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

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Abstract

Objective—Evaluate whether Asian-American adolescents have higher metabolic risk from excess weight than non-Asians.

Methods—733 students, 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 bloods measured triglycerides, high- and low-density lipoproteins, glucose, and insulin levels. Asian and non-Asians in lean or overweight/obese groups were contrasted on the 5 factors that make up the Metabolic Syndrome.

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Ms. Sweat contributed to study concept and design, the drafting of the manuscript and provided various aspects of the study supervision.
Dr. Yau contributed to the statistical analysis and interpretation of data and to the drafting of the manuscript.
Mr. Mangone contributed to the acquisition of data, drafting of the manuscript and was involved in the data collection.
Ms. Joseph contributed to the acquisition of data, drafting of the manuscript, and was involved in the data collection.
Dr. Fierman contributed to the study concept and design and the drafting and critical revision of the manuscript for important intellectual content.
Dr. Convit contributed to the original study concept and design, obtained funding, assisted in the interpretation of data, to the drafting and critical revision of the manuscript for important intellectual content.

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Results—Asian adolescents carrying excess weight had significantly higher insulin resistance (IR), triglyceride levels, and waist to height ratios (W/H), despite a significantly lower overall body mass index (BMI) than corresponding non-Asian. Similarly, Asians had a stronger relationship between W/H and the degree of IR than non-Asian counterparts; 35% and 18% of the variance 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 BMIs, 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.

Keywords

Adolescents; Asian; Obesity; Insulin Resistance; Metabolic Syndrome

Introduction

The prevalence of childhood obesity in the U.S. is rising[1] with 17% classified as obese[2], and 32% considered overweight or obese.[2] Hypertension, Type 2 Diabetes Mellitus (T2DM), dyslipidemia, and Metabolic Syndrome (MetS) are associated with obesity.[3] For example, MetS increases with increasing body weight: every half unit increase in body mass index (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 to, 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/m^2) adult Chinese men and women have significantly lower BMI and WC values than individuals of European descent who are also lean, they have equivalent levels of metabolic risk factors.[8] British South Asian children 8-11 years of age have increased cardiovascular risk compared to 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 U.S. have at least 1 of the 5 abnormalities that make up MetS and 9.2% actually fulfill criteria for MetS.[11] However, these rates would likely be higher if 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 5 factors that make up MetS to ascertain for 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 was collected at one specific New York City high school campus, where over 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 8 of our Asian participants reported having parents that were born in the US (2 both parents, and 6 one parent). Thus, nearly 99% of our Asian students are considered first generation, namely they were born in the US 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 physical education classes. BMI was calculated based on the BMI Percentile Calculator for Child and Teen on the Centers for Disease Control and Prevention website[16] for those students under age 18. Adult standards were used for those ≥ 18 years of age. Based on their BMI percentile or BMI participants were assigned to one of three non-overlapping groups, lean:< 85 %ile or BMI<25 kg/m^2; overweight: ≥85 and < 95 %ile or ≥25 and <30 kg/m^2; obese: ≥ 95%ile or ≥30 kg/m^2. All students thus determined to have excess weight were invited to participate in a medical examination on a separate day, resulting in the participation of 114 Asian and 129 non-Asian students with excess weight (see Table 1 for details). Among the much larger group of students considered lean, a subset from the same classrooms as the students with excess weight were randomly selected and also invited to participate in the study. Students in the lean group who declined to participate were replaced by another potential candidate randomly selected from the eligible pool of lean individuals within that school class. Two lean Asian students were recruited for every lean non-Asian student, resulting in 490 lean students selected (313 Asian and 177 non-Asian). In total, there were 733 students in all weight categories: 427 Asians and 306 non-Asians. The non-Asians were from varied racial/ethnic backgrounds, with 110 African American (AA), 97 Whites, 68 Hispanics, and 31 self-identified as ‘other’, who were predominantly of mixed race. Over 80% of the students approached for participation, chose to participate and where evaluated in the school.

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). 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]

Waist circumference is known to vary according to the height of the person and is also known to differ across racial groups. To account for this obesity-independent variability, waist-height ratio (W/H) was used instead of WC in some analyses as it shows less sex and race variability.[18-20]

Blood Pressure Measurements

After sitting for 5 minutes, blood pressure was measured using an electronic vital signs monitor (Sure Signs VS1; Philips) 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 2 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). Insulin was assayed using chemiluminescence (Advia Centaur; Bayer Corporation). Total cholesterol, HDL, and TG levels were analyzed using chemistry slides (VITROS DT; Johnson & Johnson). A measure of IR was estimated by the homeostatic model assessment of IR (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, Clinton Township, MI). Electrodes were placed on the standing subject's clean skin on ipsilateral hand and foot. Then, a small, imperceptible current was passed between those electrodes, and the body's electrical resistance was recorded. By utilizing reference norms provided by the RJL, and depending on body frame size, estimates of body fat percentage were derived. First, fat mass was calculated based on the National Health and Nutrition Examination Survey III data set.[23] Then, body fat percentage was derived by dividing the participant's fat mass by her/his total weight.

Definition of Metabolic Syndrome (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 impaired fasting glucose (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 non-diabetic youth. We and others have used a homeostatic model assessment of IR (HOMA-IR) ≥3.99 as the threshold for clinically significant IR.[12,27] The specific definitions of the 5 factors are: (1) central adiposity (WC ≥90th % 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: ≤18 years of age a systolic or diastolic blood pressure >90th %adjusted for age, sex, and height; for >18 years, ≥130/85mmHg[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 1-way analysis of variance (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 Asians and non-Asians 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 5 metabolic risk factors among them controlling for BMI. All analyses were performed using SPSS version 23; SPSS, Inc. Statistical significance was set at α=.05.

Results

733 participants were included in the final analyses. Table 1 presents comparisons of Asian (South Asian and East Asian combined) vs. non-Asian (African-American, Hispanic, Caucasian, and other combined), for lean, overweight/obese, 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/m^2 vs. 29.1kg/m^2; p<0.01). Despite lower BMIs, Asian adolescents with excess weight had higher TG levels (103.2 vs. 81.4; p<0.01) and 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) than their non-Asian counterparts (R^2=0.18). When all subjects, including those participants who were lean 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 ($F_{change}(1,236)$

= 12.83, $p<0.01$), 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 (HOMA-IR≥ 3.99) is low and does not differ between Asian and non-Asians students in our sample. However, the rate meeting the IR criterion is 51% greater (9.5% vs. 6.3%) among Asians classified as overweight and is nearly double (43.9% vs. 22%) among those classified as obese ($p<0.05$).

As there is a significant BMI difference between Asian and Non-Asian groups with excess weight, we controlled for BMI in comparing the 5 metabolic risk factors and W/H among the groups. When controlling for BMI, Asians have 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 to 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 Asian adolescents carrying excess weight (overweight/obese) have a significantly higher IR and TG compared to 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 reported an increased cardiovascular risk among 8-11 year old British, South Asians compared to white children[9] and augment extant literature that suggests 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 T2DM 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 B-cell reserve shared by all.[32,33] Nearly 99% of our Asian adolescents are first generation, and therefore we speculate that this suggests that their higher metabolic risk is influenced by genetics and is 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 cardio-metabolic abnormality from excess weight than their non-Asian counterparts.

It is important to note that our Asian adolescents carrying excess weight are 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 % body fat do not allow us to make that distinction, the higher level of metabolic risk despite lower overall % 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 to 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 pro-inflammatory cytokines, which have been found in greater concentrations within visceral fat 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, the 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 become more significant when we control for BMI. Future studies should focus on measuring visceral fat directly as well as comparing inflammatory marker levels among racial/ethnic groups.

Internationally recognized cut-off points of 25 and 30 kg/m2 exist that define overweight and obesity respectively in adults; 85th and 95th percentile cut-offs 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 cut scores for Asian adults of 23 and 28kg/m^2.[39] They suggested the 85th and 95th percentile that are used as cut-off 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, percentage of body fat, and health risks compared to Europeans and Americans.

Our data is 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 essential 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 cut 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 community, non-clinical sample and we utilized objective and reliable methods for all our measurements. Also, over 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.

Conclusions

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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What Is Known about the Topic

- Racial differences are known to exist in weight-related co-morbidities among middle-aged individuals, with Asian adults known to be at higher risk.
- Less is known about the extent of these racial differences, particularly among Asian-American adolescents.

What This Study Adds

- East and South Asian adolescents have increased IR and TGs, despite overall lower BMIs, which puts them at increased risk for MetS and early cardiovascular disease.
- Pediatricians should screen children of Asian extraction more thoroughly, even at lower excess weights.
- Recognizes the impact racial differences have on the diagnosis and management of weight related medical conditions.

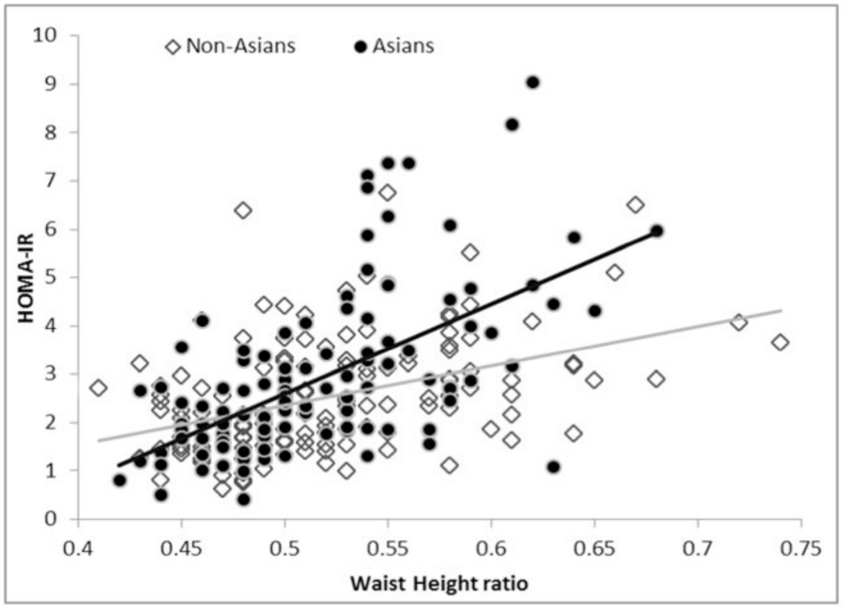

Figure 1.
Relationship between HOMA and Waist Height Ratio among Overweight/obese Asians (filled circles) and non-Asians (open rhomboids).

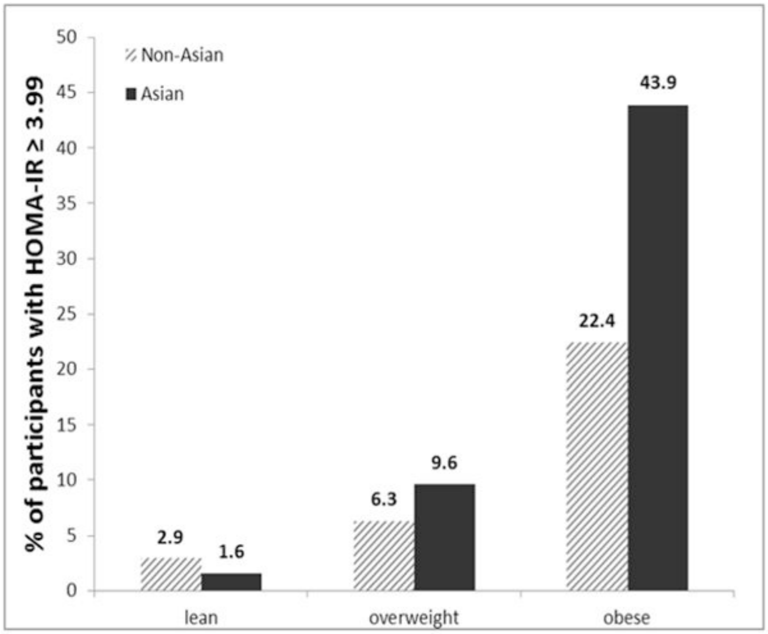

Figure 2.

Percent of Asian participants (Black bars) for each of the three weight groups (lean, overweight, and obese), who meet the criterion for IR (HOMA-IR ≥3.99) vs. non-Asian participants (Hatched bars)

Table 1

Anthropometric Data and Metabolic Risk Factors for Asian and Non-Asian Adolescents by Body Mass Index Grouping

	Lean		Overweight/Obese		Total	
	Asians (n=313)	Non-Asians (n=177)	Asians (n=114)	Non-Asians (n=129)	Asians (n=427)	Non-Asians (n=306)
Age(years)	16.78 ± .98	16.73 ± .94	16.3 ± 1	16.67 ± 1	16.65 ± 1	16.71 ± 1
Female sex (%) (No.)	49.5% (155)	43.5% (77)	28.1% (32)	41.1% (53)	43.8% (187)	42.5% (130)
Weight(lbs.)	130 ± 18.1$^{b\times}$	137.93 ± 19.6$^{b\times}$	173.65 ± 25.7$^{c\times}$	187.56 ± 36.2$^{c\times}$	141.71 ± 28$^{a\times}$	158.85 ± 37$^{a\times}$
Height (in)	64.96 ± 3.4$^{b\times}$	66.84 ± 3.7$^{b\times}$	66.26 ± 3.3	67.1 ± 3.5	65.31 ± 3.4$^{a\bullet}$	66.95 ± 3.6$^{a\bullet}$
Waist circumference(in)	28.35 ± 2.3	28.55 ± 2.3	34.25 ± 3.7	35.1 ± 4.5	29.93 ± 3.8$^{a\times}$	31.32 ± 4.7$^{a\times}$
Waist height ratio	.43 ± .03^{b*}	.42 ± .03^{b*}	.51 ± .05	.52 ± .06	.45 ± .05$^{a\bullet}$	.46 ± .06 $^{a\bullet}$
BMI(kg/m²)	21.56 ± 1.7	21.63 ± 1.9	27.73 ± 3^{c*}	29.12 ± 4.3^{c*}	23.21 ± 3.5$^{a\times}$	24.7 ± 4.8$^{a\times}$
% Body fat	24.17 ± 7.6	22.77 ± 8.4	29.43 ± 8$^{c\bullet}$	32.13 ± 8.4 $^{c\bullet}$	25.61 ± 8	26.7 ± 9.6
Triglycerides (mg/dL)	80.58 ± 36.7$^{b\bullet}$	72.6 ± 37.7$^{b\bullet}$	103.18 ±76.3^{c*}	81.38 ± 41.9^{c*}	86.63 ± 51.3^{a*}	76.29 ± 39.7^{a*}
Systolic blood pressure (mm Hg)	116.97 ± 8.9	117.64 ± 9.4	123.78 ± 10.8	125.96 ± 11.8	118.75 ± 9.9^{a*}	121.11±11.2^{a*}
HDL (mg/dl)	60.92 ± 11.4	59.61 ± 12.1	53.45 ± 10.4	53.13 ± 12.5	58.92 ± 11.6$^{a\bullet}$	56.8 ± 12.7$^{a\bullet}$
HOMA-IR	1.69 ± .72$^{b\bullet}$	1.85 ± .87$^{b\bullet}$	2.91 ± 1.7	2.55 ± 1.2	2.01 ± 1.2	2.15 ± 1
Fasting insulin (mIU/ml)	8.38 ± 3.4$^{b\bullet}$	9.16 ± 4$^{b\bullet}$	14.06 ± 7.7	12.64 ± 5.7	9.9 ± 5.5	10.63 ± 5.1
Fasting Glucose (mg/dl)	82.15 ± 5.4	82.57 ± 12.3	83.75 ± 5.9$^{c\bullet}$	82.1 ± 6$^{c\bullet}$	82.58 ± 5.6	82.37 ± 10.1

[a] significant difference between Asians and non-Asians overall (lean and overweight/obese combined)

[b] significant difference between lean Asians and lean non-Asians

[c] significant difference between Overweight/obese Asians and Overweight/obese non-Asian

[•] p<0.05,

[*] p<0.01,

[×] p<0.001

Values presented are means +/- SD

Table 2

Regression analysis with HOMA-IR as the dependent variable

	R square	R square change	F change	P value
Age, Sex, BMI	.23	.23	23.67	<.001
W/H	.293	.064	21.31	<.001
Race group (Asian vs. non-Asian)	.31	.016	5.61	<.05
Interaction (W/H*Race)	.346	.036	12.82	<.001