# Comparison of the Prevalence of Metabolic Syndrome in Overweight and Obese Filipino Adolescents Based on Two Definitions

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**ABSTRACT**

Objective. This study compared the International Diabetes Federation (IDF) definition with the modified National Cholesterol Education Program-Adult Treatment Panel-III (NCEP-ATP-III) definition to determine the prevalence of metabolic syndrome (MetS) in overweight and obese Filipino adolescents.

Methods. A total of 350 overweight and obese Filipino adolescents (10-18 years, 206 males, 144 females, mean BMI: 30.5 ± 5.8 and BMI Z-score: 2.85 ± 0.86) referred to pediatric endocrine clinics in Metro Manila were included. Their height, weight, waist circumference, blood pressure, fasting lipid profiles, glucose and insulin levels were measured. MetS was defined as the presence of three out of five clinical features: central obesity, hypertension, hypertriglyceridemia, low HDL-C level and hyperglycemia. The prevalence of MetS was determined based on IDF and modified NCEP-ATP-III definitions; the agreement was measured using Kappa statistics.

Results. The overall prevalence of MetS was 19% based on IDF and 43% according to the modified NCEP-ATP-III, which used the age- and gender-related threshold of blood pressure and lower cut-off level of triglycerides. Kappa value was 0.2.

Conclusion. The prevalence of MetS in overweight and obese adolescents varies with definitions used. It is lower based on the IDF definition that tends to identify those with greater risk whereas the NCEP-ATP-III definition includes less severe ones.

*Key Words: Metabolic syndrome, obesity, overweight, adolescent, Filipino, hypertension, dyslipidemia, hyperglycemia, IDF, NCEP-ATP-III*

## Introduction

Childhood obesity is emerging as a public health problem in the Philippines. The prevalence of childhood overweight and obesity in the Philippines has started to show an upward trend from 1993 to 2005. Among adolescents (11-19 years), the national prevalence of overweight, using a cut-off point of BMI 85$^{th}$ percentile, has doubly increased from 2.4% to 4.8 % (1993 to 2005).[1] Several studies have reported a higher prevalence of overweight and obesity among students in private schools or those from upper socioeconomic status;[2,3,4] it reached 21% in urban national capital region.[5]

Obese adolescents are at risk to develop cardiometabolic abnormalities.[6,7] Dyslipidemia and hyperinsulinemia in obese Filipino children and adolescents were reported.[8,9] MetS is defined as having three out of five cardiometabolic components, namely, abdominal adiposity or central obesity, hypertension, hypertriglyceridemia, low level of high density lipoprotein-cholesterol (HDL) and hyperglycemia.[10,11] Variable definitions of MetS have been used in children and adolescents of various ethnic populations, with different upper percentile threshold or cut-off level for the components. In the United States, several definitions including the National Cholesterol Education Program-Adult Treatment Panel-III (NCEP-ATP-III) criteria modified for children and adolescents were used.[12] The International Diabetes Federation (IDF) in 2007 proposed a definition of MetS for children and adolescents.[13] Currently, the modified NCEP-ATP-III and IDF definitions are the two most widely used definitions.

## Objective

This study aimed to compare the prevalence of MetS in overweight and obese Filipino adolescents based on two definitions: the IDF and modified NCEP-ATP-III.

## Methods

A total of 350 overweight and obese adolescents (10 to 18 years, 206 males and 144 females) referred to pediatric endocrine clinics in Metro Manila, Philippines from 2008 to 2010 were included. The sample size was determined to achieve a 95% confidence interval and 0.05 margin of error based on a 35% prevalence rate of metabolic syndrome (MetS) in overweight children and adolescents.[14,15] Adolescents who were pregnant, had known systemic diseases or endocrine problems like thyroid dysfunction, Cushing syndrome, or took medications that altered blood pressure (BP), glucose or lipid metabolism were excluded. Parental consent and participant's assent were obtained. The participant's height was measured in an upright position using a stadiometer and weight was determined using a

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standard weighing scale. The body mass index (BMI) was calculated based on the weight in kilograms divided by the square of the height in meters. Based on the World Health Organization (WHO) reference, overweight was defined as having a BMI Z-score +1 SD; obesity was defined as having a BMI Z-score +2 SD.[16] Waist circumference (WC) was measured at the midpoint between the lowest rib and the iliac crest, as recommended by WHO guidelines.[17] IDF and modified NCEP-ATP-III defined central obesity as having increased WC ≥90th percentile. Since no national data of WC in Filipino adolescents were available, in this study, central obesity was based on a waist-height ratio of ≥0.5.[18,19,20] Three seated BP readings were obtained and the mean of these BP readings was used for statistical analyses. Hypertension was defined as having a BP≥130/85 mm Hg (IDF) or ≥90$^{th}$ percentile for age and gender (modified NCEP-ATP-III). Blood was extracted for fasting blood glucose (FBG), lipid profiles and insulin level.

In this study, the prevalence of MetS in overweight and obese adolescents was determined based on IDF and modified NCEP-ATP-III definitions (Appendix). MetS was defined by the IDF as central obesity plus 2 more components by the IDF, whereas any three of five features (central obesity, hypertension, hypertriglyceridemia, low HDL level and hyperglycemia) were acceptable by the NCEP-ATP-III definition. The NCEP-ATP-III criteria for MetS was modified for adolescents by Cook;[12] the reference value of elevated FBG was originally set at ≥6.1mmol/L (≥110 mg/dl) based on the American Diabetes Association (ADA) guideline, but in 2004, ADA reduced the cut-off point for impaired fasting glucose to ≥5.6 mmol/L (≥100 mg/dl)[21] which was adopted in this study. We also determined hyperinsulinemia that was defined as fasting plasma insulin level >15 μU/ml.[22] A homeostasis model assessment (HOMA) was used to identify an insulin-resistance (IR) status.[23] HOMA-IR was calculated based on a formula: fasting serum insulin (μU/ml) multiplied by FBG (mmol/L), then divided by 22.5. The IR cut-off point in pediatric population was 3.[24]

Descriptive statistics for continuous variables were expressed as the mean ± the standard deviation. Chi square and Fischer exact tests were used for correlation of metabolic syndrome with individual components. Statistical significance was taken at P<0.05. The agreement between two definitions was measured using Kappa statistics.

## Results

### Characteristics of participants

Among 350 overweight and obese adolescents included in the study, there were 206 (59%) males and 144 (41%) females. The mean age was 13 ± 2.2 years (ranges 10-18.8 years); the mean BMI was 30.5 ± 5.8 kg/m$^2$ (ranges 20-51.7 kg/m$^2$); the mean BMI-Z score based on WHO reference was 2.85 ± 0.86 (ranges 1.21 to 6.08). The anthropometric and metabolic characteristics (age, weight, BMI, serum triglyceride and HDL levels, FBG, serum insulin and HOMA-IR) were comparable in males and females; however, males were taller and had significantly larger WC, waist-hip ratio, waist-height ratio and higher mean systolic BP than females (Table 1).

**Table 1.** The anthropometric and metabolic characteristics of participants (N=350; 206 males and 144 females).

| Characteristics | Overall | | Male | | Female | | P-value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Age (year) | 13.0 | 2.2 | 12.9 | 2.1 | 13.2 | 2.3 | 0.2064 |
| Weight (kg) | 76.1 | 21.0 | 77.4 | 22.4 | 74.3 | 18.7 | 0.1780 |
| Height (cm) | 156.5 | 10.5 | 157.5 | 11.4 | 155.1 | 8.9 | 0.0346 |
| BMI (kg/m$^2$) | 30.5 | 5.8 | 30.5 | 6.0 | 30.5 | 5.5 | 0.9473 |
| BMI Z score (+) | 2.85 | 0.86 | 2.98 | 0.88 | 2.67 | 0.80 | 0.9024 |
| Waist circumference (cm) | 96.1 | 13.7 | 98.3 | 14.6 | 93.0 | 11.7 | 0.0004 |
| Waist-Hip Ratio | 0.95 | 0.07 | 0.97 | 0.06 | 0.91 | 0.08 | 0.0000 |
| Waist-Height Ratio | 0.61 | 0.08 | 0.62 | 0.08 | 0.59 | 0.08 | 0.0009 |
| Blood pressure (mmHg) | | | | | | | |
| Systolic | 116 | 14 | 118 | 15 | 114 | 12 | 0.0168 |
| Diastolic | 74 | 10 | 73 | 10 | 75 | 10 | 0.1644 |
| Serum triglyceride | | | | | | | |
| (mmol/L) | 1.38 | 0.70 | 1.42 | 0.72 | 1.33 | 0.66 | |
| (mg/dl) | 122.2 | 61.8 | 125.6 | 63.7 | 117.5 | 58.8 | 0.2289 |
| HDL-cholesterol | | | | | | | |
| (mmol/L) | 1.23 | 0.20 | 1.23 | 0.21 | 1.22 | 0.19 | |
| (mg/dl) | 47.5 | 7.8 | 47.7 | 8.1 | 47.3 | 7.3 | 0.6649 |
| Fasting blood sugar | | | | | | | |
| (mmol/L) | 5.4 | 3.2 | 5.6 | 3.7 | 5.1 | 2.3 | 0.2092 |
| (mg/dl) | 97.3 | 57.6 | 100.9 | 66.6 | 91.9 | 41.1 | |
| Serum insulin (uU/ml) | 23.4 | 18.1 | 22.1 | 16.5 | 25.2 | 20.2 | 0.1210 |
| HOMA-IR | 5.2 | 4.0 | 5.1 | 3.8 | 5.5 | 4.3 | 0.3392 |

### Prevalence of MetS

According to the IDF definition, the overall prevalence of MetS in participants was 19.1% (67/350). Based on modified NCEP-ATP-III criteria with the FBG cut-off point at 5.6 mmol/L, the overall prevalence of MetS was 43.4% (152/350); it became 42.8% (150/350) when the FBG cut-off level was set higher at 6.0 mmol/L. The overall kappa value for two definitions of MetS was 0.2; the agreement was poor. Top three components of MetS were abdominal adiposity or central obesity, hypertension, hypertriglyceridemia, followed by low HDL and hyperglycemia. The ranking of individual components of MetS was the same with IDF and modified NCEP-ATP-III definitions, but the percentage of hypertension and hypertriglyceridemia was significantly higher based on modified NCEP-ATP-III criteria (Figure 1). The prevalence was higher in obese adolescents than overweight ones, but there was no sex predilection (Table 2).

Generally, males had higher prevalence than females in all individual components, but not statistically significant, except for systolic hypertension based on modified NCEP-ATP-III criteria (Table 3). Among participants with MetS, most had three components, followed by four components. Based on the IDF definition, none had 5 components whereas based on modified NCEP-ATP-III criteria, 1% had 5 components (Figure 2).

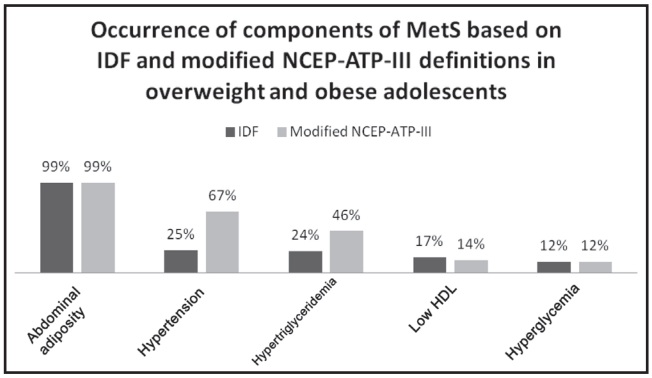


**Figure 1.** Occurrence of components of MetS based on IDF and modified NCEP-ATP-III definitions.

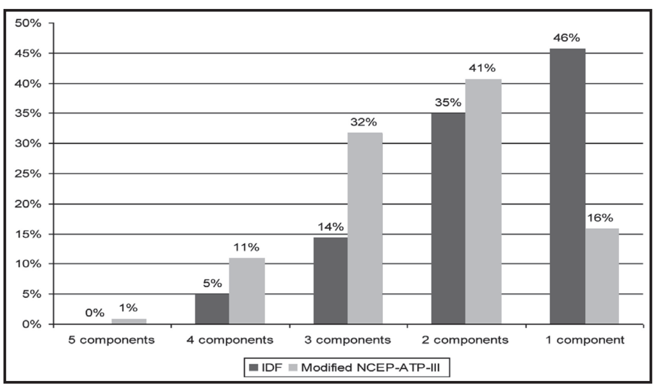


**Figure 2.** Number of MetS components based on IDF and modified NCEP-ATP-III definitions.

**Table 2.** Prevalence of MetS in participants according to definition, BMI Z-score and percentile, and sex.

| | Total (350) | | Male (206) | | Female (144) | | |
|---|---|---|---|---|---|---|---|
| Metabolic Syndrome | No. | % | No. | % | No. | % | P-value |
| **IDF** | | | | | | | |
| ≥ 3 components | 67 | 19.1 | 41 | 11.7 | 26 | 7.4 | 0.6817 |
| Obesity (Z-score ≥ +2) | 61 | 17.4 | 39 | 11.1 | 22 | 6.3 | |
| Overweight (Z-score +1) | 6 | 1.7 | 2 | 0.6 | 4 | 1.1 | |
| **Modified NCEP-ATP-III** | | | | | | | |
| ≥ 3 components | 152 | 43.4 | 96 | 27.4 | 56 | 16.0 | 0.1564 |
| Obesity (Z-score ≥ +2) | 139 | 39.7 | 91 | 26.0 | 48 | 13.7 | |
| Overweight (Z-score +1) | 13 | 3.7 | 5 | 1.4 | 8 | 2.3 | |

Majority of overweight and obese adolescents were found to have hyperinsulinemia (67% had >15 uU/ml) and insulin resistance (70% had HOMA-IR level ≥3). There was no statistically significant sex difference. Among participants with MetS, the mean levels of FBG, serum insulin and HOMA-IR (Table 4) and the prevalence of hyperinsulinemia and insulin resistance were significantly higher (Table 5). The odd ratio of having MetS was significantly higher in participants with hyperinsulinemia and IR (Table 6).

**Table 3.** Individual components of MetS according to definition and sex.

| Component | Total | Male | Female | P-value |
|---|---|---|---|---|
| **IDF** | | | | |
| Abdominal adiposity: waist circumference ≥ 90th P | 348 | 204 | 144 | 0.5143 |
| Elevated blood pressure: | 88 | 51 | 37 | 0.9005 |
| Systolic BP ≥ 130 mmHg | 65 | 41 | 24 | 0.4867 |
| Diastolic BP ≥ 85 mmHg | 52 | 29 | 23 | 0.6489 |
| Elevated triglycerides: ≥150 mg/dL (1.7 mmol/L) | 83 | 52 | 31 | 0.4459 |
| Low HDL-cholesterol (M, and F <16 yr/ F >16 yr): < 1.03/ 1.29 mmol/L (<40 /50mg/dl) (*appendix 1) | 61 | 31 | 30 | 0.1973 |
| Hyperglycemia: FBG ≥ 100 mg/dL (5.6 mmol/L) | 43 | 27 | 16 | 0.6226 |
| **Modified ATP-III** | | | | |
| Abdominal adiposity: waist circumference ≥ 90th P | 348 | 204 | 144 | 0.5143 |
| Elevated blood pressure ≥ 90th P for age and sex | 236 | 146 | 90 | 0.1060 |
| Systolic | 196 | 127 | 68 | 0.0087 |
| Diastolic | 171 | 104 | 67 | 0.5147 |
| Elevated triglycerides: ≥110 mg/dL (1.24 mmol/L) | 162 | 103 | 59 | 0.1031 |
| Low HDL-cholesterol: ≤40mg/dL (1.03 mmol/L) | 50 | 31 | 19 | 0.6456 |
| Hyperglycemia: FBG ≥100 mg/dL (5.6 mmol/L) | 43 | 27 | 16 | 0.6226 |

**Table 4.** Mean and standard deviation of FBS, serum insulin and HOMA-IR in participants with and without MetS.

| Variable | With MetS (67) | | Without MetS (283) | | P-Value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| **IDF** | | | | | |
| FBS (mmol/L) | 7.2 | 6.1 | 4.9 | 1.8 | <0.0001 |
| Serum insulin (uU/ml) | 31.3 | 24.3 | 21.5 | 15.8 | <0.0001 |
| HOMA-IR (≥3) | 7.7 | 5.3 | 4.6 | 3.4 | <0.0001 |
| **Modified NCEP-ATP-III** | | | | | |
| FBS (mmol/L) | 6.2 | 4.6 | 4.8 | 1.2 | <0.0001 |
| Serum insulin (uU/ml) | 28.2 | 20.2 | 19.7 | 15.4 | <0.0001 |
| HOMA-IR | 6.6 | 4.4 | 4.1 | 3.2 | <0.0001 |

**Table 5.** Prevalence of hyperglycemia, hyperinsulinemia and insulin resistance in participants with and without MetS.

| Variable | Total | | With MetS (n=152) | | Without MetS (n=198) | | P-Value |
|---|---|---|---|---|---|---|---|
| **IDF** | | | | | | | |
| Hyperglycemia | 43 | 12% | 24 | 36% | 19 | 7% | <0.0001 |
| Hyperinsulinemia | 233 | 67% | 53 | 79% | 180 | 64% | 0.0206 |
| Insulin resistance | 244 | 70% | 60 | 90% | 184 | 65% | <0.0001 |
| **Modified NCEP-ATP-III** | | | | | | | |
| Hyperglycemia | 43 | 12% | 38 | 25% | 5 | 3% | <0.0001 |
| Hyperinsulinemia | 233 | 67% | 121 | 80% | 112 | 57% | <0.0001 |
| Insulin resistance | 244 | 70% | 130 | 86% | 114 | 58% | <0.0001 |

**Table 6.** Odd ratio of MetS in participants with hyperinsulinemia and insulin resistance.

| | IDF | | Modified NCEP-ATP-III | |
|---|---|---|---|---|
| | Odd Ratio | 95% CI | Odd Ratio | 95% CI |
| Hyperinsulinemia | 2.1663 | 1.1459-4.0952 | 2.9971 | 1.8464-4.8649 |
| Insulin resistance | 4.6118 | 2.031-10.4718 | 4.3541 | 2.5563-7.4161 |

## Discussion

The prevalence of MetS in normal lean (BMI <85$^{th}$ P) children and adolescents was very low, at 0.1% by the IDF definition[25] and 0.1-1.9% by the modified NCEP-ATP-III definition.[12,15,25] As the weight became heavier, the prevalence of MetS increased.[26,27] In overweight and obese adolescents, the prevalence was reported to be 8.9% to 66.2% (Table 7), about 1.3 to 4.5 times higher in obese adolescents (BMI ≥95$^{th}$ percentile) than overweight ones (BMI 85$^{th}$ and 94$^{th}$ percentile). In this study, the prevalence of MetS was also higher in the obese group than overweight group (10:1).

The prevalence of MetS varied with different definitions. When comparing the prevalence of MetS in various populations, the definition used in the study should be considered. Using the IDF definition, the prevalence of MetS ranged from 8.9% to 40.4%; in Filipino overweight and obese adolescents (10 to 18 years), it was 19.1%, similar to that of Chinese (19.2%)[28] and Spanish (19.6%).[29] Using modified NCEP-ATP-III criteria, the prevalence of MetS ranged from 14.5% to 66.2%; our study reported a prevalence of 43.4%, similar to that of Chinese (43%)[28] and African- and Hispanic Americans (42%).[30] The overall prevalence of MetS in overweight and obese Filipino adolescents was lower based on the IDF definition when compared to modified NCEP-ATP-III criteria; such finding was similar to other studies (Table 7). The discrepancy could be explained by the difference in cut-off level of two components, namely, triglyceride and BP. The cut-off level of hypertriglyceridemia was set lower at 1.24 mmol/L (110 mg/dL) by modified NCEP-ATP-III criteria while it was higher at 1.7 mmol/L (150 mg/dl) by the IDF definition. The cut-off point of hypertension by modified NCEP-ATP-III criteria was set at ≥90$^{th}$ percentile for age and gender, which was generally lower than the fixed 130 mmHg systolic BP and 85 mmHg diastolic BP level set by the IDF. Another factor which could affect the prevalence was the higher cut-off level of HDL in female ≥16 years of age when using the IDF definition; however, in this study, the difference was not significant because of the relatively small number of older female adolescents with low level of HDL.

The IDF definition emphasized central obesity that was shown to correlate with visceral adiposity, a major driving force for IR and subsequent type 2 diabetes mellitus (T2DM) and cardiovascular diseases. Central obesity was measured by WC and considered a prerequisite of the diagnosis of MetS. Waist measurement, a simple screening tool, was also adopted by American Heart Association (AHA)/ the National Heart, Lung, and Blood Institute.[31] The IDF definition used an absolute cut-off value for BP (≥130/85 mmHg) which was more practical and convenient for the clinicians because multiple tables to assess BP specific for age and gender were not required.[32] Because it used a fixed cut-off level for BP, similar to that of adults, it generally diagnosed more severe cases but could miss some younger adolescents at risk, such as those having BP >90$^{th}$ percentile (which was a criterion of modified NCEP-ATP-III definition) but not yet reaching 130/85 mmHg. The IDF definition also used a higher cut-off value for triglycerides, so it would not include adolescents with triglycerides level >1.24 mmol/L but still <1.7 mmol/L. In other words, the use of the IDF definition would identify adolescents with greater risk. A study comparing four definitions found that the prevalence estimate by the IDF definition was approximately the mean of previously reported definitions and it appeared valid to use the IDF definition as a reasonable method of classifying adolescents with MetS.[33] The IDF definition has been adopted by many countries and it allowed comparisons between different studies and populations.

On the other hand, the modified NCEP-ATP-III criteria used gender- and age-related threshold (>90$^{th}$ percentile) for BP and a lower cut-off level for triglycerides for adolescents. It could identify adolescents with moderate risk or intermediate severity not captured by the IDF definition.[34] Identification of adolescents who were relatively asymptomatic, with pre-hypertension and mild hypertriglyceridemia, could lead to early lifestyle modification and consequently risk reduction. Preventive measures targeting relatively asymptomatic adolescents would be more cost effective than late-stage symptomatic treatment. However, the main disadvantages of using gender- and age-related cut-off point were variable upper percentile threshold and unavailability of large childhood population data across a wide age range.

**Table 7.** Prevalence of MetS in overweight and obese adolescents in various studies based on IDF and NCEP-ATP-III definitions.

| Author | Study population | Prevalence of MetS | | Remarks |
|---|---|---|---|---|
| | | IDF | Modified NCEP-ATP-III | |
| Chan-Cua S | 350 overweight/ obese Filipinos<br>Obesity: 85%; overweight: 15%<br>Age: 10-18 yr (13 ± 2.2 yr)<br>Male: 59%, female: 41%<br>Mean BMI: 30.5 ± 5.8<br>Mean BMI Z score: +2.85 | 19%<br><br>Obesity: 17.4%<br>Overweight: 1.7%<br>(10:1) | 43%<br><br>Obesity: 39.7%<br>Overweight: 3.7% | FBG cut-off level: ≥5.6 mmol/L (≥100 mg/dl) for both definitions |
| Lafortuna CL, et al. (2010)[37] | 661 extremely obese German<br>Age: 12-18 yr<br>Male: 39.5%, female: 60.5% | 40.4% | | 67%, 28% and 5% had 3, 4 and 5 abnormalities, respectively |
| | 665 extremely obese Italian<br>Age: 12-18 yr<br>Male: 40.8%, female: 59.2% | 23.3% | | 83%, 16%, and <1% had 3,4 and 5 abnormalities, respectively |
| Costa RF, et al. (2012)[38] | 121 obese Brazilian<br>Age: 10-14 yr<br>Male: 51.2%; female: 48.8%<br>Mean BMI: 28.8 ± 4.2 | 39.7% | 51.2% | 74.4%, higher prevalence by de Ferranti definition which used lower cut-off levels for triglycerides (1.13 mmol/L or 100mg/dl) and waist circumference ($75^{th}$ P) |
| Van Vliet M, et al. (2009)[39] | 358 overweight and obese multi-ethnic adolescents >10 yr (out of 528 children) in Netherland<br>Male: 58.7%, female: 41.3%<br>Mean BMI Z score: 2.8 ± 0.4 | 33.2% | | 20.7% based on the definition using child-specific cut-off values |
| Park J, et al. (2010)[40] | 60 obese Korean adolescents (9% of 664)<br>Age: 12-19 yr<br>Male: 54.1%, female: 65.9%<br>Mean BMI: 21.3 ± 0.2 | 24.3% | | Prevalence of MetS in obese Korean adolescents comparable to obese American adolescents(20.8%) |
| Guijarro de Armas MA, et al. (2012)[29] | 133 obese Spanish<br>Male: 50.4%, female: 49.6%<br>Mean age: 12.17 ± 3.27 yr | 19.6% | | Hypertension and hypertriglyceridemia are the most prevalent metabolic changes |
| Dhuper S, et al. (2007)[30] | 290 American, mostly African and Hispanic<br>Age: 12-19 yr<br>BMI: 37.1 ± 7.2<br>BMI Z score: 2.4 ± 0.36 | | 42% | FBG cut-off level : ≥5.6 mmol/L<br><br>Severe obesity was significantly associated with IR |
| Bustos P, et al. (2010)[41] | 461 obese Chilean<br>Age: 10-18 yr<br>Male: 42.7%, female: 57.3%<br>Mean BMI: 32.1<br>Mean BMI z-score: 2.14 | | 37.5% | FBG cut-off level: ≥5.6 mmol/L |
| Singh R, et al. (2007)[15] | 1083 Indian<br>Age: 12-17 yr<br>Obesity (BMI≥$95^{th}$ P): 5.5%<br>Overweight (BMI 85-$94^{th}$ P): 4% | | Obesity (BMI ≥$95^{th}$ P): 36.6%<br>Overweight (BMI 85-$94^{th}$ P): 11.5%<br>Overweight<br>(obese: overweight- 3.2:1) | FBG cut-off level: ≥6.0 mmol/L (≥110 mg/dl)<br>Low HDL was the most common and abdominal obesity the least common constituent of MetS. Prevalence of MetS in the normal population was 1.9% |
| Fang QY, et al. (2009)[28] | 136 obese Chinese<br>Age: 7-18 yr<br>Male: 76%, female: 24% | 19.2% (either American or Chinese cut-off) | 34.6% (American cut-off)<br>43.4% (Chinese cut-off) | |

| | | | | |
|---|---|---|---|---|
| Duncan GE, et al. (2004)[42] | 991 American<br>Age: 12-19 yr | | Obese (BMI≥$95^{th}$ P): 32.1%<br>Overweight (BMI 85- $94^{th}$P): 7.1% | Analysis of data from the National Health and Nutrition Examination Survey (NHANES 1999-2000) USA;<br>FBG cut-off level at ≥6.0 mmol/L |
| Bueno G, et al. (2006)[43] | 103 obese Spanish<br>Male: 52.4%, female: 47.6%<br>Mean BMI: 10.08 ± 2.3 | | 29.9% | 50% by de Ferranti, et al. criteria<br><br>Fasting insulin and HOMA index values increased significantly when ≥ 3 abnormalities of the MetS |
| Cook S, et al. (2003) [12] | 2430 American<br>Age: 12 - 19 yr | | Obese (BMI≥$95^{th}$ P): 28.7%<br>Overweight (BMI 85-$94^{th}$ P): 6.8% | Data obtained from NHANES , 1988-1994<br><br>FBG cut-off level at ≥6.0 mmol/L<br><br>0.1% of those with BMI <$85^{th}$P |
| Eyzaquirre F, et al. (2011)[44] | 255 obese Spanish<br>Age: 11.3 ±2.4 yr<br>Male: 45%, female: 55%<br>Mean BMI Z score: 2.7 ± 0.6 | | 22.7% | Higher prevalence by de Ferranti definition : 45%<br>FBG cut-off level: ≥5.6 mmol/L |
| Iamopas O, et al. (2011)[45] | 89 obese Thai children and adolescents<br>Age: 11.25 ± 2.74 yr<br>Male: 55.1%, female: 44.9%<br>Mean BMI: 30.09 ± 6.26 | 16.9% | | MetS had a statistically significant association with insulin level >25 μIU/mL, HOMA-IR ≥3.16 |
| Reinehr T, et al. (2007)[46] | 1205 overweight and obese German<br>Obesity: 80%<br>Overweight: 20%<br>Age: 9.5-13.4 yr (Mean: 11.8 yr)<br>Male: 46%, female: 54%<br>Mean BMI: 27.3 | 14% | 21% | FBG cut-off level : ≥5.6 mmol/L<br><br>MetS was related to insulin resistance and weight status |
| Agirbasli M , et al. (2006)[27] | 68 obese or overweight Turkish (4.9% of 1385)<br>Age: 10 - 17 years | | 21% | Nearly 10 times more common among overweight and obese students compared with lean students |
| Braga-Tavares H, et al. (2010)[47] | 237 overweight and obese Portuguese<br>Obesity: 89%<br>Overweight: 11%<br>Age: 10-20 yr (Median: 13.4 yr)<br>Male: 47%, female: 53% | 8.9% | 15.6% | Higher prevalence using definition by de Ferranti: 34.5% |
| Druet C, et al. (2010)[34] | 300 overweight and obese French<br>Median age: 11 yr (71%: 10-16 yr)<br>BMI SDS +4.7 | 10-16 yr: 8.9% | 10-16 yr: 14.5% | IDF represents a more severe definition |

Both IDF and NCEP-ATP-III definitions included blood glucose as a component but not the insulin level or degree of IR. In this study, although only 12% of participants had hyperglycemia, majority had hyperinsulinemia (67%) and IR based on HOMA (70%). The prevalence of hyperinsulinemia and IR was significantly higher in participants with MetS. Detection of hyperinsulinemia and IR should alert the clinician to do intervention to prevent the progression to overt T2DM as well as MetS. AHA recommended the determination of fasting insulin when evaluating children at risk for metabolic syndrome since hyperinsulinemia in youth has been demonstrated as a predictor of T2DM.

## Conclusion

The prevalence of MetS in overweight and obese adolescents varies with definitions used. The IDF definition tends to identify those with greater risk that may explain the lower prevalence whereas the NCEP-ATP-III definition gives higher prevalence because it includes less severe ones, with milder degree of hypertension and hypertriglyceridemia.

The IDF definition is convenient and easy to use in the clinical setting since it does not require multiple tables to assess BP specific for age and gender. It also allows the comparison between different populations since it uses a fixed cut-off level for BP and not based on percentile that may vary with ethnicity. Call to immediate action may be needed in adolescents identified by the IDF definition since they have higher BP and triglyceride levels.

The modified NCEP-ATP-III definition identifies adolescents with moderate risk or intermediate severity. An advantage is early recognition and lifestyle modification in those with pre-hypertension and borderline hypertriglyceridemia which can prevent further progression of complications. The disadvantage is that it is more tedious to use various gender- and age-related cut-off points and percentile thresholds.

## Recommendation

Once the adolescent is identified to have MetS, healthy lifestyle with behavioral modification should be started in order to halt progression to more severe condition. In the adolescent with higher risk, more intensive intervention and referral to specialists should be considered.

Prospective studies are also needed to validate prognostic values of components and to identify the cut-off points related to health risks, instead of normative values in adolescents.[35] The efforts of stakeholders should focus on the design and implementation of interventions aimed at prevention and treatment of obesity on both population and an individual scale.[36]

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**References**

1. Food and Nutrition Research Institute, Department of Science and Technology. Philippine Nutrition: Facts and Figures, 2005. FNRI-DOST. Bicutan, Taguig City, Philippines. July 2007.
2. Chan-Cua S, Cuayo-Juico C, Bugayong-Regidor P, et al. Prevalence of overweight among boys in a Metro Manila private grade school. JAFES.1995; 16-20.
3. Ley-Chua T, Cua S, Garcia RD. Correlation of body mass index with neck circumference, waist and hip circumference, waist-to-hip ratio and triceps skinfold thickness. Philipp J Pediatr. 2003; 52(3):117-26.
4. Florentino RF, Villavieja GM, Lana RD. Regional study of nutritional status of urban primary schoolchildren. 1. Manila, Philippines. Food Nutr Bull. 2002; 23(1):24-30.
5. Chan-Cua S, Amarillo MLE. Validity of body mass index based on self-reported weight and height in estimation of prevalence of overweight and obesity among adolescents. Philipp J Pediatr. 2009; 57(1):23-9.
6. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. Pediatrics. 1998; 101(3 Pt 2):518-25.
7. Sorof J, Daniels S. Obesity Hypertension in children: a problem of epidemic proportions. Hypertension. 2002; 40(4):441-7.
8. Chan-Cua S, Regidor P. Hyperlipidemia of obese Filipino children and adolescents [Abstract]. Asia Pacific J Clin Nutr. 2002; 11:S744.
9. Chan-Cua S, Bugayong-Regidor P. Fasting Hyperinsulinemia in obese children and adolescents. J Pediatr Endocrinol Metabol. 2000; 13:S1241.
10. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. Lancet. 2005; 365(9468):1415–28.
11. Alberti KGMM, Zimmet PZ, Shaw JE. The metabolic syndrome - a new world-wide definition from the International Diabetes Federation Consensus. Lancet. 2005; 366: 1059–62.
12. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the Third National Health and Nutrition Examination Survey, 1988–1994. Arch Pediatr Adolesc Med. 2003; 157(8):821-7.
13. Zimmet P, Alberti G, Kaufman F, et al. The summary metabolic syndrome in children and adolescents: the IDF consensus. Diabetic voice clinical care. 2007; 52(4):29-31.
14. Cruz ML, Goran MI. The metabolic syndrome in children and adolescents. Curr Diab Rep. 2004; 4(1):53–62.
15. Singh R, Bhansali A, Sialy R, Aggarwal A. Prevalence of metabolic syndrome in adolescents from a north Indian population. Diabet Med. 2007; 24(2):195-9.
16. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007; 85(9):660-7.
17. World Health Organization. Waist circumference and waist–hip ratio: Report of a WHO Expert Consultation, Geneva, 8–11 December 2008. p5 [Online]. 2011 [cited 2011 April]. Available from http://whqlibdoc.who.int/publications/2011/9789241501491_eng.pdf
18. McCarthy HD, Ashwell M. A study of central fatness using waist to-height ratios in UK children and adolescents over two decades supports the simple message – 'Keep your waist circumference to less than half your height'. Int J Obes (Lond). 2006; 30(6):988-92.
19. Garnett SP, Baur LA, Cowell CT. Waist-to-height ratio: a simple option for determining excess central adiposity in young people. Int J Obes (Lond). 2008; 32(6):1028-30.
20. Sung RY, So HK, Choi KC, et al. Waist circumference and waist-to-height ratio of Hong Kong Chinese children. BMC Public Health. 2008; 8:324.
21. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2004; 27 Suppl 1:S5-S10.
22. Ten S, Maclaren N. Insulin resistance syndrome in children. J Clin Endocrinol Metab. 2004; 89(6):2526-39.
23. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia.1985; 28(7):412–9.
24. Tresaco B, Bueno G, Pineda I, Moreno LA, Garagorri JM, Bueno M. Homeostatic model assessment (HOMA) index cut-off values to identify the metabolic syndrome in children. J Physiol Biochem. 2005; 61(2):381-8.
25. Wan NJ, Mi J, Wang TY, et al. Metabolic syndrome in overweight and obese schoolchildren in Beijing. [Article in Chinese]. Zhonghua Er Ke Za Zhi. 2007; 45(6):417-21.
26. Weiss R, Dziura J, Burgert TS, et al. Obesity and the metabolic syndrome in children and adolescents. N Engl J Med. 2004; 350(23): 2362-74.
27. Agirbasli M, Cakir S, Ozme S, Ciliv G. Metabolic syndrome in Turkish children and adolescents. Metabolism. 2006; 55(8):1002-6.[28] Fang QY, Wan YP, Wang JL, Shen WR, Chen ZQ, Zhao M. Comparison of different definitions on metabolic syndrome in obese children. [Article in Chinese]. Zhonghua Liu Xing Bing Xue Za Zhi. 2009; 30(12):1297-301.
28. Guijarro de Armas MA, Monereo Megías S, Merino Viveros M, Iglesias Bolaños P, Vega Piñero B. Prevalence of metabolic syndrome in a population of obese children and adolescents. [Article in Spanish]. Endocrinol Nutr. 2012; 59(3):155-9.
29. Dhuper S, Cohen HW, Daniel J, et al. Utility of the modified ATP III defined metabolic syndrome and severe obesity as predictors of insulin resistance in overweight children and adolescents: a cross-sectional study. Cardiovasc Diabetol. 2007; 6:4.
30. Grundy SM, Brewer HB Jr, Cleeman JI, 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. Arterioscler Thromb Vasc Biol. 2004; 24(2):e13-8.
31. Mancini MC. Metabolic syndrome in children and adolescents - criteria for diagnosis. Diabetol Metab Syndr. 2009; 1(1):20.
32. Studies to Treat or Prevent Pediatric Type 2 Diabetes (STOPP-T2D) Prevention Study Group. Prevalence of the metabolic syndrome among a racially/ethnically diverse group of U.S. eighth-grade adolescents and associations with fasting insulin and homeostasis model assessment of insulin resistance levels. Diabetes Care. 2008; 31(10):2020–5.
33. Druet C, Ong K, Levy Marchal C. Metabolic syndrome in children: comparison of the International Diabetes Federation 2007 consensus with an adapted National Cholesterol Education Program definition in 300 overweight and obese French children. Horm Res Paediatr. 2010; 73(3):181-6.
34. Brambilla P, Pietrobelli A. Behind and beyond the pediatric metabolic syndrome. Ital J Pediatr. 2009; 35:41.
35. Saland JM. Update on the metabolic syndrome in children. Curr Opin Pediatr. 2007; 19(2):183-91.
36. Lafortuna CL, Adorni F, Agosti F, et al. Prevalence of the metabolic syndrome among extremely obese adolescents in Italy and Germany. Diabetes Res Clin Pract. 2010; 88(1):14-21.
37. Costa RF, Santos NS, Goldraich NP, Barski TF, Andrade KS, Kruel LF. Metabolic syndrome in obese adolescents: a comparison of three different diagnostic criteria. J Pediatr (Rio J). 2012; 88(4):303-9.
38. van Vliet M, von Rosenstiel IA, Schindhelm RK, Brandjes DP, Beijnen JH, Diamant M. Identifying the metabolic syndrome in obese children and adolescents: do age and definition matter? Curr Clin Pharmacol. 2009; 4(3):233-8. [40] Park J, Hilmers DC, Mendoza JA, Stuff JE, Liu Y, Nicklas TA. Prevalence of metabolic syndrome and obesity in adolescents aged 12 to 19 years: comparison between the United States and Korea. J Korean Med Sci. 2010; 25(1):75-82.
39. Bustos P, Saez K, Gleisner A, Ulloa N, Calvo C, Asenjo S. Metabolic syndrome in obese adolescents. Pediatr Diabetes. 2010; 11(1):55-60.
40. Duncan GE, Li SM, Zhou XH. Prevalence and trends of a metabolic syndrome phenotype among U.S. Adolescents, 1999-2000. Diabetes Care. 2004; 27(10):2438-43.
41. Bueno G, Bueno O, Moreno LA, et al. Diversity of metabolic syndrome risk factors in obese children and adolescents. J Physiol Biochem. 2006; 62(2):125-33.
42. Eyzaguirre F, Silva R, Román R, et al. Prevalence of metabolic syndrome in children and adolescents who consult with obesity. [Article in Spanish]. Rev Med Chil. 2011;139(6):732-8.
43. Iamopas O, Chongviriyaphan N, Suthutvoravut U. Metabolic syndrome in obese Thai children and adolescents. J Med Assoc Thai. 2011; 94 Suppl 3:S126-32.
44. Reinehr T, de Sousa G, Toschke AM, Andler W. Comparison of metabolic syndrome prevalence using eight different definitions: a critical approach. Arch Dis Child. 2007; 92(12):1067-72.
45. Braga-Tavares H, Fonseca H. Prevalence of metabolic syndrome in a Portuguese obese adolescent population according to three different definitions. Eur J Pediatr. 2010; 169(8):935-40.

## APPENDIX

Definitions of metabolic syndrome (MetS) in adolescents.

| Component | IDF | | Modified NCEP-ATP III |
|---|---|---|---|
| | Age 10 to <16 years | ≥16 years | |
| Central obesity (WC)* | ≥90th percentile (or adult cut-off if lower) | >90 cm for male and >80 cm for female based on Asia Pacific criterion | ≥90th percentile |
| BP | ≥130 mmHg systolic or ≥85 mmHg diastolic | ≥130 mm Hg systolic or ≥85 mm Hg diastolic or treatment of previously diagnosed hypertension | ≥90th percentile |
| Triglycerides | ≥1.7 mmol/L (≥150 mg/dl) | ≥1.7 mmol/L (≥150 mg/dl) or specific treatment for this lipid abnormality | ≥1.24 mmol/L (≥110 mg/dL) |
| HDL | <1.03 mmol/L (<40 mg/dl) | In males: <1.03 mmol/L (<40 mg/dl) In females: <1.29 mmol/L (<50 mg/dl) or specific treatment for this lipid abnormality | <1.03 mmol/L (<40 mg/dl) |
| Fasting blood glucose (FBG) | ≥5.6 mmol/L (≥100 mg/dl) or known type 2 diabetes mellitus | ≥5.6 mmol/L (≥100 mg/dl) or previously diagnosed type 2 diabetes** | ≥5.6 mmol/L (≥100 mg/dl)*** |

IDF: International Diabetes Federation definition
NCEP-ATP III: National Cholesterol Education Program-Adult Treatment Panel III criteria
WC: waist circumference (main component of MetS)
* If BMI is >30kg/m², central obesity can be assumed and waist circumference does not need to be measured.
** If >5.6 mmol/L (100 mg/dL), OGTT is strongly recommended but is not necessary to define presence of MetS
*** Cut-off adjusted based on American Diabetes Association [21]