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Optimal Waist Circumference Cutoff Values for Metabolic Syndrome Diagnostic Criteria in a Korean Rural Population

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The Korean Society for the Study of Obesity (KSSO) has defined the waist circumference cutoff value of central obesity as 90 cm for men and 85 cm for women. The purpose of this investigation was to determine the corresponding waist circumference values. A total of 3,508 persons in the Korean Rural Genomic Cohort Study were enrolled in this survey. Receiver operating characteristic (ROC) curve analysis was used to find appropriate waist circumference cutoff values in relation to insulin resistance determined by homeostasis model assessment for insulin resistance (HOMA-IR), body mass index (BMI), and components of metabolic syndrome. The optimal waist circumference cutoff values were 87 cm for men and 83 cm for women by ROC analysis to HOMA-IR and 86 cm for men and 83 cm for women by ROC analysis to value with more than two components of metaobolic syndrome. By using a BMI $\geq$25 kg/m^2, 86 cm for men and 82 cm for women were optimal waist circumference cutoff values. In this study, we suggest that the most reasonable waist circumference cutoff values are 86-87 cm for men and 82-83 cm for women.

Key Words : *Waist Circumference; Cutoff Value; Metabolic Syndrome*

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INTRODUCTION

The metabolic syndrome, defined as a cluster of cardiovascular risk factors, was known to be associated with increased cardiovascular morbidity and mortality (1, 2). The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), the World Health Organization (WHO), the European Group for the Study of Insulin Resistance (EGIR), and the American Association of Clinical Endocrinologists (AACE) have defined diagnostic criteria for metabolic syndrome (3-6). These diagnostic criteria emphasized the importance of insulin resistance and obesity. However, since ethnic and regional factors were not considered in such diagnostic criteria, the International Diabetes Federation (IDF) defined in 2005 metabolic syndrome as central obesity plus two of four additional factors and applied different waist circumference cutoff values by ethnicity and sex specificity (7). The recommended waist circumference cutoff values were 90 cm for Asian males and 80 cm for Asian females. In agreement with the IDF proposal, the Korean Society for the Study of Obesity (KSSO) defined the waist circumference cutoff value as 90 cm for men and 85 cm for women (8).

In this study, we investigated optimal cutoff values of the waist circumference for Korean rural population in relation to insulin resistance as determined by homeostasis model assessment for insulin resistance (HOMA-IR), body mass index (BMI), and components of metabolic syndrome. The reason for studying these cutoff values is to determine the

waist circumference value for prediction of cardiovascular diseases before clinical onset.

MATERIALS AND METHODS

Study population

From November 2005 to April 2006, we conducted study population who participated in the Korean Rural Genomic Research Cohort Study, Korea. The study was approved by Institutional Review Board (board affiliation: Yonsei University Wonju College of Medicine, approval number: CR05-024, 2005) and all participants provided the informed consent to the investigators before participation. The total number of subjects enrolled in this survey was 3,508 persons. Of these participants, 1,437 were men and 2,071 were women.

Data collection and assays

All subjects registered for a health check, which included medical history, physical examination, a questionnaire on health related behavior, anthropometric measurements, and biochemical measurements. The questionnaire included the pattern of alcohol intake, smoking, dietary habits, physical activity, occupation, family history of medical disease, and economics. The BMI was calculated as weight (kg)/height^2 (m^2). Blood pressure was measured using a mercury sphygmomanometer while seated. The waist circumference was measured 2 cm above the anterior superior iliac spine. The levels of various biochemical markers were measured including serum total cholesterol (TC), triglyceride (TG), HDL cholesterol, fasting glucose, and fasting insulin. For assessment of insulin resistance, we checked HOMA-IR using Matthews' law. HOMA-IR was calculated as follows: fasting insulin (μU/mL) × fasting glucose (mM/L)/22.5.

Definition of the metabolic syndrome

We adopted the NCEP ATP III guidelines, in which the components of the metabolic syndrome are: 1) waist circumference >90 cm in men and >80 cm in women; 2) triglycerides ≥1.7 mM/L (normal level 150 mg/dL); 3) HDL cholesterol <1.04 mM/L (normal level 40 mg/dL) in men and <1.29 mM/L (normal level 50 mg/dL) in women; 4) blood pressure ≥130 mmHg (systolic) or ≥85 mmHg (diastolic) or a known treatment for hypertension; 5) fasting plasma glucose ≥6.1 mM/L (normal level 110 mg/dL) or a known treatment for diabetes. The subjects were classified as having metabolic syndrome if they possessed three or more of the five components. The number of metabolic syndrome components determined the metabolic syndrome score.

Laboratory measurements

Glucose, TC, TG, HDL, and cholesterol were measured using enzymatic methods (ADVIA 1650, Simens, Tarrytown, NY, USA). Serum adiponectin level was assessed by radioimmunoassay (MILLIPORE, Billerica, MA, USA). The intra-assay coefficient of variation (CV) was 1.78% and inter-assay CV was 9.25%. Serum insulin level was analyzed by immunoradiometric assay (Biosource International, Camarillo, CA, USA). The intra-assay CV was 2.2% and interassay CV was 6.5%.

Statistical analysis

The data presented in Table 1 are given as the mean±standard deviation. We used the upper quartile of HOMA-IR as the index of insulin resistance. The receiver operator characteristic (ROC) curve for waist circumference (to predict the upper quartile of HOMA-IR), BMI ≥25 kg/m^2, and the presence of two or more risk factors of the metabolic syndrome, as defined by the NCEP ATP III (except for waist

Table 1. Clinical and biochemical characteristics of study subjects

Parameters	Male (n=1,437)	Female (n=2,071)	Total (n=3,508)
Age (yr)	56.99±7.88	55.78±8.12	56.28±8.04
Body mass index (kg/m^2)	24.97±3.34	24.43±3.13	24.66±3.23
Waist circumference (cm)	86.32±7.96	82.76±8.47	84.22±8.45
Fasting insulin (μU/mL)	8.81±6.31	9.65±6.90	9.31±6.68
Fasting glucose (mg/dL)	101.96±33.80	94.96±24.81	97.83±29.03
HOMA-IR	2.34±2.73	2.39±3.76	2.37±3.38
Total cholesterol (mg/dL)	206.49±39.80	216.66±40.21	212.49±40.35
Triglyceride (mg/dL)	181.56±114.08	158.82±103.31	168.13±108.42
HDL cholesterol (mg/dL)	45.68±11.60	47.01±10.44	46.47±10.95
LDL cholesterol (mg/dL)	116.24±34.43	127.33±33.37	122.78±34.24
Systolic blood pressure (mmHg)	133.13±19.02	133.65±18.25	133.43±18.58
Diastolic blood pressure (mmHg)	83.14±11.95	81.76±10.67	82.34±11.25

All values are means±SDs.
HOMA-IR, homeostasis assessment method for insulin resistance; HDL, high dense lipoprotein; LDL, low dense lipoprotein.

circumference), were plotted using SPSS for Windows (version 12, SPSS., Chicago, IL USA). A value of $P<0.05$ was considered statistically significant.

RESULTS

Characteristics of the subjects

Table 1 shows the baseline clinical and biochemical characteristics determined in the study. The mean age of the subjects was 56.99±7.88 yr for men and 55.78±8.12 yr for women. The mean value of the BMI was 24.97±3.34 kg/m^2 for men and 24.43±3.13 kg/m^2 for women. The mean value of the waist circumference was 86.32±7.96 cm in men and 82.76±8.47 cm in women. The mean value of HOMA-IR was 2.34±2.73 in men and 2.39±3.76 in women. The upper quartile of HOMA-IR was 2.49 in men and 2.58 in women.

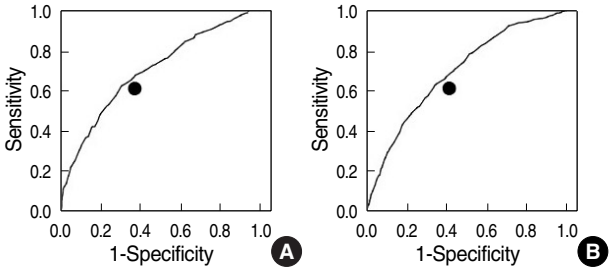

Fig. 1. ROC curves for waist circumference as predicting HOMA-IR of the insulin resistance in men (A) and women (B).

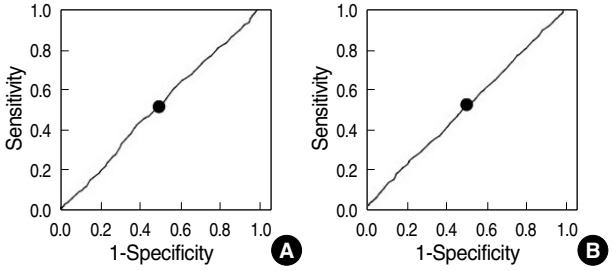

Fig. 2. ROC curves for waist circumference as predicting BMI in men (A) and women (B).

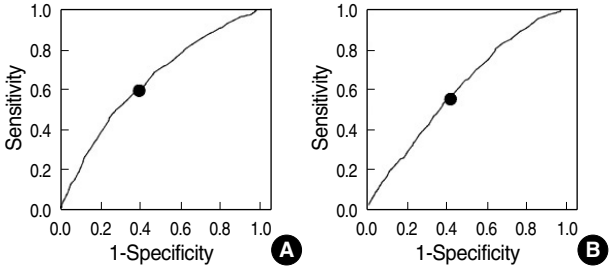

Fig. 3. ROC curves for waist circumference as predicting the presence of two or more risk factors for metabolic syndrome (other than for waist circumstance), in men (A) and women (B).

Cutoff values for waist circumference

We plotted ROC curve to determine the waist circumference cutoff values in relation to detecting multiple risk factors for the Korean population. According to the ROC curve, the cutoff level yielding maximal sensitivity plus specificity for representing insulin resistance was 87 cm for men and 83 cm for women. The sensitivity and specificity for these cutoff values were 67% and 62% in men, respectively, and 66% and 60% in women, respectively (Fig. 1). The cutoff value for predicting the BMI ≥25 kg/m^2 using ROC curve was 86 cm for men (sensitivity 50%, specificity 50%) and 82 cm for women (sensitivity 50%, specificity 50%; Fig. 2). The waist circumference cutoff value when used as a predictive value with more than two components by the ROC curve was 86 cm for men (sensitivity 59%, specificity 60%) and 83 cm for women (sensitivity 56%, specificity 57%; Fig. 3).

DISCUSSION

The metabolic syndrome has become a important health problem because it may predict both type 2 diabetes and cardiovascular disease (9, 10). Although the cause of the syndrome remains obscure, insulin resistance and visceral obesity were considered as central factor (1, 11). Since waist circumference could reflect abdominal fat mass (12), increased waist circumference has been thought to be a predictor of cardiovascular disease and is an important diagnostic marker for the metabolic syndrome (2, 13).

In 1998, WHO initially proposed a definition for metabolic syndrome emphasizing insulin resistance (4). The Third Report of NCEP ATP III proposed criteria for the diagnosis of metabolic syndrome in 2001 (3). This criteria require three or more of the following abnormalities, abdominal obesity; waist circumference ≥102 cm in men or ≥88 cm in women, hypertriglyceridemia; serum TG concentration ≥150 mg/dL (1.69 mM/L), low HDL cholesterol; serum HDL cholesterol concentration <40 mg/dL (1.04 mM/L) for men and <50 mg/dL (1.3 mM/L) for women, hypertension; blood pressure ≥130/80 mmHg or utilizing antihypertensive medication, high fasting serum glucose; serum glucose concentration ≥100 mg/dL (5.6 mM/L) or utilizing antidiabetic medication. Because the cutoff value of waist circumference was for Caucasian population, the prevalence of metabolic syndrome in the Asian population based on these criteria is very low (14, 15). Therefore, WHO (Western Pacific Region) and the International Obesity Task Force redefined overweight as BMI >23 kg/m^2 and obesity as >25 kg/m^2 in Asians in 2000 (16). Considering ethnic and regional factors in diagnostic criteria, IDF defined central obesity as more than 80 cm for women and 90 cm in men. After IDF consensus pro-

posed a new definition for the central obesity, KSSO proposed ethnically specific waist circumference cutoff points to Korean population as 90 cm for men and as 85 cm for women (8).

Since recent statement for waist circumference cutoff points based on diagnostic criteria for metabolic syndrome as long as at least 3 remainder components are present but not requiring the presence of abdominal obesity (7), we assessed abdominal obesity cutoff points according to HOMA-IR and BMI.

According to the ROC curve, the cutoff value based on HOMA-IR was 87 cm for men and 83 cm for women. The cutoff value for predicting the BMI ≥ 25 kg/m^2 was 86 cm for men and 82 cm for women. The optimal waist circumference cutoff values were 86 cm for men and 83 cm for women by ROC analysis to value with more than two components of metaobolic syndrome. These waist circumference cutoff values were similar to those found in previous studies (17, 18). In comparison with a previous study in Korea, significant difference was not recognized in the present study (8, 19).

In conclusion, our findings can support the use of ethnic-specific cutoff points for abdominal obesity as 86-87 cm for men and 82-83 cm for women. These values may be used for the diagnosis of metabolic syndrome in a Korean rural population.

REFERENCES

1. Reaven GM. *Banting lecture 1988. Role of insulin resistance in human disease. Diabetes 1988; 37: 1595-607.*
2. Isomaa B, Almgren P, Tuomi T, Forsen B, Lahti K, Nissen M, Taskinen MR, Groop L. *Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001; 24: 683-9.*
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. Alberti KG, Zimmet PZ. *Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998; 15: 539-53.*
5. Beck-Nielsen H. *General characteristics of the insulin resistance syndrome: prevalence and heritability. European Group for the study of Insulin Resistance (EGIR). Drugs 1999; 58 (Suppl 1): 7-10.*
6. Bloomgarden ZT. *American Association of Clinical Endocrinologists (AACE) consensus conference on the insulin resistance syndrome: 25-26 August 2002, Washington, DC. Diabetes Care 2003; 26: 1297-303.*
7. Alberti KG, Zimmet P, Shaw J. *The metabolic syndrome--a new worldwide definition. Lancet 2005; 366: 1059-62.*
8. Lee SY, Park HS, Kim DJ, Han JH, Kim SM, Cho GJ, Kim DY, Kwon HS, Kim SR, Lee CB, Oh SJ, Park CY, Yoo HJ. *Appropriate waist circumference cutoff points for central obesity in Korean adults. Diabetes Res Clin Pract 2007; 75: 72-80.*
9. Stern MP, Williams K, Gonzalez-Villalpando C, Hunt KJ, Haffner SM. *Does the metabolic syndrome improve identification of individuals at risk of type 2 diabetes and/or cardiovascular disease? Diabetes Care 2004; 27: 2676-81.*
10. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, Salonen JT. *The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA 2002; 288: 2709-16.*
11. Lemieux I, Pascot A, Couillard C, Lamarche B, Tchernof A, Alméras N, Bergeron J, Gaudet D, Tremblay G, Prud'homme D, Nadeau A, Després JP. *Hypertriglyceridemic waist: a marker of the atherogenic metabolic triad (hyperinsulinemia; hyperapolipoprotein B; small, dense LDL) in men? Circulation 2000; 102: 179-84.*
12. Perry AC, Applegate EB, Allison ML, Miller PC, Signorile JF. *Relation between anthropometric measures of fat distribution and cardiovascular risk factors in overweight pre- and postmenopausal women. Am J Clin Nutr 1997; 66: 829-36.*
13. Han TS, van Leer EM, Seidell JC, Lean ME. *Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. BMJ 1995; 311: 1401-5.*
14. Lear SA, Chen MM, Frohlich JJ, Birmingham CL. *The relationship between waist circumference and metabolic risk factors: cohorts of European and Chinese descent. Metabolism 2002; 51: 1427-32.*
15. Li G, Chen X, Jang Y, Wang J, Xing X, Yang W, Hu Y. *Obesity, coronary heart disease risk factors and diabetes in Chinese: an approach to the criteria of obesity in the Chinese population. Obes Rev 2002; 3: 167-72.*
16. Steering Committee of the WHO Western Pacific Region, IASO & IOTF. *The Asia-Pacific perspective: Redefining obesity and its treatment. Austrlia, 2000.*
17. Lee S, Choi S, Kim HJ, Chung YS, Lee KW, Lee HC, Huh KB, Kim DJ. *Cutoff values of surrogate measures of insulin resistance for metabolic syndrome in Korean non-diabetic adults. J Korean Med Sci 2006; 21: 695-700.*
18. Ryu S, Sung KC, Chang Y, Lee WY, Rhee EJ. *Spectrum of insulin sensitivity in the Korean population. Metabolism 2005; 54: 1644-51.*
19. Kim JA, Choi CJ, Yum KS. *Cut-off values of visceral fat area and waist circumference: diagnostic criteria for abdominal obesity in a Korean population. J Korean Med Sci 2006; 21: 1048-53.*