Asian Adolescents with Excess Weight are at Higher Risk for Insulin Resistance than Non-Asian Peers

Ahmed Elsamadony1, Kathy F. Yates1,2, Victoria Sweat1, Po Lai Yau1, Alex Mangone1, Adriana Joseph2, Arthur Fierman1,3, and Antonio Convit4,2,4,5

Objective: The purpose of this study was to evaluate whether Asian American adolescents have higher metabolic risk from excess weight than non-Asians.

Methods: Seven hundred thirty-three students, aged 14 to 19 years old, completed a school-based health screening. The 427 Asian and 306 non-Asian students were overall equivalent on age, sex, and family income. Height, weight, waist circumference, percent body fat, and blood pressure were measured. Fasting triglycerides, high- and low-density lipoproteins, glucose, and insulin levels were measured. Asian and non-Asians in lean or overweight/obesity groups were contrasted on the five factors that make up the metabolic syndrome.

Results: Asian adolescents carrying excess weight had significantly higher insulin resistance (IR), triglyceride levels, and waist-height ratios (W/H), despite a significantly lower overall BMI than corresponding non-Asians. Similarly, Asians had a stronger relationship between W/H and the degree of IR than non-Asian counterparts; 35% and 18% of the variances were explained ($R^2 = 0.35$, $R^2 = 0.18$) respectively, resulting in a significant W/H by racial group interaction ($F_{change}[1,236] = 11.56, P < 0.01$).

Conclusions: Despite lower overall BMI, Asians have higher IR and triglyceride levels from excess weight than their non-Asian counterparts. One-size-fits-all public health policies targeting youth should be reconsidered and attention paid to Asian adolescents, including those with mild degrees of excess weight.

Introduction

The prevalence of childhood obesity in the United States is rising (1), with 17% of children classified as having obesity (2) and 32% considered to have overweight or obesity (2). Hypertension, type 2 diabetes mellitus, dyslipidemia, and metabolic syndrome (MetS) are associated with obesity (3). For example, MetS increases with increasing body weight: every half unit increase in BMI is associated with a significant increase in the risk of MetS (odds ratio = 1.55) (4).

A diagnosis of MetS is established when three or more of five possible risk factors reach predefined levels of abnormality. The five risk factors are (1) central obesity as reflected in increased waist circumference (WC) (5), (2) high triglycerides (TG), (3) low high-density lipoprotein (HDL), (4) hypertension, and (5) impaired fasting glucose (IFG) or insulin resistance (IR).

Extant literature in adults indicates racial differences in weight and weight-related illness (6). It is already known that the prevalence of MetS is higher among adult Asian Americans compared with, in descending order, Hispanic, Caucasian, and African American counterparts, despite the fact that as a group, adult Asians have lower weights (7). In addition, although lean (BMI ≤ 25 kg/m²) adult Chinese men and women have significantly lower BMI and WC values than individuals of European descent who are also lean, they have

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equivalent levels of metabolic risk factors (8). British South Asian children 8 to 11 years of age have increased cardiovascular risk compared with white children (9).

Among adolescents, non-Hispanic whites have the highest prevalence of MetS, followed by Mexican Americans and non-Hispanic blacks (13.1%, 11.1%, and 4.8%, respectively) (10). Given the high rates of obesity, it is not surprising that nearly two-thirds of adolescents in the United States have at least one of the five abnormalities that make up MetS, and 9.2% actually fulfill criteria for MetS (11). However, these rates would likely be higher if homeostatic model assessment of insulin resistance (HOMA-IR) was used to define IR instead of IFG, as HOMA-IR (even a conservative value of ≥ 3.99) is much more sensitive than IFG in detecting glucoregulatory abnormalities (12). There is some emerging evidence that there are likely ethnic differences in metabolic risk factors associated with obesity in children (13,14). The goal of this study was to contrast a group of Asian high school students carrying excess weight with a comparable peer group of non-Asian students on their degree of abnormality on the five factors that make up MetS to ascertain differences in the metabolic risk imparted by excess weight between the groups.

Methods

Participants and procedures

The study was approved by the institutional review boards of the New York University School of Medicine and the New York City Department of Education as part of The Banishing Obesity and Diabetes in Youth (BODY) Project. The BODY Project is a school-based medical screening and education program that has been described in detail elsewhere (15).

The data presented here were collected at one specific New York City high school campus, where more than 50% of the student body was of Asian origin (South and East Asian). The remaining students were identified predominantly as Caucasian, Hispanic, and African American. Race was determined by student self-report and/or by student report of parent race/ethnicity and, when necessary, clarified by parents’ country of origin. Based on the country of origin of the parents, we know that only eight of our Asian participants reported having parents who were born in the United States (two reported both parents, and six reported one parent). Thus, nearly 99% of our Asian students are considered first generation, meaning they were born in the United States to foreign parents or immigrated here at a very young age.

Participant ages ranged from 14 to 19. Heights and weights of all students attending physical education class were measured by project staff during classes. BMI was calculated based on the BMI Percentile Calculator for Child and Teen on the Centers for Disease Control and Prevention’s Prentice Manual (17).

Anthropometric measurements

Height, weight, and WC were measured again on the day of the medical examination. Height was measured to the nearest quarter inch (0.6 cm) using a height rod (model 214; Seca, Hamburg, Germany). Weight was measured to the nearest 0.01 kg using a digital remote display scale (model 349KLX; Healthometer). With the participant standing and wearing a single layer of clothing, WC was measured to the nearest quarter inch by placing a flexible tape just superior to the iliac crest as per the Centers for Disease Control and Prevention’s Anthropometry Procedures Manual (17).

Blood pressure measurements

After sitting for 5 minutes, blood pressure was measured using an electronic vital signs monitor (SureSigns VS1; Philips Medical Systems, Best, Netherlands) and a cuff appropriate for the participant’s arm diameter. A second reading was taken within 10 minutes of the first. The lower of the two readings was used in data analyses. To adjust for age and sex, blood pressure percentiles were calculated using commercially available software (EZ Blood Pressure Calculator; EZ BMI Software) (21).

Blood chemistry measurements

Using blood samples collected in fluorinated tubes, the fasting blood glucose level was measured using a glucose oxidase method (VITROS 950 AT; Johnson & Johnson, New Brunswick, New Jersey). Insulin was assayed using chemiluminescence (Advia Centaur; Bayer Corporation, Leverkusen, Germany). Total cholesterol, HDL, and TG levels were analyzed using chemistry slides (VITROS DT; Johnson & Johnson). A measure of IR was estimated by HOMA-IR, calculated as the fasting blood glucose level (in milligrams per deciliter) times the fasting insulin level (in micro international units per milliliter), divided by 405 (22).

Percent body fat measurements

Body composition was estimated by a bioelectrical impedance method, using the body composition 2.1 RJL Portable System and the Quantum IV Bioelectrical Impedance Analyzer (RJL Systems,
TABLE 1 Anthropometric data and metabolic risk factors for Asian and non-Asian adolescents by BMI grouping

|                         | Lean     | Overweight/obesity | Total    |
|-------------------------|----------|--------------------|----------|
|                         | Asians   | Non-Asians         | Asians   | Non-Asians |
|                         | (n = 313)| (n = 177)          | (n = 114)| (n = 129)  |
| Age (y)                 | 16.78 ± 0.98 | 16.73 ± 0.94      | 16.3 ± 1 | 16.67 ± 1  |
| Female sex (%)          | 49.5%    | 43.5%              | 28.1%    | 41.1%      |
| Female sex (n)          | (155)    | (77)               | (32)     | (53)       |
| Weight (lb)             | 130 ± 18.1b× | 137.93 ± 19.6b×   | 173.65 ± 25.7c× | 187.56 ± 36.2c× |
| Height (in)             | 64.96 ± 3.4b× | 66.84 ± 3.7b×     | 66.26 ± 3.3 | 67.1 ± 3.5 |
| Waist circumference (in)| 28.35 ± 3.2 | 28.55 ± 2.3       | 34.25 ± 3.7 | 35.1 ± 4.5 |
| Waist-height ratio      | 0.43 ± 0.03b * | 0.42 ± 0.03b *    | 0.51 ± 0.05 | 0.52 ± 0.06 |
| BMI (kg/m²)             | 21.56 ± 1.7 | 21.63 ± 1.9       | 27.73 ± 3a * | 29.12 ± 4.3a * |
| % Body fat              | 24.17 ± 7.6 | 22.77 ± 8.4       | 29.43 ± 8a * | 32.13 ± 8.4a * |
| Triglycerides (mg/dL)   | 80.58 ± 36.7b | 72.6 ± 37.9b *   | 103.18 ± 76.3a | 81.38 ± 41.9a * |
| Systolic blood pressure (mm Hg) | 116.97 ± 8.9 | 116.74 ± 9.4 | 123.78 ± 10.8 | 125.96 ± 11.8 |
| HDL (mg/dL)             | 60.92 ± 11.4 | 59.61 ± 12.1      | 53.45 ± 10.4 | 53.13 ± 12.5 |
| HOMA-IR                 | 1.69 ± 0.72b | 1.85 ± 0.87b *    | 2.91 ± 1.7 | 2.55 ± 1.2 |
| Fasting insulin (mIU/mL)| 8.38 ± 3.4b * | 9.16 ± 4a *       | 14.06 ± 7.7 | 12.64 ± 5.7 |
| Fasting glucose (mg/dL) | 82.15 ± 5.4 | 82.57 ± 12.3      | 83.75 ± 5.9b * | 82.1 ± 6c * |

Values presented are means ± SD.
*Significant difference between Asian and non-Asian adolescents overall (lean and overweight/obesity combined).
bSignificant difference between lean Asians and lean non-Asians.
×Significant difference between Asians and non-Asians with overweight/obesity.
×P < 0.05, ×P < 0.01, ×P < 0.001.

Definition of MetS

An adolescent had MetS when ≥ 3 of the 5 factors met a threshold value. Although each factor is associated with obesity, IR is considered the central factor (24-26), and IFG is most commonly used as a marker of IR. However, in adolescents, IFG is rare owing to compensatory hyperinsulinemia and sufficient pancreatic beta-cell reserve (25,27). Consequently, some have argued that IR, rather than IFG, is a more appropriate index of glucoregulatory abnormality in youth without diabetes. We and others have used HOMA-IR ≥ 3.99 as the threshold for clinically significant IR (12,27). The specific definitions of the five factors are as follows: (1) central adiposity (WC ≥ 90th percentile for age and sex) (28); (2) hypertriglyceridemia, TG level ≥ 110 mg/dL (for mmol/L, multiply by 0.0113); (3) low HDL level, ≤ 49 mg/dL for females and ≤ 39 mg/dL for males (for mmol/L multiply by 0.0259); (4) elevated blood pressure: for ≤ 18 years of age, a systolic or diastolic blood pressure > 90th percentile adjusted for age, sex, and height; for > 18 years, ≥ 130/85 mmHg (29); and (5) IR defined as HOMA-IR ≥ 3.99.

Statistical analyses

Differences in anthropomorphic and metabolic variables were compared across race (Asian vs. non-Asian) and weight groups by ANOVA. Regression analyses were used to measure relationships between HOMA-IR and W/H and to assess for differences in the strength of those relationships between Asian and non-Asian students. Given that within the group with excess weight there were significant differences in BMI between Asians and non-Asians, we utilized ANCOVAs in order to compare the five metabolic risk factors among them, controlling for BMI. All analyses were performed using SPSS version 23 (IBM Corp, Armonk, New York). Statistical significance was set at α = 0.05.

Results

Seven hundred thirty-three participants were included in the final analyses. Table 1 presents comparisons of Asian (South Asian and East Asian combined) versus non-Asian (African American, Hispanic, Caucasian, and other combined), for lean, overweight/obesity, and all weight groups combined.
As shown in Table 1, Asians carrying excess weight had significantly lower BMI than their non-Asian counterparts (27.7 kg/m² vs. 29.1 kg/m²; \( P < 0.01 \)). Despite lower BMI, Asian adolescents with excess weight had higher TG levels (103.2 vs. 81.4; \( P < 0.01 \)) and trended toward higher HOMA-IR values (2.9 vs. 2.5; \( P = 0.06 \)). HDL, WC, and BP values did not differ between groups. Given that Asian adolescents are overall shorter in stature (Table 1) than other racial groups, to ascertain the relationship between central obesity and degree of IR, we utilized W/H. Figure 1 depicts the relationship between HOMA-IR and W/H among study participants with excess weight, separately for Asian and non-Asian groups. The variance in HOMA-IR explained by W/H among Asian adolescents was double \((R^2 = 0.35)\) that of their non-Asian counterparts \((R^2 = 0.18)\). When all subjects, including lean participants, were included, these relationships were similar, with 33% and 16% variance explained for the Asian and non-Asian groups, respectively (data not shown).

To determine whether there was a significant difference in the slopes, we conducted a regression analysis controlling for age, sex, and BMI. As seen in Table 2, we found that BMI \((P < 0.01)\), W/H \((P < 0.01)\), and race group \((P < 0.05)\) were all predictors of HOMA-IR. However, most importantly, there was a significant W/H by race interaction \((F_{change}[1,236] = 12.82, P < 0.01)\), demonstrating a significant difference in the slope of the two regression lines.

As shown in Figure 2, the rate of adolescents who were lean meeting the IR criterion \((\text{HOMA-IR} \geq 3.99)\) was low and did not differ between Asian and non-Asians students in our sample. However, the rate meeting the IR criterion was 51% greater \((9.5\% \text{ vs. } 6.3\%)\) among Asians classified as having overweight and was nearly double \((43.9\% \text{ vs. } 22\%)\) among those classified as having obesity \((P < 0.05)\).

As there is a significant BMI difference between Asian and non-Asian groups with excess weight, we controlled for BMI in comparing the five metabolic risk factors and W/H among the groups. When controlling for BMI, Asians had a significantly higher TG \((F [2,239] = 9.6, P < 0.01)\), HOMA-IR \((F [2,239] = 10.7, P < 0.01)\), fasting insulin \((F [2,239] = 8.9, P < 0.01)\), and W/H

(F\([2,240] = 4.9, P < 0.05\)) compared with their non-Asian counterparts. HDL, WC, and systolic blood pressure did not differ between groups.

Lean Asian and non-Asian students did not differ on BMI or WC (Table 1). However, given that Asian students were significantly shorter in stature than their non-Asian lean counterparts, they had significantly larger W/H ratios (Table 1). More importantly, when we adjusted for BMI, the differences in W/H became even more significant \((F [2,486] = 13.67, P < 0.01)\).

**Discussion**

Among adults, higher rates of cardiovascular mortality and a higher prevalence of MetS have been noted in Asians who have immigrated to non-Asian countries (30,31). However, very little is known about racial differences in risk associated with excess weight in children. We found that Asian adolescents carrying excess weight (overweight/obesity) had significantly higher IR and TG compared with

![Figure 2 Percent of Asian participants (black bars) for each of the three weight groups (lean, overweight, and obesity) who met the criterion for IR (HOMA-IR ≥ 3.99) vs. non-Asian participants (hatched bars).](image-url)
non-Asians, putting them at greater risk for MetS. Importantly, Asians carrying excess weight had a significantly steeper gradient in the association between HOMA-IR and W/H than non-Asian students. An important finding was that this differential risk of IR due to increasing W/H was strongly present after accounting for age, sex, and BMI. Our findings enhance early findings that have reported an increased cardiovascular risk among 8- to 11-year-old British South Asians compared with white children (9) and augment extant literature suggesting children show some of the same racial/ethnic differences in risk factors for adiposity-related comorbidities as adults (13,14).

Japanese American adults have higher risk for type 2 diabetes mellitus than their Japanese peers, which has been explained by lifestyle leading to visceral obesity that results in decreased insulin sensitivity, superimposed on the genetically decreased beta-cell reserve shared by all (32,33). Nearly 99% of our Asian adolescents were first generation, and therefore we speculate that their higher metabolic risk was influenced by genetics and was not merely from epigenetic changes due to lifestyle influences. The current work adds important evidence that first-generation Asian adolescents are also at higher risk for future cardiometabolic abnormality from excess weight than their non-Asian counterparts.

It is important to note that our Asian adolescents carrying excess weight were at increased risk despite significantly lower BMI and percent of overall body fat than their non-Asian counterparts. However, we know that the location of body fat is important in determining the risk of metabolic disease, with visceral fat increasing risk and subcutaneous fat in buttocks and thighs being protective (34,35). Although our measures of percent body fat do not allow us to make that distinction, the higher level of metabolic risk despite lower overall percent body fat could be due to our Asian students having a higher proportion of central (visceral) fat. This premise is supported by reports of racial differences in visceral fat accumulation, with greater percentages of visceral fat found in South Asian and Chinese men and women compared with their non-Asian counterparts (36). Fat accumulation in the abdominal viscera and within intra-abdominal organs has been linked to accelerated cardiovascular disease regardless of age, overall obesity, or the amount of subcutaneous fat. This phenomenon is possibly mediated by proinflammatory cytokines, which have been found in greater concentrations within visceral fat than by some researchers (37). Intra-abdominal fat accumulation and increases in fasting insulin predict the development of MetS among Japanese Americans (38).

Although our Asian and non-Asian groups carrying excess weight did not differ on W/H, when we adjusted for BMI, W/H became significant, with Asians having a higher adjusted value. Further support for this premise of higher visceral fat among our Asian adolescents is provided by the fact that our Asian group considered lean had significantly higher W/H (Table 1) despite having slightly lower average BMI and WC than their non-Asian counterparts; these differences became more significant when we controlled for BMI. Future studies should focus on measuring visceral fat directly as well as comparing inflammatory marker levels among racial/ethnic groups.

Internationally recognized cutoff points of 25 and 30 kg/m² define overweight and obesity, respectively, in adults; 85th and 95th percentile cutoffs have defined overweight and obesity, respectively, in children. However, some investigators have developed age BMI percentile curves for Indian boys and girls linked to the accepted cutoff scores for Asian adults of 23 and 28 kg/m² (39). They have suggested the 85th and 95th percentiles that are used as cutoff points for overweight and obesity in children are arbitrary, are not linked to obesity-related health risks, and likely result in underestimation of clinically relevant childhood obesity. This is in keeping with evidence that Asian populations have different associations between BMI, percent body fat, and health risks compared with Europeans and Americans.

Our data are in line with these findings and suggest Asian American youth also have an increased risk for MetS at lower weights. Our Asian participants carrying excess weight were at higher risk of IR and elevated TG at lower weights and W/H than their peers in other racial/ethnic groups. This tendency is explained by their BMI-adjusted increased IR, W/H, and TG levels, as well as a stronger relationship between W/H and the degree of IR. These data suggest that particular attention has to be paid to adolescents of East and South Asian origin when evaluating the comorbidities of excess weight.

This study highlights the clinical importance of MetS screening for early detection of metabolic risk factors with attendant consequences in order to diminish MetS prevalence among Asian adolescents. Early diagnosis of MetS or its risk factors in adolescents is critical for early therapeutic intervention, thus decreasing disease progression and complications. However, our data are not useful to derive the specific cutoff scores that should be used among Asian American youth.

In addition to the relatively large sample size, this study has several strengths. The adolescents studied are part of a nonclinical community sample, and we utilized objective and reliable methods for all our measurements. Also, more than 80% of the students approached for participation chose to participate. With that said, we conducted our initial screening for selection of study participants during physical education classes, and those students who did not partake in physical education would not have been included. This decision was made in response to requests from school administration that the students’ academic schedules not be disrupted. In addition, all students detected as carrying excess weight were invited to participate, and therefore the sample of students studied with excess weight was not randomly selected. Despite the cross-sectional nature of this work and the limitations mentioned, this study adds important information to an area where there is very little empirical published work.

Conclusion

Asian American adolescents have significantly higher degrees of metabolic abnormalities from excess weight than their non-Asian counterparts. This finding is not completely surprising, given that these racial differences have been described for adults and there is accumulating data among British South Asian as well as Indian children. In combination, these findings suggest that “one size fits all” disease prevention polices targeting youth should be reconsidered with specific attention paid to adolescents of East and South Asian extraction, even for mild degrees of excess weight.
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