Mal J Nutr 14 (1): 65 - 77, 2008

Prevalence of Metabolic Syndrome among Malaysians using the International Diabetes Federation, National Cholesterol Education Program and Modified World Health Organization Definitions

Bee Ying Tan[1], Haresh Kumar Kantilal[1] & Rajbans Singh[2]

[1] *Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, 53300 Kuala Lumpur Malaysia*
[2] *Pantai Medical Center, Bangsar, Kuala Lumpur, Malaysia*

ABSTRACT

The World Health Organization (WHO), National Cholesterol Education Program Adults Treatment Panel III (NCEP ATP III) and International Diabetes Federation (IDF) have proposed different criteria to diagnose metabolic syndrome (MetS). However, there is no single definition to accurately diagnose MetS. The objective of this study is to estimate the prevalence of MetS using WHO, NCEP ATP III and IDF in the Malaysian community, and to determine the concordance between these definitions for MetS. 109 men and women aged $\geq$ 30 years participated in the study, and the prevalence of MetS was determined according to the three definitions. Weight, height, body mass index (BMI), waist-hip circumference, blood pressure, blood lipid profile and plasma fasting glucose were measured. In order to determine the concordance between IDF and the other two definitions, the kappa index (κ-test) was used. The prevalence of MetS (95% confidence interval) was 22.9% (22.8-23.1) by IDF definition, 16.5% (16.3-16.9) by NCEP ATP III definition and 6.4% (6.2-6.6) by modified WHO definition. The sensitivity and specificity of IDF against NCEP ATP III were 88.9% and 90.1% respectively, IDF against WHO definition were 85.7% and 81.4%. The κ statistics for the agreement of the IDF definition was 68.3 $\pm$ 0.1 with the NCEP ATP III, and 30.5 $\pm$ 0.1 with the modified WHO definition. The prevalence of the MetS among respondents using the IDF definition was highest, followed by NCEP ATP III, and finally modified WHO definition. There was a good concordance between the IDF and NCEP ATP III definitions, and a low concordance between IDF and modified WHO definitions.

INTRODUCTION

Reaven (1988) introduced the concept of syndrome X for the clustering of cardiovascular risk factors like hypertension, glucose intolerance, high serum triglycerides and low high density lipoprotein (HDL) cholesterol concentrations. Nowadays, several other metabolic abnormalities have been associated with this

Correspondence author: Bee Ying Tan; Email: *beeying4011@yahoo.com*

syndrome including obesity, microalbuminuria, hyperuricemia, nephropathy, low tissue plasminogen activator, abnormalities in fibrinolysis and coagulation (Hansen, 1999). This condition was previously called insulin resistance (IR) syndrome (Undurti, 2002), and the term of metabolic syndrome (MetS) was accepted in 1998. The World Health Organization (WHO) in 1998 (Alberti & Zimmet, 1998), and the United States National Cholesterol Education Program's Adult Treatment Panel III (NCEP ATP III) in 2001 proposed the diagnostic criteria for MetS that established the cut-off points for five risk factors: abdominal girth, blood pressure, serum cholesterol, plasma triglycerides, and fasting blood glucose (NCEP, 2001). However, the WHO definition of MetS has been modified for the use of epidemiological studies (Laaksonen *et al.*, 2002) as proposed, in part, by The European Group for the Study of Insulin Resistance, which excluded microalbumin from the definition of MetS (Balkau & Charles, 1999). Besides, the NCEP ATP III criteria were updated in 2005 to correspond with the new American Diabetes Association (ADA) standard of a normal fasting glucose level of less than 100mg / dL (Grundy *et al.*, 2005). In 2005, the International Diabetes Federation (IDF) formulated a new, clinically accessible worldwide definition of the MetS in a global consensus statement built on earlier definitions (Balkau & Charles, 1999; NCEP, 2001).

The new IDF definition takes into account the mounting evidence that abdominal adiposity is common to each of the components of the MetS. Under this new definition, an increased waist circumference (well accepted proxy measurement for abdominal adiposity) is a necessary requirement for the diagnosis of the MetS. Previous studies have shown that between population groups, a variation in the levels of obesity exists at which the risk of other health condition begins to rise (Eckel, Grundy & Zimmet, 2005). Therefore, ethnicity and gender-specific waist circumference cut-off value have been incorporated into the new IDF definition (Zimmet, Alberti & Shaw, 2005).

The prevalence of MetS varied markedly between different studies. A report from Glassock (2004) estimated that 55 million adults in the United States have MetS, meaning that in the United States, one in three overweight or obese persons have the risk of getting MetS. Obesity is known as excessive body fat measured as body mass index (BMI) of more than 30 kg / m^2 or waist circumference of more than 102 cm in men and 88 cm in women (Alberti & Zimmet, 1998). Due to the worldwide epidemic character of overweight, the numbers of individuals with MetS has been increasing in recent years. The current evidence conclusively shows that presence of MetS is a 'precursor' to future coronary heart disease (CHD) diagnosed by coronary angiography (Hu *et al.*, 2000; Kyung *et al.*, 2006). Since MetS is a disorder of multiple metabolic conditions, each of the five components mentioned have been reported to increase the risk of CHD. Global risk assessment, a clinical approach, recognised that multiple risk factors occurring simultaneously can discriminate risk better than individual risk factors alone (Grundy *et al.*, 1999), and the global risk was reported to be 2.47 times higher when the five risks coexisted simultaneously (Solymoss *et al.*, 2003).

However, only few studies have been carried out on the prevalence of the MetS in Malaysia based on the NCEP ATP III definitions and its prevalence by the IDF and the WHO criteria is unknown. Thus, the objective of this study was to estimate sex-specific prevalence of MetS according to the IDF, NCEP ATP III and modified WHO definitions (which lacked the measurement of serum insulin and urine albumin excretion) in the Malaysian community. Besides, the second objective is to determine the mean value for each criterion of MetS among 109 subjects by gender. In addition, the third objective of the study is to determine the concordance between the new IDF definition for MetS with the NCEP ATP III and modified WHO definitions.

MATERIALS AND METHODS

Subjects

Subjects were recruited randomly by an individual researcher by interviewing and accepting volunteers by word-of-mouth to people in their practices, friends and family members over a period of 6 months. A total of 109 volunteers in Federal Territory and Selangor participated in this study. Acceptance of subjects was designed to include the widest possible range of the general population available.

Inclusion criteria were any individual, male and female, 30 to 65 years old, residing in Federal Territory and Selangor, not on medication or under the care of a physician, who volunteered and agreed to sign the consent form to participate in the study.

The idea was to investigate the prevalence of MetS in apparently healthy individuals who do not show or complain of any clinical symptoms of MetS. The symptoms of MetS will show among people who are 30 years old and above for both males and females. In considering the precision and accuracy of the study, subjects' exclusion were any volunteers below 30 years old or above 65 years of age, or who is currently under medication, under treatment for psychotic disorder, or who had been hospitalised within the last year for hypertension, diabetes, hypertriglyceridemia, cancer, or heart disease.

METHODS

Subjects who participated in this study were interviewed at home, and underwent a health screening program in a health screening centre. Before the subjects underwent health screening, they were required to fill out a simple structured questionnaire which surveyed demographic factors, socio-economic status, dietary, current lifestyle, self-reported family medical history on hypertension, hyperlipidemia, diabetes and cardiovascular disease.

Height was measured in a standing position without shoes, using a tape meter while shoulders were in a normal state, and body weight was measured while subjects were minimally clothed without shoes, using a digital scale and recorded to the nearest 100 g. Body mass index (BMI, kg/m^2) was calculated from the formula of body weight divided by squared height. Waist circumference was measured at the narrowest point between the lower borders of the rib cage and iliac crest using an outstretched tape meter, without any pressure to body surface, and was recorded to the nearest 0.1 cm. Blood pressure was measured using a digital blood pressure monitor in seated position after a 15-minute rest period. Three measurements were made on all subjects at 5-minute intervals. The average of three measurements was used in data analysis. Blood samples were collected from subjects in the morning after an overnight fasting, and analysed for serum triglyceride, high density lipoprotein cholesterol, and plasma fasting glucose levels.

The MetS was defined according to each of the IDF and NCEP APT III and modified WHO definitions as described in Table 1. The modified version of WHO definition used in this study differed from the proposed WHO definition (WHO, 1999) in such a way that the measurements of serum insulin and urine albumin excretion were removed from the definitions.

Statistical analysis

Statistical analyses were carried out using the SPSS 12.0 statistical software package (SPSS Inc., Chicago, IL). All data are presented as mean ± standard deviation (SD). Significant differences in general characteristics were searched using χ^2 and student's *t*-test. Agreement between the different MetS definitions was analysed using the percentage of concordant cases and the Kappa index, which was considered excellent for values > 0.81, good for values 0.61-0.80, moderate for 0.41-0.60 and weak for values < 0.40 according to Altman (1991). Values of $p < 0.05$ were considered as statistically significant.

RESULTS

A total of 109 subjects consisting of 44 males and 65 females participated in this study (Table 2). The majority of subjects in this study were Chinese (77.1%), followed by Indians (13.8%) and Malays (9.2%). The overall prevalence of the MetS (95% confidence interval) according to the IDF, NCEP ATP III, and modified WHO definitions were 22.9% (22.8-23.1), 16.5% (16.3-16.7), and 6.4% (6.17-6.6) respectively.

The prevalence of the MetS in males and females were 40.9% and 10.8% by the IDF definition, 29.6% and 7.7% by the NCEP ATP III definition, 11.4 % and 3.1% by the modified WHO definition respectively. The study showed that Malays had the highest prevalence of MetS defined by IDF (50.0%), and Indians had the highest prevalence of MetS defined by NCEP ATP III and modified WHO with 33.3% and 13.3% respectively. Meanwhile, Chinese had the lowest prevalence of MetS with 17.7%, 11.9% and 4.8% respectively. Going by age groups, subjects aged 60 years and above exhibited the highest prevalence of MetS (50.0%) by IDF definitions compared to other age groups. As for NCEP ATP III and modified WHO definition, subjects aged between 50-59 years had the highest prevalence of MetS with a percentage of 31.4% and 11.4% respectively. Thus, there was a steady increase in the prevalence of MetS with advancement in age.

The baseline characteristics of the study subjects based on gender are shown in Table 3. The mean age ± SD of the study population was 43.3 ± 10.5 years (male, 46.2 ± 9.7 years; female, 41.3 ± 10.6 years). The mean for BMI, waist circumference, systolic and diastolic blood pressure, fasting plasma glucose, triglycerides and HDL cholesterol were significantly higher in males then in females ($p < 0.01$).

As shown in Table 4, according to both the IDF and NCEP ATP III definitions, over 40.0% of the subjects had low HDL cholesterol, whereas only 10.1% of the subjects had low HDL cholesterol using the modified WHO definition. High plasma glucose was the least common component according to these three definitions (13.8%, 13.8% and 11.9% respectively). High blood pressure defined by IDF, NCEP ATP III and modified WHO showed the highest prevalence of 43.1%, 43.1% and 33.0% respectively. Obesity was observed in 40.4% of the participants by the IDF, and 14.7% by NCEP ATP III, while 19.3% of the subjects were obese using the modified WHO definition. It was found that 17.4% of the subjects had a high level of triglycerides according to the IDF, NCEP ATP III and modified WHO definitions.

Table 5 shows the mean value for the subjects diagnosed with MetS defined by IDF, NCEP ATP III and modified WHO. As

Table 1. MetS defined by the IDF, NCEP ATP III and modified WHO definitions used in this study

IDF definition	*NCEP ATP III definition*	*Modified WHO definition*
Central obesity : defined as waist circumference ≥ 90 cm for Asian men, and ≥ 80 cm for Asian women, with ethnicity specific values for other groups (Zimmet *et al.*, 2005)		Diabetes (fasting plasma glucose ≥ 6.1 mmol/L) or previously diagnosed type 2 diabetes.
Plus any two of the following four factors	Three or more of the following	Plus any two of the following four factors
	Central obesity: defined as waist circumference > 102 cm for men and > 88 cm for women	Obesity: BMI > 30 kg/m^2, or Waist-hip ratio > 0.9 in men and > 0.85 in women
Raised triglycerides level: ≥ 1.69 mmol/L (150 mg/dL), or specific treatment for this lipid abnormality	Raised triglycerides level: ≥ 1.69 mmol/L (150 mg/dL)	Dyslipidemia: triglycerides level > 1.69 mmol/L (150 mg/dL) or
Reduced HDL cholesterol: < 1.03 mmol/L (40 mg/dL) in men, and < 1.29 mmol/L (50 mg/dL) in women or on treatment for lipid abnormality	Reduced HDL cholesterol: < 1.03 mmol/L (40 mg/dL) in men, and < 1.29 mmol/L (50 mg/dL) in women.	HDL-choleseterol < 0.90 mmol/L (35 mg/dL) in men and < 1.0 mmol/L (39 mg/dL) in women
Raised blood pressure: ≤ 130/85 mmHg or treatment of previously diagnosed hypertension	Raised blood pressure: ≤ 130/85 mmHg	Raised blood pressure: ≥ 140/90 mmHg or treatment of previously diagnosed hypertension
Raised fasting plasma glucose: ≥ 5.6 mmol/L (100mg/dL) or previously diagnosed type 2 diabetes	Raised fasting plasma glucose: ≥ 5.6 mmol/L (100 mg/dL) or previously diagnosed type 2 diabetes	

shown, subjects diagnosed with MetS defined by modified WHO had the highest mean of BMI (30.0 ±3.8), mean of waist circumference (96.8 ±8.1), diastolic blood pressure (91.8 ±7.7), fasting plasma glucose (7.7 ±2.6) and mean triglycerides (3.1 ±2.1), while the mean of HDL cholesterol was the lowest according to this definition (0.9 ±0.1). Results show that mean values for IDF and NCEP ATP III for age, BMI, systolic blood pressure, and HDL cholesterol were approximately the same.

Table 2. Prevalence of MetS according to the IDF, NCEP ATP III and modified WHO definitions

	n (%)	*Definitions of MetS*		
		IDF (%)	*NCEP ATP III (%)*	*Modified WHO (%)*
Total	109 (100.0)	25 (22.9)	18 (16.5)	7 (6.4)
Gender				
Male	44 (40.4)	18 (40.9)	13 (29.6)	5 (11.4)
Female	65 (59.6)	7 (10.8)	5 (7.7)	2 (3.1)
Ethnic group				
Malay	10 (9.2)	5 (50.0)	3 (30.0)	1 (10.0)
Chinese	84 (77.1)	15 (17.7)	10 (11.9)	4 (4.8)
Indian	15 (13.8)	5 (33.3)	5 (33.3)	2 (13.3)
Age groups (years)				
20-29	11 (10.1)	0 (0.0)	0 (0.0)	0 (0.0)
30-39	30 (27.5)	4 (13.3)	3 (10.0)	1 (3.3)
40-49	31 (28.4)	8 (25.8)	3 (12.9)	2 (6.45)
50-59	35 (32.1)	12 (34.3)	11 (31.4)	4 (11.4)
≥ 60	2 (1.8)	1 (50.0)	0 (0.0)	0 (0.0)

Table 3. General characteristics of the subjects by gender

	Male (n=44)	*Female (n=65)*	*p-value* [a]
Age Mean ± S.D. (years)	46.2 ± 9.7	41.3 ± 10.6	< 0.05
BMI Mean ± S.D. (kg/m^2)	25.5 ± 4.00	22.9 ± 4.1	< 0.05
Waist circumference Mean ± S.D. (cm)	90.6 ± 10.4	76.0 ± 10.2	< 0.01
Systolic blood pressure Mean ± S.D. (mmHg)	135.2 ± 18.0	122.1 ± 16.5	< 0.01
Diastolic blood pressure Mean ± S.D. (mmHg)	87.5 ± 9.8	77.3 ± 10.3	< 0.01
Fasting plasma glucose Mean ± S.D. (mmol/L)	5.7 ± 2.0	4.8 ± 1.2	< 0.01
Fasting triglycerides Mean ± S.D. (mmol/L)	1.8 ± 1.4	0.8 ± 0.4	< 0.01
Fasting HDL cholesterol Mean ± S.D. (mmol/L)	1.1 ± 0.2	1.4 ± 0.3	< 0.01

[a] *t*-test; BMI: body mass index; HDL: high density lipoprotein

Table 6 shows the sensitivity and specificity of MetS defined by IDF against the NCEP ATP III and modified WHO definitions. Our study shows that IDF definition of MetS is successful in diagnosing up to 88.9% of NCEP ATP III patients with MetS; however, 9.9% of the individuals categorised as normal by NCEP ATP III were diagnosed with MetS according to IDF definitions (sensitivity = 88.9%, specificity = 90.1%). The kappa index between IDF definition and NCEP ATP III was 68.3 ± 0.09 ($p < 0.01$).

The IDF definition of MetS failed to diagnose 14.3% of modified WHO subjects with MetS, and 18.6% of the subjects who

Table 4. Prevalence of central risk factors of MetS in the subjects (n = 109)

MetS definitions	*IDF definition*		*NCEP ATP III*		*Modified WHO*	
	n	*% (95% C.I.)*	*n*	*% (95% C.I.)*	*n*	*% (95% C.I.)*
Central obesity	44	40.4 (40.2-40.5)	16	14.7 (14.5-14.9)	21	19.3 (19.1-19.5)
Glucose domain	15	13.8 (13.6-14.0)	15	13.8 (13.6-14.)	13	11.9 (11.7- 12.1)
Triglycerides domain	19	17.4 (17.3-17.6)	19	17.4 (17.3-17.6)	19	17.4 (17.3-17.6)
HDL cholesterol domain	44	40.4 (40.2-40.5)	44	40.4 (40.2-40.5)	11	10.1 (9.9-10.3)
Blood pressure domain	47	43.1 (43.0-43.3)	47	43.1(43.0-43.3)	36	33.0 (32.9-33.2)
MetS	25	22.9 (22.8-23.1)	18	16.5 (16.4-16.6)	7	6.4 (6.2-6.7)

* Details of the IDF, NECP ATP III and modified WHO criteria for defining MetS are described in Table 1.

Table 5. Comparison of the baseline characteristics according to IDF, NCEP ATP III and modified WHO among the MetS subjects

	IDF (n=25)	*NCEP ATP III (n=18)*	*Modified WHO (n=7)*
Age (years)	48.2 ± 9.1	48.0 ± 9.1	45.1 ± 9.7
BMI (kg/m^2)	28.0 ± 3.0	28.5 ± 3.0	30.0 ± 3.8
Waist circumference (cm)	94.7 ± 6.5	95.1 ± 6.6	96.8 ± 8.1
Systolic blood pressure (mmHg)	144.0 ± 15.2	143.5 ± 13.0	141.3 ± 12.5
Diastolic blood pressure (mmHg)	90.1 ± 7.9	91.6 ± 8.6	91.8 ± 7.7
Fasting plasma glucose (mmol/L)	6.3 ± 2.2	7.2 ± 2.9	7.71 ± 2.6
Triglycerides (mmol/L)	2.4 ± 1.8	2.5 ± 1.6	3.1 ± 2.1
HDL cholesterol(mmol/L)	1.0 ± 6.5	1.0 ± 0.1	0.9 ± 0.1

* Data are presented in mean (standard deviation); BMI, body mass index; HDL, high density cholesterol.

Table 6. Sensitivity, specificity and level of agreement for MetS defined by IDF against the NCEP ATP III, and modified WHO definitions

Definition	*IDF definition*					
	MetS	*Normal*	*Sensitivity*	*Specificity*	*Kappa index*	*P value*
NCEP ATP III						
MetS (%)	16 (89)	2 (11)	88.9	90.1	68.3 ± 0.1	< 0.001
Normal (%)	9 (10)	82 (90)				
Modified WHO						
MetS (%)	6 (86)	1 (14)	85.7	81.4	30.5 ± 0.1	< 0.001
Normal (%)	19 (19)	83 (81)				

were categorised as normal under the modified WHO definitions were found to have MetS under the IDF definition (sensitivity = 85.7%, specificity = 81.4%). The kappa index between IDF definition and modified WHO was 30.5 ± 0.10 ($p < 0.01$).

DISCUSSION

This is one of the first few studies in Malaysia focusing on the prevalence of MetS and comparing it using three different definitions which were IDF, NCEP ATP III and modified WHO. The study shows that the prevalence of MetS is 22.9% (40.9% of males; 10.8% of females) in Malaysian adults using the IDF definition. In contrast, the prevalence of MetS by using NCEP ATP III and the modified WHO definitions was 16.5% (29.6% of males; 7.7% of females) and 6.4% (11.4% of males; 3.1% of females) respectively.

This study showed that the prevalence of MetS defined by IDF among Malaysian adults was higher than the NCEP ATP III defined MetS. This finding is similar to the findings of the study carried out in South Australia, where the MetS was found in 22.8% of the subjects (men, 26.4%; women, 15.7%) using IDF definition, and 15.0% (men, 19.4%; women, 14.4%) with the NCEP APT III definition (Adams *et al.*, 2005). In addition, Ford (2005) reported that the prevalence of MetS in the United States was 39.0% (39.9% of men; 38.1% of women) using the IDF definition, and in contrast, 34.5% (33.7% of men; 35.4% of women) according to the NCEP ATP III. Among the Korean population, the prevalence of MetS was 19.5% (15.0% for men; 23.9% for women) using the IDF definition, and 18.8% (17.8%; for men and 20.5% for women,) according to the prevalence by NCEP ATP III definition (Choi *et al.*, 2007).

The main reason for the IDF definition to exhibit a higher prevalence is the difference in defining central obesity in the IDF criteria. In addition, the IDF definition requires the presence of central obesity as a prerequisite. To define central obesity for Malaysians, the criteria for South Asians and Chinese was used as in other studies (Lee *et al.*, 2004; Sone *et al.*, 2005; Zimmet *et al.*, 2005); this is also consistent with the obesity criteria recommended by the WHO Asia-Pacific Region (Steering Committee, 2000). According to this criteria, waist circumference threshold for central obesity is 90 cm or above for males and 80 cm or above for females. Whilst, applying the NCEP ATP III definition to the Asian population, it underestimates the prevalence of MetS and fails to diagnose many individuals with MetS. The underestimation is likely to be due to definition of central obesity, which uses the waist circumference of 102 cm or above for males and 88 cm or above for females. The prevalence of MetS using IDF and NCEP ATP III definitions was higher compared to the modified WHO defined MetS, which appeared to be concur with a study reported in Mexico (Guerrero-Romero & Rodriguez-Moran, 2005).

In contrast to the findings of this study, the Chinese in Hong Kong were found to have the lowest prevalence of MetS as defined by the IDF criteria, and these individuals showed the highest prevalence of the syndrome according to the WHO criteria (Ko *et al.*, 2006). This discrepancy could be explained by the variation in overall and central obesity in different populations. Thus, the IDF definition has established different criteria for central obesity according to the ethnic group, especially in the Asian population.

However, in this study the fact that the Chinese exhibited a lower prevalence of MetS according to all three definitions may be due to the higher numbers of Chinese subjects involved. On the other hand, the higher prevalence of MetS observed among the Malay and Indian population may be again due to the small number of subjects involved from these ethnic groups. Nevertheless, it should be stressed that this study is more inclined towards investigating the prevalence of MetS in the whole population rather than individual ethnic groups.

The increasing prevalence of MetS worldwide poses a public health challenge that needs the scientific community to accept a definition that would serve as an accessible practical tool to improve the ability of clinicians to adequately identify high-risk individuals of CVD. In addition, a standard definition could also serve as an indicator used by epidemiologists to follow the evolution of MetS prevalence and its relationship with the occurrence of obesity, CVD, and type II diabetes in different ethnic groups (Desroches & Lamarche, 2007). The IDF, NCEP ATP III and WHO definitions of MetS allow the inclusion of patients with diabetes mellitus and share the common goal of identifying individuals at increased risk for developing CVD (Johnson & Weinstock, 2006).

Nonetheless, the three definitions have merits and demerits. The IDF definition is favoured when diagnosing MetS among obese individuals. The IDF definition lays greater emphasis on central obesity as the core feature of the syndrome, making it an essential requirement for diagnosis of MetS. IDF definition has taken an important step forward by including central obesity for different ethnic populations as defined by waist circumference measurements based on epidemiologic data from various ethnic groups. The major disadvantage using the IDF definition is that a non-obese individual could go undiagnosed with MetS, even though other criteria of the syndrome may be fulfilled. On the other hand, NCEP ATP III definition is a more convenient method for the diagnosis of MetS, and it is commonly used in epidemiology studies. This is because the NCEP ATP III definition is flexible in terms of the criteria used to diagnose MetS. An individual is diagnosed with MetS under the NCEP ATP III definition if three out of the five criteria of the syndrome (obesity, high triglycerides level, low HDL level, high blood pressure and high plasma glucose) are fulfilled. As for the WHO definition of MetS, it was primarily based on the presence of one of several indices of insulin resistance as assessed by clamp studies, or by diagnosis of impaired glucose tolerance, glucose intolerance, or type II diabetes. The employment of WHO definition can under-diagnose a non-diabetic individual as healthy, although in reality there is a possibility that the person may have MetS. A study carried out by Grundy (2006) shows the relative risk of CVD to be double in patients with MetS under the WHO definition. Thus, the WHO definition of MetS is useful in identifying individuals at increased risk for developing CVD, especially in patients with diabetes mellitus.

In this study, the most common criteria for the IDF, NCEP ATP III and modified WHO was blood pressure, which can be explained by the high mean value for blood pressure in the Malaysian population. Hypertension is also known as ‘the silent killer’, and it is the most common chronic condition in many countries including Malaysia (Ibrahim & Yusoff, 2007). Hypertension is responsible for an important component of the burden of cardiovascular disease as well as a significant cost in all medical care services (Lim *et al.*, 2000). However, more than half of Malaysians were unaware of their hypertensive status or had never been told about it previously (Samad *et al.*, 2002). Obesity was the second common component of the IDF and modified WHO definition, and this may due to the high prevalence of overweight and obesity in Malaysia (Ismail *et al.*, 2002).

This study showed that subjects with MetS defined by modified WHO definition had the highest means for BMI, central obesity, diastolic blood pressure, fasting plasma glucose level, serum triglyceride level, and the lowest HDL levels compared to IDF and NCEP ATPIII definitions. The threshold for obesity, hypertension and dyslipidemia are also higher in value as compared to the other definitions of MetS; thus, this may be one of the reasons that led to the high mean values for the criteria of MetS under the modified WHO definition.

IDF defined MetS detected a higher prevalence of obesity (40.4%) than the NCEP ATP III and modified WHO definitions (14.7% and 19.3% respectively). This can be explained by the lower waist circumference threshold used in the IDF definition. Studies show that the rationale for using different waist circumference values is that Asians have a higher incidence of insulin resistance and diabetes mellitus at a lower body mass index and waist circumference than Europeans (WHO Expert Consultation, 2004). Thus, IDF proposed the use of several ethnic-specific cut-off points for waist circumference.

There is a good agreement between the IDF and NCEP ATP III definition of MetS, but a weak agreement between IDF and modified WHO definition (Altman, 1991). This study concurs with the results of the study above and with other studies from Mexico (Guerero-Romero & Rodriguez-Moran, 2005), and Iran (Zabetian, Hadaegh & Azizi, 2007). IDF and NCEP ATP III definitions use the same five components to diagnose MetS, with four out of five of the components being identical, giving a high agreement between IDF and NCEP ATP III definition.

There are several limitations to this study. The study population was relatively small and predominantly females, which limits the generalisability of the findings. The numbers of Malay and Indian subjects were relatively small, and this may explain the reason why Malays and Indians exhibited higher prevalence of MetS in this study compared to the Chinese. Secondly, IDF recommendation of measuring waist circumference is at the midway between the inferior margin of the ribs and the superior border of the iliac crest. This is in contrast with the NCEP ATP III recommendations of measuring the waist circumference at the iliac crest. However, in this study, waist circumference was measured at the narrowest point of the waist between the lower borders of the rib cage and iliac crest. Thus, it may not reflect the true features of the definitions for MetS due to the discrepancies. Future studies that include a more racially and socio-economically diverse population are needed to further investigate the prevalence of MetS in Malaysia, and the relationship between MetS and cardio-vascular diseases.

In conclusion, the prevalence of MetS using the IDF criteria was the highest among the three criteria in Malaysian adults. Besides, IDF definition of MetS showed a good concordance with the NCEP ATP III definition. In addition, IDF definition of MetS established different criteria for central obesity according to ethnic groups especially in the Asian population, which makes it appropriate for estimation of the prevalence of MetS among Malaysians.

ACKNOWLEDGEMENTS

We wish to thank all the volunteers who participated in this study and Universiti

Tunku Abdul Rahman Education Foundation for research funding and scholarship to Tan Bee Ying.

REFERENCES

Adams RJ, Appleton S, Wilson DH, Taylor AW, Grande ED, Chittleborough C, Gill T & Ruffin R (2005). Population comparision of two clinical approaches to the metabolic syndrome: implications of the new International Diabetes Federation consensus definition. *Diabetes Care* 28: 2777-2779.

Alberti KG & Zimmet PZ (1998). Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1. Diagnosis and classification of diabetes mellitus procisional report of a WHO consultation. *Diabetes Medicine* 15: 539-553.

Altman DG (1991). Some Practical Statistics for Medical Research. 1st ed. Champan and Hall. 404 pp.

Balkau B & Charles MA (1999). Comment of the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabetes Medicine* 16: 442-443.

Choi KY, Kim SM, Kim YE, Choi DS, Baik SY, Lee J (2007). Prevalence and cardiovascular disease risk of the metabolic syndrome using National Cholesterol Education Program and International Diabetes Federation definitions in the Korean population. *Metabolism Clinical and Experiments* 56: 552-558.

Desroches, S & Lamarche, B (2007). The evolving definitions and increasing prevalence of the metabolic syndrome. *Applied Physiology, Nutrition & Metabolism* 32: 23-32.

Eckel RH, Grundy SM & Zimmet PZ (2005). The metabolic syndrome. *Lancet* 365: 1415-1428.

Ford ES (2005). Prevalence of the metabolic syndrome defined by the International Diabetes Federation among adults in the United States. *Diabetes Care* 28: 2745-2749.

Glassock RJ (2004). The rising tide of end-stage renal disease: what can be done? *Clinical and Experimental Nephrology* 8: 291-296.

Grundy SM (2006). Metabolic syndrome: connecting and reconciling cardio-vascular and diabetes worlds. *Journal of the American College of Cardiology* 47: 1093-1100.

Grundy SM, Pasternak R, Greenland P, Smith Jr S & Fuster V (1999). AHA / ACC scientific statement: assessment of cardiovascular risk by use of multiple-risk-factor assessment equations: a statement for health care professionals from the American Heart Association and the American College of Cardiology. *Circulation* 100: 1481-1492.

Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC, Spertus JA & Costa F (2005). Diagnosis and management of the metabolic syndrome: an American Heart Association / National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 112: 2735-2752.

Guerrero-Romero F & Rodriguez-Moran M (2005). Concordance between the 2005 International Diabetes Federation definition for diagnosing metabolic syndrome with the National Cholesterol Education Program Adult Treatment Panel III and the World Health Organization Definitions. *Diabetes Care* 28: 2588-2589.

Hansen BC (1999). The metabolic syndrome X. *Annals of the New York Academy of Science* 892: 1-24.

Hu FB, Stampfer MJ, Manson JE, Grodstein F, Colditz GA, Speizer FE & Willett WC (2000). Trends in the incidence of coronary heart disease and changes in the diet and life-style in women. *New England Journal of Medicine* 343: 530-537.

Ibrahim H & Yusoff MM (2007). Plant-based ethnic remedies for hypertension from Malaysia. Thieme, DOI: 10.1055 / S-2007-987422.

Ismail MN, Chee SS, Nawawi H, Yusoff K, Lim TO & James PT (2002). Obesity in Malaysia. *Obesity Reviews* 3(3): 203-208.

Johnson LW & Weinstock RS (2006) The metabolic syndrome: concepts and controversy. *Mayo Clinic Proceedings* 81(12): 1615-1620.

Ko GTC, Cockram CS, Chow CC, Yeung VTF, Chan WB, So WY, Chan, N.N. & Chan JCN (2006). Metabolic syndrome by the international diabetes federation definition in Hong Kong Chinese. *Diabetes Research Clinical Practice*. 73: 58-64.

Kyung MC, Seon MK, Yeong EK, Dong SC, Sei HB & Lee JY (2006). Prevalence and cardiovascular disease risk of the metabolic syndrome using National Cholesterol Education Program and International Diabetes Federation definitions in the Korean population. *Metabolism Clinical and Experimental* 56: 552-558.

Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT & Lakka TA (2002). Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in prospective cohort study. *American Journal of Epidemiology* 156 (11): 1070-1077.

Lee WY, Park JS, Noh SY, Rhee EJ, Kim SW & Zimmet PZ (2004). Prevalence of the metabolic syndrome among 40,698 Korean metropolitan subjects. *Diabetes Research Clinical Practice* 65: 143-149.

Lim TO, Ding LM, Goh BL, Zaki M & Suleiman AB (2000). Distribution of blood pressure in a national sample of Malaysian adults. *Medical Journal of Malaysia* 55: 90-107.

National Cholesterol Education Program (NCEP) (2001). Executive summary of the third report of the National Cholesterol Education Program Expert Panel on Detection, Evalution, and Treatment of Hight Blood Cholesterol in Adults (Adults Treatment Panel III). *Journal of the American Medical Association* 285: 2486-2497.

Reaven GM (1988). Banting lecture 1988: role of insulin resistance in human disease. *Diabetes* 37: 1595-1607.

Samad MI, Ismail F, Salwa A, Daud NA, Omar ZA & Ooyub S (2002). National programme for the prevention and control of hypertension. *NCD Malaysia* 1(2): 16-22.

Solymoss BC, Bourassa MG, Lesperance J, Levesque S, Marcil M, Varga S & Campeau L (2003). Incidence and clinical characteristics of the metabolic syndrome in patients with coronary heart disease. *Coronary Artery Disease* 14: 207-212.

Sone H, Mizuno S, Fujii H, Yoshimura Y, Yamasaki Y, Ishibashi S, Katayama S, Saito Y, Ito H, Ohashi Y, Akanuma Y & Yamada N (2005). Is the diagnosis of metabolic syndrome useful for predicting cardiovascular disease in Asian diabetes patients? *Diabetes Care* 28(6): 1463-1471.

Steering Committee (2000). The Asia-Pacific Perspective: Redefining Obesity and its treatment. Melbourne, Australia. International Diabetes Institute.

Undurti ND (2002). Is metabolic syndrome X an inflammatory condition? Society for Experimental Biology and Medicine, pp. 989-997.

World Health Organization (WHO) (1999). Definitions, diagnosis and classification of diabetes mellitus and its complication. Report of a WHO consultation. Geneva, Switzerland: Department of Non-communicate Disease Surveillance.

World Health Organization (WHO) Expert Consultation (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 363: 157-63.

Zabetian A, Hadaegh F & Azizi F (2007). Prevalence of metabolic syndrome in Iranian adult population concordance between the IDF with the ATP III and the WHO definitions. *Diabetes Research and Clinical Practice* 77: 215-257.

Zimmet PZ, Alberti G, & Shaw J (2005). A new IDF worldwide definition of the metabolic syndrome: the rationale and the results. *Diabetes Voice* 50(3): 31-33.