in Japan. Cir J 2002;66:987-92.

[8] How to do the special health checkups and consultations. J Med J 2007;4344:4-7 [in Japanese].

[9] 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;19:585-9.

[10] Hsieh SD, Yoshinaga H. Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. Intern Med 1995;34:1147-52.

[11] Lee JS, Aoki K, Kawakubo K, Gunji A. A study on indices of body fat distribution for screening for obesity. J Occu Health 1995;37:9-18.

[12] Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. BMJ 1996;312:377.

[13] Hsieh SD, Yoshinaga H, Muto T. Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women. Int J Obes Relat Metab Disord 2003;27:610-6.

[14] Lin WY, Lee LT, Chen CY, Lo H, Hsia HH, Liu IL, et al. Optimal cut-off values for obesity: using simple anthropometric indices to predict

cardiovascular risk factors in Taiwan. Int J Obes Relat Metab Disord 2002;26:1232-8.

[15] 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;9:127-32.

[16] Lyu LC, Hsu CY, Yeh CY, Lee MS, Huang SH, Chen CL. A case-control study of the association of diet and obesity with gout in Taiwan. Am J Clin Nutr 2003;78:690-701.

[17] Ho SY, Lam TH, Janus ED, the Hong Kong Cardiovascular Risk Factor Prevalence Study Steering Committee. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann Epidemiol 2003;13:683-91.

[18] 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;40:216-20.

[19] Kahn HS, Imperatore G, Cheng YJ. A population-based comparison of BMI percentiles and waist-to-height ratio for identifying cardiovascular risk in children. J Pediatr 2005;146:482-8.

[20] Lu M, Ye W, Adami HO, Weiderpass E. Prospective study of body size and risk for stroke amongst women below age 60. J Intern Med 2006;260:442-50.

[21] McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message—"keep your waist circumference to less than half of your height". Int J Obes 2006;30:988-92.

[22] Lin CH, Chou CY, Lin CC, Huang CC Liu CS, Lai SW. Waist-to-height ratio is the best index of obesity in association with chronic renal disease. Nutrition 2007;23:788-93.

[23] Schneider HJ, Glaesmer H, Klotsche J, Bohler S, Lehnert H, Zeiher AM, et al. Accuracy of anthropometric indicators of obesity to predict cardiovascular risk. J Clin Endocrinol Metab 2007;92:589-94.

[24] Yan W, He B, Yao H, Dai J, Cui J, Ge D, et al. Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescent. Obesity 2007;15:748-52.

[25] Gelber RP, Gaziano JM, Orav EJ, Manson JE, Buring JE, Kurth T. Measures of obesity and cardiovascular risk among men and women. J Am Coll Cardiol 2008;52:605-15.

[26] The Decoda Study Group. BMI compared with central obesity indicators in relation to diabetes and hypertension in Asians. Obesity 2008;16:1622-35.

[27] He Y, Zhai F, Ma G, Feskens EJM, Zhang J, Fu P, et al. Abdominal obesity and the prevalence of diabetes and intermediate hyperglycemia in Chinese adults. Public Health Nutr 2008;6:1-7.

[28] Tseng CH. Waist-to-height ratio and coronary artery disease in Taiwanese type 2 diabetic patients. Obesity 2008;16:2754-9.

[29] Nambiar S, Truby H, Abbott RA, Davies PSW. Validating the waist-to-height ratio and developing centiles for use amongst children and adolescents. Acta Paediatrica 2009;98:148-52.

[30] Hsieh SD, Muto T. Metabolic syndrome in Japanese men and women with special reference to the anthropometric criteria for the assessment of obesity: proposal to use the waist-to-height ratio. Prev Med 2006;42:135-9.

[31] Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972;18:499-502.

[32] Sanyal AJ. AGA technical review on nonalcoholic fatty liver disease. Gastroenterology 2002;123:1705-25.

[33] Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. J Clin Epidemiol 2008;61:646-53.

[34] Hsieh SD, Yoshinaga H. Do people with similar waist circumference share similar health risks irrespective of height? Tohoku J Exp Med 1999;188:55-60.

[35] Tricoci P, Allen JM, Kramer JM, Califf RM, Smith SC. Scientific evidence underlying the ACC/AHA clinical practical guidelines. JAMA 2009;301:831-41.

[36] 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 message on obesity. Int J Food Sci and Nutr 2005;56:303-7.