The Prevalence of Metabolic Syndrome According to Various Definitions and Hypertriglyceridemic-Waist in Malaysian Adults

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Date of Submission: Feb 23, 2011
Date of Acceptance: May 12, 2011

INTRODUCTION

Metabolic syndrome is known as the clustering of several metabolic abnormalities; centrally distributed obesity, low high density lipoprotein cholesterol (HDL-C), elevated triglycerides, high blood pressure, and hyperglycaemia.¹ It is associated with increased morbidity and mortality. Since WHO proposed the first criteria in 1998, many organizations have used the criteria to classify patients with metabolic syndrome. Currently, the common definitions used to define metabolic syndrome are based on International Diabetes Federation (IDF),² National Cholesterol Education Program Adult Treatment Program III (NCEP ATPIII),³ and World Health Organization (WHO) criteria.⁴ Asian ethnicity was suggested to be more predisposed to metabolic syndrome than other...
A recent study showed that the prevalence of metabolic syndrome ranged from 35.8% to 45.3% in India and 30.5% to 31.5% in China. In a study based in Malaysia, the prevalence of metabolic syndrome according to IDF, NCEP ATP III, and WHO definitions were 22.9%, 16.5% and 6.4%, respectively.

Central obesity plays a very important role in diagnosing metabolic syndrome. Metabolic syndrome risk factors have been found to be correlated with visceral adipose tissue accumulation. Even in the absence of hyperglycemia and elevated low density lipoprotein cholesterol, metabolic syndrome can substantially increase the risk of coronary artery disease. Therefore, Lemieux et al. proposed a simple and inexpensive tool known as 'hypertriglyceridemic-waist' to identify individuals at risk of developing coronary artery disease.

One local study was carried out on the prevalence of metabolic syndrome in Malaysian based on the IDF, NCEP ATP III, and modified WHO definitions. It also investigated the concordance between different metabolic syndrome criteria but did not analyze the concordance with hypertriglyceridemic-waist. To our knowledge, there was no published report on the concordance between IDF criteria with NCEP ATP III criteria, modified WHO criteria and hypertriglyceridemic-waist criteria in Malaysia. Therefore, the first objective of this study was to estimate the prevalence of metabolic syndrome in Kelantan. In addition, the second objective of the study was to determine the concordance between the IDF definition for metabolic syndrome with NCEP ATP III, modified WHO definition and hypertriglyceridemic-waist.

**METHODS**

This was a cross-sectional study in Bachok district (East-coast Malaysia) involving three subdistricts; Tawang, Mahligai and Bekelam where five villages were selected using the multi-stage random sampling method. Participants were recruited by convenience sampling based on the inclusion criteria. A total of 298 respondents participated in this study. The inclusion criteria were individuals aged between 18 to 70 years old, volunteered and agreed to participate in the study, completed the questionnaire and clinical test, not pregnant and not under insulin medication if they were diabetic. This study was approved by the Human Research Ethics Committee of Universiti Sains Malaysia. Data collection and health screening was held at a local mosque on weekends as most of male participants were working on weekdays.

A simple questionnaire was administered on one-to-one basis to collect information on socio-demographic variables, medical history, and medication. This questionnaire was not validated as data obtained from this questionnaire was not intended to be used in any statistical analysis. These data was collected for record purposes only.

Height was measured to the nearest 0.1 cm using the portable stadiometer (Seca, Germany). Weight was measured in the upright position to the nearest 0.1 kg using body composition monitor (TANITA BC 545, Japan). BMI (body mass index) was calculated by dividing weight (kg) by height squared (m$^2$). Waist circumference measurements were taken at the end of normal expiration in a horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest. Hip measure was taken as the greatest circumference at the level of greater trochanters (the widest portion of the hip) on both sides. All measurements were made to the nearest cm. Waist-hip-ratio (WHR) was calculated by dividing waist circumference (cm) by hip circumference (cm).

Blood pressure was measured using automated blood pressure monitor (Omron, Germany). Measurements were taken when participants were in resting positions with their hands resting on an adjutant table so that the cuffs were at same level with the heart. Blood pressure was measured three times and the mean value was used in the analysis.

Venous blood samples were collected from the forearm of participants in the morning after ten hours fasting. The samples were stored in an ice box and were centrifuged at 3500rpm for ten minutes. The specimens were stored at -20°C until required for laboratory use. Serum samples were analyzed for triglycerides and high density lipoprotein cholesterol. Plasma samples were used to measure glucose levels.

All laboratory assays were performed using commercially available kits (Randox, UK). All analyses were done using SELECTRA-E chemistry analyzer (Vital Scientific, Netherlands) in the Central Research Lab, Universiti Sains Malaysia.

Table 1 depicts the definitions of metabolic syndrome according to the IDF, NCEP ATP III, modified WHO definition, and hypertriglyceridemic-waist. Modified WHO definition of metabolic syndrome was adapted from Tan et
al. while hypertriglyceridemic-waist definition was adapted from Ma et al. The modified WHO criterion of metabolic syndrome differed from the proposed WHO definition through the exclusion of serum insulin and urine albumin excretion measurements.

**Statistical analysis**

Statistical analyses were conducted using the SPSS 18.0 statistical software package (SPSS Inc., Chicago, IL). All data are presented as mean and standard deviation (SD). Significant differences in general characteristics were established using $\chi^2$ and student’s t-test. Agreement between the different metabolic syndrome definitions were analyzed using the percentage of concordant cases and the Kappa index, which is considered excellent for values > 0.81, good for values 0.61-0.80, moderate for values between 0.41-0.60 and weak for values < 0.40. P-values less than 0.05 were considered as statistically significant.

**RESULTS**

The baseline characteristics of the participants based on sex are shown in Table 2. The mean age for males and females had 49.82 ± 11.74 and 48.58 ± 11.67 years of age, respectively. Males were older, showed larger waist circumference and higher fasting plasma glucose level. However, their BMI and HDL-C level were lower than female participants.

Table 3 shows the prevalence of metabolic syndrome according to IDF, NCEP ATP III and modified WHO criteria and the prevalence of hypertriglyceridemic-waist. Prevalence of metabolic syndrome by IDF definition showed the highest prevalence (32.2%); followed by NCEP ATP III (28.5%) and modified WHO (12.4%) respectively. The prevalence of hypertriglyceridemic-waist was 19.7%. Overall, female participants showed higher prevalence of metabolic syndrome and hypertriglyceridemic-waist compared to male participants. Participants aged

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**Table 1. Metabolic syndrome defined by the IDF, NCEP ATP III, and modified WHO used in this study and hypertriglyceridemic-waist definition.**

| Risk factors                  | IDF Alberti et al (2005) | NCEP ATP III (2001) | Modified WHO (Tan et al., 2008) | Hypertriglyceridemic-waist (Ma et al., 2010) |
|------------------------------|--------------------------|---------------------|-------------------------------|---------------------------------------------|
| Metabolic syndrome           | Waist circumference plus any 2 factors | Three or more of the following factors | Diabetes (fasting plasma glucose > 6.1 mmol/L) or previously diagnosed diabetes type 2 plus any 2 factors | - |
| Central obesity - BMI/WHR    | -                        | -                   | WHR: male (0.9), female: 0.8 or BMI > 30 kg/m$^2$ | - |
| Central obesity - Waist circumference BMI/WHR | Male: > 90 cm, Female: > 80 cm | Male: > 102 cm, Female: > 88 cm | Male: > 90 cm, Female: > 80 cm |
| Raised blood pressure        | $\geq$ 130/85 mmHg/ treatment of previously diagnosed hypertension | $\geq$ 130/85 mmHg | $\geq$ 140/90 mmHg/ treatment of previously diagnosed hypertension | - |
| Raised triglycerides         | $\geq$ 1.7 mmol/L (150 mg/dL) or specific treatment for this lipid abnormality | $\geq$ 1.7 mmol/L (150 mg/dL) | $\geq$ 1.7 mmol/L (150 mg/dL) | $\geq$ 1.7 mmol/L |
| Raised fasting plasma glucose| $\geq$ 5.6 mmol/L (100 mg/dL) or previously diagnosed diabetes type 2 | $\geq$ 5.6 mmol/L (100 mg/dL) or previously diagnosed diabetes type 2 | 6.1 mmol/L or previously diagnosed with diabetes type 2 | - |
| Reduced HDL-C                | Male: < 1.03 mmol/L, Female: < 1.29 mmol/L or specific treatment for this lipid abnormality | Male: < 1.03 mmol/L, Female: < 1.29 mmol/L | Male: < 0.9 mmol/L, Female: < 1.0 mmol/L | - |

BMI: body mass index, WHR: waist-hip ratio, HDL-C: high density lipoprotein-cholesterol
more than 40 years were more associated with metabolic syndrome and hypertriglyceridemic-waist.

Table 4 exhibits the prevalence of central risk factors of metabolic syndrome in participants. Based on IDF and NCEP ATPIII definitions, more than half of the participants had high blood pressure and low HDL-C levels. The common risk factor according to modified WHO definition was central obesity which was defined using the waist to hip ratio. However, the least common risk factor varied according to definition. According to IDF, NCEP ATP III and modified WHO definition, central obesity, elevated fasting triglycerides level and low HDL cholesterol level were the least common risk factors respectively. Among hypertriglyceridemic-waist participants, almost half of them had central obesity.

The sensitivity and specificity of the IDF definition for detecting metabolic syndrome by the NCEP ATP III, modified WHO definition, hypertriglyceridemic-waist and κ statistics are shown in Table 5. The IDF definition of metabolic syndrome was successful in diagnosing up to 69.8% of participants with metabolic syndrome defined by NCEP ATPIII. However, the IDF definition failed to recognize 9.8% of normal participants as defined by NCEP ATPIII (sensitivity = 69.8%, specificity = 90.2%).

The κ statistic between IDF definition and modified WHO definition was 0.26. The IDF definition detected only 58.3% of participants with hypertriglyceridemic-waist. The IDF definition failed to recognize 2.5% of normal participants defined by hypertriglyceridemic-waist. The κ statistic between IDF definition and hypertriglyceridemic-waist was 0.62.

**DISCUSSION**

In this study, the prevalence of metabolic syndrome ranged from 12.4% to 32.2% using three different definitions. Prevalence defined by IDF definition showed the highest percentage followed by NCEP ATPIII and modified WHO definition. This result is consistent with a recent study by Mohamud et al. The prevalence found in this nationwide study in Malaysia were 32.1%, 34.3%, 37.1% and 42.5% according to WHO, ATPIII, IDF and ‘harmonized’ definition, respectively. In Korea, the prevalence of metabolic syndrome using IDF and NCEP ATPIII criteria were 19.5% and 18.8%. In CURES-34 study, Deepa et al. reported that the prevalence

**Table 2. General characteristic of the study participants by gender**

| Characteristics          | Male (n = 124) Mean ± SD | Female (n = 175) Mean ± SD | P-value*  |
|--------------------------|--------------------------|---------------------------|-----------|
| Age (years)              | 49.82 ± 11.74            | 48.58 ± 11.67             | >0.05     |
| BMI (kg/m²)              | 24.51 ± 3.58             | 26.27 ± 4.54              | <0.05     |
| Waist circumference (cm) | 86.26 ± 10.32            | 82.28 ± 11.67             | >0.05     |
| Systolic blood pressure (mmHg) | 135.86 ± 21.84          | 134.53 ± 23.65            | >0.05     |
| Diastolic blood pressure (mmHg) | 79.19 ± 11.05           | 79.21 ± 11.35             | >0.05     |
| Fasting plasma glucose (mmol/L) | 5.87 ± 2.74              | 5.53 ± 1.82               | <0.05     |
| Fasting triglycerides (mmol/L) | 1.72 ± 0.85              | 1.38 ± 0.83               | >0.05     |
| Fasting HDL-cholesterol (mmol/L) | 1.16 ± 0.28              | 1.25 ± 0.30               | >0.05     |
Table 3. The prevalence of metabolic syndrome according to IDF, NCEP ATP III and modified WHO criteria and the prevalence of hypertriglyceridemic-waist

| Definitions of metabolic syndrome | Hypertriglyceridemic-waist |
|----------------------------------|---------------------------|
| n (%)                            | IDF (%) | NCEP ATP-PIII (%) | WHO (%) | n (%) |
| Gender                           |         |                  |         |       |
| Male                             | 124 (41.7) | 33 (34.4) | 25 (29.4) | 17 (45.9) | 28 (47.5) |
| Female                           | 174 (58.3) | 63 (65.6) | 60 (70.6) | 20 (54.1) | 31 (52.5) |
| Total                            | 298 (100) | 96 (32.2) | 85 (28.5) | 37 (12.4) | 59 (19.7) |
| Age groups (years)               |         |                  |         |       |
| 18-19                            | 6 (2.0) | 2 (2.1) | 2 (2.4) | 0 (0) | 2 (3.4) |
| 20-29                            | 12 (4.0) | 4 (4.2) | 2 (2.4) | 0 (0) | 2 (3.4) |
| 30-39                            | 45 (15.2) | 11 (11.6) | 9 (10.7) | 1 (2.7) | 7 (12.1) |
| 40-49                            | 90 (30.3) | 28 (29.5) | 20 (23.8) | 12 (32.4) | 18 (31.0) |
| 50-59                            | 80 (26.9) | 27 (28.4) | 27 (32.1) | 13 (35.1) | 19 (32.8) |
| 60-69                            | 57 (19.2) | 22 (23.2) | 22 (26.2) | 10 (27.0) | 10 (17.2) |
| >70                              | 7 (2.4) | 1 (1.1) | 2 (2.4) | 1 (2.7) | 0 (0) |

Details of the IDF, NCEP ATPIII, modified WHO for defining metabolic syndrome and hypertriglyceridemic-waist were described in Table 1.

The prevalence of metabolic syndrome was highest using the IDF definition (25.8%), followed by WHO definition (23.2%) and NCEP ATP III definition (18.3%). The variation in defining the central obesity using IDF criteria is likely the main reason for the differences found in the prevalence of metabolic syndrome. According to the IDF definition, a lower cut off point is needed to define the subject as having central obesity compared to NCEP ATP III. The IDF also requires central obesity as the prerequisite in the determination of metabolic syndrome.

Table 4. Prevalence (95% CI) of components of metabolic syndrome and hypertriglyceridemic-waist (n= 298)

| Metabolic abnormalities | IDF | NCEP ATP III | Modified WHO | Hypertriglyceridemic-waist |
|-------------------------|-----|--------------|--------------|---------------------------|
|                         | % (95% CI) | % (95% CI) | % (95% CI) | % (95% CI) |
| Central obesity         | 48.8(43.2-54.5) | 18.3(13.9-22.6) | 52.2(46.2-57.8) | 48.8(43.2-54.5) |
| Elevated fasting plasma glucose | 29.3(24.2-34.4) | 29.3(24.2-34.4) | 17.8(13.5-22.1) | - |
| Elevated triglycerides  | 28.9(23.8-33.9) | 28.9(23.8-33.9) | 28.9(23.8-33.9) | 28.9(23.8-33.9) |
| Reduced HDL-C           | 51.0(45.3-56.7) | 51.0(45.3-56.7) | 15.7(11.6-19.8) | - |
| High blood pressure     | 53.3(47.7-58.9) | 53.3(47.7-58.9) | 37.4(32.0-42.9) | - |
| Metabolic syndrome      | 32.2(26.9-37.5) | 28.5(26.9-37.5) | 12.4(8.7-16.2) | - |

Details of the IDF, NCEP ATPIII, modified WHO for defining metabolic syndrome and hypertriglyceridemic-waist were described in Table 1.
Table 5. Sensitivity, specificity and level of agreement for metabolic syndrome defined by IDF definition against NCEP ATP III, modified WHO, and hypertriglyceridemic-waist

| Definition                        | MS (n) | Normal (n) | Sensitivity (%) | Specificity (%) | Kappa index | P-value |
|----------------------------------|--------|------------|----------------|-----------------|-------------|---------|
| NCEP ATP III                     | 67     | 18         | 69.8           | 90.2            | 0.63        | <0.001  |
| Modified WHO                     | 26     | 11         | 27.1           | 93.6            | 0.26        | <0.001  |
| Hypertriglyceridemic-waist       | 56     | 3          | 58.3           | 97.5            | 0.62        | <0.001  |

Details of the IDF, NCEP ATP III, modified WHO for defining metabolic syndrome (MS) and hypertriglyceridemic-waist (HW) were described in Table 1.

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syndrome is more prevalent as age increases.

The prevalence of hypertriglyceridemic-waist was 19.7%. In the Quebec Health Survey, 19% of the respondents had an elevated waist circumference and elevated triglycerides level. In a cohort study located in France, the prevalence of hypertriglyceridemic-waist was 26.2%. In another study by LaMonte et al. among 137 postmenopausal women, 11% of the participants were found to have hypertriglyceridemic-waist. The prevalence of hypertriglyceridemic-waist in the present study was higher because of the lower value used in defining hypertriglyceridemic-waist in previous studies.

Limited studies have been conducted in the area of hypertriglyceridemic-waist since the concept was introduced in 2000. Hypertriglyceridemic-waist was proposed as an alternative and cost-effective tool to assess cardiometabolic risk that was also associated with metabolic syndrome. However, to define metabolic syndrome, all five components as listed in Table 1 must be investigated. In clinical setting, the availability and accessibility of some of these components or markers are difficult. In contrast, hypertriglyceridemic-waist only requires waist circumference and triglycerides level for its determination. Thus, hypertriglyceridemic phenotype represents a simple and inexpensive tool to screen for high risk participants. This method may suite in poor and developing countries as it is not costly, does not require complicated machinery or technology, and is relatively simple to conduct hence perhaps cater the need of the low income population with higher cases of obesity but received limited healthcare.

Current study found that metabolic syndrome was more common among female participants. There are some studies in line with this finding. Pregnancy, lactation, gestational diabetes mellitus, preeclampsia, hormonal contraceptives, menopause and polycystic ovary syndrome are several factors unique to women that can impact the prevalence and characteristics of metabolic syndrome in women. In addition, higher prevalence of metabolic syndrome among women may be due to different socioeconomic status, work-related activities, and cultural perception on body image. Santos et al. found that the odds favoring metabolic syndrome decreased significantly with education level and social class.

Other than gender, another factor that contributes to the prevalence of metabolic syndrome was age. Participants aged more than 40 years old exhibited higher prevalence of metabolic syndrome and hypertriglyceridemic-waist than younger participants. The same finding was observed in other surveys. According to Son et al. this trend might be contributed by the increasing trend of components such as aging. We also found that the prevalence of hypertriglyceridemic-waist increased with age. Participants aged more than 40 years old showed the higher prevalence compared to younger participants. Abdominal fat and triglycerides increases with age. The prevalence was higher as the respondents got older. Gomez-Huelgas et al. also stated that hypertriglyceridemic-waist
increased with age, where the prevalence reached as high as 25% in those aged 50-59 years old.

There were substantial differences in distribution of each trait in men versus women. Male participants exhibited larger waist circumference, higher systolic blood pressure, fasting blood glucose and triglycerides level. Female participants showed higher BMI, diastolic blood pressure and low HDL cholesterol. The result was in agreement with Tan et al.\(^8\) Based on findings of the Malaysian Adult Nutrition Survey, female participants were significantly obese compared to male counterparts.\(^31\) However, findings by Rampal et al.\(^32\) showed that male participants had significantly higher systolic and diastolic blood pressure compared to female participants. Mafauzy et al.\(^33\) found that female participants showed higher prevalence of impaired glucose tolerance compared to male participants. In contrast, males generally have higher total cholesterol levels than females and the total cholesterol increases as age increases.\(^36\)

The total cholesterol level in Malaysia showed an increasing trend. The population cholesterol level rose from 4.9 mmol/L in 1960\(^5\) to 5.7 mmol/L in 1997.\(^35\)

In present study, the common abnormality showed by the participants defined by IDF and ATPIII criteria was high blood pressure. Rampal et al.\(^32\) reported that the prevalence of hypertension for those aged more than 30 years old is rising as the number increased from 32.9% in 1996 to 40.5% in 2004. The most common abnormality by modified WHO criteria was central obesity which was defined using waist-to-hip ratio. The second and third most common components of metabolic syndrome defined by IDF criteria were low HDL cholesterol level and central obesity.

These findings are in line with another study in Malaysia\(^6\) where elevated blood pressure, central obesity and low HDL cholesterol level were the common abnormalities. The second and third most common components of metabolic syndrome defined by ATPIII were low HDL cholesterol level and elevated fasting blood glucose level, while according to modified WHO definition were high blood pressure and elevated triglycerides level respectively.

Similar to other studies,\(^8,37\) a good agreement between IDF and NCEP ATP III definition of metabolic syndrome and a weak agreement between IDF and modified WHO definition was found in this study. The good agreement between IDF and NCEP ATP III was expected as both IDF and NCEP ATPIII definitions shared similar criteria except for the waist circumference.

Poor agreement between IDF and modified WHO criteria is likely a result of the prerequisite of diabetes mellitus. There was also a good agreement between IDF definition and hypertriglyceridemic-waist. Gomez Huelgas et al.\(^30\) reported that hypertriglyceridemic-waist showed a moderate agreement with metabolic syndrome defined by IDF and ATPIII definitions. High concordance was expected as IDF definition and hypertriglyceridemic-waist had overlapped values for the waist circumference and fasting triglycerides level. Although with less measured parameter, the hypertriglyceridemic-waist could still show high agreement with IDF criteria.

However, the low prevalence of hypertriglyceridemic-waist (19.7%) as compared to the IDF definition (32.2%) in this study may not favor hypertriglyceridemic-waist to be used as a tool for detecting individuals with metabolic syndrome. Further modification of hypertriglyceridemic waist criteria such as addition of HDL-C parameter may increase the detection of individuals with metabolic syndrome. Unfortunately, this may increase the costs of using this new criterion and deviate from the main objective of using it in poor countries. Further research looking at the possibility of modifying hypertriglyceridemic-waist criteria can be carried out to increase its application in metabolic syndrome and other chronic diseases.

Several limitations of this study should be noted. First of all, it is a non-representative cross-sectional study; hence, a causal relationship could not be defined. The variance in variables made the causal analyses impractical, as in some instances there were too few cases for computation. Secondly, the study population was relatively small and predominantly female, which limits the generalizability of the findings. Gender bias in hypertriglyceridemic-waist measurement may be due to the higher number of female respondents. Another factor was the age of female participants where majorities were more than 30 years old. There is substantive evidence that hypertriglyceridemic-waist is associated with older women in especially those in the 55-64 years old age group.\(^30\) Hypertriglyceridemic-waist was also associated with lower education level and presence of obesity.\(^30\)

In conclusion, the prevalence of metabolic syndrome using the IDF definition was the highest among the three criteria. IDF definition
showed a good concordance with NCEP ATPIII definition. Modified WHO criteria might erroneously underestimate metabolic syndrome because of lowest prevalence. As hypertriglyceridemic-waist showed a good concordance with IDF definition, it might be suggested that hypertriglyceridemic-waist may be used as the first screening phenotype to identify a subgroup of individuals likely to be characterized by a cluster of features of the metabolic syndrome, especially in developing countries. Due to the rapid increase of metabolic syndrome prevalence it is prime time for action in the detection and prevention of metabolic syndrome across all ages in Malaysia.

ACKNOWLEDGEMENTS
We would like to thank all the participants who participated in this study, and Dr Geshina Ayu Mat Saat for her assistance in proofreading this manuscript.

Conflict of interest statement: All authors declare that they have no conflict of interest.

Source of funding: Universiti Sains Malaysia by funding the research (Research University Grant 1001/PPSK/812022) and Universiti Sultan Zainal Abidin Malaysia and Public Service Department of Malaysia by funding the scholarship for Laila Ruwaida.

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