Which obesity index is a better predictor for cardiometabolic risk factors in a young adult rural population of Telangana State, India?

G. N. Kusneniwar¹,², Guru R. Jammy³, D. Shailendra⁴, C. H. Bunker⁵, P. S. Reddy⁶,⁷

¹Community Medicine and Family Medicine, AIIMS, Bibinagar (Near Hyderabad), Bhuvanagiri-Yadadari District, ²Department of Community Medicine, SHARE INDIA, MediCiti Institute of Medical Sciences, Ghanpur (V), Medchal (M) and District, ³Department of Community Medicine, SHARE INDIA, MediCiti Institute of Medical Sciences, Ghanpur (V), Medchal (M) and District, ⁴Department of Pharmacology, SHARE INDIA, MediCiti Institute of Medical Sciences, Ghanpur (V), Medchal (M) and District, ⁵SHARE INDIA, MediCiti Institute of Medical Sciences, Ghanpur(V), Medchal(M) and District, Telangana, India, ⁶Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA 15261, ⁷School of Medicine, University of Pittsburgh. Pittsburgh, PA 15213, USA

Abstract

Background: Waist-to-height ratio (WHtR) has recently been found to be a useful marker of cardiovascular disease (CVD) risk in populations in developed countries; the comparison of various obesity indices, particularly WHtR, has received little study in India and other developing countries. Aim: This study aimed to compare the associations of common obesity indices, body mass index (BMI), waist circumference, waist-hip ratio (WHR), and WHtR, with cardiometabolic risk factors in a young, rural Indian population. Subjects and Methods: Anthropometric measurements and cardiometabolic risk factors (hypertension, diabetes, and dyslipidemia) were measured using standardized protocols at the baseline visit of the Longitudinal Indian Family hEalth Pilot Study, a population-based cohort study of child-bearing age women and their husbands in rural Telangana, India. Results: In comparison with most previously studied populations, this population sample (642 males and 980 females) was younger; had lower BMI; and lower rates of diabetes, hypertension, and abnormal lipids (exception of high rates of low high-density lipoprotein). With regard to each of the cardiometabolic risk factors, the associations across the obesity indices tended to be significant, but weak, and similar to each other, whereas the association with WHR was less strong. Conclusion: Although WHtR was not a better predictor of cardiometabolic risk than conventional obesity indices, in this young adult Indian population, it was equally good. This raises the prospect of using WHtR as an alternative to BMI for assessing cardiometabolic risk in Indians considering the ease with which it can be easily done and interpreted.

Keywords: Considered risk factors, obesity indices, waist-to-height ratio (WHtR)

Address for correspondence: Dr. G. N. Kusneniwar, Department Community Medicine and Family Medicine, AIIMS, Bibinagar, Bhuvanagiri-Yadadari District, Telangana - 508 126, India. E-mail: drkgn2012@gmail.com

Received: 14-05-2020
Accepted: 14-07-2020
Published: 30-09-2020

Introduction

Globally, overweight and obesity are the fifth leading cause of death.⁴ Among populations aged 18 years and older in 2016, the prevalence of overweight was 39% and obesity was 13%.⁵ This is increasing rapidly in developing countries.⁶,⁷ Body mass
index (BMI) is the standard international obesity index.[2] However, reviews have found that indices of central obesity, waist circumference (WC), and waist-to-hip ratio (WHR) are more strongly associated with cardiometabolic risk than BMI.[5-8] The waist-to-height ratio (WHtR) was superior to WC and BMI for detecting cardiometabolic risk.[9,11]

Southeast Asians experience higher cardiometabolic risk at lower BMI compared with other populations.[12-14] Data regarding obesity markers with cardiometabolic risk factors among Indians are sparse and inconsistent.[8,15-19] We cross-sectionally analyzed obesity indices as predictors of cardiometabolic risk factors, including hypertension, diabetes, and dyslipidemia, in a cohort of young adults in rural India.

Subjects and Methods

The present study was a cross-sectional analysis of the Longitudinal Indian Family Health (LIFE) cohort study in a rural area of Telangana State, India. The details are published elsewhere.[20]

Study setting and participant

The ongoing LIFE Study in rural Telangana State collected baseline data from 2009 to 2011. It is a population-based representative cohort of 1227 women belonging to the child-bearing age and 642 husbands followed prospectively to study birth outcomes. After excluding 247 women at the baseline who were pregnant during the time of recruitment, data for 980 women and 642 men were included in this analysis. The study was approved by the institutional ethics committee and written informed consent was obtained from all participants 07.06.2008.

Collection of field data and blood samples for analysis

The LIFE Study methods have been described in detail elsewhere.[20] Briefly, extensively trained male and female field workers performed the various exams; administered questionnaires in the local language, Telugu; and performed anthropometric measurements.

Anthropometric measurements

Height and weight were measured using a portable stadiometer and a portable calibrated scale (SECA scale designed by UNICEF); WC was measured in duplicate to 0.1 cm by using nonstretchable tailors tape at the narrowest point between the ribs and the hips or the umbilicus if there was no narrowest point; and hip circumference was measured at the widest part of the buttocks. The type of clothing worn during measurement was recorded. At the time of data analyses, subtractions were made to minimize errors because of clothing: for women, sari =1 cm and for men pants =0.7 cm and dhoti =3.0 cm.

Blood pressure

Blood pressure was measured thrice by an observer trained according to the Multiple Risk Factor Intervention Trial (MRFIT) protocol,[21] using the OMRON HEM-705 automated blood pressure monitor (Omron Health care, INC. Bannockburn, IL, Made in China). The average of the second and third readings was used in the analysis.

Fasting blood sample collection and assay

One day before the test, all the participants were instructed to fast after 10:00 PM until their blood was drawn the following morning in a small, temporary study laboratory in the village office or school. From the antecubital fossa, 15 ml of blood (10 ml red top, 5 ml purple top vacutainers) was drawn. Immediately after collection, the fasting blood sample was transported to the MediCiti Hospital Laboratory, Society for Health Allied Research & Education India (SHARE INDIA). Standard clinical pathology protocols were used to measure fasting blood sugar (Dimension Xp and Plus auto analyzer, SIEMENS, New York, USA) and the lipid profile (Ximola auto analyser, Randox, Ireland) at the MediCiti Hospital Clinical Laboratory. If triglycerides were <500 mg/dl, the low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula.[22] If triglycerides were ≥500 mg/dl, the LDL cholesterol was estimated using an analyzer. Definitions and criteria used in this study are mentioned in Table 1.

Statistical analysis

Data entry was done using double key entry and analyzed using the Statistical Package for the Social Sciences software, version 17.0 and MedCalc, version 12.7.0, statistical program. Nonparametric Spearman’s correlations were calculated. Continuous predictor variables were compared across groups using the student t-test/Wilcoxon rank-sum test. Categorical variables were presented as percentages and 95% confidence limits and compared with a Chi-square test.

The area under the receiver operating curve (AUROC) analysis was used to measure the association between outcome variables hypertension, diabetes, and dyslipidemia and obesity indices and to determine cut-off values. For AUROC analysis, outcome variables hypertension, diabetes, and dyslipidemia were used in a binary form. The optimal cut-off was measured by calculating the maximum sensitivity and specificity of the obesity index for various cut-offs. Z-statistics were used to compare AUROC of BMI with other central obesity indices.

Results

There were 1622 participants, including 642 men (40%) and 980 women (60%), in the present study. Their anthropometric and metabolic characteristics are shown in Table 2. Women were 5 years younger than men (22.0 ± 3.0) versus (27.7 ± 3.9). This was a lean population with men’s mean weight being 61.1 kg and women’s being 47.3 kg and men’s BMI being 22.4 kg/m² and women’s BMI being 20.4 kg/m².

In this younger population, the prevalence of cardiometabolic risk factors [Table 1] was relatively low, except for low high-density
lipoprotein cholesterol (HDL-C) and dyslipidemia prevalence, which were similar in men and women. In men, obesity-related indices significantly correlated with cardiometabolic risk factors [Table 3]. For each cardiometabolic risk factor, the strength of the correlations across BMI, WC, and WHR was similar. In women [Table 3], the correlation of obesity-related indices with cardiometabolic risk factors was statistically significant, except for systolic blood pressure. As in men the correlation between WHR and cardiometabolic risk factors was weak in women too. Moreover, compared with men, the correlation between all obesity indices and cardio-metabolic risk factors were weaker in women.

![Table 1: Prevalence of cardiovascular risk factors (n=1622)](image)

| Variables                    | Men (n=642) | Women (n=980) | All subjects (n=1622) |
|------------------------------|-------------|---------------|-----------------------|
|                             | %           | %             | %                     |
| Hypertensive §               | 18.2        | 4.7           | 10                    |
| Diabetic §                   | 3.1         | 1.1           | 1.9                   |
| Dyslipidemia §               | 71.3        | 70.0          | 70.0                  |
| BMI ≥23 ©                   | 42.6        | 20.9          | 29.5                  |
| TC ≥200 mg/dl                | 15.9        | 4.8           | 9.2                   |
| TG ≥150 mg/dl                | 32.4        | 5.1           | 15.9                  |
| Low HDL-C                    | 56.7        | 66.8          | 62.8                  |
| Men ≤40 mg/dl                |             |               |                       |
| Women ≤50 mg/dl              |             |               |                       |
| LDL-C ≥130 mg/dl             | 14.2        | 7.2           | 10.0                  |

Table 2: Anthropometric and metabolic characteristics (n=1622)

| Variables | Men (n=642) | Women (n=980) | All subjects (n=1622) |
|-----------|-------------|---------------|-----------------------|
| Age (years) | 27.7        | 22.0          | 24.3                  |
| Height (cm) | 164.8       | 151.8         | 156.9                 |
| Weight (kg) | 61.1        | 47.3          | 52.7                  |
| WC (cm)     | 81.8        | 65.4          | 71.9                  |
| HC (cm)     | 89.9        | 85.0          | 87.0                  |
| BMI (kg/m²) | 22.4        | 20.4          | 21.2                  |
| WHR         | 0.90        | 0.76          | 0.82                  |
| WHtR        | 0.49        | 0.43          | 0.457                 |
| SBP (mmHg)  | 122.5       | 112.6         | 116.5                 |
| DBP (mmHg)  | 78.8        | 73.9          | 75.8                  |
| FBS mg/dl   | 93.8        | 89.6          | 91.2                  |
| TC (mg/dl)  | 163.0       | 148.3         | 154.1                 |
| TG (mg/dl)  | 137.8       | 105.2         | 97.1                  |
| HDL-C (mg/dl) | 39.4      | 45.7          | 43.2                  |
| LDL-C (mg/dl) | 96.6      | 88.7          | 91.8                  |

Table 3: Spearman’s correlation coefficients between anthropometric indices and cardiometabolic risk factors in men (n=642) and women (n=980)

| Variables | Men | Women |
|-----------|-----|-------|
|           | WC  | BMI   | WHR  | WHR  | WC  | BMI   | WHR  | WHR  |
| SBP       | 0.35| 0.39  | 0.11  | 0.32  | 0.04| 0.05  | 0.05  | 0.03  |
| DBP       | 0.39| 0.31  | 0.19  | 0.39  | 0.13| 0.13  | 0.10  | 0.13  |
| FBS       | 0.19| 0.22  | 0.12  | 0.23  | 0.12| 0.19  | 0.05  | 0.14  |
| TC        | 0.38| 0.34  | 0.15  | 0.33  | 0.20| 0.23  | 0.13  | 0.23  |
| TG        | 0.46| 0.46  | 0.25  | 0.46  | 0.28| 0.29  | 0.18  | 0.30  |
| HDL-C     | -0.23| -0.20| -0.15| -0.21| -0.22| -0.23| -0.12| -0.23|
| LDL-C     | 0.22| 0.21  | 0.10  | 0.21  | 0.22| 0.26  | 0.13  | 0.25  |
The AUROC was modest for all four anthropometric indices for predicting hypertension, diabetes, and dyslipidemia, particularly in women [Table 4]. None of the predictors were significantly stronger than BMI, except for WHtR, for predicting diabetes in men. The optimal cut-off values for sensitivity and specificity for each of the obesity indices [Table 5] generally had low predictive value for hypertension, diabetes, and dyslipidemia.

### Discussion

In this community-based sample of rural young adults, comprising 642 men and 980 women, we compared the strength of obesity indices as predictors of cardiometabolic risk factors. Prevalence of dyslipidemia, primarily determined by low HDL, was high, whereas hypertension and diabetes were relatively low prevalence. All studied obesity indices were significant, though weakly or moderately correlated with the continuous cardiometabolic risk factors. In AUROC analyses for predicting hypertension, diabetes, and dyslipidemia, none of the predictors were significantly stronger than BMI, except for WHtR, for predicting diabetes in men. Similar findings were reported by Patel, et al. in their analysis of baseline data of a large cohort of urban south Asians, including participants from India. They reported that none of the obesity indices were better than the others in their strength of association with cardiometabolic risk factors. However, WHtR had a stronger association with diabetes than hypertension. Although we found that WHtR was not better than BMI in its association with hypertension and dyslipidemia, the association between WHtR and diabetes was better than BMI. A recent study from Kerala, India, by Kapoor, et al. also showed that the WHtR ratio had a better strength of association with diabetes than other obesity indices.

Our finding of similarity in the strength of association between various indices of obesity and the cardiometabolic risk factors are also in concurrence with the findings of the Japanese Epidemiology Collaboration group, which analyzed the association between various indices of obesity and cardiometabolic risk factors in more than 45,000 adults in Japan.

However, the findings of this study are somewhat at variance with published results of the meta-analysis by Ashwell, et al. and Browning, et al. who showed that WHtR had significantly greater discriminatory power for cardiometabolic risk factors than BMI; however, these differences maybe because of age, BMI, ethnicity, and sample size variation between this and previous studies.

Some strengths of our study are it was a population-based, large sample of women of child-bearing age and their husbands, it followed a standardized protocol that was consistent with international protocols, and it offered the opportunity to study the associations of obesity indices and cardiometabolic risk factors in a population that was younger, less obese, and of a different ethnicity than previous populations that were usually used for such studies.

Some studies have shown that age, a diverse ethnic group, and place modify the discriminative ability of anthropometric indices to identify subjects with cardiometabolic risk factors. The key finding from our study, which is consistent with other Indian studies, is that the utility of BMI and WHtR is similar for identifying individuals at risk for hypertension and dyslipidemia, but WHtR is slightly better than BMI in identifying individuals at risk for diabetes. Considering the ease with which the WHtR can be obtained with a measuring tape alone in contrast to the need for a measuring tape and a weighing scale for assessing BMI, the WHtR may be a good alternative to BMI in primary care facilities. More importantly, the WHtR is easy to interpret, as its cut-off, which is >0.5, can be communicated effectively to

### Table 4: Area under the receiver operating characteristic curve values with 95% CI in men and women (n=1624)

| Cardiometabolic risk factors | Men (n=642) | Women (n=982) |
|-----------------------------|------------|--------------|
|                             | AUROC (95% CI) | P comparison with BMI | AUROC (95% CI) | P comparison with BMI |
| Hypertension                |             |               |                |                      |
| BMI                         | 0.661 (0.622-0.697) | 0.010† | 0.542 (0.510-0.574) | 0.019 |
| WC                          | 0.628 (0.589-0.665) | 0.0003† | 0.571 (0.539-0.602) | 0.451 |
| WHR⁴                        | 0.548 (0.508-0.587) | 0.073 | 0.578 (0.546-0.608) | 0.095 |
| WHtR⁴                       | 0.636 (0.597-0.673) | 0.037 | 0.580 (0.549-0.612) | 0.219 |
| Diabetes                    |             |               |                |                      |
| BMI                         | 0.650 (0.610-0.687) | 0.156 | 0.648 (0.617-0.678) | 0.270 |
| WC                          | 0.693 (0.656-0.729) | 0.499 | 0.730 (0.701-0.757) | 0.212 |
| WHR                         | 0.723 (0.687-0.757) | 0.015 | 0.650 (0.619-0.680) | 0.263 |
| WHtR                        | 0.680 (0.642-0.716) | 0.570 | 0.661 (0.631-0.691) | 0.946 |
| Dyslipidemia                |             |               |                |                      |
| BMI                         | 0.668 (0.630-0.765) | 0.662 (0.632-0.692) | 0.499 |
| WC                          | 0.705 (0.668-0.741) | 0.086 | 0.656 (0.625-0.686) | 0.618 |
| WHR                         | 0.639 (0.600-0.676) | 0.548 | 0.662 (0.556-0.619) | 0.001* |
| WHtR                        | 0.680 (0.642-0.716) | 0.570 | 0.661 (0.631-0.691) | 0.946 |

AUROC=Area under the receiver operating characteristic curve; Z statistic for heterogeneity between obesity indices (body mass index vs waist circumference; body mass index vs waist-to-hip ratio; body mass index vs waist-to-height ratio). BMI=Body mass index. WC=Waist circumference. WHR=Waist-to-hip ratio. WHtR=Waist-to-height ratio. Significant difference at P<0.01.
laypeople attending primary care centers by mentioning that if the waist measurement is greater than half of the height in an individual, it indicates a risk for development of hypertension, diabetes, and abnormal lipid profile.

In conclusion, the WHtR is like BMI in predicting cardiometabolic risk in this younger lean population of rural Indians. The utility of WHtR as a predictor of cardiovascular risk is promising, and it needs to be explored further in longitudinal studies across diverse settings.

Acknowledgment

The authors were trainees in the Fogarty International Center of the National Institutes of Health training program under Award Number D43-TW009078. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

This research received institutional support from SHARE INDIA. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Conflicts of interest

There are no conflicts of interest.

References

1. European Association for the Study of Obesity. Obesity Statistics. World Health Organization (Fact Sheets N° 311). Facts about overweight and obesity. Available from: https://easo.org/media-portal/statistics/. [Last accessed on 2019 Dec 18].

2. World Health Organization. Obesity and Overweight. Key facts 16 February 2018. Geneva, Switzerland: World Health Organization. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. [Last accessed on 2019 Dec 18].

3. Balarajan Y, Villamor E. Nationally representative surveys show recent increases in the prevalence of overweight and obesity among women of reproductive age in Bangladesh, Nepal, and India. J Nutr 2009;139:2139-44.

4. Misra A, Srivastava U. Obesity and dyslipidaemia in South Asians. Nutrients 2013;5:2708-44.

5. Shen W, Punyanitya M, Chen J, Gallagher D, Albu J, Pi-Sunyer X, et al. Waist circumference correlates with metabolic syndrome indicators better than percentage fat. Obesity (Silver Spring, Md) 2006;14:727-36.

Table 5: Optimum cut-off of obesity indices for maximum sensitivity and specificity for cardiometabolic risk factors

| Hypertension | Diabetes Mellitus |
|--------------|------------------|
| **BMI**      |                  |
| Men          | >23.02           | >19.84 |
| Women        | >27.03           | >25.92 |
| WC           |                  |
| Men          | >85.5            | >87.3 |
| Women        | >61.3            | >80.3 |
| WHR          |                  |
| Men          | >0.9             | >0.9 |
| Women        | >0.8             | >0.9 |
| WHtR         |                  |
| Men          | >0.51            | >0.52 |
| Women        | >0.4             | >0.4 |

a BMI=Body mass index.
b WC=Waist circumference.
c WHR=Waist-to-hip ratio.
d WHtR=Waist-to-height ratio. Optimal cut-off values for all obesity indices were calculated by using the AUROC= Area under the receiver operating characteristic curve analysis separately for men and women.
6. Zhu S, Heymsfield SB, Toyoshima H, Wang Z, Pietrobelli A, Heshka S. Race-ethnicity-specific waist circumference cut-offs for identifying CVD risk factors. Am J Clin Nutr. 2005;81:409-15.

7. Aekplakorn W, Pakpeankitwatana V, Lee CM, Woodward M, Barzi F, Yamwong S, et al. Abdominal obesity and coronary heart disease in Thai men. Obesity (Silver Spring) 2007;15:1036-42.

8. Vikram NK, Latifi AN, Misra A, Luthra K, Bhatt SP, Guleria R, et al. Waist-to-height ratio compared to standard obesity measures as predictor of cardio-metabolic risk factors in Asian Indians in North India. Metab Syndr Relat Disord 2016;14:492-9.

9. Savva SC, Lamnisos D, Kafatos AG. Predicting cardio-metabolic risk: Waist-to-height ratio or BMI. A meta-analysis. Diabetes Metab Syndr Obes 2013;6:403-19.

10. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of CVD and diabetes: 0.15 could be a suitable global boundary value. Nutr Res Rev 2010;23:247-69.

11. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardio-metabolic risk factors: Systematic review and meta-analysis. Obes Rev 2012;13:275-86.

12. Vikram NK, Pandey RM, Misra A, Sharma R, Devi JR, Khanna N. Non-obese (body mass index≤=25 kg/m²) Asian Indians with normal waist circumference have high cardiovascular risk. Nutrition 2003;19:503-9.

13. Misra A. Ethnic-specific criteria for classification of BMI: A perspective for Asian Indians and ADA position statement. Diabetes Technol Ther 2015;17:667-71.

14. Misra A. Revisions of cutoffs of body mass index to define overweight and obesity are needed for the Asian-ethnic groups. Int J Obes Relat Metab Disord. 2003;27(11):1294-6.

15. Kotian GB, Prathapchandra Kedilaya H. BMI is the best anthropometric index to predict CVD risks in young adult women. Int J Pharm Sci Res Rev 2013;22:188-91.

16. C S, Jayalakshmi L, Sidd MAM. Anthropometric variables predicting risk of CAD in type 2 diabetics. IOSR J Dent Med Sci 2013;10:9-13.

17. Kaur P, Radhakrishnan E, Sankarasubbaian S, Rao SR, Kondalsamy-Chennakesavan S, Rao TV, et al. Comparison of anthropometric indices for predicting hypertension and type 2 diabetes in a male industrial population of Chennai, South India. Ethn Dis 2008;18:31-6.

18. Deshmukh PR, Gupta SS, Dongre AR, Bharambe MS, Maliye C, Kaur S, et al. Relationship of anthropometric indicators with blood pressure levels in rural Wardha. Indian J Med Res 2006;123:657-64.

19. Patel SA, Deepa M, Shivashankar R, Ali MK, Kapoor D, Gupta R, et al. Comparison of multiple obesity indices for cardiovascular disease risk classification in South Asian adults: The CARRS Study. PLoS One 2017;12:e0174251.

20. Kusneniwar GN, Whelan RM, Betha K, Robertson JM, Ramidi PR, Balasubramanian K, et al. Obes profile: The longitudinal Indian family health (LIFE) Pilot Study, Telangana State, India. Int J Epidemiol 2017;46:788-9j.

21. Dischinger P, DuChene AG. Quality control aspects of blood pressure measurements in the Multiple Risk Factor Intervention Trial. Control Clin Trials 1986;7 (3 Suppl):1375-57.

22. Friedewald WT, Levy RI, Frederickson DS. Estimation of concentration of LDL cholesterol in plasma without use of ultracentrifuge. Clin Chem 1972;18:499-502

23. Kapoor N, Lotfaliani M, Sathish T, Thankappan KR, Thomas N, Furler J, et al. Obesity indicators that best predict type 2 diabetes in an Indian population: Insights from the Kerala Diabetes Prevention Program. J Nutr Sci 2020;9:e15.

24. Xiang M, Hu H, Imai T, Nishihara R, Sasaki N, Ogawara T, et al.; Japan Epidemiology Collaboration on Occupational Health Study Group. Association between anthropometric indices of obesity and risk of cardiovascular disease in Japanese men. J Occup Health 2020;62:e12098.

25. WHO Expert Consultation. Appropriate BMI for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.

26. Snelahata C, Viswanathan V, Ramachandran A. Cut-off values for normal anthropometric variables in Asian Indian adults. Diabetes Care 2003;26:1380-4.

27. 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;56:303-7.

28. Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome. A joint interim statement of the IDF Task Force on epidemiology and prevention; NHLBI; AHA; WHF; IAS; and IASO. Circulation 2009;120:1640-5.

29. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al. JNC-VII Report. JAMA 2003;289:60-71.

30. Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diabetes Care 2003;26:S5-20.

31. Executive summary of the third report of the NCEP expert panel on detection, evaluation, and treatment of high blood cholesterol in adults. ATP III. JAMA 2001;285:2486-97.

32. Neufeld LM, Jones-Smith JC, Garcia R, Fernald LCH. Anthropometric predictors for risk of chronic disease in non-diabetic, non-hypertensive young Mexican women. Public Health Nutr 2007;11:1359-67.

33. Zhu S, Wang Z, Heshka S, Heo M, Faith MS, Heymsfield SB. Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. Am J Clin Nutr. 2002;76:743-9. doi:10.1093/ajcn/76.4.743.