Metabolic Syndrome in Hispanic Youth: Results from the Hispanic Community Children's Health Study/Study of Latino Youth

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Abstract

Background: Metabolic syndrome (MetS), a cluster of cardiovascular risk factors, is being diagnosed in youth. Specific diagnostic criteria used to define MetS influence prevalence estimates and populations considered at risk for cardiovascular disease. The National Cholesterol Education Program's Adult Treatment Panel III (ATP), the World Health Organization (WHO), and the International Diabetes Federation (IDF) provide three MetS definitions used in medical research. This study examined concordance among these definitions in 1137 children 10–16 years of age, who participated in the Hispanic Community Children's Health Study/Study of Latino Youth.

Methods: Prevalence of MetS and of individual components was estimated using SAS. Mplus was used to test a single-factor model of MetS components (triglycerides, high-density lipoprotein cholesterol, systolic and diastolic blood pressure, waist circumference, and fasting glucose).

Results: The ATP definition identified most MetS cases in 10–15 ($N=19$, 4.7%) and 16-year-old girls ($N=3$, 7.3%). The IDF definition identified most cases of MetS in 10–15 ($N=16$, 3.1%) and 16-year-old boys ($N=2$, 2.8%). Fewest cases of MetS were identified with the WHO definition across age and sex groups.

Conclusion: Only one participant was classified as having MetS across all three definitions. Confirmatory factor analysis indicated fasting glucose and systolic blood pressure did not reliably cluster with other risk factors that define MetS in Hispanic/Latino adolescents. We conclude that prevalence estimates of MetS in youth are unstable across current criteria, calling into question the accuracy of defining and diagnosing MetS in youth.

Keywords: youth, Hispanic/Latino, diagnosis, metabolic syndrome

Introduction

METABOLIC SYNDROME (MetS) predicts cardiovascular disease (CVD) and type 2 diabetes (T2D).^{1–3} Risk factors for MetS include abdominal obesity, atherogenic dyslipidemia, elevated blood pressure, and insulin resistance.⁴ Criteria for diagnosing MetS influence prevalence estimates and guide which populations are considered at risk for developing CVD or T2D. Since prevalence of T2D in adolescents has increased dramatically in the past decade,⁵ it is important to accurately diagnose MetS in youth to identify and treat children at risk before disease develops.

However, studies are inconsistent with respect to MetS criteria used for diagnosis. The Bogalusa Heart Study defined MetS by body mass index quartile, insulin resistance, systolic blood pressure, and total to high-density lipoprotein (HDL) cholesterol ratio to examine how MetS in childhood related to adult health outcomes. This study followed black and white children ages 4–17 at baseline into adulthood. High MetS risk in childhood corresponded to high risk in adulthood.⁶ Similarly, another study of black and white youth found that MetS defined by the National Cholesterol Education Program's Adult Treatment Panel (ATP) III criteria predicted T2D, impaired fasting glucose, and CVD up to 25 years later.^{3,7}

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Evidently, identifying MetS in youth has predictive value; however, since the pathophysiology of the syndrome continues to be disputed, studies utilize different diagnostic criteria. Various definitions have attempted to capture key underlying and emerging risk factors (*e.g.*, adiposity, insulin resistance) associated with elevated risk for developing CVD and T2D. Three definitions cited in medical research for adults have been used. These definitions come from the ATP III,⁸ World Health Organization (WHO),⁹ and the International Diabetes Federation (IDF). With current approaches, there are 16 possible combinations of symptoms that meet the ATP III definition and 11 combinations for the WHO definition of MetS, resulting in inconsistent diagnosis.¹⁰

Golley et al.¹¹ applied six different definitions of MetS to a group of overweight prepubertal children and found prevalence ranging from 0% to 60%, depending on the definition. Similarly, in a sample of girls, prevalence ranged from 0.4% to 24% depending on which of 14 different definitions was applied.¹² The WHO diagnostic definition requires impaired fasting glucose; the IDF definition requires central obesity. Also, the IDF definition, unlike WHO and ATP, differs based on two age groups: 10–15 and 16+ years and does not provide criteria for children under 10. Overall, the lack of concordance across the WHO, IDF, and ATP MetS criteria highlight the need for consensus in adolescent populations to facilitate comparisons across studies and reliably estimate disease risk.

A joint statement delivered by the American Diabetes Association and European Association for the Study of Diabetes concluded that MetS has been imprecisely defined and there is uncertainty in its pathogenesis.¹⁰ In youth a single-factor model that explains correlations among the MetS components has been supported, with significant loadings for all components.^{13,14} However, inclusion of glucose or insulin for diagnosis in youth has been disputed, given that fasting blood glucose is typically normal in youth.¹⁵ Some studies examining MetS in youth include insulin resistance, rather than glucose, to assess disruption in homeostasis of glucose/insulin metabolism.¹⁶

Ethnicity is an influential factor in MetS prevalence. Hispanic/Latino adults have the highest prevalence of MetS,¹⁷ and obesity in Hispanic/Latino youth is higher than in non-Hispanic white youth,¹⁸ placing them at a greater risk for disease.¹⁹ Yet, few studies have examined how different MetS criteria capture risk in Hispanic/Latino youth. The purpose of the current study was to illustrate how application of ATP III, WHO, and IDF criteria for MetS differentially determine prevalence in a sample of Hispanic/Latino girls and boys; examine concordance among the diagnostic criteria; and determine the contribution of the components to the clustering of MetS.

Methods

Participants and procedures

Eligible participants ages 8–16 whose parents/legal guardians participated in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) were recruited to participate in the SOL Youth study. HCHS/SOL is a population-based study of Hispanic/Latino adults living in the United States, who were selected using probability sampling from four cities (Bronx, Chicago, Miami, and San Diego). Briefly, representative samples of participants were drawn from census tracts in the defined communities and recruited from households to maximize

participation, reduce nonresponse, and minimize attrition during follow-up (see LaVange et al.²⁰ for additional details on recruitment). The SOL Youth ancillary study recruited a total of 1466 youth across the four field sites between 2012 and 2014, which reflects the diversity of the main parent study.

All 8–9-year olds were excluded due to IDF age cut-points, leaving a sample of 1137 youth. The sample included 50.3% girls and the breakdown of Hispanic/Latino background was 48.6% Mexican, 13.5% Dominican, 10.0% Mixed Hispanic, 9.8% Puerto Rican, 6.3% Central American, 5.7% Cuban; 4.2% South American, and 1.9% other.

Youth and parent participants underwent a 3.5-hr examination, during which biospecimens, anthropometric measures, blood pressure, fitness level, dietary intake, and physical activity were assessed. Psychosocial characteristics were also assessed by questionnaire in the participant's preferred language (Spanish or English). Parents provided consent and children provided consent or assent in accordance with requirements of the local institutional review boards (IRBs). IRB approval was attained for all sites. For more information on the aims and design of SOL Youth, see Isasi et al.²¹

Measures

Consistent with current definitions of MetS, the following indicators were used: triglycerides; HDL cholesterol; systolic and diastolic blood pressures; waist circumference; and fasting glucose. All MetS criteria are listed in Table 1.

Waist circumference was measured to the nearest 1 cm at the uppermost lateral border of the right ilium using a measuring tape. After resting for 5 min in the seated position, systolic and diastolic blood pressures were measured three times at 1 min intervals using an automatic sphygmomanometer (Omron model HEM-907 XL; Omron Healthcare, Inc., Bannockburn, IL), and the average of the last two readings was used. Blood specimens (HDL, triglycerides, fasting glucose, and insulin) were taken after an overnight fast, stored at -70°C , and shipped to the central laboratory for processing the specimen collection (see Isasi et al.²¹). HDL and triglycerides were measured in serum on a Roche/Modular P Chemistry Analyzer (Roche Diagnostics Corporation, Indianapolis, IN) using a direct magnesium/dextran sulfate method (HDL) and glycerol blanking enzymatic method (triglycerides). Glucose was measured in EDTA plasma using a hexokinase enzymatic method; insulin was measured in serum on a Roche COBAS 6000 Analyzer using a sandwich immunoassay method (Roche Diagnostics).

Statistical analyses

Prevalence of MetS and of individual components was estimated using SAS Version 9.3, SURVEYFREQ procedure, separately for girls and boys. The absence or presence of each metabolic component was examined using the cut-points specific to each definition. The McNemar test was used to compare prevalence between definitions. This statistical test is appropriate when examining differences in frequencies on a dichotomous dependent variable between two related groups. These results are described below. SOL Youth weights, clustering, and stratification adjustments were utilized in the estimation of prevalence.

Similar to Llabre et al.,²² a confirmatory factor analysis in Mplus Version 7.4 tested a model that specified all components

TABLE 1. CRITERIA SUMMARY TABLE FOR ATP-III, WHO, AND IDF

Criteria	Requirements	Central obesity/waist circumference (cm)	Triglycerides (mg/dL)	HDL cholesterol (mg/dL)	Blood pressure (mmHg)	Fasting glucose (mg/dL)
NCEP ATP III	3 of 5	≥88 in females, ≥102 in males	≥110	<40	≥85 DBP or ≥130 SBP	≥110, or known diabetes
WHO	Impaired fasting glucose, plus 2 of 3 (obesity; triglycerides or HDL; BP)	BMI ≥95th% or ≥88 cm in females, ≥102 cm in males	≥150	<35	≥85 DBP or ≥130 SBP	≥110, or known diabetes
IDF (Ages 10–15)	Central obesity required, plus 2 of 4	Waist circumference ≥90th%	≥150	<40	≥85 DBP or ≥130 SBP	≥100
IDF (Ages 16+)	Central obesity required, plus 2 of 4	≥80 cm in females, ≥94 cm in males	≥150	<50 <40	≥85 DBP or ≥130 SBP	≥100

BMI, body mass index; DBP, diastolic blood pressure; IDF, International Diabetes Federation; NCEP ATP III, National Cholesterol Education Program's Adult Treatment Panel; HDL, high-density lipoprotein; SBP, systolic blood pressure; WHO, World Health Organization.

of MetS loading on a single latent factor. Variable distributions were examined for outliers, skewness, and kurtosis. Fasting glucose and triglycerides were log transformed to approximate normality. Additional correlations between the residuals of systolic and diastolic blood pressure and HDL and triglycerides were specified to account for method variance. In a second model, insulin was examined, with corresponding correlation with glucose.

Results

Weighted descriptive statistics on all measures are displayed in Table 2. Girls were significantly shorter, weighed less, had lower blood pressure, had lower fasting glucose, and higher insulin levels when compared with boys. There was no other significant difference between girls and boys with regard to clinical characteristics.

Prevalence of MetS

The prevalence of each component of MetS, as well as overall MetS, are listed in Table 3 for 10–15-year olds and in Table 4 for 16-year olds. As depicted in the tables, prevalence

for MetS differed by definition and sex, although confidence intervals (CIs) overlap. The fewest cases of MetS for 10–15-year olds (0% of girls, $N=2$ or 0.5% of boys) and 16-year olds (0% of girls, 0% of boys) were identified following the WHO definition. In girls, the highest prevalence was found following the ATP III criteria (for 10–15-year olds: $N=19$ or 4.7%; for 16-year olds: $N=3$ or 7.3%). Boys had the highest prevalence following the IDF definition (for 10–15-year olds $N=16$ or 3.1% of boys; for 16-year olds: $N=2$ or 2.8%).

Prevalence of elevated triglycerides for 10- to 15-year-old girls (16.2%) and boys (17.7%) according to ATP III criteria (≥110 mg/dL) was higher compared with the WHO and IDF criteria (≥150 mg/dL) (girls—6.4%, boys—9.3%). Prevalence of elevated HDL cholesterol levels was higher following ATP III and IDF criteria (<40 mg/dL) (girls—12.4%, boys—13.1%) compared with WHO criteria (<35 mg/dL) (girls—3.7%, boys—3.9%). Prevalence of impaired fasting glucose was low. Using the ATP III and WHO cutpoints of 110 mg/dL, only 0.2% of cases were identified in 10- to 15-year-old girls and 2.2% of boys. The IDF criteria (≥100 mg/dL) identified a few more cases, totaling 7.0% of girls and 15.5% of boys. There was no case of elevated systolic or diastolic blood pressure identified in girls of any age.

TABLE 2. SAMPLE CHARACTERISTICS OF STUDY OF LATINOS YOUTH PARTICIPANTS [MEAN (STANDARD DEVIATION)]

	All	Girls	Boys	Significance level ^a
N	1137	567	570	
Age (years)	13.1 (2.0)	13.1 (2.0)	13.1 (2.0)	NS
Height (cm)	156.5 (11.1)	153.8 (8.4)	159.2 (12.7)	<0.001
Weight (kg)	57.5 (18.6)	56.2 (18.3)	58.7 (18.7)	0.02
BMI (kg/m ²)	23.1 (6.0)	23.5 (6.6)	22.8 (5.4)	NS
Triglyceride (mg/dL)	81.4 (51.9)	83.5 (54.0)	79.3 (49.6)	NS
LDL cholesterol (mg/dL)	86.1 (22.6)	87.5 (21.5)	84.8 (23.6)	NS
HDL cholesterol (mg/dL)	51.2 (10.8)	51.1 (9.8)	51.4 (11.8)	NS
Systolic BP (mm/Hg)	105.6 (10.6)	101.7 (8.7)	109.4 (11.0)	<0.001
Diastolic BP (mm/Hg)	60.5 (8.0)	60.0 (7.4)	61.1 (8.5)	0.02
Waist circumference (cm)	79.6 (14.6)	79.6 (13.8)	79.7 (15.5)	NS
Fasting glucose (mg/dL)	92.4 (10.1)	90.0 (6.6)	94.6 (12.2)	<0.001
Insulin (pmol/L)	95.2 (65.8)	103.1 (71.2)	87.7 (59.0)	<0.001

^aIndicates significant difference between girls and boys.

LDL, low-density lipoprotein; NS, not significant.

TABLE 3. FREQUENCY OF METABOLIC INDICATORS AND PREVALENCE OF METS BY DEFINITION IN 10–15-YEAR OLDS

Definition % abnormal [95% CI]	Girls N = 479			Boys N = 506		
	ATP III	WHO	IDF	ATP	WHO	IDF
MetS	4.7% [1.7–7.6]	0%	3.1% [0.4–5.7]	2.4% [0.9–3.9]	0.5% [0.0–1.2]	3.1% [1.3–4.9]
Triglyceride	16.2% [11.8–20.6]	6.4% [3.0–9.8]	6.4% [3.0–9.8]	17.7% [13.1–22.4]	9.3% [5.6–12.9]	9.3% [5.6–12.9]
HDL	12.4% [8.4–16.4]	3.7% [1.0–6.5]	12.4% [8.4–16.4]	13.1% [9.6–16.6]	3.9% [1.8–5.9]	13.1% [9.6–16.6]
Systolic or diastolic BP	0%	0%	0%	0.6% [0.0–1.1]	0.6% [0.0–1.1]	0.6% [0.0–1.1]
Waist circumference	22.3% [17.0–27.6]	29.9% [24.2–35.6]	14.7% [10.2–19.2]	6.8% [4.2–9.4]	28.0% [22.8–33.2]	14.6% [10.5–18.7]
Fasting glucose	0.2% [0.0–0.7]	0.2% [0.0–0.7]	7.0% [4.3–9.7]	2.2% [0.6–3.7]	2.2% [0.6–3.7]	15.5% [11.4–19.6]

See Table 1 for clinical cut-offs.

CI, confidence interval; MetS, metabolic syndrome.

TABLE 4. FREQUENCY OF METABOLIC INDICATORS AND PREVALENCE OF METS BY DEFINITION IN 16-YEAR OLDS

Definition % abnormal [95% CI]	Girls N = 88			Boys N = 64		
	ATP III	WHO	IDF	ATP	WHO	IDF
MetS	7.3% [0–17.8]	0%	6.3% [0–16.6]	1.9% [0–4.7]	0%	2.8% [0–6.7]
Triglyceride	20.5% [6.0–35.0]	6.4% [0.0–16.9]	6.4% [0.0–16.9]	17.4% [4.1–30.7]	11.5% [0.5–22.5]	11.5% [0.5–22.5]
HDL	8.3% [0–19.0]	0%	34.9% [21.7–48.1]	15.8% [5.0–26.5]	0.9% [0.0–2.8]	15.8% [5.0–26.5]
Systolic or diastolic BP	0%	0%	0%	18.4% [4.4–32.3]	18.4% [4.4–32.3]	18.4% [4.4–32.3]
Waist circumference	30.3% [17.7–42.9]	32.7% [20.0–45.4]	52.6% [39.7–65.5]	10.8% [0.7–21.0]	27.1% [12.1–42.0]	25.3% [9.8–40.8]
Fasting glucose	0%	0%	3.9% [0–7.9]	0.8% [0–2.5]	0.8% [0.0–2.5]	15.2% [2.7–27.8]

See Table 1 for clinical cut-offs.

TABLE 5. FACTOR LOADINGS FOR A SINGLE LATENT VARIABLE MODEL OF METS IN GIRLS AND BOYS

Variable <i>B</i> [95% CI]	Unstandardized	Standardized (girls)	Standardized (boys)
Triglycerides	0.171 [0.078–0.264]	0.592 [0.415–0.769]	0.737 [0.526–0.949]
HDL cholesterol	–0.746 [–1.08 to –0.413]	–0.554 [–0.696 to –0.412]	–0.625 [–0.758 to –0.492]
Systolic BP	0.198 [0.079–0.317]	0.163 [0.077–0.249]	0.178 [0.065–0.292]
Diastolic BP	0.252 [0.136–0.367]	0.244 [0.160–0.329]	0.295 [0.161–0.430]
Waist circumference	1.00 [1.00–1.00]	0.528 [0.348–0.708]	0.637 [0.465–0.809]
Glucose	0.006 [0.000–0.011]	0.129 [0.030–0.228]	0.137 [0.035–0.240]

In 16-year olds, similar patterns emerged, such that most cases of elevated triglycerides in girls and boys were identified following ATP III criteria. Most cases of low HDL cholesterol were identified following the IDF criteria for 16-year-old girls (34.9%). Elevated waist circumference measurements were more common in 16-year-old girls than boys. For example, the IDF criteria identified 52.6% of girls as having an elevated waist circumference, compared with 25.3% of boys.

In 10–15-year olds, the proportion identified as having MetS differed significantly between ATP III and WHO ($S=18.9$, $P<0.0001$), ATP III and IDF ($S=6.9$, $P=0.008$), and WHO and IDF ($S=10.6$, $P=0.001$). In 16-year olds, the proportion of girls identified as having MetS under the ATP definition differed significantly from WHO ($S=34.2$, $P<0.0001$). Similarly, the proportion of 10- to 15-year-old boys identified as having MetS differed between ATP and WHO ($S=9.6$, $P=0.002$) and WHO and IDF ($S=10.6$, $P=0.001$). In 16-year olds, the proportion of those identified as having MetS did not differ across definitions.

Latent variable model

A latent variable model with all indicators loading onto a common factor was evaluated based on several common fit indices [Comparative Fit Index (CFI) >0.95], the Root Mean Squared Error of Approximation (RMSEA <0.06), and the Standardized Residuals (SRMR <0.10]. With loadings constrained equal between girls and boys, the model fit the data [CFI = 0.964; RMSEA = 0.049 90% CI (0.032–0.067); SRMR = 0.053].

Unstandardized and standardized factor loadings are reported in Table 5 with corresponding 95% CIs. We used a standardized loading of 0.30 or greater to index an adequate indicator of a factor. As shown in Table 5, the upper limit of the CI for the standardized loading associated with fasting glucose and systolic blood pressure did not meet this threshold, suggesting that these components may not cluster together as strongly with the other components of MetS in Hispanic/Latino girls or boys.

Latent variable model with insulin

A second model added insulin as a component of MetS. Constraining the loadings for all components equal between girls and boys, except for fasting insulin, the model fit the data [CFI = 0.963; RMSEA = 0.048 90% CI (0.035–0.061); SRMR = 0.060]. The insulin indicator had an unstandardized loading of 6.97 for girls (standardized = 0.86) and 4.04 for boys (standardized = 0.83). In contrast, the fasting glucose indicator had an unstandardized loading of 0.003 for girls (standardized = 0.08) and boys (standardized = 0.08). These

results suggest that fasting insulin clusters more strongly than fasting glucose with other MetS indicators in youth.

Discussion

It is important to have an accurate diagnosis of MetS in youth, given that early detection can prevent more complicated disease later in life.^{2,3,6} However, findings from the current study show a lack of concordance among the prevalence of MetS based on ATP III, WHO, and IDF definitions for MetS in Hispanic/Latino children aged 10–16 years old. The prevalence of MetS among girls and boys was different across criteria and only one child was classified as having MetS across all three definitions.

Given different definitions, it was expected to see differences in the prevalence of MetS and its indicators. The WHO criteria yielded the lowest prevalence in both boys and girls. However, the highest prevalence among 10–15-year olds and 16-year-old girls (7.3%, 4.7%, respectively) was found using the ATP III definition, whereas the highest prevalence among 10- to 15-year-old and 16-year-old boys was found using the IDF definition (3.1% and 2.8%, respectively). Compared with published estimates in the literature, the prevalence for MetS in 10–15-year olds following the IDF criteria (3.1%) is consistent with the national estimates of MetS using the same definition.²³

Previous studies show comparable prevalence of MetS in Hispanic/Latino youth using ATP III, but higher prevalence following WHO criteria compared with those found in this sample. In a study examining Hispanic/Latino adolescents ages 10–18 in northern Mexico, 6.5% met criteria for MetS based on the ATP III definition and 4.5% based on WHO.²⁴ These rates contrast with those in a school-based study of 1513 North American adolescents, which yielded estimates of 4.2% and 8.4% for ATP III and WHO, respectively.²⁵

Central obesity is a requirement in the IDF definition, whereas the WHO definition requires impaired fasting glucose as a central criterion. Given that impaired fasting glucose is rarely seen in children, WHO may be considered to be a very strict definition of MetS. Our finding that fasting glucose did not cluster strongly with the other indicators of MetS would suggest that the strict primary criterion required by the WHO may not be most appropriate in children.

In the absence of obesity, we found metabolic risk to be low; therefore, detection efforts should focus on obese populations, and the IDF definition may be most relevant, given its requirement. However, to establish the optimal definition and clinical cutpoints, empirical research with a clear disease outcome is needed. Only with a clear criterion can the point which maximizes sensitivity and specificity be determined. Such research can also determine the need for age- and sex-specific criteria.

Longitudinal research may also elucidate which cutpoints of individual indicators are associated with the greatest risk of poor metabolic functioning in adulthood. Results from the current study show a diverse range of prevalence for each MetS component. For example, the prevalence of elevated triglycerides and HDL cholesterol is more than double among both girls and boys using the ATP III criteria when compared with the WHO criteria. These differing cutpoints classify children as “abnormal” under one definition, but “normal” under another, calling into question the reliability of a diagnosis.

Consistent with prior research,²⁶ our results show that blood pressure, lipids, insulin, and waist circumference reliably loaded on the factor. However, fasting glucose did not load as well. Our data suggest that insulin rather than glucose should be further examined as an indicator of metabolic health risk in youth. Hyperinsulinemia precedes hyperglycemia²⁷ and, therefore, it may be more clinically useful in young populations. Insulin resistance/hyperinsulinemia was proposed as the underlying cause of MetS based on cross-sectional animal studies that were fed diets high in sucrose or fructose.^{28,29} Additional support for this hypothesis came after the San Antonio Heart Study showed that fasting hyperinsulinemia preceded the development of hypertension, hypertriglyceridemia, and depressed HDL.³⁰

Given the changes that occur during adolescence, puberty is often a critical time for developing MetS. During puberty, insulin resistance increases and insulin sensitivity is reduced, which is often compensated by increased insulin secretion.^{15,31,32} Some studies of MetS in youth utilize insulin rather than fasting glucose,¹⁶ given that fasting glucose levels are usually normal in youth, even overweight youth.^{15,33} Thus, in puberty, insulin may be a more appropriate indicator of MetS than fasting glucose.

A confirmatory factor analysis done by Gurka et al. found that fasting glucose did not correlate with any MetS factor across different ethnic/racial (black, white, Hispanic) and sex groups in youth ages 12–19.²⁶ Systolic blood pressure also correlated more strongly with a single MetS factor for non-Hispanic White males than other ethnic groups. In our study, systolic blood pressure also did not correlate strongly with the other MetS risk factors. Of note, the blood pressure cut-offs use absolute numbers, rather than percentiles from norms, which is how blood pressure is typically evaluated in children. Using percentile norms would likely yield higher prevalence of elevated blood pressure levels.

Data are cross-sectional and did not include an outcome variable, which is a notable limitation to the study. Future research should aim to examine how adolescent health predicts later disease development, particularly in Hispanics/Latinos. The current study utilized one fasting sample to limit participant burden; however, future research may wish to examine multiple measures of insulin, given that insulin values may vary day to day. Several insulin resistance surrogates are currently being utilized in empirical research studies, including the hyperinsulinemic euglycemic glucose clamp, oral glucose tolerance test, and glucose/insulin ratio.³⁴ In addition, clinical cutpoints are often needed to inform a diagnosis; however, a continuous MetS score in pediatric epidemiologic research has emerged, given the lack of a universal definition. Future studies may wish to compare the clinical utility of a continuous risk score to increase understanding of an individual's overall metabolic profile, particularly in youth.¹⁶

Although the sample is limited to Hispanic/Latino adolescents, making it hard to draw conclusions across race/ethnicities, strengths of this study include its even ratio of girls to boys, its large sample size, and its exploration of an understudied and often underserved population of Hispanic/Latino youth. This study contributes in a unique way to the present literature exploring the MetS criteria in this population. Specifically, results from the confirmatory factor analysis suggest systolic blood pressure and fasting glucose are not appropriate representations of MetS risk in youth. A standard definition is needed and should be validated with disease endpoints in adulthood. Overall, findings from the current study call into question the sets of criteria currently in practice when applied to Hispanic/Latino children.

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Author Disclosure Statement

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