ARTICLE

Prevalence of a Metabolic Syndrome Phenotype in Adolescents

Findings From the Third National Health and Nutrition Examination Survey, 1988-1994

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Background: In adults the metabolic syndrome imposes a substantial risk for type 2 diabetes mellitus and premature coronary heart disease. Even so, no national estimate is currently available of the prevalence of this syndrome in adolescents.

Objective: To estimate the prevalence and distribution of a metabolic syndrome among adolescents in the United States.

Design and Setting: Analyses of cross-sectional data obtained from the Third National Health and Nutrition Examination Survey (1988-1994), which was administered to a representative sample of the noninstitutionalized civilian population of the United States.

Participants: Male and female respondents aged 12 to 19 years (n=2430).

Main Outcome Measures: The prevalence and distribution of a metabolic syndrome among US adolescents, using the National Cholesterol Education Program (Adult Treatment Panel III) definition modified for age.

Results: The overall prevalence of the metabolic syndrome among adolescents aged 12 to 19 years was 4.2%; 6.1% of males and 2.1% of females were affected ($P=.01$). The syndrome was present in 28.7% of overweight adolescents (body mass index [BMI], ≥95th percentile) compared with 6.8% of at-risk adolescents (BMI, 85th to <95th percentile) and 0.1% of those with a BMI below the 85th percentile ($P<.001$). Based on population-weighted estimates, approximately 910000 US adolescents have the metabolic syndrome.

Conclusions: Perhaps 4% of adolescents and nearly 30% of overweight adolescents in the United States meet these criteria for a metabolic syndrome, a constellation of metabolic derangements associated with obesity. These findings may have significant implications for both public health and clinical interventions directed at this high-risk group of mostly overweight young people.

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THE PREVALENCE of obesity and diabetes mellitus among adults in the United States has increased during the past decade.[1] Recent data indicate that 65% of the US adult population is either overweight, defined as a body mass index (BMI, calculated as the weight in kilograms divided by the height in meters squared) of 25 or more, or obese (BMI ≥ 30).[2] In children and adolescents, the term overweight is used in place of obese and is defined as a BMI at or above the 95th percentile on age- and sex-specific growth charts from the Centers for Disease Control and Prevention.[3] Overweight tripled among US children between 1970 and 2000, and 15% of 6- to 19-year-olds are overweight according to the most recent estimates.[4] Obesity is estimated to cause approximately 300000 deaths annually, and its 1-year direct and indirect costs are estimated to be $117 billion.[5]

Leaders in the emerging field of preventive cardiology have increasingly recognized obesity's role in adult cardiovascular disease. Correspondingly, the guidelines for adult cholesterol and the primary prevention of cardiovascular disease reflect this increased recognition of obesity's role.[6,7] The guidelines for cholesterol also target the metabolic syndrome, a constellation of metabolic derangements that predict both type 2 diabetes mellitus and premature coronary artery disease, as a newly recognized entity that warrants clinical intervention. According to the National Cholesterol Education Program (NCEP, or

Table 1. Criteria for the Metabolic Syndrome*

Criterion	Adults	Adolescents
High triglyceride level, mg/dL	≥150	≥110
Low HDL-C level, mg/dL		
Males	<40	≤40
Females	<50	≤40
Abdominal obesity, waist circumference, cm		
Males	>102	≥90th Percentile
Females	>88	≥90th Percentile
High fasting glucose level, mg/dL	≥110	≥110
High blood pressure, mm Hg	≥130/85	≥90th Percentile

Abbreviation: HDL-C, high-density lipoprotein cholesterol.

SI conversion factors: To convert triglycerides to millimoles per liter, multiply by 0.01129; HDL-C to millimoles per liter, multiply by 0.02586; glucose to millimoles per liter, multiply by 0.05551.

*For definitions of criteria, see the "Definitions" subsection of the "Methods" section.

Adult Treatment Panel III [ATP III]), persons meeting at least 3 of the following 5 criteria qualify as having the metabolic syndrome: elevated blood pressure, a low high-density lipoprotein (HDL) cholesterol level, a high triglyceride level, a high fasting glucose level, and abdominal obesity. Because of the increasing rates of adult obesity and obesity's association with insulin resistance and type 2 diabetes, the NCEP panel stated that the metabolic syndrome will soon have a greater impact on premature coronary artery disease than does tobacco.[8] According to recent estimates, the metabolic syndrome affects 22% of the US adult population overall, including 7% of men and 6% of women in the 20- to 29-year age group.[9]

As childhood overweight increases,[10,11] its medical complications are becoming more common and more frequently recognized.[12-14] For example, the prevalence of type 2 diabetes has risen dramatically among adolescents in the past 20 years.[13] Studies suggest that a substantial percentage of overweight children and adolescents may be afflicted with the metabolic syndrome because many have 1 or more of the following: an elevated triglyceride level, a low HDL cholesterol level, and high blood pressure.[15,16] Many overweight children also have elevated insulin levels, indicating an increase in insulin resistence.[16] When one considers that autopsy studies have revealed that overweight in adolescence is associated with accelerated coronary atherosclerosis,[17] recent trends become even more troubling.

The purpose of the current study is to estimate the prevalence and distribution of a metabolic syndrome in adolescents using a nationally representative sample of the US population.

METHODS

Data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988-1994) were examined. The NHANES III used a complex, multistage design to provide a representative sample of the noninstitutionalized civilian population of the United States. Approximately 40 000 persons aged 2 months to 65 years or older were studied. Young and old persons and ethnic minorities such as African Americans and Mexican Americans were oversampled.[18] After being evaluated in a home interview to determine family medical history, current medical conditions, and medication use, participants were randomly assigned to undergo a morning, afternoon, or evening examination at the mobile examination centers. Morning participants were asked to fast for 8 hours; afternoon and evening participants were asked to fast for 6 hours.

The details of the determination and analysis of triglyceride levels, HDL cholesterol levels, and glucose values have previously been described.[9,19] For adolescents aged 17 years and older, 6 seated blood pressure readings were taken in 2 separate settings. The household interviewer took 3 measurements at the participant's home, and the study physician took 3 during the evaluation in the center. The first and fifth Korotkoff sounds were used to represent the systolic and diastolic values.[18] We used the mean of these 6 measurements in these analyses. Adolescents aged 12 to 16 years did not have their blood pressure taken at home, and thus this age group had only the 3 measurements taken by the physician. Again, the mean was used. Height was measured in an upright position with a stadiometer, and weight was measured at a standing position using a self-zeroing scale (Mettler-Toledo, Inc, Columbus, Ohio). The waist circumference measurement was made at the midpoint between the bottom of the rib cage and above the top of the iliac crest. Measurements of waist circumference were made for each subject at minimal respiration to the nearest 0.1 cm.[18] The Tanner stage of pubic hair development was used as an indicator of sexual maturity because it was obtained for both sexes.[20] There was standardized training for physicians performing these examinations, and photographs and written descriptions were available for reference. Pubic hair was staged from 1, representing immaturity, to 5, for full maturity.[20]

The initial sample consisted of 3211 subjects aged 12 to 19 years, to whom the following exclusion criteria were applied: (1) had not fasted for 6 hours, (2) was currently pregnant, or (3) was taking medication classified as a blood glucose regulator, such as insulin, androgens or anabolic steroids, or adrenal corticosteroids. The final sample numbered 2430, including some individuals with 1 or more excluding factors. No children younger than 12 years were instructed to fast as part of NHANES III.

DEFINITIONS

The criteria for the metabolic syndrome in adults specified by NCEP's ATP III and the adapted definition used in this analysis for adolescents aged 12 to 19 years are shown in **Table 1**.[7] Because these criteria have never been formally defined or applied in children or adolescents, we modified the adult criteria to the closest representative values obtainable from pediatric reference data. In developing a definition for metabolic syndrome in adolescents,[21] we considered reference values from the NCEP Pediatric Panel report,[22] the American Diabetes Association statement on type 2 diabetes in children and adolescents,[23] and the updated Task Force report on the diagnosis and management of hypertension in childhood as well as ATP III.[8] Because no reference values for waist circumference exist for adolescents or children, we analyzed all adolescents in the data set who had a waist circumference recorded. We classified participants with a waist circumference at or above the 90th percentile value for age and sex from this sample population as having abdominal obesity. Elevated systolic or diastolic blood pressure was defined as a value at or above the 90th percentile for age, sex, and height.[21] If subjects reported current use of any antihypertensive drugs, they were labeled as participants with elevated blood pressure. This approach of counting participants taking medications was also used for examining the prevalence of the metabolic syndrome in adults

in the same national data set.[9] The NCEP *Report of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents*[22] and a table summarizing these values in a review by Styne[14] were used to establish the criteria for cholesterol level abnormalities. The range of 35 to 45 mg/dL (0.91-1.16 mmol/L) is given for borderline low HDL cholesterol levels for all sexes and ages. In children aged 10 to 19 years, a borderline high range for triglyceride levels is given as 90 to 129 mg/dL (1.02-1.46 mmol/L). Therefore the midpoint value for HDL cholesterol (≤40 mg/dL [≤1.03 mmol/L]) was used as a 10th percentile value, and the midpoint value for triglycerides (≥110 mg/dL [≥1.24 mmol/L]) was taken as the 90th percentile value for age. The reference value for elevated fasting glucose was taken from the American Diabetes Association guideline of 110 mg/dL or higher (≥6.1 mmol/L).[23]

STATISTICAL ANALYSIS

Prevalence values were compared using the χ^2 test for proportions for those children with and without the metabolic syndrome. Comparisons of means of continuous variables were done with the *t* test. Children identified in the racial/ethnic category "other" were included in the overall sample analyzed, but this subsample was too small for meaningful analysis separately. To account for the complex sampling design, SAS[24] and SUDAAN[25] statistical software were used in the analysis, and SUDAAN was used to apply sampling weights to produce national estimates.

RESULTS

Demographic characteristics associated with the metabolic syndrome in bivariate analyses are shown in **Table 2**. The overall prevalence of the metabolic syndrome in adolescents was 4.2%. It was more common in males (6.1%) than in females (2.1%) and was more frequent in Mexican Americans (5.6%) and whites (4.8%) than black subjects (2.0%). By region of the country, the rate was highest in the West and Midwest and lowest in the Northeast. Findings for age (12-14 years vs 15-19 years), Tanner stage by pubic hair, poverty level, and parental history of diabetes and myocardial infarction were not significant. When stratified by BMI, 28.7% of overweight adolescents (BMI ≥95th percentile for age and sex) met criteria for the metabolic syndrome. A comparison of the final sample with those subjects who were excluded revealed only 1 difference by demographic characteristics (BMI also did not differ): The percentage of African Americans was slightly higher in the excluded group (18.9% vs 14.6% in the overall sample; $P=.05$). The proportion of subjects with 1 or more abnormalities of the metabolic syndrome is presented in **Table 3**. In this sample, 41% of subjects had 1 or more of these risk factors, whereas 14% had 2 or more. There were no subjects who had all 5 of these risk factors.

The prevalence of the metabolic syndrome by sex and race/ethnicity is shown in the **Figure**. The prevalence among white (7.1%) and Mexican American males (7%) was nearly the same, whereas black males had the lowest rate at 2.6% ($P=.003$). Among females, Mexican Americans (4.1%) had the highest rate, whereas black females (1.4%) had the lowest rate ($P<.001$).

Table 2. Demographic Characteristics and Prevalence of the Metabolic Syndrome Among US Adolescents Aged 12 to 19 Years, NHANES III

	No. of Subjects	% of Subjects With the Metabolic Syndrome (95% CI)	*P* Value
Total	2430	4.2 (2.9-5.4)	
Sex			
Male	1150	6.1 (3.7-8.6)	.001
Female	1280	2.1 (0.9-3.3)	
Race/ethnicity			
White	646	4.8 (3.1-6.5)	.004
Black	824	2.0 (0.8-3.2)	
Mexican American	846	5.6 (3.6-7.5)	
Age, y			
12-14	968	4.3 (2.0-6.5)	.92
15-19	1462	4.1 (2.5-5.7)	
Poverty level			
Below	804	5.7 (1.9-9.6)	.33
At or above	1394	3.7 (2.3-5.0)	
Region			
Northeast	264	1.2 (0.0-2.9)	<.001
Midwest	443	5.3 (4.6-6.0)	
South	1116	3.9 (1.6-6.2)	
West	607	6.0 (2.5-9.5)	
Parental history of diabetes mellitus			
Yes	185	5.8 (3.3-8.4)	.23
No	2187	4.2 (2.8-5.5)	
Parental history of myocardial infarction			
Yes	410	7.3 (3.3-11.2)	.12
No	1964	3.6 (2.2-5.1)	
BMI status, percentile			
Normal (<85th)	1694	0.1 (0.0-0.1)	
At risk (85th to <95th)	366	6.8 (1.6-12.0)	<.001
Overweight (≥95th)	338	28.7 (20.7-36.7)	
Tanner stage, pubic hair, 12-18 y			
1	83	3.3 (0.0-7.6)	.54
2	97	7.0 (0.0-15.4)	
3	207	7.2 (2.5-11.9)	
4	594	3.5 (0.7-6.3)	
5	893	3.4 (1.5-5.4)	

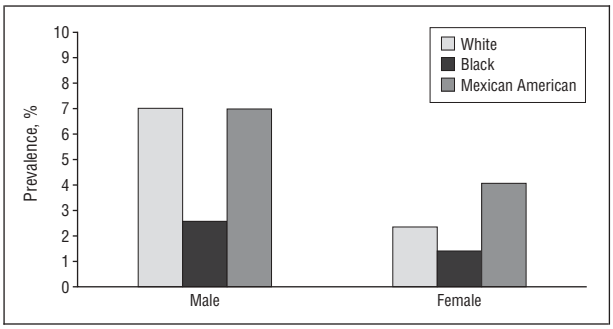
Abbreviations: BMI, body mass index; CI, confidence interval; NHANES III, Third National Health and Nutrition Examination Survey.

The distribution of each element of the metabolic syndrome is shown in **Table 4**. Overall, high triglyceride levels and low HDL cholesterol levels were most common, whereas high fasting glucose levels were the least common. White adolescents had the highest rates of high triglyceride levels (25.5%) and low HDL cholesterol levels (26.1%). Mexican American subjects had the highest rate of abdominal obesity by waist circumference (13.0%). Black adolescents had the highest proportion of elevated blood pressure (6.2%). Adolescents with the metabolic syndrome had a mean BMI of 30.1 and, on average, were at the 95.5th percentile for BMI by age and sex (data not shown). Of those adolescents who fulfilled these criteria for the metabolic syndrome, 25.2% were at risk for overweight, by BMI, and 73.9% were overweight.

Table 3. Prevalence of 1 or More Abnormalities of the Metabolic Syndrome Among 2430 US Adolescents Aged 12 to 19 Years, NHANES III

	% (95% CI)			
	≥1 Risk Factors	≥2 Risk Factors	≥3 Risk Factors	≥4 Risk Factors
Total	40.9 (37.2-44.6)	14.2 (12.0-16.4)	4.2 (2.9-5.4)	0.9 (0.2-1.7)
Sex				
Male	47.5 (42.4-52.5)	17.1 (13.6-20.5)	6.1 (3.7-8.6)	1.6 (0.2-3.0)
Female	34.2 (29.1-39.2)	11.4 (8.4-14.3)	2.1 (0.9-3.3)	0.2 (0.0-0.6)
Race/ethnicity				
White	42.9 (37.7-48.0)	16.1 (13.4-18.8)	4.8 (3.1-6.5)	1.3 (0.2-2.3)
Black	29.7 (26.0-33.5)	7.9 (5.6-10.2)	2.0 (0.8-3.2)	0.5 (0.0-1.1)
Mexican American	40.7 (35.8-45.6)	15.4 (11.3-19.5)	5.6 (3.6-7.5)	0.3 (0.1-0.5)
BMI status, percentile*				
Normal (<85th)	31.4 (27.2-35.5)	6.4 (4.9-8.0)	0.1 (0.0-0.1)	0.0 (0.0-0.0)
At risk (85th to <95th)	54.4 (43.3-65.5)	23.2 (16.3-30.0)	6.8 (1.6-12.0)	2.1 (0.0-6.2)
Overweight (≥95th)	88.5 (83.5-93.4)	56.0 (46.4-65.6)	28.7 (20.7-36.7)	5.8 (2.6-9.1)

Abbreviations: BMI, body mass index; CI, confidence interval; NHANES III, Third National Health and Nutrition Examination Survey.



Prevalence of the metabolic syndrome by sex and race/ethnicity.

COMMENT

The metabolic syndrome has been called several other names, including syndrome X, insulin resistance syndrome, dysmetabolic syndrome X, Reaven syndrome, and the metabolic cardiovascular syndrome.[15,26] Obesity, insulin resistance, dyslipidemia, and hypertension are common to all. The World Health Organization used "metabolic syndrome" in their 1998 report on diagnosis and classification of diabetes mellitus.[27] Both the World Health Organization and ATP III chose this title for their consensus definitions.[7,27] We believe that this is the first study to examine the prevalence and distribution of a metabolic syndrome in a nationally representative sample of US adolescents. Perhaps 4% of adolescents overall and nearly 30% of overweight adolescents meet the criteria for this syndrome, suggesting that almost 1 million adolescents in the United States are affected.

The metabolic syndrome affects an estimated 47 million American adults.[9] The syndrome emerges when a person's predisposition for insulin resistance is worsened by increasing adiposity; dyslipidemia, elevated blood pressure, and proinflammatory and prothrombotic properties result.[28] Adults with this syndrome frequently progress to type 2 diabetes and demonstrate markedly increased risk for morbidity and mortality from cardiovascular disease.[29-31] The metabolic syndrome in adults is largely confined to the overweight population[32] and represents a subgroup of obese persons who bear a level of risk for cardiovascular disease that exceeds that of the obese in general. An estimated 7% of men and 6% of women aged 20 to 29 years are affected with the metabolic syndrome,[9] so our finding that 4% of those aged 12 to 19 years may have this syndrome should not be surprising. Four previous regional studies of children that relied on US and international samples demonstrated the clustering of the risk factors for the metabolic syndrome and reported rates from 2% to 9%.[33-36]

Overweight has important implications for the future health of our young people, especially in terms of coronary heart disease and diabetes. The Pathobiological Determinants of Atherosclerosis in Youth research group, for example, found that overweight (by BMI) in young men was associated with fatty streaks, raised lesions, and low-grade stenosis of the coronary arteries.[17] In addition, studies have established that child and adolescent obesity tracks into adulthood and also predicts the metabolic syndrome in adults.[37-39] Results of one of the many reports from the Bogalusa Heart Study[40] show that when insulin concentrations are increased in childhood they tend to remain elevated in adulthood, and those adults with consistently elevated insulin levels tend also to have increased rates of obesity, hypertension, and dyslipidemia. In the present study, adolescents with the metabolic syndrome had a mean BMI just above the 95th percentile; thus, they represent a fairly common clinical problem, one likely to be encountered routinely by general pediatricians.

Abdominal or centrally distributed fat is associated with type 2 diabetes and a poor cardiovascular profile in adults.[41-45] In children, an increased waist circumference has been shown to correlate with abnormal systolic and diastolic blood pressures and elevated serum levels of total cholesterol, low-density lipoprotein, triglyceride, lipoprotein, and insulin, as well as lower concentrations of HDL.[36,46,47] The association between the clustering of cardiovascular risk factors and waist circumference is not only a reflection of the degree of obe-

Table 4. Prevalence of Individual Metabolic Syndrome Risk Factors Among US Adolescents Aged 12 to 19 Years, NHANES III*

	% (95% CI)				
	Abdominal Obesity	High Glucose Level	High Triglyceride Levels	Low HDL-C Level	Elevated BP
Total	9.8 (8.2-11.4)	1.5 (0.1-2.8)	23.4 (19.9-27.0)	23.3 (20.6-26.0)	4.9 (3.4-6.4)
Sex					
Male	10.2 (8.0-12.4)	2.4 (0.0-4.9)	24.7 (18.9-30.5)	31.2 (27.1-35.3)	6.7 (4.1-9.4)
Female	9.4 (6.9-11.8)	0.5 (0.2-0.8)	22.1 (17.6-26.6)	15.1 (11.9-18.3)	3.0 (1.8-4.2)
Race/ethnicity					
White	9.3 (6.9-11.7)	1.6 (0.0-3.6)	25.5 (20.7-30.3)	26.1 (22.5-29.7)	5.2 (3.1-7.3)
Black	12.2 (9.6-14.8)	1.7 (0.6-2.8)	10.5 (8.0-14.5)	11.7 (9.0-14.5)	6.2 (4.4-8.1)
Mexican American	13.0 (9.4-16.5)	1.6 (0.7-2.4)	24.7 (21.0-28.4)	20.2 (15.5-24.9)	5.1 (3.2-6.9)
BMI status, percentile					
Normal (<85th)	0.3 (0.0-0.6)	0.7 (0.0-1.4)	17.6 (13.9-21.2)	17.7 (14.7-20.8)	3.2 (2.2-4.3)
At risk (85th to <95th)	11.5 (5.4-17.8)	4.5 (0.0-9.5)	33.5 (23.9-43.0)	32.3 (24.0-40.5)	8.6 (2.8-14.4)
Overweight (≥95th)	74.5 (67.1-81.8)	2.6 (0.0-6.3)	51.8 (40.7-62.9)	50.0 (42.3-57.8)	11.2 (5.7-16.8)

Abbreviations: BMI, body mass index; BP, blood pressure; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; NHANES III, Third National Health and Nutrition Examination Survey.
*For definitions of criteria, see the "Definitions" subsection of the "Methods" section.

sity but is also dependent on the regional distribution of the excess body fat.[48,49] Thus, because a more central distribution of fat correlates with worse cardiovascular risk and waist circumference has been shown to be the strongest correlate of central fat distribution in children,[50] it seems appropriate to use waist circumference in a pediatric definition of metabolic syndrome. In fact, BMI is a less sensitive indicator of fatness in children and fails to account for fat distribution.[51] Perhaps for these reasons, an American Heart Association statement has recommended the inclusion of waist circumference measurements in evaluating children for insulin resistance or those who manifest features resulting from insulin resistance that constitute much of the metabolic syndrome.[49]

Given the growing concern about metabolic syndrome, coupled with the alarming increase in the prevalence of overweight in children and adults, it is not surprising that the American Heart Association set forth a series of guidelines for promoting cardiovascular health as part of comprehensive pediatric care.[49,52,53] Evidence shows that obesity and insulin resistance has already started "the clock of coronary heart disease" in some adults, even before the onset of diabetes.[29] We cannot definitely state that this would be the case for overweight adolescents with the metabolic syndrome according to our definition, but this seems likely for many because the syndrome is a constellation of cardiovascular risk factors. Cluster-tracking studies have shown that multiple cardiovascular risk factors persist from childhood into adulthood in 25% to 60% of cases.[54,55] One study showed that subjects who either developed or lost their risk factor clustering over time had significant changes in their adiposity and lifestyle behaviors related to nutrition and physical activity.[55]

The first limitation of the data we present is to consider how to define the metabolic syndrome for pediatric patients. The intent was to create a definition for metabolic syndrome in adolescents for initial epidemiologic investigation and for possible future clinical consideration. The concept was to identify borderline high (or borderline low in the case of HDL) values for each criterion from established guidelines for children and adolescents. In some instances, as with BMI, age- and sex-specific criteria are recommended to identify abnormal patients.[56,57] In contrast, in the case of glucose and serum cholesterol, screening guidelines give single specific cutoff values for identifying abnormal subjects.[23,58,59] Although the rates of abnormal cholesterol values in adolescent subjects may seem higher than expected, 30% of adults from the same data set had hypertriglyceridemia and 37% had a low HDL cholesterol value according to the ATP III criteria for the metabolic syndrome.[9] There might also be concern that the cholesterol cutoff values used might lead to some overestimation or underestimation, but there was no difference in the prevalence of metabolic syndrome between 12- to 14-year-olds vs 15- to 19-year-olds ($P=.92$). When teenagers were stratified by Tanner stage, there was also no statistical difference in the rates of this syndrome phenotype, but rates increased among Tanner 2 and Tanner 3 individuals and decreased among Tanner 4 and 5 subjects. Although no national definition of the metabolic syndrome in adolescents currently exists, obesity treatment guidelines recommend identifying youth with medical complications of their obesity.[56,57] Even recent scientific statements on cardiovascular disease prevention or obesity and insulin resistance in children have not presented a definition of metabolic syndrome for research or clinical application.[49,52]

Some other limitations to consider include the cross-sectional nature of these data, which do not allow causal inferences and limit any assumptions about the duration of the existence of any of the criteria, such as blood pressure or cholesterol level. Also, since NHANES III was conducted, both obesity and type 2 diabetes have become more common among adolescents,[13,60] which may mean that this clustering of risk factors may have a higher prevalence now than it did during data collection. Despite subjects 12 years and older being instructed to fast, just more than 700 subjects from the original sample had to be eliminated for not fasting for at least 6 hours. Although 6 hours of fasting may not be ideal, it allowed a larger sample size to be analyzed by having subjects from afternoon and evening examinations included.

What This Study Adds

Childhood overweight currently affects 15% of children, and more than 60% of adults are overweight. Recently, the metabolic syndrome has been shown to affect more than 20% of the age-adjusted adult population and is closely related to the obesity epidemic. It is a clustering of metabolic derangements that reflect or portend insulin resistance, type 2 diabetes, and premature cardiovascular disease. To date, there has been no estimate of the potential disease burden for children or adolescents.

This study suggests that the phenotype of the metabolic syndrome may affect 4% of adolescents in the United States, with nearly 80% of adolescents who meet the criteria employed for the metabolic syndrome being overweight. Almost 30% of the overweight youth in this sample have 3 or more of the risk factors for the metabolic syndrome, thus qualifying under the criteria employed. Because metabolic syndrome significantly increases the risk of type 2 diabetes and premature coronary artery disease in adults, adolescent subjects who continue to manifest this risk factor profile may constitute a subgroup of overweight teenagers to target for lifestyle behavior changes.

Finally, it should be noted that owing to the low prevalence of the metabolic syndrome, some cell sizes were small when stratified by demographic characteristics. Multiple prospective reports confirm that the clustering of risk factors for the metabolic syndrome are developing during childhood,[16,33,40,46,61] and studies of the metabolic syndrome in adults show that its prevalence increases with age.[9]

Our findings highlight a high percentage of overweight adolescents who may bear a heightened risk for future metabolic syndrome in adulthood with subsequent increased risks for premature cardiovascular disease and type 2 diabetes. Consistent with recent commentaries that have called for better ways to define overweight in children,[62] use of a consensus definition for the metabolic syndrome to assess overweight adolescents might be a useful strategy to target a group at increased risk. Targeting adults with glucose intolerance and other markers of the metabolic syndrome has been employed in trials to prevent type 2 diabetes in adults.[63-65] The high prevalence of metabolic syndrome in overweight adolescents, however, emphasizes the need for effective preventive and therapeutic strategies that rely on diet, exercise, and lifestyle modification rather than medications. Otherwise, the financial burden imposed by obesity may be matched by the costs of treatment.

CONCLUSIONS

This study demonstrates that a metabolic syndrome phenotype may exist in perhaps 4% of the US adolescent population and almost 30% of overweight adolescents. Of those adolescents with metabolic syndrome, the great majority were overweight. This syndrome may affect almost 1 million adolescents in the United States. The impact of the metabolic syndrome in adolescents on subsequent morbidity and mortality has not, however, been explored, nor has the potential to reduce these risks by weight loss, increased activity, or pharmacological alteration of associated metabolic derangements. Nonetheless, these data indicate that a substantial percentage of US adolescents may be at significantly heightened risk for the metabolic syndrome in adulthood and the subsequent risks for type 2 diabetes and premature coronary artery disease. Perhaps they should be considered candidates for aggressive therapeutic interventions to maintain healthy lifestyle into and throughout adulthood.

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