Adolescence Metabolic Syndrome or Adiposity and Early Adult Metabolic Syndrome

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Objective To investigate the predictive role of adolescent metabolic syndrome (MetS) in development of early adult MetS, independent of adult body mass index (BMI).

Study design 1424 adolescents (639 boys), participants of the Tehran Lipid and Glucose Study, followed for 10.4 years, were analyzed and logistic regression models were developed. Using the areas under the receiver operating characteristic curve, the discriminatory ability of adolescent MetS and overweight or obesity was evaluated. Net reclassification improvement was calculated to determine the accuracy of classification by adolescent MetS in place of overweight or obesity.

Results The mean ± SD of age and BMI were 14.6 ± 2.2 years and 20.3 ± 4.2 kg/m^2, respectively. The prevalence of MetS was 13.3% and 14.6% at baseline and after follow-up, respectively. The risk of developing early adult MetS among subjects who were overweight or obese in adolescence but nonobese as adults (OR: 1.65) was lower than the risk among subjects who were obese as adults but nonobese as adolescents (OR: 8.45). After adjustment for adult BMI, adolescent MetS and overweight or obesity did not show any association with the risk of adult MetS. Area under the receiver operating characteristic curve was higher for obesity (0.619) than MetS (0.589) and the net reclassification improvement value for MetS was 1.5% (P = .398).

Conclusion Adolescent MetS or adiposity did not predict early adult MetS independent of adult BMI. The addition of adolescent MetS to obesity does not improve the predictive power for early adult MetS. *(J Pediatr 2013;163:1663-9)*.

Metabolic syndrome (MetS) is a complex disorder defined by a cluster of interconnected factors including dyslipidemia, elevated blood pressure, and dysregulated glucose homeostasis, with abdominal obesity and/or insulin resistance as the core manifestations of the syndrome in both children and adults.[1,2] Different proposed definitions of pediatric MetS are modified from adult criteria with use of sex- and age-specific national curves; therefore, different prevalence of MetS has been reported in different studies of children and adolescents.[3]

The clinical utility of pediatric MetS for identifying who develops MetS in adulthood is controversial.[4-6] There is substantial evidence on the predictive value of childhood MetS and increased risk of MetS, type 2 diabetes, and surrogates of cardiovascular disease such as carotid intima-media thickness in adulthood.[7] To date, the contribution of childhood MetS to long-term MetS risk, independent of adult body mass index (BMI), has not been clearly established. Furthermore, some studies report that some simpler screening tools such as BMI in pediatric settings seem to be equally useful compared with pediatric MetS in identifying adolescents at risk of developing adult MetS.[7] Moreover, the majority of studies addressing role of childhood or adolescent BMI for prediction of adult MetS also failed to adjust for adult BMI.[6,8] Interestingly, the findings of 2 recent systematic reviews challenged the independent role of pediatric obesity for adult MetS and cardiovascular disease.[9,10]

Therefore, it seems important to explore predictive factors in childhood or adolescents for prediction of early adult MetS. Tracking of adiposity between childhood and adulthood would be important. In the current study, we aimed to investigate the possible role of adolescent MetS on development of early adult MetS, independent of adult BMI among the Tehran Lipid and Glucose Study (TLGS) during a mean follow-up of 10.4 years.

BMI	Body mass index
HDL-C	High-density lipoprotein cholesterol
MetS	Metabolic syndrome
NPV	Negative predictive value
NRI	Net reclassification improvement
PPV	Positive predictive value
ROC	Receiver operating characteristic
TG	Triglyceride
TLGS	Tehran Lipid and Glucose Study
WC	Waist circumference

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Methods

This study was conducted within the framework of the TLGS, a prospective study of the prevalence of noncommunicable diseases and their risk factors among Tehran's urban population.[11,12] The participants were followed up every 3 years; the baseline survey was a cross-sectional study conducted from 1999-2001, and surveys 2 (2002-2005), 3 (2006-2008), and 4 (2009-2011) were prospective follow-up surveys. Multistage cluster sampling was used to randomly select people aged 3 years or older from district 13 of Tehran, the capital of Iran. This population is served by 3 medical centers. The age distribution of the population in district 13 is representative of the overall population of Tehran (Iran National Census, 1996). Of the 15 005 subjects who participated in baseline examination of the TLGS (1999-2001), 2688 subjects were children and adolescents, aged 11-18 years (mean age 14.5 ± 2.2 years, 48% male). For the current study, after excluding those with missing anthropometric values and biochemical data (n = 106), 2582 remained. Of 2582 children and adolescents, 1424 (639 boys and 785 girls) aged 18-31 years, returned for follow-up with a mean of 10.2 years.

The protocols of this study were approved by the institutional ethics committee of the Research Institute for Endocrine Sciences, affiliated with the Shahid Beheshti University of Medical Sciences.

Anthropometric measurements including height, weight, and waist circumference (WC) were measured by trained examiners at baseline and at follow-up using standardized protocols.[11] Height was measured in a standing position, without shoes, using a measuring tape while the shoulders were in a normal position. Weight was measured using digital scales (Seca 707; Seca Corporation, Hanover, Maryland; range 0.1-150 kg) and was recorded to the nearest 100 g while the subjects were minimally clothed and without shoes. BMI (weight [kg]/square of height [m]) was calculated. WC was measured at the umbilicus, using a measuring tape without pressure to body surfaces and was recorded to the nearest 0.5 cm. Systolic and diastolic blood pressure was measured using a standard mercury sphygmomanometer (calibrated by the Iranian Institute of Standards and Industrial Researches), in the right arm after 15-minute rest in a sitting position. A qualified physician measured the blood pressure of the seated subject twice; the mean of the 2 measurements was used in the analysis. A blood sample was drawn into vacutainer tubes from all subjects between 7:00 a.m. and 9:00 a.m. after 12-14 hours overnight fasting for measurement of glucose and lipid concentrations. The samples were centrifuged 30-45 minutes after collection. All analyses were done at the TLGS research laboratory on the day of blood collection. Fasting plasma glucose was measured by the enzymatic colorimetric method using glucose oxidase. Serum triglyceride (TG) was assayed using an enzymatic colorimetric method with glycerol phosphate oxidase, and serum total cholesterol was assayed using an enzymatic colorimetric method with cholesterol esterase and cholesterol oxidase. High-density lipoprotein cholesterol (HDL-C) was measured after precipitation of the apolipoprotein B–containing lipoproteins with phosphotungstic acid. These analyses were performed using commercial kits (Pars Azmoon Inc, Tehran, Iran) and a Selectra 2 auto analyzer (Vital Scientific, Spankeren, The Netherlands). Inter- and intra-assay coefficients of variations at baseline were 2.2% for serum glucose, 2% and 0.5% for HDL-C, and 1.6% and 0.6% for TG, respectively.

Because no universally accepted definition of the MetS exists for children, the definition proposed by Cook et al was used.[13] It defines MetS as 3 or more of the following: fasting TGs ≥110 mg/dL; HDL-C <40 mg/dL; WC ≥90th percentile for age and sex, according to national reference curves[14]; systolic blood pressure and/or diastolic blood pressure ≥90th percentile for sex, age, and height, from the National Heart, Lung, and Blood Institute's recommended cut-off points;[15] and fasting blood glucose ≥100 mg/dL, according to the recent recommendations of American Diabetes Association.[16] The joint interim statement[17] defines MetS as the presence of any 3 of 5 risk factors of the following: (1) abdominal obesity as WC ≥91 cm for women and ≥89 cm for men according to population- and country-specific cut-off point for Iranians[18]; (2) fasting plasma glucose ≥100 mg/dL or drug treatment; (3) fasting TGs ≥150 mg/dL or drug treatment; (4) fasting HDL-C <50 mg/dL for women and <40 mg/dL for men or drug treatment; and (5) elevated blood pressure was defined as systolic blood pressure ≥130 mm Hg, diastolic blood pressure ≥85 mm Hg, or antihypertensive drug treatment.

Obesity, overweight, and normal BMI were defined based on the standardized percentile curves of BMI suggested for Iranian children and adolescents as ≥95th, between ≥85th and <95th, and <85th percentiles of BMI for age and sex, respectively.[19] To observe tracking of BMI from adolescence into early adulthood, the participants were categorized into 4 groups on the basis of adiposity status in adolescence and adulthood. Group I were defined as subjects with normal BMI in adolescence who were nonobese as adults; group II, those who were overweight or obese in adolescence but nonobese as adults; group III, those with normal BMI in adolescence who were obese as adults; and group IV, those who were overweight or obese in adolescence and obese as adults.

Statistical Analyses

Baseline and follow-up characteristics of subjects were expressed as mean and SD or median and IQR for continuous variables and percentages for dichotomous variables. These variables were compared among adiposity groups using the one-way ANOVA for continuous variables and χ^2 test for categorical variables. The variables without normal distribution were log transformed. Multiple logistic regression analysis was used to evaluate the predictive power of adolescent MetS, overweight or obesity, and abdominal obesity for adult MetS. ORs and 95% CIs were calculated for boys and girls. Furthermore, the predictive power of adiposity groups for