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Research Article

Optimal Cutoffs of Cardiometabolic Risk for Postmenopausal Korean Women

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SUMMARY

Purpose: The purpose of the study was to identify the optimal cutoff values of indices for cardiometabolic risk in postmenopausal Korean women. Specifically, we intended to determine the cutoffs of waist circumference, waist-to-hip ratio (WHR), serum lipid profile, and homeostatic model of assessment-insulin resistance (HOMA-IR) for detecting metabolic syndrome (MetS), and metabolic obesity (MO).
Methods: The study participants were 397 postmenopausal women. We defined MetS and MO with the International Diabetes Federation criteria except for waist circumference. A receive operating characteristic curve analysis was used to assess the accuracy of diagnostic indices for identifying MetS and MO. Cutoff values were obtained both from the point on the receive operating characteristic curve which was closest to (0,1) and from the Youden's index.
Results: Among the participants, 34.5% and 73% were classified as having MetS and MO. The optimal cutoff of waist circumference and WHR were 81.9 cm [area under curve (AUC): 0.687, sensitivity: 61.7%, specificity: 68.9%], 0.87 (AUC: 0.660, sensitivity: 64.7%, Specificity: 60.2%) for MetS and 77.4 cm (AUC: 0.655, sensitivity: 65.6%, specificity: 57.8%), 0.86 (AUC: 0.680, sensitivity: 67.0%, specificity: 62.7%) for MO. Triglyceride to high-density lipoprotein ratio for MetS and MO were 2.11 (AUC: 0.838, sensitivity: 71.5%, specificity: 79.6%) and 1.59 (AUC: 0.725, sensitivity: 65.9%, specificity: 68.2%) respectively. The HOMA-IR for MetS was 1.36 (AUC: 0.773, sensitivity: 73%, specificity: 71.9%) and for MO was 1.17 (AUC: 0.713, sensitivity: 64.5%, specificity: 69.2%).
Conclusions: For postmenopausal women, we suggest waist circumference of 81.9 cm and WHR of 0.87 as criteria of MetS. However, women with waist circumference over 77.4 cm and WHR over 0.86 should be monitored for the future development of MetS.

Introduction

Obesity, an increasing problem worldwide, is related to the risk of cardiovascular disease, diabetes mellitus, hypertension, metabolic syndrome and several types of cancer [1–3]. In particular, people with central obesity, an excessive deposit of fat in the abdomen is at high risk of health problems than people with any other types of obesity due to a functional abnormality of adipose tissues and accumulations of triglycerides (TG) [4,5]. Central obesity is considered the leading factor of cardiometabolic risk [5]. Cardiometabolic risk has increased the incidence of cardiovascular disease and mortality rate due to the combined action of abdominal obesity, impaired fasting glucose, dyslipidemia, and elevated blood pressure [6]. Central obesity can be detected directly and indirectly. Computed tomography scan, magnetic resonance imaging, and dual-energy X-ray absorptiometry detect central obesity directly. Even though these methods can detect visceral fats precisely, the costs are quite expensive. Waist circumference or waist-to-hip ratio (WHR) is a convenient indicator of central obesity; however, there is a limit in distinctions between visceral fats and subcutaneous fats.

Waist circumference, the most widely used indices of central obesity is one of the diagnostic criteria for metabolic syndrome. The European Group for the Study of Insulin Resistance defined central obesity as more than 94 cm of waist circumference in male, and more than 80 cm of waist circumference in female [7]. The National Cholesterol Education Program Adult Treatment Panel III defined it as more than 102 cm in male, and more than 88 cm in the female.

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However, in the case of Asians, they presented lower criteria, which are 90 cm in male, 80 cm in female [8]. The criteria of the International Diabetes Federation (IDF) are the same as those of the European Group for the Study of Insulin Resistance (94 cm in male, 80 cm in female), and those of the National Cholesterol Education Program Adult Treatment Panel III (90 cm in male, 80 cm in female) in the Asian group [9]. The Korean Society for the Study of Obesity presented the Korean specific criteria as more than 90 cm in male, and 85 cm in female by the Korean National Health and Nutrition Examination Survey 1998 [10]. However, there are arguments that these criteria are inadequate to identify the cardiometabolic risk [11,12]. In the case of a female, menopausal status, and age, influencing factors on the cardiometabolic risk should be considered in determining central obesity with waist circumference [13,14].

There is a high probability of central obesity in postmenopausal women on account of redistribution of adipose tissues and deficiency of estrogen [15]. Thus, it is important to set the optimal cutoff of waist circumference or WHR for identifying central obesity to predict and to manage the metabolic syndrome or metabolic obesity in postmenopausal women. The prevalence of metabolic syndrome in postmenopausal women is increasing with age, ranging from 19.6% in the 50s to 30.6% in the 60s [16]. Metabolic obesity is the state of increased cardiometabolic risk in consideration of endocrinal function and metabolism independent of external obesity [17]. Metabolic obesity is not a matter of the amount of body fat, but a matter of areas with lipid accumulation, which is distinct from typical obesity; it usually has an association with the increase of visceral adiposity [18].

Moreover, even though serum lipid ratio and the homeostatic model of assessment-insulin resistance (HOMA-IR) are cardiometabolic risks [19–21]. To the best of our knowledge, no studies tried to determine postmenopausal women specific cutoff values of these indices.

The purpose of this study was to identify the optimal cutoff values of various cardiometabolic risk factors in postmenopausal women in South Korea. Specifically, we intended to identify the cutoffs of waist circumference, WHR, serum lipid ratio, and HOMA-IR for detecting metabolic syndrome and metabolic obesity.

Methods

Study design

This is a cross-sectional study of 397 postmenopausal women.

Setting and participants

The participants of the study were the postmenopausal women in their fifties and sixties who helped with hospital chores as volunteers at the Catholic University of Korea St. Mary's hospital in Seoul and St. Vincent's Hospital in Suwon. The study period was from May 2012 to April 2015.

The researchers explained the purpose of the study to 800 volunteers, using volunteer meetings or by telephone. Of these, 485 agreed to participate in the study, and 397 volunteers met the study criteria. Inclusion criteria for the study were as follows: (a) at least 1 year has passed since the last menstruation; (b) those who were not under hormonal treatments; (c) absence of psychiatric problems; and (d) no history of strokes, acute myocardial infarctions, or malignant tumors. A total of 397 women participated in the study.

Ethical consideration

The Catholic University Institutional Review Board approved the content and methods of the study (MC15EISE0094). The study participants understood the purpose of the study, participated voluntarily and knew that they could withdraw their participation at any time according to the informed consent. In addition, the data used for the analysis were encrypted so that the direct personal identity could not be confirmed.

Data collection

For blood sampling, the participants fasted from 12 pm on the night before the hospital visit to 8 or 8:30 am the next day. On the day of the visit, they wrote consent to participate in the study. After the consent, the researchers carried out the examination in the order of waist circumference, hip circumference, blood pressure, and blood test.

A tape measure, marked with units of 0.1 cm, was used to measure waist circumference (Hoechst, Germany). Participant stood straight with both feet together and both arms relaxed by their side; after finding the lower edge of the participant's last rib on their side and the upper edge of their iliac crest, the waist circumference was measured horizontally between these two points. At this time, the participant wore a single layer of light clothing on top and was made to exhale gently. Hip circumference was measured horizontally in a standing position by putting the participant's feet apart and arms at their chest using the same tape measure at the most prominent area of the buttock when seen sideways. Waist-to-hip ratio was calculated as waist circumference (cm) to hip circumference (cm).

Blood pressure was measured three times from the right arm at 5-minute intervals using an automated blood pressure monitor (TM 2655P; A&D, Japan) in a seated position, after resting for at least 5 minutes. The present study defined blood pressure as the mean of the second and third measurements.

A venous blood sample of 4 mL was collected following 8 hours of fasting. For measurement, the enzymatic method (Modular DDP, Roche, Germany) for lipid profile, the glucose oxidase (HITACHI 7600, Roche, Germany) method for fasting blood glucose, and the chemiluminescent microparticle immunoassay (Architect I4000SR, Architect insulin, Abbott, USA) for fasting insulin were applied.

The Friedewald equation, a commonly used method, was used to calculate the low-density lipoprotein cholesterol (LDL). Moreover, a recent study of metabolic syndrome patients proved its usability [22]. The Friedewald equation is as follows: LDL (mg/dL) = Total cholesterol (TC) − High-density lipoprotein cholesterol (HDL) − (TG/5).

HOMA-IR, index for insulin resistance was calculated using following equation: HOMA-IR = [glucose (mg/dL) × insulin (μU/mL)] ÷ 405 [21].

Definitions for the study

Postmenopausal women

The present study defined postmenopausal women as females in whom the last menstruation ceased at least a year ago [16].

Metabolic syndrome

The present study defined metabolic syndrome as the presence of any two of the IDF criteria except central obesity to determine the optimal cutoff value of the cardiometabolic risk including waist circumference [10]. IDF criteria were as follows: TG $\geq$ 150 mg/dL, or specific treatment for this lipid abnormality; HDL < 40 mg/dL in males, HDL < 50 mg/dL in females, or specific treatment for this lipid abnormality; systolic blood pressure (BP) $\geq$ 130 mmHg or diastolic BP $\geq$ 85 mmHg, or treatment of previously diagnosed hypertension; fasting serum glucose: $\geq$ 100 mg/dL, or previously diagnosed type 2 diabetes.

Table 1 *Characteristics of Study Participants (N = 397).*

Variables	*M* ± *SD* or *n* (%)
Age (yr)	59.12 ± 4.98
Time after menopause (yr)	8.96 ± 6.73
Waist circumference (cm)	79.99 ± 7.82
Waist-to-hip ratio	0.87 ± 0.05
Systolic blood pressure (mmHg)	128.24 ± 18.75
Diastolic blood pressure (mmHg)	78.82 ± 10.02
TC (mg/dL)	203.05 ± 38.28
TG (mg/dL)	115.29 ± 61.24
HDL (mg/dL)	60.40 ± 15.86
LDL (mg/dL)	121.61 ± 35.90
Fasting serum glucose (mg/dL)	96.76 ± 15.68
Insulin (μU/mL)	6.36 ± 3.91
Homeostatic model of assessment-insulin resistance	1.56 ± 1.13
TG/HDL	2.20 ± 1.83
TC/HDL	3.54 ± 0.98
LDL/HDL	2.14 ± 0.81
Metabolic syndrome *n* (%)[a]	
No	260 (65.5)
Yes	137 (34.5)
Metabolic obesity *n* (%)[b]	
No	107 (27.0)
Yes	290 (73.0)

Note. HDL = high-density lipoprotein; LDL = low-density lipoprotein; TC = total cholesterol; TG = triglyceride.
[a] Having any two of the IDF criteria except central obesity.
[b] Having any one of the IDF criteria except central obesity.

Metabolic obesity

The present study defined metabolic obesity as any one of the IDF criteria except central obesity [17].

Statistical analysis

Characteristics of the study participants were expressed as means with standard deviations or as percentages. A receiver operating characteristic (ROC) curve analysis was performed to obtain the optimal cutoff values of diagnostic indices for the metabolic syndrome and metabolic obesity. The optimal cutoff values were obtained both from the point on the ROC curve of which was the closest to (0, 1) the minimum distance, and from the Youden index [maximum (sensitivity + specificity − 1)]. The closest point was calculated as the minimum value of the square root of $[(1 - \text{sensitivity})^2 + (1 - \text{specificity})^2]$ [23]. The area under the curve (AUC) and the 95% confidence interval (CI) confirmed diagnostic validity. ROC curve is defined by the sensitivity and 1 − specificity of the examination values. ROC curve analysis is useful for identifying the diagnostic cutoff values [23]. Diagnostic validity is higher when the AUC is closer to 1, and it has no diagnostic validity below .5. All statistical analyses were performed using the SPSS (version 18.0; SPSS Inc., Chicago, IL, USA).

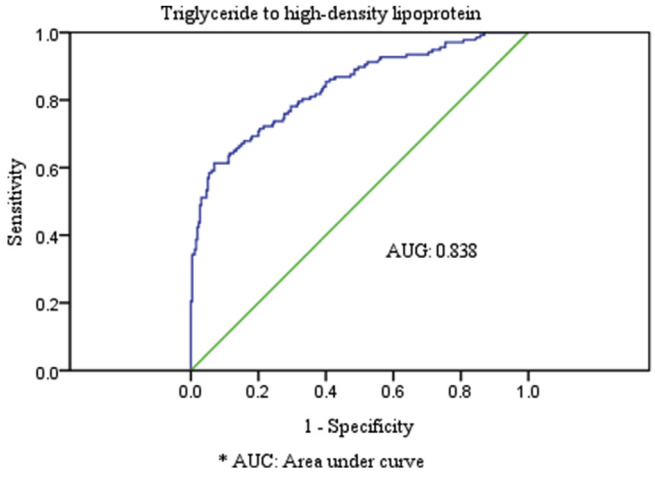

Figure 1. The receiver operating characteristic curves of triglyceride to high-density lipoprotein ratio for predicting metabolic syndrome. *Note*. AUC = area under the curve.

Results

Participant characteristics

Table 1 outlines characteristics of the participants. The mean age was 59.1 years and the mean postmenopausal period was 9 years. The mean waist circumference was 80 cm, and WHR was 0.87. Metabolic syndrome and metabolic obesity prevalence were 34.5%, and 73.0% respectively.

Optimal cutoffs of diagnostic indices for metabolic syndrome

The cutoff values of the diagnostic indices for metabolic syndrome are shown in Table 2. Within the framework of central obesity, the cutoff values of waist circumference and WHR for detecting metabolic syndrome were 81.9 cm and 0.87 respectively.

In the case of serum lipid profile, the cutoff values of TG/HDL for detecting metabolic syndrome were 2.11 when obtained from the closest point on the ROC curve from (0,1) and 2.61 by the Youden index. The cutoff of TC/HDL was 3.65 from both methods. The cutoffs of LDL/HDL were 2.16 from the closest point method and 2.41 by the Youden index method. The AUC of TG/HDL was the biggest [.838, 95% CI (.795, .881)] among the serum lipid ratio (Figure 1).

Table 2 *Optimal Cutoffs of Diagnostic Indices for Metabolic Syndrome.*

Metabolic syndrome indices	Metabolic syndrome						
	Cutoff	AUC (95% CI)	Sens (%)	Spec (%)	PPV (%)	NPV (%)	*J*
Waist circumference	81.9[a,b]	.687 (.632, .741)	61.7	68.9	51.1	77.4	.306
Waist-to-hip ratio	0.87[a,b]	.660 (.603, .716)	64.7	60.2	46.1	76.4	.249
TG/HDL	2.11[a]	.838 (.795, .881)	71.5	79.6	64.9	84.1	.511
	2.61[b]		61.3	93.1	82.4	82.0	.544
TC/HDL	3.65[a,b]	.750 (.699, .801)	68.6	72.3	56.6	81.4	.409
LDL/HDL	2.16[a]	.682 (.626, .738)	63.5	66.5	50.0	77.6	.300
	2.41[b]		54.7	75.8	54.3	76.1	.305
HOMA-IR	1.36[a]	.773 (.725, .821)	73.0	71.9	57.8	83.5	.449
	1.30[b]		75.9	69.2	56.5	84.5	.451

Note. AUC = area under the curve; CI = confidence interval; HDL = high-density lipoprotein; HOMA-IR = homeostatic model of assessment-insulin resistance; LDL = low-density lipoprotein; NPV = negative predictive value; PPV = positive predictive value; Sens = sensitivity; Spec = specificity; TC = total cholesterol; TG = triglyceride.
[a] Value obtained from the closest method.
[b] Value obtained from the Youden index.

Table 3 *Optimal Cutoffs of Diagnostic Indices for Metabolic Obesity.*

	Metabolic obesity						
	Cutoff	AUC (95% CI)	Sens (%)	Spec (%)	PPV (%)	NPV (%)	*J*
Waist circumference	77.4[a,b]	.655 (.596, .715)	65.6	57.8	80.8	38.3	.234
Waist-to-hip ratio	0.86[a,b]	.680 (.619, .742)	67.0	62.7	82.9	41.3	.297
TG/HDL	1.59[a]	.725 (.676, .775)	65.9	68.2	84.9	42.5	.341
	2.10[b]		48.6	89.7	92.7	39.2	.383
TC/HDL	3.42[a,b]	.637 (.578, .695)	57.2	66.4	82.2	36.5	.236
LDL/HDL	1.96[a]	.579 (.518, .641)	60.7	55.1	78.5	34.1	.158
	2.41[b]		39.3	77.6	82.6	32.1	.169
HOMA-IR	1.17[a,b]	.713 (.657, .769)	64.5	69.2	85.0	41.9	.337

Note. AUC = area under the curve; CI = confidence interval; HDL = high-density lipoprotein; HOMA-IR = homeostatic model of assessment-insulin resistance; LDL = low-density lipoprotein; NPV = negative predictive value; PPV = positive predictive value; Sens = sensitivity; Spec = specificity; TC = total cholesterol; TG = triglyceride.

[a] Value obtained from the closest method.

[b] Value obtained from the Youden index.

Concerning insulin resistance, the cutoffs of HOMA-IR for detecting metabolic syndrome were 1.36 from the closest point method and 1.30 by the Youden index method.

Optimal cutoffs of diagnostic indices for metabolic obesity

The cutoff values of diagnostic indices for the metabolic obesity are shown in Table 3. Within the framework of central obesity, the cutoff values of waist circumference and WHR for detecting metabolic obesity were 77.4 cm and 0.86 respectively.

In the case of serum lipid profile, the cutoff values of TG/HDL for detecting the metabolic obesity were 1.59 when obtained from the closest point on the ROC curve from (0,1) and 2.10 from the Youden index. The cutoff of TC/HDL was 3.42 from both methods. The cutoffs of LDL/HDL were 1.96 from the closest point method and 2.41 by the Youden index method. The AUC of TG/HDL was the biggest [.725, 95% CI (.676, .775)] among the serum lipid ratio (Figure 2).

Concerning insulin resistance, the cutoff of HOMA-IR for detecting metabolic obesity was 1.17 from both methods.

Discussion

This study intended to identify the optimal cutoffs of waist circumference, WHR, serum lipid profile, and HOMA-IR for detecting metabolic syndrome or metabolic obesity in postmenopausal women in South Korea. Our results showed that the optimal cutoffs of waist circumference for metabolic syndrome or metabolic obesity were 81.9 cm and 77.4 cm respectively, which were lower than the criterion of the Korean Society for the Study of Obesity (85 cm). In the study of Oh et al [24], they suggested 80 cm of waist circumference as central obesity for Korean women. Also, they insisted that the range of 70–80 cm for waist circumference should be monitored for the development of metabolic syndrome. Also, Lee et al [14] proposed 82.5 cm (AUC 0.676, sensitivity 57.9%, specificity 70.5%) as the optimal cutoff for the postmenopausal Korean women. Whereas in the study of Seo et al [25], they had proposed 86.5 cm (AUC 0.682, sensitivity 69.3%, specificity 60.4%), which was 4.6 cm higher than our study result. This could be because Seo et al's [25] study participants were relatively older than those in our study. The mean age of their study participant was 70.5 years, which was 11.7 years older than our study participants. Subgroup analysis of 46–55 year-old women, those who started menopause in the Lee et al's study [14] showed that central obesity could be defined as over 76.8 cm in waist circumference for premenopausal women, and over 79.1 cm for postmenopausal women [14]. These results indicate that central obesity should be defined not just by current criteria, which considered race and gender, but also by age and menopausal status. As a result of this study, we suggest 81.9 cm of waist circumference as central obesity for postmenopausal Korean women in their fifties and sixties. Additionally, postmenopausal women with waist circumference over 77.4 cm should be monitored for possible cardiometabolic risks.

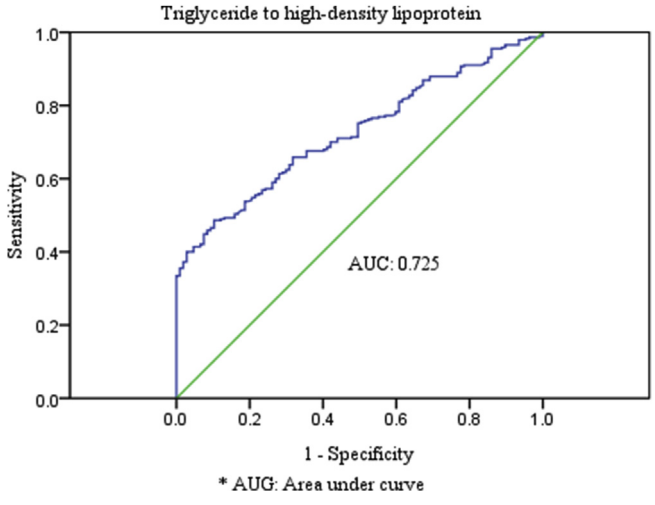

Figure 2. The receiver operating characteristic curves of triglyceride to high-density lipoprotein ratio for predicting metabolic obesity. *Note*. AUC = area under the curve.

WHR is another indicator for central obesity. The World health Organization (WHO) defined central obesity as more than 0.90 for man, and 0.85 for women [26]. In this study, the optimal point of WHR for detecting metabolic syndrome and metabolic obesity were 0.87 and 0.86 respectively, which were higher than the criteria of WHO. These results could be related to the physical characteristics of the Korean women whose pelvis is relatively small compare to that of the western population. The cutoff value of WHR for metabolic syndrome was 0.87 in Bangladeshi women, which was in line with our study result [27]. For postmenopausal Korean women in their fifties and sixties, central obesity can be defined as a WHR over 0.87, according to our study result. Also, a WHR of 0.86–0.87 for that population can be classified as being in danger of developing metabolic syndrome.

Blood lipid profile is another major indicator for the prediction of cardiovascular disease [19]. In particular, TG to HDL ratio (TG/HDL) is an important indicator for early detection of insulin resistance [20]. In fact, those with high TG/HDL ratios should be provided with an intervention for the assessment of cardiovascular risk

factors and risk factor management [28]. The cutoff value of TG/HDL for cardiometabolic risk detection of European women was 2.5 [29]. In the study focusing on East Asian population, the cutoff value of high metabolic risk for women was a TG/HDL ratio of 2 [30]. Taking into consideration of results from previous studies, and considering the sensitivity and specificity, it seemed reasonable to define high cardiometabolic risk for the postmenopausal women as a TG/HDL over 2.11. Moreover, postmenopausal women with TG/HDL ratios from 1.59 to 2.11 should be classified as having a moderate cardiometabolic risk.

HOMA-IR is a standard index for measuring insulin resistance and has been recognized as a cardiometabolic risk [21]. Research on this is still lacking. Future research should be conducted. The results of this study can serve as a comparative index for other studies. Serum lipid ratio and HOMA-IR may serve as useful markers for cardiometabolic risk [21,28]. However, it is hard to find studies that presented the optimal cutoff values for the detection of cardiometabolic risk in the Korean population.

This study has some limitations. First, this study analyzed cross-sectional data. Thus, longitudinal data are needed to determine cardiometabolic risk changes depending on the time variable. Second, the participants of this study were from a limited population pool, hospital volunteers, whose educational and living levels are relatively high. Thus, it is necessary to confirm the results through repeated studies using a representative sample. Third, though its usability proved and widely used, LDL was indirectly obtained.

Despite these limitations, the study findings can be used by nurses to identify clients who are at risk for cardiometabolic problems. The first step of preventive interventions for health promotion or disease prevention is to identify those with potential problems in advance. Future development of effective preventive nursing interventions, such as education or awareness-raising, is needed for clients with cardiometabolic risks.

Conclusion

To promote health and to prevent disease in the middle-aged women, it is essential to detect cardiometabolic risk. The first thing in the detection of cardiometabolic risk is to set the optimal values of each indicator depending on the age and menopausal state of the clients.

For the postmenopausal women, we suggest waist circumference of 81.9 cm and WHR 0.87 as criteria of metabolic syndrome. However, women with over 77.4 cm of waist circumference and 0.86 of WHR should be considered has having a cardiometabolic risk. We also suggest postmenopausal women with a TG/HDL ratio of over 2.11 as having a high cardiometabolic risk and those with a ratio of 1.59–2.11 as having a moderate cardiometabolic risk.

Conflict of interest

There is no conflict of interest for this work.

Acknowledgments

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