

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 85th 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 \geq 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 \geq 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 \geq 130/85 mm Hg (IDF) or \geq 90th 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 \geq 6.1 mmol/L (\geq 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 \geq 5.6 mmol/L (\geq 100 mg/dl)²¹ which was adopted in this study. We also determined hyperinsulinemia that was defined as fasting plasma insulin level >15 μ U/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 (μ U/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 \pm 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/m² (ranges 20-51.7 kg/m²); 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).

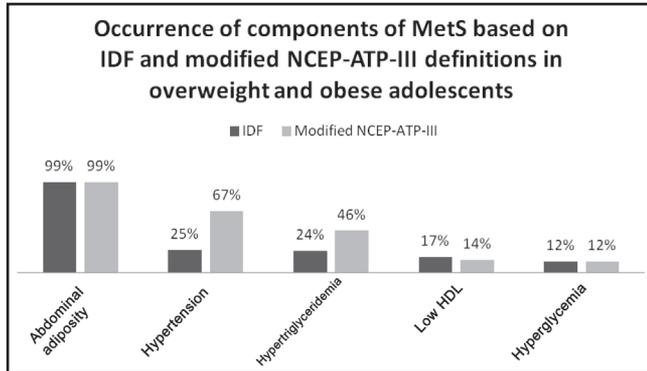


Figure 1. Occurrence of components of MetS based on IDF and modified NCEP-ATP-III definitions.

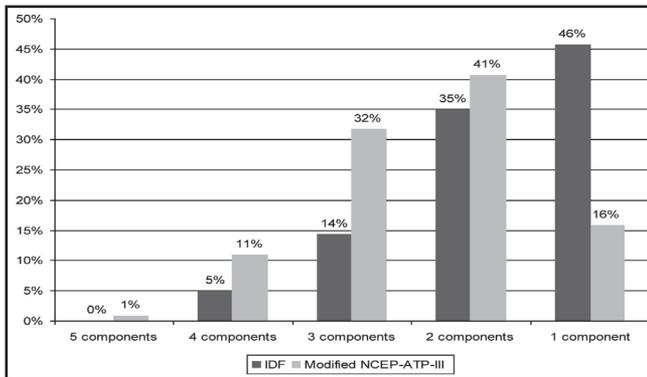


Figure 2. Number of MetS components based on IDF and modified NCEP-ATP-III definitions.

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

Metabolic Syndrome	Total (350)		Male (206)		Female (144)		P-value
	No.	%	No.	%	No.	%	
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 high 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 ≥ 90 th 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 ≥ 90 th P	348	204	144	0.5143
Elevated blood pressure ≥ 90 th 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 <85th P) children and adolescents was very low, at 0.1% by the IDF definition²⁵ 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 51.2% (Table 7), about 1.3 to 4.5 times higher in obese adolescents (BMI ≥95th percentile) than overweight ones (BMI 85th and 94th 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 51.2%; 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 ≥90th 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 >90th 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 (>90th 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 Obesity: 85%; overweight: 15% Age: 10-18 yr (13 ± 2.2 yr) Male: 59%, female: 41% Mean BMI: 30.5 ± 5.8 Mean BMI Z score: +2.85	19% Obesity: 17.4% Overweight: 1.7% (10:1)	43% Obesity: 39.7% 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 Age: 12-18 yr Male: 39.5%, female: 60.5%	40.4%		67%, 28% and 5% had 3, 4 and 5 abnormalities, respectively
	665 extremely obese Italian Age: 12-18 yr 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 Age: 10-14 yr Male: 51.2%; female: 48.8% 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 Male: 58.7%, female: 41.3% 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) Age: 12-19 yr Male: 54.1%, female: 65.9% 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 Male: 50.4%, female: 49.6% 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 Age: 12-19 yr BMI: 37.1 ± 7.2 BMI Z score: 2.4 ± 0.36		42%	FBG cut-off level : ≥5.6 mmol/L Severe obesity was significantly associated with IR
Bustos P, et al. (2010) ⁴¹	461 obese Chilean Age: 10-18 yr Male: 42.7%, female: 57.3% Mean BMI: 32.1 Mean BMI z-score: 2.14		37.5%	FBG cut-off level: ≥5.6 mmol/L
Singh R, et al. (2007) ¹⁵	1083 Indian Age: 12-17 yr Obesity (BMI≥95 th P): 5.5% Overweight (BMI 85-94 th P): 4%		Obesity (BMI ≥95 th P): 36.6% Overweight (BMI 85-94 th P): 11.5% Overweight (obese: overweight- 3.2:1)	FBG cut-off level: ≥6.0 mmol/L (≥110 mg/dl) 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 Age: 7-18 yr Male: 76%, female: 24%	19.2% (either American or Chinese cut-off)	34.6% (American cut-off) 43.4% (Chinese cut-off)	

Duncan GE, et al. (2004) ⁴²	991 American Age: 12-19 yr		Obese (BMI \geq 95 th P): 32.1% Overweight (BMI 85- 94 th P): 7.1%	Analysis of data from the National Health and Nutrition Examination Survey (NHANES 1999-2000) USA; FBG cut-off level at \geq 6.0 mmol/L
Bueno G, et al. (2006) ⁴³	103 obese Spanish Male: 52.4%, female: 47.6% Mean BMI: 10.08 \pm 2.3		29.9%	50% by de Ferranti, et al. criteria Fasting insulin and HOMA index values increased significantly when \geq 3 abnormalities of the MetS
Cook S, et al. (2003) ¹²	2430 American Age: 12 - 19 yr		Obese (BMI \geq 95 th P): 28.7% Overweight (BMI 85-94 th P): 6.8%	Data obtained from NHANES , 1988-1994 FBG cut-off level at \geq 6.0 mmol/L 0.1% of those with BMI <85 th P
Eyzaquirre F, et al. (2011) ⁴⁴	255 obese Spanish Age: 11.3 \pm 2.4 yr Male: 45%, female: 55% Mean BMI Z score: 2.7 \pm 0.6		22.7%	Higher prevalence by de Ferranti definition : 45% FBG cut-off level: \geq 5.6 mmol/L
Iamopas O, et al. (2011) ⁴⁵	89 obese Thai children and adolescents Age: 11.25 \pm 2.74 yr Male: 55.1%, female: 44.9% Mean BMI: 30.09 \pm 6.26	16.9%		MetS had a statistically significant association with insulin level >25 μ U/mL, HOMA-IR \geq 3.16
Reinehr T, et al. (2007) ⁴⁶	1205 overweight and obese German Obesity: 80% Overweight: 20% Age: 9.5-13.4 yr (Mean: 11.8 yr) Male: 46%, female: 54% Mean BMI: 27.3	14%	21%	FBG cut-off level : \geq 5.6 mmol/L MetS was related to insulin resistance and weight status
Agirbasli M , et al. (2006) ²⁷	68 obese or overweight Turkish (4.9% of 1385) 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 Obesity: 89% Overweight: 11% Age: 10-20 yr (Median: 13.4 yr) 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 Median age: 11 yr (71%: 10-16 yr) 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 the early recognition of those with pre-hypertension and borderline hypertriglyceridemia. 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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APPENDIX

Definitions of metabolic syndrome (MetS) in adolescents.

Component	IDF		Modified NCEP-ATP III
	Age 10 to <16 years	≥16 years	
Central obesity (WC)*	≥90 th percentile (or adult cut-off if lower)	>90 cm for male and >80 cm for female based on Asia Pacific criterion	≥90 th percentile
BP	≥130 mmHg systolic or ≥85 mmHg diastolic	≥130 mm Hg systolic or ≥85 mm Hg diastolic or treatment of previously diagnosed hypertension	≥90 th 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