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# Predictive Ability of Childhood Metabolic Components for Adult Metabolic Syndrome and Type 2 Diabetes

**Christine M. Schubert, PhD**, **Shumei S. Sun, PhD**, **Trudy L. Burns, MPH, PhD**, **John A. Morrison, PhD**, and **Terry T.-K. Huang, PhD, MPH**
Department of Biostatistics, School of Medicine, Virginia Commonwealth University (C.S., S.S.), Richmond, VA, the Department of Epidemiology, College of Public Health, University of Iowa (T.B.), Iowa City, IA, Division of Cardiology, Cincinnati Children's Hospital Medical Center (J.M.), Cincinnati, OH, and the Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health (T.H.), Bethesda, MD

## Abstract

**Objective—**To estimate sensitivity, specificity, and positive and negative predictive values of components of the metabolic syndrome (MetS) during childhood for MetS and type 2 diabetes (T2D) in adulthood.

**Study design—**Data from 3 major studies—the Fels Longitudinal Study, the Muscatine Study, and the Princeton Follow-up Study—were combined to examine how thresholds of metabolic components during childhood determine adult MetS and T2D. Available metabolic components examined in the 1789 subjects included high-density lipoprotein, triglyceride levels, glucose, and percentiles for body mass index, waist circumference, triglycerides, and systolic and diastolic blood pressures. Sensitivity, specificity, and positive and negative predictive values for a refined set of component threshold values were examined individually and in combination.

**Results—**Sensitivity and positive predictive values remained low for adult MetS and T2D for individual components. However, specificity and negative predictive values were fairly high for MetS and exceptionally so for T2D. In combination, having 1 or more of the components showed the highest sensitivity over any individual component and high negative predictive value. Overall, specificity and negative predictive values remained high whether considering individual or combined components for T2D.

**Conclusions—**Sensitivity and positive predictive values on the basis of childhood measures remained relatively low, but specificity and negative predictive values were consistently higher, especially for T2D. This indicates that these components, when examined during childhood, may provide a useful screening approach to identifying children not at risk so that further attention can be focused on those who may be in need of future intervention.

Metabolic syndrome (MetS) in adults is defined as the clustering of 3 or more of the following metabolic risk factors: high waist circumference, systolic or diastolic blood pressure, fasting glucose and triglyceride levels, and low high-density lipoprotein (HDL)



Reprint requests: Christine M. Schubert, PhD, MBA, Department of Biostatistics, School of Medicine, Virginia Commonwealth University, Theatre Row, Room 3084, 730 E Broad St, PO Box 980032, Richmond, VA 23298-0032. cmschubert@vcu.edu..

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cholesterol. Specific threshold values separating high and low risk levels for these components in adults were previously established by the Adult Treatment Panel (ATP) III[1] and further refined for fasting glucose.[2] These values represent the standard for the adult definition of MetS, which has been linked to type 2 diabetes and cardiovascular disease outcomes.[3-7]

In the past decade, efforts have focused on extending definitions of MetS to children, with the ultimate goal of identifying children at risk for adult disease. This strategy could make possible early, conservative interventions. Such an extension requires study designs that include data on the same individuals during both childhood and adulthood; it also requires a definition of pediatric MetS. Although there are definitions of pediatric MetS—Ford et al[8] counted as many as 40 different definitions in 27 pediatric studies published after the definition from the World Health Organization was set forth—the definitions differ widely. Most studies have used some variant of the ATP III guidelines, but differed in how they adjusted the guidelines. Some definitions used age-specific percentile values for waist circumference and triglycerides,[9] others used actual values. Some definitions used a body mass index (BMI) percentile when waist circumference was not measured. [10,11] Finally, different percentile cutoffs and values were used, ranging from the fifth to the 25th percentile for HDL and from the 75th to the 95th percentile for triglyceride levels and blood pressure. The cutoffs for glucose have included both 100 mg/dL and 110 mg/dL. Despite the lack of a standard operational definition, modified ATP III guidelines have shown that pediatric MetS predicts adult diabetes and cardiovascular disease (CVD).[10,11] These studies have used specific threshold values to define pediatric MetS and determined its predictive ability with logistic regression. They have not compared relative differences in disease risk across a range of threshold values for the individual components. The sensitivity, specificity, and predictive ability of individual components have been examined in relation to adult MetS, and combinations of factors have been suggested as potentially useful for the prediction of adult MetS.[12] Despite these advances, further research is needed to provide evidence for the usefulness of these thresholds to predict the cluster of diseases associated with the MetS, such as cardiovascular disease and type 2 diabetes, as well as to examine risk factors for which information is lacking, such as waist circumference.

In this study, we sought to examine these issues by combining data from several large studies, the Fels Longitudinal Study (FLS), the Muscatine Study (MS), and the Princeton Follow-up Study (PFS), all of which collected biologic data during both childhood and adulthood. The combination of data across studies allowed us to look at specific disease states with relatively lower prevalence, that is, type 2 diabetes, as well as examine ranges of threshold values for individual components of MetS whose disease prevalence in adulthood has been estimated much higher.[13] Specific research aims for this study included (1) examining specific threshold values of individual risk factors and components of MetS for the sensitivity, specificity and predictive ability of these factors for adult MetS and type 2 diabetes, (2) examining suggested combinations of components for their ability to predict adult disease outcomes, and (3) examining differences in the sensitivity, specificity and predictive values for the 90th triglyceride percentile value versus standard values between 90 and 130 mg/dL. This work seeks to extend previous efforts[12] to add to the growing knowledge and understanding of how such components during childhood should be combined to best identify those children at risk for specific adult onset disease.

## Methods

### Subjects

The analysis sample included subjects participating in 1 of 3 studies: the Fels Longitudinal Study (FLS), the Muscatine Study (MS), or the Princeton Follow-up Study (PFS). Each

subject had risk factor information that spanned both childhood (ages 6 to 20 years) and adulthood (25 to 55 years). Further inclusion criteria required the ability to classify each subject as to their type 2 diabetes (T2D) or MetS status during adulthood and the availability of data on at least 1 component of the MetS during childhood. Because the PFS design consisted of 1 wave of childhood data with 1 wave of adulthood data, subsequent data chosen from the FLS and the MS longitudinal databases were matched to this design. Descriptions of each of the studies, as well as the childhood and adulthood measures as related to the MetS are given below.

**The Princeton Follow-up Study—**The PFS was conducted between 2000 and 2004 as a follow-up to an original multistage survey of elementary and high school students attending public and parochial schools in the Princeton School District of Cincinnati, Ohio, between 1973 and 1976. Specifics of the original school-based study have been described,[14-15] as well as the sample specific to linking childhood to adult outcomes.[12] Childhood data included weight, height, BMI, blood pressures, lipids and lipoproteins, as well as fasting glucose. A total of 608 subjects (273 men and 335 women) with data from both the adult follow-up and childhood were included in this analysis.

**The Fels Longitudinal Study—**The FLS is an ongoing study of growth and maturation that began in 1929 in the town of Yellow Springs, Ohio. Anthropometric measures of growth including weight, height, and BMI, as well as systolic (SBP) and diastolic (DBP) blood pressures are available starting with the 1929 cohort. Measurers for lipid and lipoproteins were added to the study protocol in 1976 and glucose and insulin in 1989. To match the PFS, a random selection from all examinations with available data for each subject was chosen resulting in data for a total of 332 subjects (164 men and 168 women) being included in this analysis. The childhood measurements for these subjects were obtained from examinations between 1976 and 1996 with corresponding adult measurements between 1988 and 2006. Further details regarding the FLS have been reported.[16]

**The Muscatine Study—**The MS began in 1970 as a population-based observational investigation of atherosclerotic cardiovascular disease risk factors measured biennially through 1981 in the school children of Muscatine, Iowa.[17] School survey measurements included weight, height, blood pressures, and lipids. Lipoprotein measurements were added to young adult examinations that were targeted at ages 23, 28, and 33 years. Beginning in 1992, an adult cohort of previous participants was recruited for investigation of subclinical cardiovascular disease. All of the components of the MetS were measured during these examinations. To match the PFS, a random selection of subjects with available data from the most recent adult examination (from 1992 to 2007) and the earliest school survey examination (from 1970 to 1981) was chosen, resulting in a total of 849 subjects (380 men and 469 women) for this analysis.

## Measurements

Examination methods for each of these studies have been previously described.[12,14-19] All studies included childhood measures of weight (kg), height (cm), SBP and DBP (mm Hg), triglyceride level (mg/dL), and calculated BMI (kg/m$^2$). Fasting glucose (mg/dL) and HDL (mg/dL) were available in the FLS and PFS cohorts only, but not the MS cohort. Percentiles for most of these measurements were also included. BMI percentile was computed with the 2000 Growth Charts from the Centers for Disease Control and Prevention,[20] and SBP and DBP percentiles were computed with methods outlined in the fourth report from the National High Blood Pressure Education Program Working Group.[21] Classifications of children above and below specific triglyceride percentiles[22] and waist circumference

percentiles (see Cook et al in this supplement) was also included, as was the definition for an abnormal HDL[23] in which boys under the age of 12 years and all girls (<20 years) were considered as having abnormal HDL if HDL was lower than 50 mg/dL; boys between the ages of 12 and 20 whose HDL was lower than 40 mg/dL were considered as having an abnormal HDL level.

Adult data included measures of waist circumference, SBP, DBP, triglyceride level, HDL and fasting glucose and self-report disease status. Adults were classified as having MetS with the ATP III guidelines for high waist circumference, hypertriglyceridemia, low HDL, and hypertension,[1] and suggested lowering of the fasting glucose threshold to 100 mg/dL[2]. T2D was determined through self-report. Classifications with regard to CVD, although highly relevant, were not included because the methods with which to determine CVD was not consistent across the studies, varying from medical records documentation of morbidity/death to self-report of specific CVD-related conditions. Demographic and other data included sex, race (black, white), childhood age at examination, and age at the determination of MetS and T2D status.

### Statistical Methods

Descriptive statistics for childhood and adult demographic and metabolic values were computed. Adult MetS and T2D status were recorded as yes/no. Mean childhood values of the metabolic components were compared by use of simple *t* tests between those with disease and those without disease. Specific threshold values during childhood for the components of the MetS were chosen with previously derived values,[12] common values found in the literature, and values corresponding to a specificity or sensitivity of at least 0.80. Additional percentile values for BMI, SBP, DBP, triglyceride levels, and waist circumference were also examined. Sensitivity, specificity, positive (PPV) and negative (NPV) predictive values were computed for each component and component percentile using the identified threshold values. In addition, 2 combinations of the MetS components were also examined, with the presence of at least 1, 2, 3, 4, or all 5 components to predict adult MetS. Sensitivity, specificity, PPV, and NPV were computed for these combinations and compared. Finally, sensitivity, specificity, PPV, and NPV were compared between triglyceride components by use of observed and percentile values, as was the HDL component with observed values and the previously defined abnormal HDL level.[23]

The measures of sensitivity, specificity, PPV, and NPV correspond to how well each threshold classifies the subjects. Here, sensitivity is the probability that the subject who was classified as obtaining the disease in adulthood (was over the childhood threshold value) really will acquire the disease. Specificity is the probability that the subject is classified as not obtaining the disease in adulthood (was below the childhood threshold value) given that they truly will not have the disease. The PPV is the probability that a subject will acquire the disease given that they are above the threshold value and the NPV is the probability that a subject will not acquire the disease given that they are below the threshold value.

## Results

Sample characteristics and adult disease prevalence for the 3 studies separately and combined are given in **Table I**. Slightly more than one half of the 1789 subjects in the combined data set were women (54.3%), and this proportion was similar across studies. The FLS and MS were predominantly white (>99%), and 177 of the combined total of 181 black subjects came from the PFS. Adult MetS prevalence overall was 24.6% and was slightly higher in the PFS as compared with the FLS and MS (29.1% vs 22.3% to 22.4%). T2D prevalence ranged from 2.1% (FLS) to 5.6% (PFS), for a combined prevalence of 3.9%.

Descriptive statistics by study and the combined sample for metabolic variables are given in **Table II** for childhood values and **Table III** for adult values. Children in the MS group were similarly aged to children in the FLS group, although they were slightly heavier and bigger with higher blood pressure (**Table II**). Children in the PFS group were younger, although at follow-up, they were heavier with higher blood pressure and lower HDL on average than adults in the FLS group (**Table III**).

Significant differences in all childhood metabolic components were observed between those with and those without adult MetS although age between the groups was similar (**Table IV**). Those with adult MetS had significantly higher waist circumference, weight, height, BMI, BMI percentile, blood pressure and blood pressure percentiles, glucose, and triglyceride and lower HDL. These trends were not the same for T2D. Significant differences in childhood metabolic components were observed between those with and those without T2D for weight, BMI, BMI percentile, SBP percentile, glucose, triglyceride, and HDL, but not for age, waist circumference, height, SBP, DBP or DBP percentile (**Table V**). Those with adult T2D had significantly higher weight, BMI, BMI and SBP percentile, glucose and triglyceride, and lower HDL.

The use of specific childhood threshold values for BMI, waist circumference, SBP and DBP percentile, glucose, triglyceride, and HDL as individual thresholds with which to classify subjects with adult MetS or T2D are given in **Table VI**. Each value listed with the exception of HDL considers classifying subjects with the specific disease if the subject has a value over the threshold listed. For example, with the BMI 85th entry (**Table VI**), all subjects who had a BMI percentile value above the 85th level were classified with adult MetS and adult T2D, and the prevalence of subjects above the 85th percentile for BMI was 18.3% in the total sample.

Several patterns emerge when examining these individual thresholds for adult MetS and T2D. First, sensitivity values were low (< 60%), as were PPV in most cases. PPV reaches above 60% when the 90th percentile of waist circumference is used for MetS, but a lack of cases for T2D makes comparisons not possible. In contrast, specificity and NPV achieved quite high values, demonstrating the existence of threshold values for which the individual components accurately identify children not at risk. Overall, NPV values for T2D across all the thresholds considered were much higher than those for MetS (about 20% higher), although specificity was comparable. Thus individually these components are much better at screening out children not at risk for T2D than for MetS. In contrast, PPV values for MetS across all thresholds considered were much higher than those for T2D (about 30% higher), demonstrating that individually these components are much better at identifying those children who will truly have MetS than for T2D.

Individually, a BMI 85th percentile value shows reasonably high specificity and NPV and relatively higher sensitivity and comparable PPV to other BMI percentiles for both MetS and T2D (**Table VI**). Glucose of 100 mg/dL does not show as high sensitivity but is remarkably higher in specificity and NPV than at 90 mg/dL and is comparable with the predictive ability of glucose at 110 mg/dL. A similar pattern holds for the 85th percentiles of SBP and DBP. These values represent reasonable thresholds for T2D and MetS in terms of their ability to screen out children not at risk.

Little difference in sensitivity or NPV, but remarked increase in specificity and PPV demonstrate potential usefulness of the 90th percentile of triglycerides as opposed to empirical triglyceride values of 90, 100, and 110 mg/dL (**Table VI**). In contrast, the definition of an abnormal HDL does not seem to add much to the individual thresholds of 40 or 50 mg/dL, except that it results in a weighted average between the 2 thresholds.

Finally, 2 groups of multiple components were examined. The first group, group I, included the following component thresholds: BMI ≥ 90th percentile, fasting glucose ≥ 100 mg/dL, triglycerides ≥ 90 mg/dL, HDL< 45 mg/dL, and SBP or DBP ≥ 90th percentile. Group II used slightly different thresholds as follow: BMI ≥ 85th percentile, fasting glucose ≥ 100 mg/dL, TG ≥ 90th percentile, HDL < 45 mg/dL, and SBP or DBP ≥ 85th percentile. Group I replicates the best combination highlighted in Huang et al[12] whereas group II uses many of the individual components highlighted from **Table VI**.

Disease classifications were compared for both groups whether individuals had 1 or more (1+), 2 or more (2+), 3 or more (3+), or 4 or more (4+) threshold values greater than the cutoffs given for each group. The results, whether with group I or II, are comparable when examining MetS or T2D, except that in group I, PPV values increase dramatically with increasing components above threshold levels (**Table VII**). Having 1 or more of the components showed the highest sensitivity over any individual component, while maintaining high NPVs. Furthermore, NPV values remain fairly stable, but specificity values increase dramatically once 2 or more components over thresholds are considered. Both groups I and II show higher PPV values for MetS and lower PPV values for T2D, but higher NPV values for T2D and lower NPV values for MetS. This indicates that multiple components are better at predicting adult MetS and, conversely, at screening out who is not at risk for T2D in adulthood.

## Discussion

This article is an extension of previous work examining the ability of specific pediatric MetS thresholds to predict adult disease. Unique to this study is the combination of data from 3 major studies, as well as the examination of the prediction of adult T2D. Results for MetS were similar to those previously reported.[12] Results for T2D demonstrate low PPV, but very high NPV (>90%). NPV was also high for MetS, but ranged about 20% lower than those values seen for T2D. This result is expected because T2D is less prevalent in this sample than MetS (3.9% as compared with 24.6%) and both NPV and PPV are disease prevalence dependent.

Specificity and NPV remained consistently high for both disease states. This demonstrates the ability, especially in T2D, for metabolic components to identify those children not at risk for adult disease. The ability of these components to screen out children to focus attention on those children with unclear potential for development of MetS or T2D is consistent with most screening tests and is the major finding of this study.

There remain several limitations to this study. First, examining cardiovascular disease (CVD) as an endpoint in adulthood, although desired, could not be adequately examined because a consistent definition to identify CVD could not be reconciled. Second, the combined data used in this study contained nearly 1800 subjects; however, only the FLS contained measures of waist circumference in childhood. This limited our ability to examine relative impact of waist circumference thresholds for the identification of adult Mets and T2D. To a lesser extent, glucose was measured in both the FLS and the PFS, but not the MS. Furthermore, data from the Bogalusa Heart Study was examined for inclusion to reduce deficiencies for measures such as waist circumference. However, subjects in the Bogalusa Heart Study with metabolic components in childhood and adult disease classification is still too young to be included with the same comparable adult classification age range. Finally, the PFS study has a sizeable number of black subjects, whereas the FLS and MS studies do not. Although not enough to have studied these subjects separately in the combined sample, the inclusion of these individuals may explain why the prevalence of both adult MetS and

T2D was higher for PFS despite not necessarily having the highest means for adult BMI, TG, SBP, and triglyceride.[11]

In conclusion, the metabolic components as measured during childhood appear useful as screening mechanisms to identify the children not at risk. For the remaining children, continued monitoring is warranted. Further studies invoking larger samples are needed to fully examine other metabolic components such as waist circumference and disparities associated with race. Finally, examining these measures in a longitudinal setting to develop childhood profiles may provide additional insight into critical thresholds that help identify children both not at risk for adult metabolic diseases and those potentially in need for intervention.

## Glossary

| | |
|---|---|
| **ATP** | Adult Treatment Panel |
| **BMI** | Body mass index |
| **DBP** | Diastolic blood pressure |
| **FLS** | Fels Longitudinal Study |
| **HDL** | High-density lipoprotein |
| **MetS** | Metabolic syndrome |
| **MS** | Muscatine Study |
| **NPV** | Negative predictive value |
| **PFS** | Princeton Follow-up Study |
| **PPV** | Positive predictive value |
| **SBP** | Systolic blood pressure |
| **T2D** | Type 2 diabetes |

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**Table I**

Sample characteristics and adult disease prevalence

| | FLS | | MS | | PFS | | Total | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Sex | | | | | | | | |
| Men | 164 | 49.4 | 380 | 44.8 | 273 | 44.9 | 817 | 45.7 |
| Women | 168 | 50.6 | 469 | 55.2 | 335 | 55.1 | 972 | 54.3 |
| Race | | | | | | | | |
| Black | 1 | 0.3 | 3 | 0.3 | 177 | 29.1 | 181 | 10.1 |
| White | 331 | 99.7 | 846 | 99.7 | 434 | 70.9 | 1608 | 89.8 |
| Disease prevalence | | | | | | | | |
| Adult MetS | | | | | | | | |
| Yes | 74 | 22.3 | 190 | 22.4 | 176 | 29.0 | 440 | 24.6 |
| No | 258 | 77.7 | 659 | 77.6 | 431 | 71.0 | 1348 | 75.4 |
| Adult T2D | | | | | | | | |
| Yes | 7 | 2.1 | 29 | 3.4 | 34 | 5.6 | 70 | 3.9 |
| No | 325 | 97.9 | 820 | 96.6 | 574 | 94.4 | 1719 | 96.1 |

## Table II

Mean (standard deviation) childhood metabolic values by study

| | FLS | MS | PFS | Total |
|---|---|---|---|---|
| Age (years) | 14.49 (3.08) | 14.32 (2.70) | 12.65 (3.18) | 13.78 (3.05) |
| Anthropometrics | | | | |
| WC (cm) | 72.68 (8.84) | — | — | 72.68 (8.84) |
| Weight (kg) | 52.92 (14.83) | 53.39 (15.10) | 47.24 (17.61) | 51.21 (16.20) |
| Height (cm) | 161.14 (15.07) | 158.70 (13.59) | 151.71 (16.73) | 156.78 (15.45) |
| BMI ($kg/m^2$) | 19.95 (3.14) | 20.77 (3.55) | 19.80 (4.37) | 20.29 (3.81) |
| BMI % | 50.02 (27.01) | 58.63 (25.08) | 55.01 (29.22) | 55.95 (27.07) |
| Blood pressure | | | | |
| SBP (mm Hg) | 100.49 (9.41) | 116.06 (13.22) | 107.26 (6.47) | 110.18 (12.26) |
| SBP % | 21.36 (19.41) | 63.72 (28.30) | 40.01 (28.84) | 47.83 (31.66) |
| DBP (mm Hg) | 60.06 (8.86) | 68.54 (10.30) | 63.10 (3.33) | 65.12 (8.96) |
| DBP % | 35.63 (23.30) | 61.27 (26.16) | 48.18 (27.97) | 52.08 (28.04) |
| Blood data | | | | |
| Glucose (mg/dL) | 82.86 (13.22) | — | 86.68 (7.98) | 86.36 (8.60) |
| HDL (mg/dL) | 50.64 (9.57) | — | 53.78 (12.72) | 53.00 (12.09) |
| Triglycerides (mg/dL) | 83.99 (38.84) | 84.79 (37.55) | 76.63 (40.79) | 81.70 (39.09) |

*WC*, Waist circumference.

Child examination dates for FLS: 1976–1996; Muscatine Study: 1970–1981; PFS: 1973–1976.

## Table III

Mean (standard deviation) adult metabolic values by study

| | FLS | MS | PFS | Total |
|---|---|---|---|---|
| Age (years) | 39.59 (7.59) | 44.27 (4.80) | 38.58 (3.55) | 41.47 (5.75) |
| Anthropometrics | | | | |
| WC (cm) | 94.95 (14.56) | 92.14 (17.00) | 96.83 (16.80) | 94.18 (16.62) |
| Weight (kg) | 80.36 (18.87) | 84.56 (19.88) | 83.78 (22.82) | 83.51 (20.79) |
| Height (cm) | 172.98 (10.10) | 169.95 (9.34) | 170.73 (9.37) | 170.78 (9.55) |
| BMI ($kg/m^2$) | 26.75 (5.49) | 29.19 (6.10) | 28.60 (6.97) | 28.54 (6.36) |
| Blood pressure | | | | |
| SBP (mm Hg) | 115.25 (15.01) | 120.65 (14.62) | 119.75 (15.69) | 119.34 (15.19) |
| DBP (mm Hg) | 74.62 (10.86) | 77.42 (10.38) | 78.97 (11.08) | 77.43 (10.81) |
| Blood data | | | | |
| Glucose (mg/dL) | 92.84 (11.09) | 93.45 (20.77) | 92.06 (29.02) | 92.89 (22.37) |
| HDL (mg/dL) | 50.84 (13.20) | 52.21 (15.76) | 46.40 (15.44) | 49.99 (15.44) |
| Triglyceride (mg/dL) | 143.84 (106.71) | 131.20 (116.15) | 137.21 (142.03) | 135.50 (124.05) |

Adult examination dates for FLS: 1988–2006; MS: 1992–2007; PFS: 2000–2004.

## Table IV

Means and standard deviations of childhood values by adult metabolic syndrome status

| | Without adult MetS (n = 1348) | | | With adult MetS (n = 440) | | | *P* value for |
|---|---|---|---|---|---|---|---|
| | N | Mean | SD | N | Mean | SD | Difference |
| Age (years) | | 13.81 | 3.04 | | 13.69 | 3.09 | .4826 |
| Anthropometrics | | | | | | | |
| WC (cm) | 185 | 71.95 | 7.95 | 45 | 75.65 | 11.44 | .0451 |
| Weight (kg) | 1348 | 49.68 | 15.08 | 440 | 55.88 | 18.45 | <.0001 |
| Height (cm) | 1348 | 156.32 | 15.45 | 439 | 158.13 | 15.38 | .0322 |
| BMI ($kg/m^2$) | 1348 | 19.82 | 3.41 | 439 | 21.73 | 4.55 | <.0001 |
| BMI % | 1316 | 52.22 | 26.33 | 430 | 67.36 | 26.14 | <.0001 |
| Blood pressure | | | | | | | |
| SBP (mm Hg) | 1348 | 109.41 | 12.05 | 440 | 112.52 | 12.59 | <.0001 |
| SBP % | 1348 | 45.93 | 31.23 | 439 | 53.65 | 32.35 | <.0001 |
| DBP (mm Hg) | 1348 | 64.83 | 9.04 | 440 | 66.00 | 8.67 | .0178 |
| DBP % | 1348 | 51.24 | 27.99 | 439 | 54.64 | 28.06 | .0274 |
| Blood data | | | | | | | |
| Glucose (mg/dL) | 474 | 85.73 | 8.62 | 189 | 87.92 | 8.37 | .0030 |
| HDL (mg/dL) | 592 | 54.48 | 12.06 | 217 | 49.04 | 11.20 | <.0001 |
| Triglyceride (mg/dL) | 1252 | 78.04 | 35.78 | 407 | 92.88 | 46.14 | <.0001 |

## Table V

Means and standard deviations of childhood values by T2D disease status

| | Without adult T2D (n = 1719) | | | With adult T2D (n = 70) | | | *P* value for |
|---|---|---|---|---|---|---|---|
| | N | Mean | SD | N | Mean | SD | Difference |
| Age (years) | 1719 | 13.77 | 3.06 | | 14.20 | 2.92 | .2446 |
| Anthropometrics | | | | | | | |
| WC (cm) | 225 | 72.64 | 8.83 | 5 | 74.50 | 10.07 | .6420 |
| Weight (kg) | 1719 | 50.91 | 16.07 | 70 | 58.68 | 17.45 | <.0001 |
| Height (cm) | 1718 | 156.71 | 15.54 | 70 | 158.38 | 13.11 | .3748 |
| BMI ($kg/m^2$) | 1718 | 20.18 | 3.73 | 70 | 22.96 | 4.69 | <.0001 |
| BMI % | 1671 | 55.25 | 26.88 | 69 | 72.82 | 26.31 | <.0001 |
| Blood pressure | | | | | | | |
| SBP (mm Hg) | 1719 | 110.07 | 12.30 | 70 | 112.97 | 10.74 | .0524 |
| SBP % | 1718 | 47.25 | 31.52 | 70 | 61.94 | 32.16 | .0001 |
| DBP (mm Hg) | 1719 | 65.08 | 9.02 | 70 | 66.16 | 7.48 | .2442 |
| DBP % | 1718 | 51.98 | 27.99 | 70 | 54.61 | 29.19 | .4414 |
| Blood data | | | | | | | |
| Glucose (mg/dL) | 630 | 86.20 | 8.57 | 34 | 89.44 | 8.67 | .0319 |
| HDL (mg/dL) | 772 | 53.30 | 12.06 | 38 | 46.84 | 10.98 | .0013 |
| Triglyceride (mg/dL) | 1593 | 81.03 | 38.54 | 67 | 97.69 | 48.09 | .0067 |

## Table VI

Predictive ability of specific threshold values of individual metabolic components for adult MetS and T2D

| Childhood threshold | | Adult metabolic syndrome | | | | T2D | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prevalence % | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % |
| BMI 85th | 18.3 | 34.0 | 86.8 | 45.6 | 80.1 | 44.9 | 82.8 | 9.7 | 97.3 |
| BMI 90th | 13.1 | 25.6 | 91.0 | 48.0 | 79.0 | 31.9 | 87.7 | 9.6 | 96.9 |
| BMI 95th | 6.3 | 11.9 | 95.5 | 46.4 | 76.9 | 20.3 | 94.3 | 12.7 | 96.6 |
| Waist 75th | 15.2 | 26.7 | 87.6 | 34.3 | 83.1 | 40.0 | 85.3 | 5.7 | 98.5 |
| Waist 90th | 1.3 | 4.4 | 99.5 | 66.7 | 81.1 | 0.0 | 98.7 | 0.0 | 97.8 |
| Glucose 90 | 33.4 | 37.6 | 75.3 | 37.8 | 75.2 | 32.4 | 71.7 | 5.8 | 95.2 |
| Glucose 100 | 5.1 | 5.8 | 96.6 | 40.7 | 72.0 | 14.7 | 96.5 | 18.5 | 95.4 |
| Glucose 110 | 1.1 | 1.6 | 99.4 | 50.0 | 71.7 | 2.9 | 99.2 | 16.7 | 95.0 |
| Triglyceride 90 | 31.6 | 42.0 | 73.5 | 34.0 | 79.6 | 47.8 | 70.4 | 6.3 | 97.0 |
| Triglyceride 100 | 22.8 | 32.4 | 80.8 | 35.5 | 78.6 | 38.8 | 78.2 | 7.0 | 96.8 |
| Triglyceride 110 | 17.2 | 24.6 | 86.6 | 37.3 | 77.9 | 29.9 | 84.4 | 7.4 | 96.6 |
| Triglyceride 90th | 8.3 | 14.5 | 93.8 | 43.1 | 77.1 | 17.9 | 92.2 | 8.8 | 96.4 |
| HDL 35 | 4.8 | 7.4 | 97.8 | 55.2 | 74.2 | 13.2 | 96.8 | 16.7 | 95.8 |
| HDL 40 | 15.4 | 20.7 | 90.0 | 43.3 | 75.6 | 34.2 | 88.1 | 12.4 | 96.5 |
| HDL 45 | 27.0 | 35.9 | 81.3 | 41.3 | 77.6 | 42.1 | 77.5 | 8.4 | 96.5 |
| HDL 50 | 45.7 | 57.6 | 64.7 | 37.4 | 80.6 | 57.9 | 59.5 | 6.6 | 96.6 |
| Abnormal HDL | 32.4 | 45.6 | 72.6 | 37.9 | 78.5 | 52.6 | 68.7 | 7.6 | 96.7 |
| SBP 75th | 26.0 | 33.8 | 76.5 | 31.8 | 78.0 | 38.6 | 74.5 | 5.8 | 96.7 |
| SBP 85th | 18.0 | 24.7 | 84.1 | 33.5 | 77.5 | 31.4 | 82.5 | 6.8 | 96.7 |
| SBP 90th | 14.0 | 20.1 | 88.0 | 35.2 | 77.2 | 27.1 | 86.5 | 7.6 | 96.7 |
| DBP 75th | 25.7 | 28.1 | 75.1 | 26.8 | 76.3 | 37.1 | 74.7 | 5.7 | 96.7 |
| DBP 85th | 14.8 | 17.4 | 86.0 | 28.7 | 76.2 | 17.1 | 85.3 | 4.5 | 96.2 |
| DBP 90th | 9.5 | 11.4 | 91.1 | 29.4 | 76.0 | 10.0 | 90.5 | 4.1 | 96.1 |

BMI, SBP, and DBP are expressed in percentile. Fasting glucose, triglycerides, and HDL are expressed in mg/dL.

## Table VII

Predictive ability of combinations of metabolic components for adult MetS and T2D

| Variable Group | | Adult metabolic syndrome | | | | T2D | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prevalence % | Sensitivity % | Specificity % | PPV % | NPV % | Sensitivity % | Specificity % | PPV % | NPV % |
| Group I | | | | | | | | | |
| 1+ | 49.4 | 65.8 | 57.2 | 37.9 | 80.8 | 82.4 | 52.4 | 8.8 | 98.2 |
| 2+ | 21.1 | 35.3 | 84.7 | 47.8 | 76.7 | 44.1 | 80.1 | 11.0 | 96.3 |
| 3+ | 7.9 | 16.9 | 95.7 | 60.8 | 74.3 | 20.6 | 92.8 | 13.7 | 95.5 |
| 4+ | 1.7 | 4.9 | 99.6 | 81.8 | 72.5 | 14.7 | 99.0 | 45.5 | 95.5 |
| Group II | | | | | | | | | |
| 1+ | 33.3 | 59.8 | 60.3 | 37.4 | 79.0 | 76.5 | 56.2 | 8.8 | 97.7 |
| 2+ | 8.5 | 30.4 | 89.9 | 54.4 | 76.5 | 38.2 | 85.3 | 12.6 | 96.2 |
| 3+ | 2.0 | 7.6 | 98.1 | 60.9 | 72.8 | 17.7 | 97.2 | 26.1 | 95.5 |
| 4+ | 0.3 | 1.1 | 99.8 | 66.7 | 71.7 | 2.9 | 99.7 | 33.3 | 94.9 |

Group I (BMI ≥ 90th percentile, fasting glucose ≥ 100 mg/dL, triglycerides ≥ 90 mg/dL, HDL< 45 mg/dL, and SBP or DBP ≥ 90th percentile).

Group II (BMI ≥ 85th percentile, fasting glucose ≥ 100 mg/dL, triglycerides ≥ 90th percentile, HDL < 45 mg/dL, and SBP or DBP ≥ 85th percentile).