Adverse Childhood Experiences and Weight Status among Adolescents

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Objective To investigate the relationship between adverse childhood experiences (ACEs) and weight status among adolescents.

Study design Data were drawn from the Minnesota Student Survey, a large (n = 105 759), statewide, anonymous survey of public school students in eighth, ninth, and eleventh grades. Self-reported height and weight were used to calculate body mass index. Multinomial logistic regression was used to examine associations between self-reported ACEs and weight status, controlling for key sociodemographic characteristics.

Results ACEs were positively associated with weight status; adolescents with more ACEs were more likely to have overweight, obesity, and severe obesity than adolescents with no ACEs. Adolescents who reported an ACE were 1.2, 1.4, and 1.5 times as likely to have overweight, obesity, and severe obesity, respectively, compared with their peers with no ACEs. There was no relationship between ACEs and underweight.

Conclusions The results of this large sample of adolescents with anonymous data support the hypothesis that ACEs and obesity are strongly associated. The directionality of this relationship needs to be understood. Moreover, these findings suggest that child health professionals may need to screen for ACEs as an important aspect of clinical weight management. *(J Pediatr 2019;204:71-6).*

The etiology of obesity in childhood is complex including socioeconomic status, genetics and underlying biology, and psychosocial factors (eg, quality of life, depression, anxiety).[1-6] Twenty years ago, physicians began documenting the relationship between a variety of indicators of poor health in adulthood (eg, obesity, heart disease, cancer, etc) and exposure to abuse and other types of household dysfunction, which are collectively termed adverse childhood experiences (ACEs).[7] Numerous potential mechanisms for the association between ACEs and obesity have been proposed. Research suggests a causal relationship between maltreatment during childhood and psychological distress,[8] which has been implicated as a potential cause of obesity.[9,10] Similarly, health risk behaviors may mediate the relationship between ACEs and obesity.[11] Several biological systems, most notably the hypothalamic pituitary adrenal axis, but also the autonomic nervous system and the development of the prefrontal cortex, have been suggested as mechanisms and may be expressed in genetic, epigenetic, and behavioral effects.[12-14]

The assessment of ACEs during childhood is particularly challenging because of mandated reporting requirements, which necessitate reporting of children's exposure to some ACEs (eg, physical or sexual abuse) to authorities. Thus, there is an increased likelihood of reporting bias when parents are asked to report on their children's ACEs. Using youth report of ACEs is a promising alternative strategy, but with the exception of data collected in clinical settings,[15] young people are usually not directly asked about their exposure to ACEs in research on weight status in pediatric samples.[16-18]

The Minnesota Student Survey (MSS) is a statewide, anonymous survey that provides data on weight and height along with many ACEs. Because of its anonymity, the MSS offers a unique opportunity to examine the associations between ACEs and weight status prior to adulthood with limited response bias. Moreover, the MSS is administered to a large and diverse group of adolescents, permitting the examination of key demographic characteristics, which could have independent effects on weight status.[19] Our hypothesis is that ACEs will be positively associated with weight status after accounting for key covariates.

Methods

This secondary data analysis used the 2016 MSS, a statewide, anonymous, cross-sectional survey administered every 3 years to public school students in eighth,

ACE	Adverse childhood experience
BMI	Body mass index
MSS	Minnesota Student Survey

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ninth, and eleventh grades. The MSS assesses a wide range of demographic characteristics, health-related behaviors, and risk and protective factors. The survey is administered in both online (84%) and paper/pencil (16%) formats, on a day chosen by the school district; no makeup surveys are offered. Passive parental consent is obtained prior to survey administration; no records are kept regarding the number of parents who decline to have their children participate in the survey. In 2016, middle and high school students in 85% of the school districts in Minnesota completed the survey. Because this study involved secondary analysis of publicly available anonymous data, the University of Minnesota's Institutional Review Board deemed this study exempt from human-subject review.

Demographic covariates included sex, age, poverty exposure, nonmetropolitan status, and race/ethnicity. Because the survey is completed by youth, household income is not available. Thus, poverty exposure was defined as endorsing either of 2 proxy items that indicate family financial stress: "Do you currently get free or reduced-price lunch at school?" or "During the last 30 days, have you had to skip meals because your family did not have enough money to buy food?" Nonmetropolitan status was determined by whether or not youth attend a school located in the 7-county metropolitan area. Race and ethnicity were assessed via 4 questions (1 about race and 3 about Hmong, Somali, and Hispanic ethnicities, respectively) which were recoded to create 9 mutually exclusive race and ethnic categories: American Indian, Asian, black, Pacific Islander, white, Hispanic, Somali, Hmong, and multiple races or ethnicities. Youth who endorsed only 1 race or ethnicity were coded into that category; youth who endorsed any combination of more than 1 race or ethnicity were coded as multiple races or ethnicities.

A series of yes/no questions assessed youths' self-reported exposure to 6 ACEs: psychological abuse, physical abuse, sexual abuse, familial substance abuse, domestic violence, and parental incarceration. Psychological abuse was assessed with 1 item, "Does a parent or other adult in your home regularly swear at you, insult you, or put you down?" Physical abuse was assessed with 1 item, "Has a parent or other adult in your household ever hit, beat, kicked, or physically hurt you in any way?" Sexual abuse was assessed with 2 items, "Has any adult or other person outside of the family ever touched you sexually against your wishes or forced you to touch them sexually?" and "Has any older or stronger member of your family ever touched you or had you touch them sexually?" Familial substance abuse was assessed with 2 items, "Do you live with anyone who drinks too much alcohol?" and "Do you live with anyone who uses illegal drugs or abuses prescription drugs?" Domestic violence was assessed with 1 item, "Have your parents or other adults in your home ever slapped, hit, kicked, punched, or beat each other up?" Finally, parental incarceration was assessed with 1 item, "Have any of your parents or guardians ever been in jail or prison?" Youth who endorsed either of the 2 items about sexual abuse or substance abuse were considered to have experienced that ACE. Each of the 6 ACEs were coded as indicator variables (0 = "no", 1 = "yes"), which were summed to yield a count of exposure to different types of ACEs, ranging from zero to 6.

Self-reported height (inches or centimeters) and weight (pounds or kilograms) were used to calculate body mass index (BMI). BMI was calculated as the body weight in kilograms divided by the height in meters squared. BMI percentiles were determined using age- and sex-based definitions from the US Centers for Disease Control and Prevention. Underweight was defined as <5th percentile; normal-weight was defined as ≥5th to the < 85th percentile; overweight was defined as ≥85th to the <95th percentile; obesity was defined as ≥95th to <120% of the 95th percentile; and severe obesity was defined as ≥120% of the 95th percentile or an absolute BMI ≥35 kg/m.[12,20]

Statistical Analyses

We examined differences in weight status separately by key demographic characteristics (ie, sex, age, poverty exposure, nonmetropolitan status, and race/ethnicity) and ACEs. In addition, we used multinomial logistic regression to examine the effect of ACEs on youths' weight status, controlling for these same demographic characteristics. Logistic regression produces ORs, which describe the relative odds that a child will be in a given weight category (eg, underweight, overweight, obese, severely obese) compared with normal weight (significance was set at $P < .05$). We also present 95% CIs for those ORs. Analyses were conducted in SPSS v 24 (SPSS Inc, Armonk, New York). Missing data were low for all study variables. Youth who were missing BMI data (12%) or responses on 1 or more ACE questions (8%) were excluded from the analytic sample.

Results

Descriptive statistics for the full sample by weight status are presented in **Table I**. A majority (70.9%; n = 74 951) of adolescents had normal weight; 15.3% (n = 16 183) had overweight, 7.8% (n = 8274) had obesity, 3.2% (n = 3419) had severe obesity, and 2.8% (n = 2932) had underweight. The majority of youth reported no ACEs; overall, 35.4% had 1 or more ACEs. The proportion of youth who reported 1 or more ACE by sex and race/ethnicity are presented in **Figure 1** and **Figure 2** (available at www.jpeds.com).

Sociodemographic characteristics were related to both ACEs and weight status. Being female, experiencing poverty, and living in a nonmetropolitan area were significantly associated with higher ACEs. Being male, older, experiencing poverty, living in a nonmetropolitan area, and ACEs were significantly associated with higher BMI. Intercorrelations for all study variables are shown in **Table II** (available at www.jpeds.com).

Results of the multinomial logistic regression for each weight status with all covariates included in the model are presented in **Table III**. ACEs were significantly associated with having overweight, obesity, or severe obesity, but not underweight. Generally, results reveal a stepwise pattern, such that youth with more ACEs had higher odds of having overweight, obesity, or severe obesity than youth with fewer ACEs. For example, youth with a single ACE were more than 1.5 times as likely and those with 2 ACEs were 1.7 times as likely to have severe obesity than youth with no ACEs. **Figure 3** shows the odds of having each weight status (underweight, overweight, obesity, or severe

Table I. Descriptive statistics by weight status

	Full sample	Underweight	Normal weight	Overweight	Obese	Severely obese
Age, mean (SD)	14.9 (1.3)	14.9 (1.3)	14.9 (1.3)	14.9 (1.3)	14.9 (1.3)	15 (1.4)
Sex (% female)	49.6	46.4	52.3	46.1	39.3	35.6
Poverty (%)	27.7	27.5	24.3	32.9	39.8	48.3
Rural status (% rural)	47.8	43.0	46.3	51.3	53.4	54.2
Race/ethnicity						
American Indian (%)	1.1	0.8	0.9	1.4	2.1	3.2
Asian (%)	3.3	6.5	3.5	2.6	2.1	1.2
Black (%)	3.9	3.5	3.5	4.9	5.0	5.6
Pacific Islander (%)	0.1	0.1	0.1	0.1	0.2	0.4
Hispanic (%)	6.5	4.7	5.7	8.0	9.2	10.7
Somali (%)	1.2	1.5	2.0	2.9	3.7	4.0
Hmong (%)	2.3	2.9	1.2	1.0	0.8	0.6
White (%)	72.1	70.4	74.4	68.1	64.4	60.5
Multiple races or ethnicities (%)	9.6	9.5	8.7	11.1	12.5	13.6
ACEs						
0 (%)	64.6	66.3	67.4	59.7	54.7	49.9
1 (%)	19.0	18.5	17.9	20.9	23.3	24.9
2 (%)	8.6	8.4	7.9	10.0	11.2	12.4
3 (%)	4.4	4.0	4.0	5.3	6.1	6.8
4 (%)	2.1	1.8	1.9	2.4	2.9	3.6
5 (%)	1.0	0.9	0.8	1.4	1.4	1.7
6 (%)	0.2	0.3	0.2	0.2	0.3	0.7
n (% of full sample)	105,759	2,932 (2.8%)	74,951 (70.9%)	16,183 (15.3%)	8,274 (7.8%)	3,419 (3.2%)

obesity), compared with having normal weight, with no ACEs as the reference group. Sex, poverty, nonmetropolitan location, and race/ethnicity were also significant predictors of weight status in the multinomial models. Female adolescents were less likely to have underweight, overweight, obesity, or severe obesity than male adolescents. Experiencing poverty also increased the likelihood that a youth would have underweight or overweight. Youth living in a non-metropolitan area were less likely to have underweight and more likely to have overweight, obesity, or severe obesity. Youth who were American Indian, black,

Table III. Logistic regression models of weight status, by sociodemographics and ACEs

	Underweight	Overweight	Obese	Severely obese
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (range = 12-18 y)	**1.04 (1.01-1.07)**	1.00 (0.99-1.02)	**1.03 (1.02-1.05)**	**1.01 (1.05-1.11)**
Sex				
Male	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Female	**0.78 (0.73-0.84)**	**0.76 (0.74-0.79)**	**0.57 (0.54-0.59)**	**0.47 (0.44-0.51)**
Poverty				
No poverty risks	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
One or more poverty risks	**1.15 (1.04-1.26)**	**1.31 (1.25-1.36)**	**1.67 (1.58-1.76)**	**2.24 (2.07-2.43)**
Urbanicity				
Urban	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Rural	**0.90 (0.84-0.98)**	**1.25 (1.20-1.29)**	**1.34 (1.28-1.41)**	**1.37 (1.27-1.47)**
Race and ethnicity				
White Non-Hispanic	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
American Indian	0.93 (0.61-1.41)	**1.35 (1.15-1.58)**	**1.87 (1.57-2.22)**	**2.47 (1.99-3.07)**
Asian	**1.88 (1.61-2.21)**	**0.83 (0.74-0.92)**	**0.72 (0.62-0.85)**	**0.42 (0.31-0.57)**
Black	0.95 (0.77-1.17)	**1.38 (1.27-1.51)**	**1.33 (1.19-1.49)**	**1.37 (1.17-1.61)**
Pacific Islander	1.12 (0.41-3.05)	0.97 (0.59-1.57)	1.30 (0.75-2.26)	**2.91 (1.67-5.09)**
Hispanic	**0.82 (0.69-0.99)**	**1.37 (1.28-1.47)**	**1.52 (1.40-1.66)**	**1.67 (1.48-1.88)**
Somali	**2.26 (1.78-2.87)**	**0.76 (0.64-0.91)**	**0.56 (0.43-0.73)**	**0.40 (0.26-0.63)**
Hmong	**0.72 (0.53-0.98)**	**1.52 (1.36-1.69)**	**1.83 (1.60-2.09)**	**1.85 (1.53-2.24)**
Multiple races or ethnicities	1.10 (0.96-1.26)	**1.25 (1.18-1.33)**	**1.37 (1.27-1.48)**	**1.44 (1.29-1.61)**
ACEs				
0	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
1	1.04 (0.95-1.15)	**1.21 (1.16-1.27)**	**1.38 (1.30-1.47)**	**1.49 (1.37-1.63)**
2	1.07 (0.93-1.23)	**1.30 (1.22-1.38)**	**1.49 (1.38-1.61)**	**1.67 (1.49-1.87)**
3	1.03 (0.85-1.25)	**1.35 (1.25-1.47)**	**1.57 (1.42-1.74)**	**1.75 (1.52-2.03)**
4	0.97 (0.73-1.29)	**1.29 (1.15-1.45)**	**1.59 (1.38-1.83)**	**1.92 (1.57-2.33)**
5	1.01 (0.67-1.52)	**1.60 (1.37-1.87)**	**1.64 (1.33-2.00)**	**1.93 (1.47-2.55)**
6	1.74 (0.85-3.58)	**1.47 (1.02-2.11)**	**2.03 (1.33-3.10)**	**4.24 (2.71-6.65)**

Bolded values represent statistically significant results ($P < .05$). All variables are included in the models.

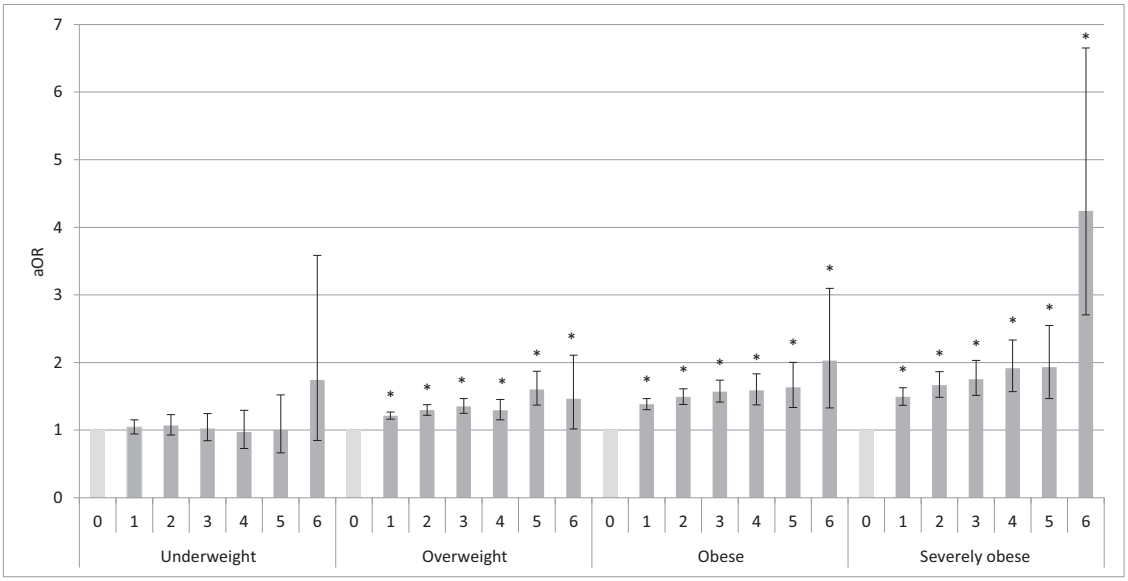

Figure 3. †Likelihood of being underweight, overweight, obese, or severely obese by number of ACEs.
†The aORs have been adjusted for age, sex, poverty status, nonmetropolitan status, and race/ethnicity. Note: Asterisks (*) represent statistically significant differences (reference group is youth with zero ACEs). Example: Youth with 1 ACE are about 1.2 times as likely to be overweight as youth with no ACEs, whereas youth with 6 ACEs are about 1.5 times as likely to be overweight as youth with no ACEs.

Hispanic, Hmong, or multiple races/ethnicities were more likely to have overweight, obesity, or severe obesity than non-Hispanic whites. Asian and Somali youth were more likely to have underweight and less likely to have overweight, obesity, or severe obesity than non-Hispanic whites.

Discussion

Youth in this survey reported concerning rates of exposure to ACEs. These results parallel recent findings from national surveys indicating that nearly one-half of all children in the US have had at least 1 ACE.[21] Notably, 40%-50% of youth in our sample who reported having overweight, obesity, or severe obesity also reported at least 1 ACE. Overall, we observed incremental increases in weight status in concordance with increases in ACEs.

From an obesity prevalence perspective, pediatric obesity (specifically severe obesity) could at least partially be explained by ACEs. Importantly, as we continue to find that youth with severe obesity have different risk profiles when compared with peers with normal weight, overweight, and obesity,[22,23] this study shows that the health challenges of this high-risk group are compounded by external influences, particularly their exposure to adversity. These results suggest that obesity prevention and treatment efforts should include components that prevent or treat ACEs and their associated negative impacts (eg, psychological distress).

A recent American Academy of Pediatrics Annual Survey of Fellows revealed that few pediatricians ask about ACEs and 89% are unfamiliar with the original ACEs study[7] that linked adult health outcomes with childhood adversity.[24] The survey also found that pediatricians who believe that promoting positive parenting, screening for social-emotional risk factors, or managing pediatric mental health problems are within their scope of practice are more likely to screen for ACEs.[24] Our results imply that child health professionals should understand the relationship between ACEs and weight status in adolescence, and that screening for ACEs and referring youth and their families to appropriate services might be an important part of clinical weight management.

Although this study was not able to explore causal processes behind the relationship between ACEs and weight status, there are a number of potential mechanisms that could be responsible for this relationship, including chronic stress, activation of the hypothalamic-pituitary-adrenal axis, and biobehavioral factors, such as diet and exercise. One potential causal mechanism is psychological distress, which is related to both ACEs and obesity.[9,10] Pediatricians who work with children experiencing adversity might refer families to appropriate mental health resources, which have the potential to positively impact distress associated with adversity and, thus, have implications for weight status. Furthermore, because ACEs tend to co-occur,[25] clinical systems that screen for ACEs have the opportunity to refer families to important behavioral services that could mitigate the experience of future ACEs. For example, in families in which parents are divorcing, connecting parents to effective interventions that have been shown to improve parents' discipline strategies[26] can potentially prevent other ACEs, such as physical abuse.

These findings are not without limitations. First, both of our primary variables of interest—ACEs and weight status—are likely underestimated in our data. Several publications using large, nationally representative samples have found that self-reported height and weight are reliable measures compared with standard measurement, but self-report may underestimate the proportion of youth with overweight and obesity.[27,28] According to data from the 2016 National Survey of Children's Health, 27.7% of youth between the ages of 10 and 17 years in Minnesota have a BMI >85th percentile, compared with 26.5% in our sample,[29] indicating that our data are capturing the majority of youth who have overweight, obesity, or severe obesity. Future studies would benefit from direct measurement of BMI. Recent studies confirm that self-report of ACEs is accurate during adolescence[30]; however, we do not have a measure of some types of ACEs, such as parental separation/divorce or parent mental illness. As such, our index of ACEs underrepresents the true prevalence of adversity in our sample. However, it is notable that we found a strong and consistent relationship between ACEs and weight status, despite these other unmeasured ACEs. Given the fact that our ACEs score is an underestimation of youths' exposure to adversity, these findings are a conservative estimate of the true relationship between ACEs and weight status, which might be even stronger than our data suggests.

Although the level of missing data in our sample was low, it is possible that those youth who were omitted from the analysis were different from those who had complete data. Specifically, youth who face shame or stigma about their weight might have been less likely to report it, though the use of an anonymous data collection tool likely ameliorates some of the effect of under-reporting because of weight-based stigma, and our data are similar to recent prevalence estimates from other sources.[29] Furthermore, our sample was limited to youth attending public schools and, therefore, results cannot be generalized to youth attending private schools, alternative schools, or those who are homeschooled. In addition, we do not have any information regarding the youth who did not take the survey because they were absent from school on the day the survey was administered. Given that ACEs have been shown to be associated with chronic absenteeism from school,[31] youth in public schools who were not present to take the survey are likely to have the highest level of exposure to ACEs, once again indicating that our observed relationships, although quite strong, are likely underestimates.

Some variables could not be measured precisely. For example, household income was not available, so we had to rely on proxy measures (free/reduced lunch, food insecurity) to assess youths' exposure to poverty.

Many different assessments of ACEs exist for both clinical and research settings, but most do not allow for youth report, and it is unclear which assessments are most effective, and acceptable to patients and clinicians.[32] Further development of standardized screening tools for use by both parents and youth in the clinical setting is needed.

We used a count of cumulative exposure to different types of ACEs to examine the overall effect of adversity in childhood on weight status. Though it is beyond the scope of this study, it is possible that particular ACEs might be more strongly related to having obesity than others. Future research should explore the relationships between specific types of adversity and having overweight or obesity in adolescence.

Pediatricians should consider standardized screening for ACEs and referrals as needed for appropriate psychosocial interventions. Preventing ACEs and identifying ACEs early to prevent or delay the development of obesity may help to reduce the prevalence of obesity. ■

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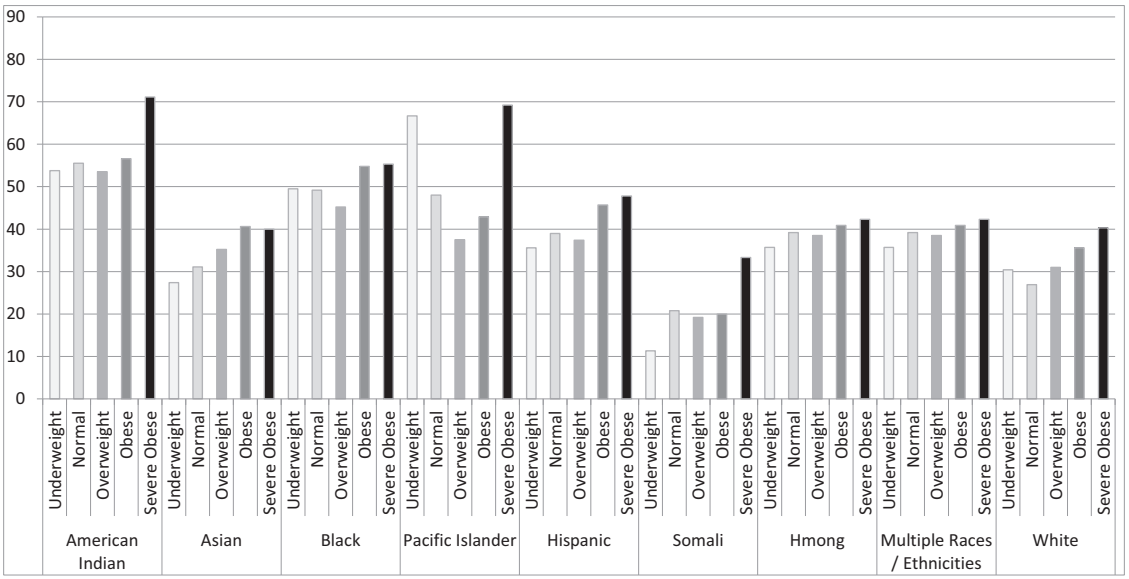

Figure 1. Prevalence of 1 or more ACE by race/ethnicity and weight status for male adolescents.

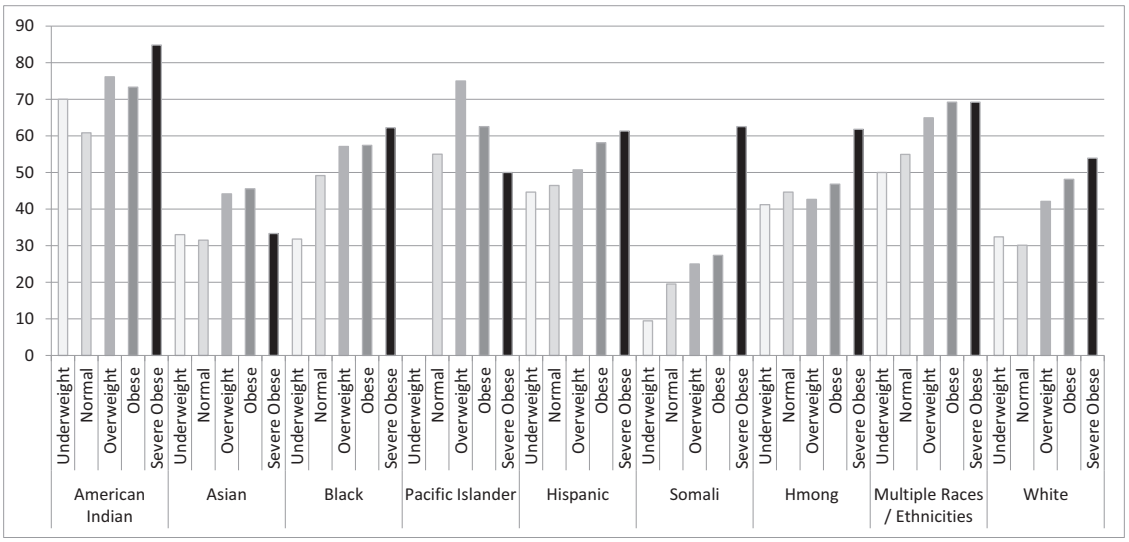

Figure 2. Prevalence of 1 or more ACE by race/ethnicity and weight status for female adolescents.

Table II. Intercorrelations of sociodemographics, ACEs, and BMI

	Age	Sex	Poverty	Urbanicity	Race/Ethnicity	ACEs	BMI
Age	—	**–.032**	**–.020**	**.035**	–.002	.000	**.206**
Sex (1 = female)		—	**.011**	–.005	**–.008**	**.071**	**–.036**
Poverty (1 = yes)			—	.001	**.015**	**.270**	**.132**
Urbanicity (1 = rural)				—	**–.012**	**.036**	**.061**
Race/ethnicity (1 = not white non-Hispanic)					—	.004	-.003
ACEs						—	**.106**
BMI							—

Bolded values represent statistically significant results ($P < .05$).