Original Article

# The Optimal Cut-off Points of Waist Circumference for Identification of Metabolic Syndrome in Royal Thai Army Personnel in Bangkok and Suburban

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**Abstract:**

**Objective:** To determine the optimal cut-off points of waist circumference (WC) for identification of metabolic syndrome (MetS) in Royal Thai Army (RTA) personnel.  **Methods:** The design of this study was a cross sectional research conducted with 2,809 samples (1,549 males and 1,260 females) aged 35-60 years old.  The MetS is defined according to Joint Interim Statement (JIS) criteria.  WC was measured horizontally at the umbilicus level.  Data collection was by using existing annual health checkup data in the fiscal year 2014 from Armed Forces Research Institute of Medical Sciences (AFRIMS).  Receiver operating characteristic (ROC) curve analysis was used for identifying the cut-off points of WC.  **Results:** The WC optimal cut-off points for detection of the MetS in male were 82.5 cm (sensitivity 81.9% and specificity 43.2%) and in female were 77.5 cm (sensitivity 81.3% and specificity 53.1%).  **Conclusion:** WC is potential as screening tools for classifying MetS.  RTA personnel should take care of their health by receiving annual health checkup every year and follow-up the results.  Their WC can be self-measured and prevention of MetS with lifestyle changes; weight loss, improved diet, and regular physical exercise should be performed.

**Keywords:**  ● Metabolic syndrome  ● Cut-off points  ● Receiver operating characteristic curve  ● Royal Thai Army

## Introduction

Metabolic syndrome (MetS) is a cluster of the risk factors for cardiovascular diseases (CVD) that includes abdominal obesity, atherogenic dyslipidemia, elevated blood pressure, insulin resistance, and proinflammatory and prothrombotic states[1]. The importance of MetS is associated with subsequent development of type 2 diabetes mellitus and cardiovascular events, patients with MetS have a 2-fold increase risk of mortality from coronary heart disease and a 5-fold increased risk of developing type 2 diabetes mellitus[2]. A recent meta-analysis including 43 cohorts (172,573 individuals) reported that MetS conveyed a relative risk (RR) for CVD events and death of 1.78, with higher risk in women (RR as 2.63). In addition, risk was still associated with

the syndrome after adjusting for traditional CVD risk factors (RR = 1.54)[3]. At the present, it is generally accepted that MetS is a major contributor for the development of CVD, type 2 diabetes mellitus and many noncommunicable *diseases* (NCDs). Thus, early MetS detection was essential for prevention and management offer the best solution for reduction of risk for CVD and other NCDs.

Metabolic syndrome detection criteria have evolved over the past decade. The recommended measurements for detection have been conditioned in part by views of the pathogenesis of the syndrome. The two most widely used criteria to diagnose the MetS are those developed by the United States Adult Treatment Panel III of the National Cholesterol Education Program (ATP III) and by the International Diabetes Federation (IDF). The main difference between the two criteria is that central obesity, as measured by WC, is a prerequisite in the IDF definition, with cut-off points of WC being ethnic specific and lower than in the ATPIII definition[1,4]. Recently, an additional definition of MetS was proposed as a joint interim statement (JIS) by several organizations in an attempt to harmonize the definition of MetS. The available information based on ATPIII and IDF criteria suggests that MetS is pandemic but that prevalence varies widely depending on the ethnic groups studied and criteria applied. Thus, the definition proposed is appropriate to use in epidemiologic studies, it does not built in any preconceived notion of the underlying cause of MetS, whether it is insulin resistance or obesity. The proposed criteria does not require any specific criterion, only at least any three of five criteria as following are met; elevated waist circumference (population and country specific definitions), elevated triglycerides ($\geq$ 150 mg/dL), reduced HDL-C (< 40 mg/dL in males and < 50 mg/dL in females), elevated blood pressure (SBP $\geq$ 130 and/or DBP $\geq$ 85

mm Hg), and elevated fasting glucose ($\geq$ 100 mg/dL)[2].

Abdominal obesity is the major disorder constituting a base for the development of MetS. Furthermore, waist circumference (WC) is recommended as anthropometric indicators assessment of abdominal obesity and suitable screening tools for early MetS detection, it has been widely used in epidemiologic studies because it is simple, most practical and expedient[5]. It was found that the WC measurement has strong positive correlations to the biochemical markers such as blood glucose and lipid profile[6-9]. The World Health Organization (WHO) suggests using cut-off points for WC concurrently but declares that the use of WC for assessing health risk would need to be specific for population and depends on the presence or absence of other risk factors. In Thailand, there are many groups of researcher studies for discovering appropriate WC cut-off points in Thai population. However, it has not documented of finding WC cut-off points for screening MetS in Royal Thai Army (RTA) personnel. Therefore, the aim of the study was to determine the optimal cut-off points of WC for identification of MetS in RTA personnel.

## Materials and Methods

The design of this study was a cross sectional research conducted in 2,809 samples (1,549 males and 1,260 females). The sample population aged 35-60 year old and worked in RTA units in Bangkok and suburban who receiving annual health checkup from Armed Forces Research Institute of Medical Sciences (AFRIMS), Royal Thai Army Medical Department, Bangkok during 1st October, 2013 to 30th September, 2014. WC was measured horizontally at the umbilicus level (WC-U) using a measuring tape. Receiver operating characteristic curve (ROC) analysis was used for identifying the cut-off points of WC. The ROC curve was plotted using present at least two other components of the MetS,

excluding WC, as defined by the Joint Interim Statement (JIS) criteria. The distance on the ROC curve for each WC value was calculated by plotting the true-positive rate (sensitivity) against the false positive rate (1-specificity). The sensitivity at least 80% was used for determining the appropriate WC cut-off points. The area under the curve (AUC) with 95% confidence interval (CI) was used as indicators of the diagnostic performance of WC for identifying MetS.

### Results

The general characteristics of the study subjects were shown in Table 1. The age average of the subjects was 48.3 ± 6.9 years (48.1 ± 6.9 years for male and 48.4 ± 6.9 years for female). The mean WC was 87.2 cm in male and 80.2 cm in female. The metabolic risk factors of the subjects were classified by the JIS criteria. It was found that the percentage of elevated triglyceride, elevated blood pressure and elevated fasting plasma glucose were higher in males than in females, while the percentage of low HDL cholesterol was higher in females than in males. The prevalence of MetS as defined by JIS criteria was 30.4%, regarding gender, the prevalence of MetS in male is higher as compared to female (34.8% and 25.1%).

The result of ROC analysis to identify subjects with two or more risk factors of MetS using the JIS criteria was shown in Table 2. In males, the optimal cut-off points of WC yielding at least 80% sensitivity was 82.5 cm (Youden's index = 0.252, Sensitivity 81.9%, Specificity 43.2%, PPV 43.7%, NPV 81.6%), while 85.5 cm was the optimal cut-off points of WC with the highest Youden's index (Youden's index = 0.267, sensitivity 70.0%, specificity 56.8%, PPV 46.6%, NPV 77.8%). For female, the optimal cut-off points of WC yielding at least 80% sensitivity was 77.5 cm (Youden's index = 0.344, Sensitivity 81.3%, Specificity 53.1%, PPV 36.6%, NPV 89.5%), while 81.5 cm was the optimal cut-off of WC yielding the highest Youden's index (Youden's index = 0.398, sensitivity 69.2%, specificity 70.6%, PPV 43.9%, NPV 87.3%). The AUC values of WC in both sexes have range 0.6-0.7 (male AUC = 0.686,

**Table 1** General characteristic of study subjects stratified by gender.

|  | Male (n = 1,549) | Female (n = 1,260) | Total (n = 2,809) |
|---|---|---|---|
| Age (years)[a] | 48.1 ± 6.9 | 48.4 ± 6.9 | 48.3 ± 6.9 |
| Waist circumference (cm)[a] | 87.2 ± 8.9 | 80.2 ± 10.3 | 84.0 ± 10.2 |
| Metabolic risk factors (%)[b] |  |  |  |
|    Elevated triglyceride | 675 (43.6) | 284 (22.5) | 959 (34.1) |
|    Low HDL cholesterol | 286 (18.5) | 238 (18.9) | 524 (18.7) |
|    Elevated systolic blood pressure | 866 (55.9) | 556 (44.1) | 1422 (50.6) |
|    Elevated diastolic blood pressure | 566 (36.5) | 298 (23.7) | 864 (30.8) |
|    Elevated fasting plasma glucose | 544 (35.1) | 278 (22.1) | 822 (29.3) |
| Prevalence MetS by JIS[b] | 539 (34.8) | 316 (25.1) | 855 (30.4) |

[a] The values are presented as means ± SD

[b] Metabolic syndrome were defined according to JIS criteria[2]. Elevated WC, ≥ 90 cm for male and ≥ 80 cm for female; Elevated triglyceride, ≥ 150 mg/dL; reduced HDL cholesterol, < 40 mg/dL for male and < 50 mg/dL for female; elevated blood pressure: systolic blood pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg, or treatment for previously diagnosed hypertension; elevated fasting plasma glucose, ≥ 100 mg/dL or previously diagnosed type 2 diabetes.

**Table 2** The WC cut-off points, sensitivity, specificity, positive predictive value, negative predictive value and Youden's index to predict metabolic syndrome stratified by gender.

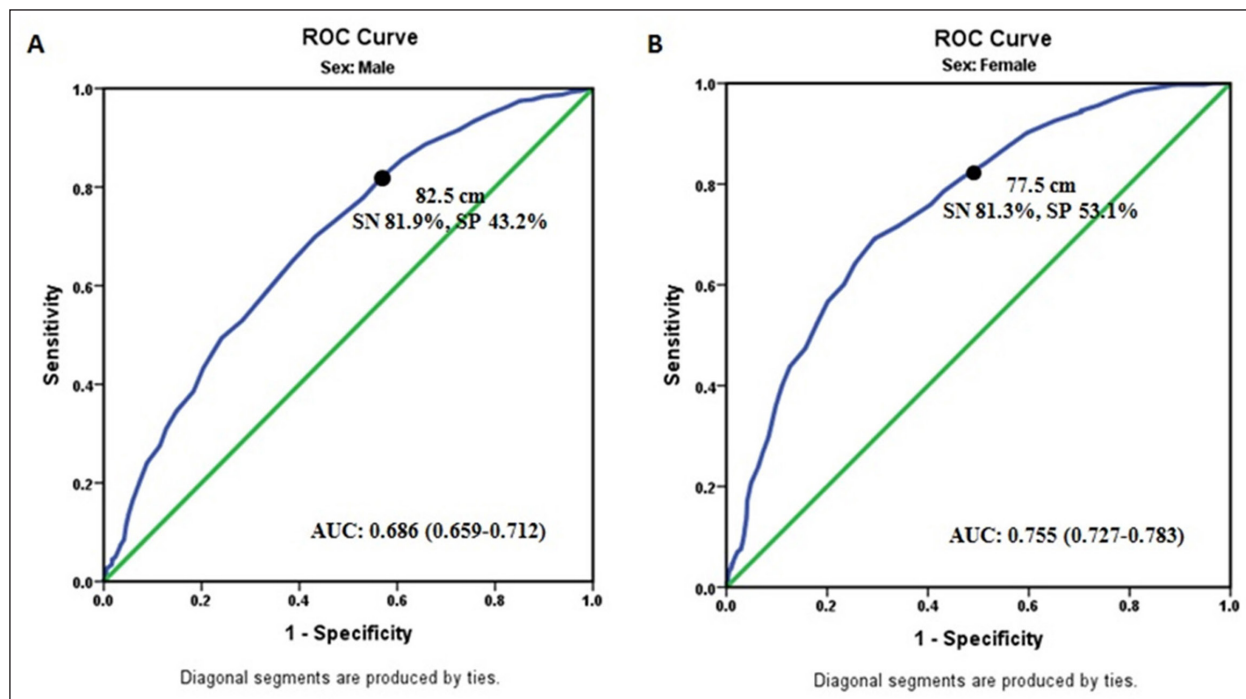|        | WC cut-off points (cm) | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Youden's index |
|--------|------------------------|-----------------|-----------------|---------|---------|----------------|
| **Male** | 82.50 | 81.9 | 43.2 | 43.7 | 81.6 | 0.252 |
|        | 85.50 | 70.0 | 56.8 | 46.6 | 77.8 | 0.267 |
| **Female** | 77.50 | 81.3 | 53.1 | 36.6 | 89.5 | 0.344 |
|        | 81.50 | 69.2 | 70.6 | 43.9 | 87.3 | 0.398 |



**Figure 1** Receiver operating characteristic (ROC) curves of waist circumference (WC) to detect the metabolic syndrome in male (A) and female (B), based on having at least two of four the JIS criteria.

95%CI: 0.659-0.712 and female AUC = 0.755, 95%CI: 0.727-0.783) that is sufficient for discrimination between MetS and non MetS group (Figure 1).

#### Discussion and Conclusion

This study aims to find the appropriate WC cut-off points to be used as a screening tool for metabolic syndrome. The statistics used in this analysis is ROC curve analysis, using the diagnosis of the MetS of JIS as the gold standard. There are many ways to select the optimal cut-off points such as select the point at the shortest distance on ROC curve, select the point that gives highest Youden's index, select the point with the same sensitivity and specificity or even select by using the sensitivity and specificity together with PPV and NPV[10]. In this study, the researcher used the optimal cut-off points by using two methods and compares the value between these two methods which is the cut-off points with the maximum Youden's index and the sensitivity consideration. The result from both methods are compared, it is found that the cut-off points with maximum Youden's index have lower sensitivity than specificity. The researcher considers for selecting the optimal cut-off points by using maximum Youden's

index. It was found that it may be not serve in the right objective as well as the use in the RTA personnel. Moreover, the study requires preliminary tool to screen the occurrence of the MetS, if the MetS is diagnosed since the begining, it will be able to reduce the incidence of CVD, stroke and diabetes.

Therefore, the researcher decided to obtain the optimal cut-off points by considering the sensivity. Previous study suggested that the WC cut-off points yielding at least 80% sensitivity is a good screening tool for MetS even if the specificity would be lower and the false positive would be high[11]. Thus, the proposed optimal WC cut-off points in this study is 82.5 cm for male RTA personnel (Sensitivity 81.9% and Specificity 43.2%) and 77.5 cm for female RTA personnel (Sensitivity 81.3% and Specificity 53.1%). Result of this study gives the value that lower than the value recommended by WHO and IDF ( 90.0 cm for male and 80.0 cm for female)[4,12]. After the analysis is considered, if the cut-off points of 90 cm is used in this study of male RTA personnels, the sensitivity will be lower than specificty (43.3% and 79.7% respectively). Regarding female RTA personnels, the cut-off points of 80 cm has a sensitivity that is lower than the cut-off points recommended to be used in this study.

Previous studies in Thai population, the result also give a lower value. The study conducted by Worachartcheewan et al.[13] on 5,646 Thai population who reported the WC cut-off points for male is 87.75 cm and for female is 79.75 cm and Narksawat et al.[14] on 998 Thai people who reported 84.0 cm for male and 80.0 cm for females. It is found that even the studies are conducted in that same nationality of people, the results are different. It may be effect by the RTA personnel have working characteristic, lifestyle, and health behavior that are different for general people such as participation in military training in order to be ready

to work at all time, or be on day or night duty, etc. When compared the results with other studies in Asian countries, it is found that the results of this study is similar to the findings of Kim HK et al.[15], which studied 31,076 Korean people. The WC cut-off point for male is 83.0 cm and for female is 76.0 cm Another study conducted by Ko and Tang[16] on 14,919 Chinese people reveals WC cut-off points for male of 83.3 cm and 76.1 cm for female.

The limitations of the WC cut-off points with high sensitivity should be considered. Because this cut-off point is used in practice, there will be a large number of false positive result making general RTA personnel being diagnosed as having MetS. This may lead to further expense in laboratory test to confirm the diagnosis. Oppositely, it is likely to provide benefit to the RTA personnel. RTA personnel with false positive result may have higher concern on health and more tendency to change to even more healthy lifestyle which may cause no additional expenses with no complications.

In conclusion, the proposed optimal WC cut-off point in this study is 82.5 cm and 77.5 cm for male and female RTA personnel, respectively. WC is a suitable screening tool for early MetS detection. Especially in field setting, screening by using WC would be more convenient and simple than laboratory test. RTA personnel should take care of their health by receiving annual health checkup every year and follow-up the results. Their WC can be self-measured and prevention of MetS with lifestyle changes; weight loss, improved diet, and regular physical exercise should be performed.

istry Section, Analysis Division, Armed Forces Research Institute of Medical Sciences for the data set used in this study.

## References

1. Grundy SM, Brewer HB Jr., Cleeman JI, Smith SC Jr., Lenfant C, American Heart A, et al.  Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition.  Circulation 2004;109:433-8.

2. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al.  Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity.  Circulation 2009;120: 1640-5.

3. Gami AS, Witt BJ, Howard DE, Erwin PJ, Gami LA, Somers VK, et al.  Metabolic Syndrome and Risk of Incident Cardiovascular Events and DeathA Systematic Review and Meta-Analysis of Longitudinal Studies.  J Am Coll Cardiol 2007;49:403-14.

4. Zimmet P, Alberti KGMM, Ríosc MS.  A New International Diabetes Federation (IDF) Worldwide Definition of the Metabolic Syndrome: the Rationale and the Results.  Rev Esp Cardiol 2005;58:1371-5.

5. National Heart L, and Blood Institute in cooperation with The National Institute of Diabetes and Digestive and Kidney Diseases.  Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults.  NIH Publication.  September 1998.

6. Mamtani MR, Kulkarni HR.  Predictive Performance of Anthropometric Indexes of Central Obesity for the Risk of Type 2 Diabetes.  Arch Med Res 2005;36:581-9.

7. Bambrick HJ.  Relationships between BMI, waist circumference, hypertension and fasting glucose: Rethinking risk factors in Indigenous diabetes.  Australian Indigenous Health Bulletin. September - December 2005;5(4):1-15.

8. Gierach M, Gierach J, Ewertowska M, Arndt A, Junik R. Correlation between Body Mass Index and Waist Circumference in Patients with Metabolic Syndrome.  ISRN Endocrinol 2014; 2014:1-6.

9. Arlette Perry, Xuewen Wang, Yi-Tzu Kuo.  Anthropometric correlates of metabolic syndrome components in a diverse sample of overweight/obese women.  Ethn Dis. 2008;18.

10. Wang Z, Ma J, Si D.  Optimal cut-off values and population means of waist circumference in different populations.  Nutrition research reviews 2010;23:191-9.

11. Hara K, Matsushita Y, Horikoshi M, Yoshiike N, Yokoyama T, Tanaka H, et al.  A Proposal for the Cutoff Point of Waist Circumference for the Diagnosis of Metabolic Syndrome in the Japanese Population.  Diabetes Care 2006;29:1123-4.

12. World Health Organization.  Appropriate body-mass index for Asian populations and its implications for policy and intervention. Lancet.  January 2004:363.

13. Worachartcheewan A, Dansethakul P, Nantasenamat C, Pidetcha P, Prachayasittikul V.  Determining the optimal cutoff points for waist circumference and body mass index for identification of metabolic abnormalities and metabolic syndrome in urban Thai population.  Diabetes Research and Clinical Practice 2012;98: e16-21.

14. Narksawat K, Podang J, Punyarathabundu P, Podhipak A.  Waist Circumference, Body Mass Index and Health Risk Factors among Middle Aged Thais.  Asia-Pacific Journal of Public Health 2007; 19:10-5.

15. Kim HK, Kim CH, Park JY, Lee KU.  Lower waist-circumference cutoff point for the assessment of cardiometabolic risk in Koreans. Diabetes research and clinical practice 2009;85:35-9.

16. Ko GTC, Tang JSF.  Waist Circumference and BMI Cut-off Based on 10-year Cardiovascular Risk: Evidence for "Central Pre-Obesity".  Obesity 2007;15:2832-9.

# การหาจุดตัดที่เหมาะสมของเส้นรอบวงเอวเพื่อบ่งชี้ถึงภาวะเมตาบอลิคซินโดรมในกำลังพลกองทัพบกสังกัดกรุงเทพมหานครและปริมณฑล

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*วัตถุประสงค์*  เพื่อหาจุดตัดที่เหมาะสมของเส้นรอบวงเอวในการบ่งชี้ภาวะเมตาบอลิคซินโดรมในกำลังพลกองทัพบก *วิธีการ* การศึกษาแบบภาคตัดขวางโดยใช้ข้อมูลการตรวจสุขภาพประจำปีจากสถาบันวิจัยวิทยาศาสตร์การแพทย์ทหาร ในช่วงวันที่ 1 ตุลาคม 2556 ถึง 30 กันยายน 2557 กำลังพลอายุตั้งแต่ 35-60 ปี จำนวนทั้งหมด 2,809 คน การวินิจฉัยภาวะเมตาบอลิคซินโดรมใช้เกณฑ์ของ Joint Interim Statement และหาจุดตัดที่เหมาะสมของเส้นรอบวงเอวโดยใช้การวิเคราะห์ Receiver operating characteristic curve (ROC)  *ผลการวิจัย* จากการวิเคราะห์ ROC พบว่าจุดตัดของเส้นรอบวงเอวที่เหมาะสมในการบ่งชี้ภาวะเมตาบอลิคซินโดรมกำลังพลชายคือ 82.5 ซม. (ความไวร้อยละ 81.9 และความจำเพาะร้อยละ 43.2) และกำลังพลหญิงคือ 77.5 ซม. (ความไวร้อยละ 81.3 และความจำเพาะร้อยละ 53.1)  *สรุป* การวัดเส้นรอบวงเอวสามารถนำมาใช้เป็นเครื่องมือคัดกรองเบื้องต้นสำหรับภาวะเมตาบอลิคซินโดรมได้ โดยกำลังพลสามารถทำได้ด้วยตนเองเพื่อเป็นการป้องกันและเฝ้าระวังการเกิดภาวะเมตาบอลิคซินโดรม

*Keywords:*   ● *ภาวะเมตาบอลิคซินโดรม*  ● *จุดตัดเส้นรอบวงเอว*  ● *กำลังพลกองทัพบก*
                ● *การวิเคราะห์ Receiver operating characteristic curve*

**เวชสารแพทย์ทหารบก 2558;68:147-53.**