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Sensitivity, Specificity, and Predictive Values of Pediatric Metabolic Syndrome Components in Relation to Adult Metabolic Syndrome: The Princeton LRC Follow-up Study

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Abstract

Objective—To estimate the sensitivity, specificity, and predictive values of pediatric metabolic syndrome (MetS) components (obesity, fasting glucose, triglycerides, high-density lipoprotein, and blood pressure) at various cutoffs in relation to adult MetS.

Study design—Data from the NHLBI Lipid Research Clinics (LRC) Princeton Prevalence Study (1973–76) and the Princeton Follow-up Study (PFS, 2000-4) were used to calculate sensitivity, specificity, and positive and negative predictive values for each component at a given cutoff, as well as for aggregates of components.

Results—Individual pediatric components alone showed low to moderate sensitivity, high specificity, and moderate predictive values in relation to adult MetS. When all five pediatric MetS components were considered, the presence of at least one abnormality had higher sensitivity for adult MetS than individual components alone. When multiple abnormalities were mandatory for MetS, positive predictive value was high and sensitivity was low. Childhood body mass alone showed neither high sensitivity nor high positive predictive value for adult MetS.

Conclusions—Considering multiple metabolic variables in childhood can improve the predictive utility for adult MetS, compared to each component or body mass alone. MetS variables may be useful for identifying some at risk children for prevention interventions.

The clustering of obesity, high blood pressure, high triglycerides, low high-density lipoprotein cholesterol (HDL), and impaired fasting glucose has been termed the metabolic syndrome (MetS). In adults, MetS is associated with increased risk of type 2 diabetes and cardiovascular disease (1–5). Features of the MetS have also been linked to the increasing prevalence of type 2 diabetes among children (6); however, there is no standardized pediatric definition of the MetS or its risk components. Variations in the definition of MetS have produced wide-ranging prevalence estimates (7) and have hampered the ability to compare findings across studies (8).

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Due to limited data that track individuals from childhood to adulthood, less is known about how well pediatric MetS predicts adult disease. Using the MetS definition of Cook et al (9), 30-year data from the Princeton LRC Follow-up Study (PFS) showed that the risk was almost 9-fold for cardiovascular disease and almost 4-fold for type 2 diabetes in children with the MetS vs. those without, after adjusting for age, sex, ethnicity, and family history (10). However, it is not clear whether the MetS definition of Cook et al or any other definition is the most optimal in identifying children who develop type 2 diabetes or cardiovascular disease later on in life. Indeed, although the majority of children with MetS tend to be overweight or obese (11), not all overweight or obese children develop MetS, type 2 diabetes, or cardiovascular disease. Therefore, the question is whether tools can be developed to identify children who are most metabolically at risk.

In this study, using data from the PFS, we aimed to examine the sensitivity, specificity, and predictive values of each component of the MetS in childhood at different cutoffs in relation to adult MetS. In addition, we also investigated the predictive utility of aggregates of the MetS components (with different numbers of abnormal components) in childhood in relation to adult MetS. Group differences by sex, ethnicity or age at baseline were also explored. The purpose of this paper was not to provide cutoff guidelines for the MetS in childhood; rather, we aimed to explore the statistical properties of defining MetS components in different ways in order to guide us in the future to determine potential ways to standardize pediatric MetS.

METHODS

Study Population

PFS participants were drawn from the Cincinnati Clinic of the NIH-NHLBI Lipid Research Clinics (LRC) Prevalence Program (Years 1973–6). The Cincinnati LRC, a multistage survey of lipids and other cardiovascular disease risk factors in students in grades 1–12 of the public and parochial schools in the Princeton School District, has been described previously (12–14). The student population was 73% white and 27% black, 52.3% male and 47.7% female (14). Race was self-declared as “white or black.” After an initial visit, at which total cholesterol and triglycerides were measured and basic demographic information collected, there were two subsequent screenings focused on complete lipid profiles and blood chemistries, anthropometry, blood pressure and family history of cardiovascular disease—one of which (Visit 2) focused on subsets of individuals from Visit 1, and the other (the Family Study or Visit 3) focused on first degree relatives of selected index cases from Visit 2.

The PFS (Years 2000–4) was conducted to assess long-term changes in familial lipid correlation and included Visit 3 families and Visit 2 participants with at least one first degree relative who also attended Visit 2. The minimum length of follow-up was 22 years and the maximum was 31 years, depending on when participants attended their LRC and PFS visits. Participation was 84% at Visit 1, 91% at subsequent LRC visits and did not differ significantly between races (12,13).

Clinical Measures

In both the LRC and PFS, data were collected using standard protocols. Measurement of height and weight was made with subjects in light indoor clothing, with shoes removed. In the LRC, one measurement of height and weight was made. In the PFS, two measurements of height and weight were made, with a third measurement if the first two differed by more than 0.5 cm for height or 0.3 kg for weight. The mean of the measurements was used for PFS analyses. The body mass index (BMI = kg/m^2) percentile was used to characterize obesity in childhood (15) because waist circumference was not measured in LRC. Childhood blood pressure percentiles were calculated based on the latest national guidelines (16). In each study, fasting

blood was drawn into vacutainers containing EDTA, kept on wet ice (LRC) or cold packs (PFS), and delivered to the laboratory within three hours for processing; lipid profiles were measured in LRC-CDC standardized laboratories. In the LRC, glucose was measured on the ABA-100 by a hexokinase method (17). In the PFS, glucose was measured on the Dade Dimension Xpand, using the hexokinase-glucose-6-phosphate dehydrogenase method (18).

Definition of Adult MetS

Adult MetS was chosen as the outcome measure for the current paper due to the limited cases of type 2 diabetes and cardiovascular disease. Additional efforts are underway to determine the feasibility of calculating prediction statistics of childhood MetS components for adult incidence of type 2 diabetes and cardiovascular disease, using both PFS and other longitudinal data. Adult MetS, including WC, was defined using the Adult Treatment Panel III guidelines (19) consistent with most U.S. population-based report. Adequate measures of insulin sensitivity were also not available in the current data set.

Statistical Methods

Each participant included in the analysis provided one wave of complete data in childhood and one wave of complete data in adulthood, with an average follow-up of 26 years (n=611). Descriptive statistics for demographic and metabolic variables were calculated at baseline and at follow-up. MetS and its components in adulthood were coded dichotomously. To narrow the number of possible cutoffs of each pediatric MetS component for which we would calculate prediction statistics, we first examined mean childhood values of each component in those with adult MetS vs. those without. In addition, we performed receiving operating characteristics (ROC) curves to determine the values of each component that corresponded to a preset sensitivity or specificity of 0.65–0.9 in relation to adult MetS. Based on findings from these two procedures, as well as conventional cutoffs used in the literature, we estimated the sensitivity, specificity, and positive and negative predictive values for a limited set of component cutoffs in relation to corresponding adult metabolic component and adult MetS. To further reduce the set of component cutoffs to construct definitional permutations of pediatric MetS, we selected two cutoff values for each metabolic component – one representing a conventional cutoff from previous literature and one alternative cutoff based on the above analyses (considering all diagnostic statistics and the prevalence rate). For each permutation of pediatric MetS, sensitivity, specificity, and predictive values in relation to adult MetS were calculated as associated with one or more, two or more, three or more, four or more, and all five abnormal pediatric components in relation to adult MetS. This generated five sets of 32 permutations, totaling 160 definitions. Limited stratified analyses were performed to examine potential variations between the two sexs, white vs. black participants, and younger (6–11.99 y) vs. older (12–19 y) participants at baseline.

Sensitivity refers to the proportion of individuals who truly had the MetS as adults that were captured by a given pediatric component or pediatric MetS. Specificity refers to the proportion of individuals who truly did not have the MetS as adults that were categorized correctly in childhood. Positive predictive value is the proportion of individuals categorized as at risk in childhood who truly had the MetS in adulthood. A high positive predictive value would indicate a low false positive rate as yielded by the screening criterion. Negative predictive value is the proportion of individuals categorized as not at risk in childhood who truly did not have the MetS in adulthood. A high negative predictive value would indicate a low false negative rate as yielded by the screening criterion. All analyses were conducted using SAS v. 9.1.3 (Cary, NC).

RESULTS

Table I shows the sample characteristics in childhood and in adulthood. Of the 611 participants, 179 (29.3%) were classified as having MetS in adulthood. (Table II). Those with adult MetS had higher BMI percentile (68th vs. 50th percentile, p<0.001), fasting glucose (88.3 vs. 86 mg/dL, p=0.001), triglycerides (89 vs. 71.5 mg/dL, p<0.001), systolic blood pressure (47th vs. 37th percentile, p<0.001), and lower HDL (49.1 vs. 55.8 mg/dL, p<0.001) in childhood than those without adult MetS.

Results from the ROC analyses are shown in Table III (available at www.jpeds.com). The value of a given variable was estimated based on a preset sensitivity or specificity level of 65–90% for adult MetS. For BMI, given a specificity of 80%, 85%, and 90%, the cutoff values were the 78th, 85th, and 90th percentile, with corresponding sensitivity values of 43%, 36%, and 27%, respectively. BMI values were below the 60th percentile for sensitivity values >65%. The values of fasting glucose ranged from 91 mg/dL to 95 mg/dL for a preset specificity value of 80–90%, with corresponding sensitivity values from 33% down to 13%. A triglyceride level of 88, 95, and 109 md/dL yielded sensitivity values of 40%, 31%, and 22%, respectively, given a specificity value of 80–90%. In the case of HDL, a cutoff of 40 mg/dL had a sensitivity of 20% and a specificity of 90%. The sensitivity was increased to 35% with a specificity of 80% when the cutoff was relaxed to 46 mg/dL. Systolic blood pressure at the 81st percentile yielded a sensitivity value of 18% and a specificity value of 90%. Diastolic blood pressure at the 85th percentile showed a sensitivity value of 14% and a specificity value of 90%.

Based on the above analyses, we determined a limited set of cutoff values, approximating upper and lower bounds of diagnostic and practical utility, for each metabolic component, for which sensitivity, specificity, and predictive values were estimated in relation to the corresponding adult component alone or to adult MetS as a whole (Table IV). As the cutoff for each component was relaxed to capture more individuals, the prevalence rate and sensitivity level rose. Specificity did not fall below 80% except when the fasting glucose cutoff was decreased to the 90 mg/dL level and when the HDL cutoff was raised to the 50 mg/dL level. In general, positive predictive values increased along with increasing stringency in the cutoffs, whereas the negative predictive values remained fairly stable. With the exception of fasting glucose and triglycerides, the positive predictive values were markedly higher when childhood variables were used to predict individual corresponding adult variables alone vs. adult MetS as a whole.

For each metabolic variable, findings from the above analyses suggested a more relaxed cutoff value than previously used conventional cutoffs. Thus, two cutoff values were selected for each metabolic variable – one representing a conventional cutoff and one representing the cutoff that increased the sensitivity level while maintaining a reasonable level of specificity and predictive value. This resulted in 32 possible definitional permutations of pediatric MetS. Sensitivity, specificity, and predictive values associated with one or more, two or more, three or more, four or more, and all five pediatric risk components in relation to adult MetS are shown in Table V (available at www.jpeds.com). Definitions with more stringent cutoffs tended to yield higher specificity and lower sensitivity, whereas definitions with more relaxed cutoffs tended to yield lower specificity and higher sensitivity. For instance, with three or more risk components considered in the definition, the most stringent set of cutoffs (definition set #30: BMI ≥ 90th percentile, fasting glucose ≥ 100 mg/dL, triglycerides ≥ 110 mg/dL, HDL < 40 mg/dL, systolic or diastolic blood pressure ≥ 90th percentile) resulted in a specificity of 97.5% and a sensitivity of 10.1% (prevalence of 4.7%). Conversely, the most relaxed set of cutoffs (definition set #3: BMI ≥ 85th percentile, fasting glucose ≥ 90 mg/dL, triglycerides ≥ 90 mg/dL, HDL < 45 mg/dL, systolic or diastolic blood pressure ≥ 75th percentile) increased sensitivity to 34.6% but decreased specificity to 88.9% (prevalence of 18%). Use of the most relaxed definition with four or more risk components considered resulted in a specificity of

96.3%, and a somewhat improved sensitivity of 15.6% (prevalence of 7.2%) compared to more restrictive definitions.

When positive predictive values were considered in addition to sensitivity and specificity levels, the choice of the best definition became more complicated. A high positive predictive value may be desirable if one wishes to be more confident that children who test positive are truly going to develop adult MetS. However, our findings suggest that a high positive predictive value often does not correspond to a high sensitivity value. When four or more components were used to define pediatric MetS, definition set #24 (BMI $\geq 90^{th}$ percentile, fasting glucose $\geq$ 100 mg/dL, triglycerides $\geq$ 90 mg/dL, HDL < 45 mg/dL, and systolic or diastolic blood pressure $\geq 90^{th}$ percentile) appeared to indicate the best combination of diagnostic values, with a sensitivity of 10.1%, specificity of 98.8%, positive predictive value of 78.3%, and negative predictive value of 72.6% (prevalence of 3.8%).

Sensitivity values were highest and positive predictive values lowest when any one or more abnormal components were used to define pediatric MetS. Sensitivity decreased and positive predictive values increased as more abnormal components were deemed necessary for the categorization of MetS cases.

Stratified analyses by sexs, race, and age group indicated no meaningful differences in the diagnostic utility of these cutoffs. Therefore, given limited space, results are presented for the total sample only.

DISCUSSION

Twenty-nine percent of our sample was categorized as having the MetS in adulthood, a slight increase from national estimates based on data from 10 years earlier (21.8% or 23.7% age-adjusted) (20). Our results demonstrate that, using metabolic markers associated with the MetS in childhood, it is difficult to capture the majority of adult MetS cases in childhood without also generating a high proportion of false positive results. In general, we found the more stringent the cutoff for each component, the lower the sensitivity and the higher the positive predictive value. Specificity and, to some extent, negative predictive values remained fairly stable across variations in cutoffs. No apparent sex, ethnic or age group discrepancies were found in the current study.

Sensitivity values were quite high with a number of definitions when MetS was defined as having one or more abnormalities (Table V). These sensitivity values were higher than the sensitivity of any individual components considered alone (Table IV), supporting the importance of measuring all five components even in primary prevention. It is also interesting to note that different cutoffs of BMI did not impact the positive predictive values greatly, suggesting that obesity as a lone marker may simply capture more individuals but not necessarily improve the precision of identifying children who are most metabolically at risk. This observation supports the idea that biomarkers in addition to obesity may be useful in screening children for targeted interventions. The determination of risk thresholds for MetS components in childhood may be one step in that direction. We note that because WC was not available in the pediatric data, we were not able to examine whether WC would impact the positive predictive values to a greater extent than BMI.

Blood pressure in childhood did not show high sensitivity or positive predictive values in relation to either adult blood pressure or adult MetS. Others have indicated that a hemodynamic factor may be distinct from the other metabolic variables, though both may be correlated with obesity and insulin dynamics (21). Nevertheless, it is important to note that, in relation to adult MetS, the combination of variables yielded higher positive predictive values while maintaining the average sensitivity of individual components. This was true especially when at least three

abnormal components were considered mandatory. When at least four abnormal components were mandatory, sensitivity decreased but the positive predictive values also increased dramatically.

Given that the etiology of MetS is complex, its development highly lifestyle-dependent, and that symptoms of metabolic dysregulation often arise over a long period of time, it is not surprising that pediatric metabolic components are not particularly sensitive for identifying those who eventually develop adult metabolic abnormalities. In order to increase the sensitivity of a given marker, cutoffs would need to be relaxed. There is evidence that at least in adults, elevated risk may be associated with variables below clinical thresholds, suggesting the potential utility of preventive efforts at lower thresholds (22). In many instances, however, this results in an inflation of the prevalence rate, which may be unacceptably large to be clinically plausible (Table IV). It is important to note that, even with the dramatic increase in sensitivity, these values remain low per conventional epidemiological practice. An important question is whether children who exhibit early abnormal variables are at greater risk for long-term adverse outcomes. Data from the PFS and other longitudinal studies indicate that this may be the case (10,23). If confirmed, then a screening tool with high positive predictive value yet low sensitivity may prove to still be useful.

In epidemiological practice, sensitivity is expected to be high when the disease outcome is serious, acute, and the cure for which is available and cost-effective (24,25). Specificity should be high if mislabeling a non-diseased patient as diseased could be detrimental, resulting in unnecessary, invasive, and/or expensive investigations and treatments or other undesirable consequences for the patient. Pediatric MetS variables are used to identify children at risk for rather than suffering currently from metabolic disease. Many examples of medical screening tools with low sensitivity and high specificity exist (26–28). Additional screening tools are often needed to improve the accuracy of a diagnostic test.

It is arguable that, given limited resources and the goal to screen for children most metabolically at risk for type 2 diabetes and cardiovascular disease, there is value in targeting these children specifically rather than capturing a wider population that may include a high proportion of children who may be overweight but are at lesser risk for disease. If an intervention modality carries risk, this is especially true. Although primary prevention among overweight youth remains an important goal, the identification of those at greater metabolic risk is important given the realities of the level of effort required to achieve and sustain behavior change, and the frequent need to allocate limited resources. In addition, focusing on weight regardless of metabolic risk may result in unintended psychosocial consequences. As our understanding of metabolic dysregulation advances, additional markers or tools may be developed and combined with the markers considered in this paper to increase the sensitivity of such a screening strategy.

Limitations of the current study include the availability of only one wave of data each in childhood and adulthood. MetS variables may fluctuate over time; therefore, the lack of repeated measures may result in the misclassification of individuals. In addition, though we attempted to be objective, the determination of which cutoffs to test inevitably involved a certain degree of subjectivity. Nonetheless, the prediction properties of pediatric MetS variables for adult MetS, as shown in this study, illustrate many of the strengths and weaknesses of MetS classification in childhood.

In sum, the current study used a unique data set to examine the predictive utility of pediatric MetS and its components for adult MetS. It is difficult to capture adult MetS cases early in life without generating many false positives, such is the case when using BMI as the sole marker. However, measuring multiple metabolic variables can improve our ability to identify truly metabolically at-risk children for targeted intervention. The current study is part of an ongoing

working group, which is employing similar methods to examine pediatric MetS in relation to adult type 2 diabetes and cardiovascular disease using multiple data sets. Findings from this study and ongoing studies may help propose risk thresholds of metabolic components that can be used for comparison across future studies and refine the screening of children who are most metabolically at risk.

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Table I

Sample characteristics.

	Childhood Assessment		Adult Follow-up	
	N	Percent	N	Percent
Sex				
Male	276	45.2	276	45.2
Female	335	58.8	335	58.8
Race				
White	434	71	434	71
Black	177	29	177	29
	Mean	SD	Mean	SD
Age (years)	12.7	3.2	38.6	3.5
BMI (percentile)	55	29.2	-	-
WC (cm)	-	-	96.8	16.8
FG (mg/dL)	86.7	8	92.1	29
TG (mg/dL)	76.6	40.7	137.2	142
HDL (mg/dL)	53.8	12.7	46.4	15.4
SBP (mmHg)	107.3	6.5	119.8	15.7
SBP (percentile)	40.1	28.9	-	-
DBP (mmHg)	63.1	3.3	79	11.1
DBP (percentile)	48.1	28	-	-

Note. Abbreviations used:

BMI Body mass index

FG Fasting glucose

TG Triglycerides

HDL High density lipoprotein cholesterol

SBP Systolic blood pressure

DBP Diastolic blood pressure

Table II

Means of childhood metabolic parameters by adult metabolic syndrome status

Childhood Variables	Adults without MetS N=432 mean (SD)	Adults with MetS N=179 mean (SD)	p
BMI (percentile)	49.8 (28)	67.5 (28.1)	<.001
FG (mg/dL)	86 (8.1)	88.3 (7.5)	.001
TG (mg/dL)	71.5 (34)	89 (51.6)	<.001
HDL (mg/dL)	55.8 (12.8)	49.1 (11.2)	<.001
SBP (percentile)	37.3 (27.5)	46.9 (30.1)	<.001
DBP (percentile)	46.9 (28.1)	51 (27.5)	.1

Table III

ROC analysis of sensitivity and specificity for childhood metabolic variables

Variable	Value	Sensitivity	Specificity
BMI(percentile)	59	0.65	0.63
	54	0.7	0.56
	44	0.75	0.45
	37	0.8	0.38
	20	0.85	0.28
	23	0.9	0.21
	61	0.63	0.65
	66	0.59	0.7
	71	0.5	0.75
	78	0.43	0.8
	85	0.36	0.85
	90	0.27	0.9
FG(mg/dL)	85	0.65	0.44
	84	0.7	0.4
	83	0.75	0.35
	82	0.8	0.31
	81	0.85	0.23
	78	0.9	0.16
	88	0.5	0.65
	89	0.45	0.7
	90	0.4	0.75
	91	0.33	0.8
	93	0.22	0.85
	95	0.13	0.9
TG(mg/dL)	63	0.65	0.5
	59	0.7	0.42
	56	0.75	0.37
	52	0.8	0.3
	50	0.85	0.24
	46	0.9	0.19
	72	0.54	0.65
	77	0.49	0.7
	81	0.45	0.75
	88	0.4	0.8
	95	0.31	0.85
	109	0.22	0.9
HDL(mg/dL)	54	0.65	0.55
	55	0.7	0.53
	56	0.75	0.47
	58	0.8	0.4
	60	0.85	0.31
	63	0.9	0.24
	50	0.55	0.65
	49	0.52	0.7
	47	0.4	0.75
	46	0.35	0.8
	44	0.3	0.85
	40	0.2	0.9
SBP(percentile)	27	0.65	0.45
	22	0.7	0.38
	18	0.75	0.31
	15	0.8	0.25
	12	0.85	0.2
	8	0.9	0.14
	44	0.49	0.65
	50	0.44	0.7
	58	0.39	0.75
	66	0.33	0.8
	73	0.25	0.85
	81	0.18	0.9
DBP(percentile)	38	0.65	0.43
	35	0.7	0.38
	27	0.75	0.29
	23	0.8	0.24
	17	0.85	0.2
	13	0.9	0.14
	63	0.36	0.65
	66	0.33	0.7
	71	0.28	0.75

Variable	Value	Sensitivity	Specificity
	74	0.23	0.8
	79	0.18	0.85
	85	0.14	0.9

Note. In ROC analysis, we pegged either sensitivity or specificity to preset values of 0.65 – 0.9 and estimated the corresponding values in the variable of interest.

Table IV

Predictive utility of candidate childhood metabolic variable at different cut-off values for **corresponding adult metabolic variables alone vs. adult metabolic syndrome as a whole**

		Adult Metabolic Variables				Adult Metabolic Syndrome			
Childhood Cutoff	**Prevalence %**	**Sensitivity %**	**Specificity %**	**PV (+) %**	**PV (−) %**	**Sensitivity %**	**Specificity %**	**PV (+) %**	**PV (−) %**
BMI 85	21.1	33.1	90.5	76.9	58.5	36.9	85.4	51.2	76.6
BMI 90	15.7	26.5	94.7	82.8	57.4	29.6	90.1	55.2	75.5
BMI 95	8.3	14.7	96.8	81.6	54.2	15.1	94.4	52.9	72.9
FG 90	34.2	46.2	69.6	25.4	85.3	45.3	70.4	38.8	75.6
FG 100	4.7	8.6	96.1	33.3	82.4	5	95.4	31	70.8
FG 110	0.7	1.1	99.5	33.3	81.8	1.1	99.5	50	70.8
TG 90	24.5	38.4	82	47.2	76	36.9	80.8	44.3	75.5
TG 100	18	29.9	87.4	50	74.9	26.3	85.4	42.7	73.7
TG 110	14.4	25.4	90.5	52.9	74.3	22.9	89.1	46.6	73.6
HDL 40	13.7	22.3	95.5	84.2	53.6	20.7	89.1	44.1	73.1
HDL 45	23.6	37.5	91	81.7	57.8	36.9	81.9	45.8	75.8
HDL 50	39.9	57.9	78.3	74	63.6	58.1	67.6	42.6	79.6
SBP 75	16.4	24.8	86.1	34.3	79.6	22.9	86.1	40.6	72.9
SBP 90	7.4	15.3	95.3	48.8	79.4	12.9	94.9	51.1	72.4
DBP 75	19.5	24	82.3	35.6	72.7	21.2	81	31.7	71.3
DBP 90	7.2	9.1	93.7	37.2	71.7	8.9	93.5	36.4	71.3

Note. BMI, SBP, and DBP are expressed in percentile. FG, TG, and HDL are expressed in mg/dL.

Table V

Predictive utility of candidate childhood metabolic syndrome classifications for adult metabolic syndrome.

# of Components	Variable Set*	Prevalence %	Sensitivity %	Specificity %	PV (+) %	PV (−) %
1	1	65	77.7	40.3	35	81.3
	2	59.7	74.3	46.3	36.4	81.3
	3	67.4	79.9	37.7	34.7	81.9
	4	62.5	77.1	43.5	36.1	82.1
	5	61.9	74.3	43.3	35.2	80.3
	6	56	71	50.2	37.1	80.7
	7	64.8	77.7	40.5	35.1	81.4
	8	59.2	74.9	47.2	37	81.9
	9	54.2	67	51.2	36.3	54.2
	10	46.6	62.6	60	39.3	79.5
	11	58.1	71	47.2	35.8	80
	12	51.2	67.7	55.6	38.7	80.5
	13	49.3	60.9	55.6	36.2	77.4
	14	40.9	56.4	65.5	40.4	78.4
	15	53.7	65.9	51.4	36	78.5
	16	46	62.6	60.9	39.9	46
	17	63.7	77.7	42.1	35.7	82
	18	58.4	74.3	48.2	37.3	81.9
	19	66.1	79.9	39.6	35.4	82.6
	20	61.2	77.1	45.4	36.9	82.7
	21	60.6	74.3	45.1	36	60.6
	22	54.5	70.4	52.1	37.8	54.5
	23	63.5	77.7	42.4	35.8	82.1
	24	57.8	74.3	49.1	37.7	82.2
	25	52.4	66.5	53.5	37.2	79.4
	26	44.4	61.5	62.7	40.6	79.7
	27	56.3	70.4	49.5	36.6	80.2
	28	48.9	66.5	58.3	39.8	80.8
	29	47.5	60.3	57.9	37.2	77.9
	30	38.5	54.8	68.3	41.7	78.5
	31	51.9	65.4	53.7	36.9	78.9
	32	43.5	60.9	63.7	41	79.7
2	1	32.7	50.3	74.5	45	78.4
	2	27.5	46.4	80.3	49.4	78.3
	3	36.2	54.8	71.5	44.3	79.2
	4	31.3	50.8	76.9	47.6	79.1
	5	30.3	47.5	76.9	46	77.9
	6	24.7	42.5	82.6	50.3	77.6
	7	33.2	50.8	74.1	44.8	78.4
	8	28.2	45.8	79.2	47.7	77.9
	9	23.7	39.1	82.6	48.3	76.6
	10	19.5	33.5	86.3	50.4	75.8
	11	27	44.7	80.3	48.5	77.8
	12	22.6	38.6	84	50	76.7
	13	22.3	38	84.3	50	76.6
	14	17.5	30.7	88	51.4	75.4
	15	25	42.5	82.2	49.7	77.5
	16	20.3	34.6	85.7	50	76
	17	31.3	48	75.7	45	77.9
	18	25.4	43	81.9	49.7	77.6
	19	34.9	53.1	72.7	44.6	78.9
	20	29.3	48	78.5	48	78.5
	21	28.5	44.1	78	45.4	77.1
	22	39.1	84.3	50.7	77	22.6

# of Components	Variable Set*	Prevalence %	Sensitivity %	Specificity %	PV (+) %	PV (−) %
	23	31.6	48	75.2	44.6	77.8
	24	26.2	43	80.8	48.1	77.4
	25	22.1	36.9	84	48.9	76.3
	26	18	31.3	87.5	50.9	75.5
	27	25.5	43	81.7	49.4	77.6
	28	21.3	36.9	85.2	50.8	76.5
	29	20.1	34.1	85.7	49.6	75.8
	30	15.9	27.9	89.1	51.6	74.9
	31	23.1	39.1	83.6	49.7	76.8
	32	18.8	32.4	86.8	50.4	75.6
3	1	16	30.7	90.1	56.1	75.8
	2	13.1	25.7	92.1	57.5	75
	3	18	34.6	88.9	56.4	76.7
	4	14.9	29.6	91.2	58.2	75.8
	5	12.9	25.1	92.1	57	74.8
	6	10.1	20.1	94	58.1	74
	7	15.1	29.1	90.7	56.5	75.5
	8	11.9	24.6	93.3	60.3	74.9
	9	10.5	20.7	93.8	57.8	74
	10	7.7	16.8	96.1	63.8	73.6
	11	12.1	25.1	93.3	60.8	75.1
	12	9.2	20.7	95.6	66.1	74.4
	13	7.4	14.5	95.6	57.8	73
	14	5.6	11.7	97	61.8	72.6
	15	9.3	19.6	94.9	61.4	74
	16	7.2	16.8	96.8	68.2	73.7
	17	14.9	28.5	90.7	56	75.4
	18	12.4	24.6	92.6	57.9	74.8
	19	16.7	31.8	89.6	55.9	76
	20	14.1	27.9	91.7	58.1	75.4
	21	11.9	23.5	92.8	57.5	74.5
	22	9.5	1	94.4	58.6	73.8
	23	13.9	26.8	91.4	56.5	75.1
	24	11.1	22.9	93.8	60.3	74.6
	25	9.3	17.9	94.2	56.1	73.5
	26	6.7	14	96.3	61	73
	27	11	22.4	93.8	59.7	74.5
	28	8.2	17.9	95.8	64	73.8
	29	6.5	13.4	96.3	60	72.9
	30	4.7	10.1	97.5	62.1	72.3
	31	8.5	18.4	95.6	63.5	73.9
	32	6.4	15.1	97.2	69.2	73.4
4	1	5.7	11.7	96.8	60	72.3
	2	3.9	8.9	98.2	66.7	72.2
	3	7.2	15.6	96.3	63.6	73.4
	4	5.1	12.9	98.2	74.2	73.1
	5	4.6	9.5	97.5	60.7	72.2
	6	3.6	7.8	98.2	63.6	72
	7	6.2	14.5	97.2	68.4	73.3
	8	4.7	11.7	98.2	72.4	72.9
	9	2.9	6.2	98.4	61.1	71.7
	10	2	4.5	99.1	66.7	71.5
	11	3.8	7.8	97.9	60.9	71.9
	12	2.6	6.7	99.1	75	71.9
	13	2.5	5.6	98.8	66.7	71.6
	14	1.8	4.5	99.3	72.7	71.5

# of Components	Variable Set*	Prevalence %	Sensitivity %	Specificity %	PV (+) %	PV (−) %
	15	3.1	7.3	98.6	68.4	72
	16	2.1	5.6	99.3	76.9	71.7
	17	4.6	9.5	97.5	60.7	72.2
	18	2.8	6.2	98.6	64.7	71.7
	19	6.2	14	97	65.8	73.1
	20	4.1	10.6	98.6	76	72.7
	21	3.4	7.8	98.4	66.7	72
	22	2.5	5.6	98.8	66.7	71.6
	23	5.2	13.4	98.2	75	73.2
	24	3.8	10.1	98.8	78.3	72.6
	25	2.1	4.5	98.8	61.5	71.4
	26	1.3	3.4	99.5	75	71.3
	27	2.8	5.6	98.4	58.8	71.6
	28	1.8	5	99.5	81.8	71.7
	29	1.8	3.9	99.1	63.6	71.3
	30	1.3	3.4	99.5	75	71.3
	31	2.3	5	98.8	64.3	71.5
	32	1.5	3.9	99.5	77.8	71.4
5	1	1.6	3.9	99.3	70	71.4
	2	1.3	3.4	99.5	75	71.3
	3	2.1	5.6	99.3	76.9	71.4
	4	1.6	4.5	99.5	80	71.6
	5	1.5	3.9	99.5	77.8	71.4
	6	1.1	3.4	99.8	85.7	71.4
	7	1.6	4.5	99.5	80	71.6
	8	1.3	3.9	99.8	87.5	71.5
	9	0.3	1.1	100	100	70.9
	10	0.3	1.1	100	100	70.9
	11	0.5	1.7	100	100	71
	12	0.3	1.1	100	100	70.9
	13	0.3	1.1	100	100	70.9
	14	0.3	1.1	100	100	70.9
	15	0.3	1.1	100	100	70.9
	16	0.3	1.1	100	100	70.9
	17	1.3	3.4	99.5	75	71.3
	18	1.1	3.4	99.8	85.7	71.4
	19	1.6	4.5	99.5	80	71.6
	20	1.3	3.9	99.8	87.5	71.5
	21	1.3	3.4	99.5	75	71.3
	22	1.1	3.4	99.8	85.7	71.4
	23	1.3	3.4	99.5	75	71.3
	24	1.1	3.4	99.8	85.7	71.4
	25	0.3	1.1	100	100	70.9
	26	0.3	1.1	100	100	70.9
	27	0.5	1.7	100	100	71.1
	28	0.3	1.1	100	100	70.9
	29	0.3	1.1	100	100	70.9
	30	0.3	1.1	100	100	70.9
	31	0.3	1.1	100	100	70.9
	32	0.3	1.1	100	100	70.9

*Note. Cut-points used for each set of variables are as follows:

1 BMI 85, FG 90, TG 90, HDL 40, SBP 75 or DBP 75

2 BMI 85, FG 90, TG 90, HDL 40, SBP 90 or DBP 90

3 BMI 85, FG 90, TG 90, HDL 45, SBP 75 or DBP 75

4 BMI 85, FG 90, TG 90, HDL 45, SBP 90 or DBP 90

5 BMI 85, FG 90, TG 110, HDL 40, SBP 75 or DBP 75
6 BMI 85, FG 90, TG 110, HDL 40, SBP 90 or DBP 90
7 BMI 85, FG 90, TG 110, HDL 45, SBP 75 or DBP 75
8 BMI 85, FG 90, TG 110, HDL 45, SBP 90 or DBP 90
9 BMI 85, FG 100, TG 90, HDL 40, SBP 75 or DBP 75
10 BMI 85, FG 100, TG 90, HDL 40, SBP 90 or DBP 90
11 BMI 85, FG 100, TG 90, HDL 45, SBP 75 or DBP 75
12 BMI 85, FG 100, TG 90, HDL 45, SBP 90 or DBP 90
13 BMI 85, FG 100, TG 110, HDL 40, SBP 75 or DBP 75
14 BMI 85, FG 100, TG 110, HDL 40, SBP 90 or DBP 90
15 BMI 85, FG 100, TG 110, HDL 45, SBP 75 or DBP 75
16 BMI 85, FG 100, TG 110, HDL 45, SBP 90 or DBP 90
17 BMI 90, FG 90, TG 90, HDL 40, SBP 75 or DBP 75
18 BMI 90, FG 90, TG 90, HDL 40, SBP 90 or DBP 90
19 BMI 90, FG 90, TG 90, HDL 45, SBP 75 or DBP 75
20 BMI 90, FG 90, TG 90, HDL 45, SBP 90 or DBP 90
21 BMI 90, FG 90, TG 110, HDL 40, SBP 75 or DBP 75
22 BMI 90, FG 90, TG 110, HDL 40, SBP 90 or DBP 90
23 BMI 90, FG 90, TG 110, HDL 45, SBP 75 or DBP 75
24 BMI 90, FG 90, TG 110, HDL 45, SBP 90 or DBP 90
25 BMI 90, FG 100, TG 90, HDL 40, SBP 75 or DBP 75
26 BMI 90, FG 100, TG 90, HDL 40, SBP 90 or DBP 90
27 BMI 90, FG 100, TG 90, HDL 45, SBP 75 or DBP 75
28 BMI 90, FG 100, TG 90, HDL 45, SBP 90 or DBP 90
29 BMI 90, FG 100, TG 110, HDL 40, SBP 75 or DBP 75
30 BMI 90, FG 100, TG 110, HDL 40, SBP 90 or DBP 90
31 BMI 90, FG 100, TG 110, HDL 45, SBP 75 or DBP 75
32 BMI 90, FG 100, TG 110, HDL 45, SBP 90 or DBP 90

BMI, SBP, and DBP are expressed in percentile. FG, TG, and HDL are expressed in mg/dL.