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Proposed Waist Circumference Measurement for Waist-to-Height Ratio as a Cardiovascular Disease Risk Indicator: Self-Assessment Feasibility

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Abstract

The health campaign refers to waist circumference measured at the midpoint between the lower costal margin and iliac crest (WCM) for calculating Waist-to-Height Ratio (WHtR) indicator. WCM is difficult for layperson and health personnel who usually use waist circumference measured at umbilical level (WCU). This study aimed to determine whether WHtR is an appropriate indicator for risk factors of Cardiovascular Disease (CVD), to compare WHtR using different waist circumference measurements, and to propose practical anthropometry indicator for self-assessment for risk factors of CVD. From 2012 through 2013, the Medicine Faculty of Chiang Mai University provided a non-communicable disease screening for health personnel. The participants were interviewed, anthropometry measurements were taken, and laboratory investigations were performed. A WCM of over 90 cm in man and 80 cm in woman (WCM9080) was defined as the reference point. WHtR was calculated as waist circumference divided by height. WHtRM used the WCM and WHtRU used the WCU for calculation. The cutoff level was 0.5 (WHtRM0.5 and WHtRU0.5). Risk factors for CVD included hypertension, diabetes, and dyslipidemia. There were 3242 personnel with the mean age of 40.2 +/- 10.7 years. The majority of the participants were females (76.8%). Prevalence of hypertension, diabetes, and dyslipidemia were 61.0%, 15.7%, and 32.9%. WCU9080, WHtRM0.5, and WHtRM0.5 demonstrated a larger area than that of WCM9080 when comparing the area under the ROC curve of having at least one risk factors of CVD. WHtRU0.5 had the highest sensitivity (73.6%) with 67.6% specificity and 69.1% corrected classification of having at least two risk factors of CVD. WHtRU0.5 is the appropriate anthropometry indicator for screening risk factors of CVD in health personnel. It can be proposed for screening, self-assessment, and self-monitoring for the health campaign in Thai adults based on its feasibility.

Key words: Waist Circumference; Waist-to-Height Ratio; Body Mass Index; Obesity; Adult; Thailand; Self-Assessment; Self-Monitoring

Abbreviations

WCM: waist circumference measured at the midpoint between the lower costal margin and iliac crest;

WCU: waist circumference measured at umbilical level;

WtHR: Waist-to-Height Ratio;

WCM9080: waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm;

WCU9080: waist circumference measurement at the umbilical level; WCM man >90 cm woman >80 cm;

WHtRM0.5: waist-to-height ratio using WCM; cutoff level is at least 0.5;

WHtRU0.5: waist-to-height ratio using WCU; cutoff level is at least 0.5

Introduction

One of anthropometry indicators for obesity is waist circumference (WC) [1-4]. The cutoff levels in Asians are lower than those of Europeans. The cutoff values should be set according to ethnic groups [3,5-8]. Some studies recommend that WC cutoff levels should be set to lower values for specific populations [9-12]. Waist circumference was reported as low as 85 cm in men and 80 cm in women [13]. The measurement of obesity in association with disease risk has population-dependent variations. Therefore, the World Health Organization suggests that each country should define the appropriate cutoff levels for its population[14]. The Thai Ministry of Public Health defined the cutoff level for screening and health education as 90.0 cm in men and 80.0 cm in women. These cutoff values are based on a waist circumference measurement at the midpoint between the lower costal margin and superior iliac crest (WCM). When implementing the WCM measurement, however, it is practically based on the umbilical level (WCU). The WCU measurement is easier than that of the WCM and more understandable. The problem is that different methods of waist circumference measurements result in different waist circumference values, which lead to bias prediction. Although the WCM was used, the cutoff levels were different and an inappropriate indicator for CVD risk factors[7, 8, 15-17]. The Fourth Regional Health Promotion Center reported that the differences between the WCM and the WCU ranged from -10 to +16 cm among 76 Thai women attending the health service. WC at the umbilical level was about 3 cm higher than that of the ileac crest level (The Fourth Regional Health Promotion Center of Thai Ministry of Public Health, Government Report, August, 2012).

There are studies that found that the WHtR was a better indicator than the WCM[18, 19]. The WHtR correlated with visceral fat and had high accuracy in discrimination[20]. The waist circumference measurement used for calculating WHtR is the WCM, whereas the WCU measurement is easier than WCM in practice. Although the value of the WCU differs from that of the WCM in each individual, the WHtR is weighted by each individual's height. Thus, the value of WHtR that uses the WCU as numerator (WHtRU) may not have much difference from that of the WHtR that uses the WCM as the numerator (WHtRM). No study was found that supported this hypothesis. The ultimate usefulness of the WHtRU is its practical implementation because adult heights do not change much over many years. The WHtRU does not require measurements in centimeters or inches in order self-assessment and self-monitoring to be performed. In addition, the WHtRU will support the latest health promotion policy of Thai Ministry of Public Health that defines that the appropriate WHtR should be less than 0.5. In another words, an appropriate waist circumference should be lower than half of each individual's height. No study was found that indicated how accurate the WCU is instead of the WCM for the WHtR indicator.

For chronic disease prophylaxis and treatment, prevention and control of overweight and obesity is one of the key aspects [21]. The health personnel of Chiang Mai University hospital are a middle aged group on average and prone to have non-communicable diseases. It is not easy to determine the risk profile for each individual and monitor them over time due to the large number of personnel. Thus, self-assessment and self-monitoring is another option. This study aimed to determine whether the WHtR is an appropriate indicator for risk factors of CVD, to compare the WHtR using different waist circumference measurements, and to propose a practical anthropometry indicator for self-assessment for risk factors of CVD.

Material and Methods

Recruitment of Subjects

From January, 2012 to June, 2013, the Medicine Faculty of Chiang Mai University provided a non-communicable disease screening for all health personnel.

Data collection

There were two parts of data collection. The first one was the online registration with a subsequent online questionnaire. The second part performed when the participants come in for their interview and received a physical examination along with laboratory investigations. For the first part, health personnel could log in online using their Thai National Identification Number in order to confirm their working status within the faculty hospital. The screen showed a study information sheet and consent form. Once the health personnel gave consents, they were asked to fill in their basic demographic information. The participants chose the time and date for their interview and examination. On the examination dates, study identification numbers were given to each individual. Anthropometry measurements included height, weight, and waist circumference. Standing height (without shoes) in centimeters (cm) and weight in kilograms (kg) were measured using a portable stadiometer, an electronic scale, and a standard measuring tape. Waist circumference was measured horizontally at the umbilical level (WCU) and at the midway point between the lowest

palpable rib and the superior iliac crest (WCM). All measurements were done by trained investigators. Three blood pressure readings were taken five minutes apart using an ADC ® Digital E-Sphyg two non-mercury sphygmomanometers. Two different cuff sizes were available and the machines were calibrated every two months. Venous blood samples were drawn and processed at the Central Diagnostic Laboratory in CMU Hospital. The complete list of laboratory examinations included a fasting blood glucose and lipid profiles.

Definitions Anthropometry indicators

According to the policy of the Thai Ministry of Public Health, overweight and obesity was defined as the WCM over 90 cm in men and over 80 cm in women (WCM9080). Thus, WCM9080 was defined as a reference for comparing different anthropometry indicators. The WHtR was calculated as waist circumference in cm divided by height in cm. Based on the Thai Ministry of Public Health, the obesity cutoff level is at least 0.5. WHtRM0.5 was the WHtR that used the WCM as the numerator and WHtRU0.5 was the WHtR that used the WCU as the numerator.

Risk factors for cardiovascular diseases

Risk factors for CVD include hypertension, diabetes mellitus (DM), and dyslipidemia. Hypertension was present if each individual had any one of these following conditions: 1) known case of hypertension, or 2) systolic blood pressure at least 140 and/or diastolic blood pressure at least 90 mmHg [22]. DM was present if each individual had any one of this following conditions: 1) known case of DM, or 2) fasting blood glucose at least 126 milligram per deciliter (mg/dl),or 3) hemoglobin A1c at least 6.5%[23]. Dyslipidemia was defined as any one of this following conditions: 1) known case of dyslipidemia, or 2) one of these abnormal lipid profiles, which were total cholesterol at least 200 mg/dl, triglyceride at least 150 mg/dl, low density lipoprotein at least 160 mg/dl, or high density lipoprotein less than 40 mg/dl in man and less than 46 mg/dl in woman [24].

Data analysis

Descriptive analyses included proportion, means +/- standard deviation (SD), or median (range) depending on data distribution. Receiver Operating Characteristics (ROC) analysis, sensitivity, specificity, and classification were used in order to determine appropriate anthropometric indicators. A Sidak p-value of less than 0.05 was considered significant. Data management and analyses were performed using Epi Info for Windows version 3.5.4 (Centers for Disease Control and Prevention, Atlanta, GA) and STATA version 11 (Statacorp LP. College Station, TX).

Results

Demographic data

There were 3242 personnel with a mean age of 40.2 years (SD=10.7 years). The majority of the participants were females (76.8%). The prevalence of hypertension, dyslipidemia, and DM were 61.0%, 32.9%, and 15.7%, respectively.

Anthropometry indicators for each risk factor of cardiovascular diseases

When comparing the area under the ROC curve of all the CVD risk factors (high BP, DM, dyslipidemia) using WCM9080 as the reference, WHtRM0.5 and WHtRU0.5 had larger areas than that of WCM9080, with statistical significance (Table 1). For the area under the ROC curve of dyslipidemia, WCU9080 also had a larger area than that of WCM9080, with statistical significance (Table 1).

Table 1. Receiver operating characteristic analysis of hypertension, diabetic mellitus, and dyslipidemia by the cutoff level of waist circumference and waist-to-height ratio.

Indicators [1]	Area under curve	Standard error	Chi square p-value [2]	Sidak p-value [2]
Hypertension				
WCM9080 (Reference)	0.595	0.008		
WCU9080	0.604	0.008	0.089	0.244
WHtRM0.5	0.656	0.008	<0.001	<0.001
WHtRU0.5	0.646	0.009	<0.001	<0.001
Diabetic Mellitus				
WCM9080 (Reference)	0.618	0.012		
WCU9080	0.634	0.012	0.037	0.108
WHtRM0.5	0.671	0.012	<0.001	<0.001
WHtRU0.5	0.657	0.011	<0.001	<0.001
Dyslipidemia				
WCM9080 (Reference)	0.551	0.007		
WCU9080	0.566	0.008	0.005	0.014
WHtRM0.5	0.590	0.008	<0.001	<0.001
WHtRU0.5	0.600	0.009	<0.001	<0.001

Note: 1 WCM9080 = waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm.

WCU9080= waist circumference measurement at the umbilical level; man >90 cm woman >80 cm

WHtRM0.5= waist-to-height ratio using WCM; cutoff level is at least 0.5 WHtRU0.5 = waist-to-height ratio using WCU; cutoff level is at least 0.5

2 Statistical significant p-value < 0.05

Anthropometry indicators for having at least one risk factor of cardiovascular diseases

When comparing the area under the ROC curve of having at least one risk factor of CVD, using WCM9080 as the reference, WCU9080, WHtRM0.5, and WHtRM0.5 had a larger area than that of WCM9080, with statistical significance (Table 2). WHtRU0.5 had similar area under curve as that of WHtRM0.5.

Table 2. Receiver operating characteristic analysis of having at least one risk factor of cardiovascular diseases by the cutoff levels of waist circumference and waist-to-height ratio.

Indicators [1]	Area under curve	Standard error	Chi square p-value [2]	Sidak p-value [2]
Indicators [1]	Area Under Curve	Standard Error	Chi square p-value [2]	Sidak p-value [2]
WCM9080 (Reference)	0.598	0.007		
WCU9080	0.614	0.008	0.005	0.012
WHtRM0.5	0.660	0.008	<0.001	<0.001
WHtRU0.5	0.658	0.008	<0.001	<0.001

Note: 1 WCM9080 = waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm

WCU9080= waist circumference measurement at the umbilical level; man >90 cm woman >80 cm

WHtRM0.5= waist-to-height ratio using WCM; cutoff level is at least 0.5 WHtRU0.5 = waist-to-height ratio using WCU; cutoff level is at least 0.5

2 Statistical significant p-value < 0.05.

Sensitivity, specificity, and corrected classification of anthropometry indicators for having one risk factor of cardiovascular diseases

When using health problems as having at least one risk factor of CVD, WHtRU at least 0.5 had the highest corrected classification (64.1%) with 56.0% sensitivity and 75.7% specificity. WHtRM at least 0.5 had the second highest corrected classification (62.6%) with 46.6% sensitivity and 85.3% specificity (Table 3).

Table 3. Sensitivity, specificity, and corrected classification of the cutoff levels from anthropometry indicators for having at least one risk factor of cardiovascular diseases.

Indicators [1]	ROC	Sensitivity	Specificity	Correctly classified
WCM9080 (Reference)	0.598	28.6%	91.1%	54.4%
WCU9080	0.614	38.5%	84.2%	57.4%
WHtRM0.5	0.660	46.6%	85.3%	62.6%
WHtRU0.5	0.658	56.0%	75.7%	64.1%

Note: 1 WCM9080 = waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm

WCU9080= waist circumference measurement at the umbilical level; man >90 cm woman >80 cm

WHtRM0.5= waist-to-height ratio using WCM; cutoff level is at least 0.5 WHtRU0.5 = waist-to-height ratio using WCU; cutoff level is at least 0.5

Anthropometry indicators for having at least two risk factors of cardiovascular diseases

When comparing the area under the ROC curve of having at least two risk factor of CVD, using WCM9080 as the reference, WCU9080, WHtRM0.5 and WHtRM0.5 had the larger areas than that of WCM9080, with statistical significance (Table 4).

Table 4. Receiver operating characteristic analysis of having at least two risk factors of cardiovascular diseases by the cutoff levels of waist circumference and waist to height ratio.

Indicators [1]	Area Under Curve	Standard Error	Chi square p-value [2]	Sidak p-value [2]
WCM9080 (Reference)	0.630	0.009		
WCU9080	0.646	0.010	0.015	0.045
WHtRM0.5	0.714	0.009	<0.001	<0.001
WHtRU0.5	0.706	0.009	<0.001	<0.001

Note: 1 WCM9080 = waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm.

WCU9080= waist circumference measurement at the umbilical level; man >90 cm woman >80 cm

WHtRM0.5= waist-to-height ratio using WCM; cutoff level is at least 0.5 WHtRU0.5=waist-to-height ratio using WCU; cutoff level is at least 0.5

2 Statistical significant p-value < 0.05

Sensitivity, specificity, and corrected classification of anthropometry indicators for having at least two risk factors of cardiovascular diseases

When using health problems as having at least two risk factor of CVD, WHtRM at least 0.5 had the highest corrected classification (74.4%) with 65.3% sensitivity and 77.5% specificity. WHtRU at least 0.5 had the highest sensitivity (73.6%)with 67.6% specificity and 69.1% corrected classification (Table 5).

Table 5. Sensitivity, specificity, and corrected classification of the cutoff levels from anthropometry indicators for having at least two risk factors of cardiovascular diseases.

Indicators [1]	Area Under Curve	Sensitivity	Specificity	Correctly classified
WCM9080 (Reference)	0.630	39.8%	86.2%	74.4%
WCU9080	0.646	50.9%	78.3%	71.3%
WHtRM0.5	0.714	65.3%	77.5%	74.4%
WHtRU0.5	0.706	73.6%	67.6%	69.1%

Note: 1 WCM9080 = waist circumference measurement at the midpoint between the superior iliac crest and lower costal margin; man >90 cm woman >80 cm.

WCU9080= waist circumference measurement at the umbilical

level; man >90 cm woman >80 cm.

WHtRM0.5= waist-to-height ratio using WCM; cutoff level is at least 0.5 WHtRU0.5 = waist-to-height ratio using WCU; cutoff level is at least 0.5

Innovation of screening tool for self-assessment and self-monitoring

Based on the findings, a simple screening tool for self-assessment and self-monitoring of CVD risk factors was created and tested in health personnel. A thin rope used for wrapping box was chosen because of availability, durability, cheap, and function. Steps of making screening tool were as following (Figure 1): 1) Folded the rope 2) Put a heel on the rope 3) Pulled the rope up to the level of height 4) Cut the rope at the height level 5) Folded the rope in half-length 6) Cut the rope at this half-length level 7) Used the haft-length rope to measure waist circumference at the umbilical level 8) Put the hand to measure a distance between the end of the rope and the umbilical (made sure that the second knuckle lied in the same level of umbilical) and counted number of finger (When WC was smaller than the haft-length rope, marked a line on the rope) 9) Wrote down date of measurement and number of finger at the end of rope.

Figure 1. Steps of making screening tool for self-assessment and self-monitoring.

Discussion

Body mass index (BMI) was previously used as an indicator for obesity [25, 26]. Recently, WHtR has been recognized as a better indicator for screening obesity than waist circumference [18, 27-29]. Both the waist circumference and WHtR require valid measurements to be able to predict risk factors. Waist circumference measurement that has been accepted by the WHO is midway between the lower costal margin and superior iliac crest [3]. In practice, however, waist circumference is often measured at the umbilical level. This leads to measurement bias because the value of waist circumference measurement at the umbilical level differs from that measurement midway between the lower costal margin and superior iliac crest in each individual. A government report of Thai women attending the health service indicated that the differences ranged from -10 to +16 cm (The Fourth Regional Health Promotion Center of Thai Ministry of Public Health, Government Report, August, 2012). Royal Thai Ministry of Public Health launched a campaign with the cutoff level (over 90 cm for man and 80 cm for woman) for health screening of obesity. Practical level health personnel usually measure waist circumference at the umbilical level. The WCU is also easy to perform by the general population. According to our results when comparing the area under the ROC curve of high BP, DM and dyslipidemia using WCM9080 as the reference, we found that the WCU9080 had larger areas than that of WCM9080 for each of the CVD risk factors. However, only dyslipidemia had statistical significance. Based on the health promotion and prevention programs, the indicator cutoff level for each CVD risk factor for the public is hard to remember and easily confused. Thus, having one indicator for screening any one (or two) risk factor (s) of CVD is more important massage and feasible in practice than in having many indicators for each CVD risk factor. When the area under the ROC curve was compared with having at least one risk factor of CVD, we found that the WCU9080 had a larger area than that of the WCM9080. Similar results were found in the ROC curve of having at least two risk factors of CVD. WCU9080 also had a higher sensitivity than that of the WCM9080. It had slightly lower overall corrected classification than that of WCM9080. In practice, the WCU measurement is easier than the WCM. Therefore, The WCU9080 may be more appropriate for CVD risk factor screening in population than the WCM9080.

Although the WCM9080 had the second highest corrected classification (74.4%) the sensitivity was very low (39.8%). When using health problems as having at least two risk factors of CVD, WHtRU0.5 had the highest sensitivity (73.6%) with about seventy percent corrected classification. For screening and self-monitoring of CVD risk factors, sensitivity is more important than specificity. In addition, the WC measurement method of the WCM and the WHtRM are more difficult for the layperson and less feasible than that of the WHtRU. Recently, the Royal Thai Ministry of Public Health launched a campaign of WHtR for health promotion and prevention programs. The government indicated the cutoff level below 0.5 as an appropriate WHtR. This cutoff level was also recommended by other systemic reviews studied [18, 30]. Our findings showed that both WHtRM0.5 and WHtRU0.5 had larger areas than that of WCM9080 when comparing the area under the ROC curve of high BP, DM and dyslipidemia. For having at least one risk factor of CVD, both WHtRM0.5 and WHtRU0.5 had a larger area than that of WCM9080. WHtRU0.5 had similar area under the curve as that of WHtRM0.5. Similar results were found in

having at least two risk factors of CVD and in having at least three risk factors of CVD (data not shown). There were similar results when analyzed by gender (data not shown). Another study in Asia was conducted by Cai et al among general population of China. They showed that the WHtR was better than BMI and WC for the relationships between hypertension and DM [19]. Based on our findings and Thai Ministry of Public Health's policy, therefore, we propose WHtRU0.5 as an appropriate indicator for CVD risk factor screening, self-assessment, and self-monitoring instead of WC9080. Furthermore there is no need to measure height and waist in application and implementation. WC cutoff levels are needed for different populations [5-8, 31]. However, the WHtRU does not require these cutoff values for implementation in the general population for self-assessment and self-monitoring. A rope can be utilized to measure each individual's height and then folded in half. This half-length rope is equal to the waist WCU cutoff level of each individual. This procedure is feasible to implement in the general population for self-assessment and monitoring [18, 30]. A thin rope used for wrapping box was chosen. It is durable and also available at a local markets in any provinces of Thailand. Its wide shape provides enough space for writing information on the surface. Its costs was approximately 2 baht per person (32 baht equals to 1 US dollar). This screening tool was tested in health personnel of Medicine Faculty who attended obesity project and received good feedback.

Some limitations of this study were that not all health personnel were included for participation in the study. However, the majority of them participated and sample size was large enough. The nature of cross-sectional study is temporal ambiguity. The strengths of this study were that anthropometry measurements were done by trained health personnel who had many years of experience, all instruments were calibrated, and the quality of the standard laboratory test that were done by the Faculty of Medicine.

Conclusion

Taking area under the curve, overall correct classification, sensitivity and feasibility of implementation into consideration, we recommend that WHtR using the waist circumference measurement at the umbilical level at the cutoff level 0.5 (WHtRU0.5) is the appropriate anthropometry indicator for screening risk factors of CVD and self-monitoring in health personnel. We also propose this WHtRU0.5 for screening risk factors of CVD and self-assessment for the health campaign in Thai adults. Further study should be conducted for generalization.

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