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Sex differences in the association between perceived stress and adiposity in a nationally representative sample

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Abstract

Purpose—Prior studies examining the association between perceived stress and adiposity have reported mixed findings and sex differences have largely not been examined.

Methods—We examined the relationship between perceived stress and BMI and waist circumference in young adults in the National Longitudinal Study of Adolescent to Adult Health. Participants (mean age 29; n=14,044) completed the short form of Cohen's Perceived Stress Scale during a home visit. Height, weight, and waist circumference were assessed during the same visit. BMI was calculated based on measured height and weight.

Results—In the sample, 52% were male and 65% identified as White. In adjusted linear regression analyses, a sex by PSS interaction was noted ($p < 0.05$) for both BMI and waist circumference. Perceived stress was statistically significantly associated with lower BMI (B: -0.09 ; SE: 0.05) and was associated with lower waist circumference, though not statistically significant (B: -0.18 ; SE: 0.10) among men. No associations were noted among women.

Conclusions—In this nationally representative sample of young adults, perceived stress was associated with lower levels of adiposity among men. Noted differences could be attributed to different behavioral and coping strategies in response to stress between men and women as well as biological mechanisms which should be explored further.

Keywords

stress; sex differences; obesity

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Introduction

The high prevalence of obesity among racial/ethnic minorities and socioeconomically disadvantaged populations in the US has been hypothesized to be due in part to increased experiences of stress (1, 2). Stress, both the experience of negative life events as well as the perception of psychological stress, has been found to impact behavioral (i.e., sleep, diet, physical activity, smoking) and biological factors (i.e., cortisol dysregulation) (3, 4), which can in turn affect adiposity, though not all these factors are obesogenic. Mixed findings have been noted when examining the relation between stress and obesity (5).

Mixed findings in the relation between stress and adiposity may be attributable in part to the differential conceptualization of stress as a determinant of health across studies. For example, some studies have focused on negative life events that may cause stress, (i.e., divorce, job loss, experiences of discrimination, intimate partner violence), (6–9) while other studies have focused on the perception of stress or its impact on eliciting distress, (10) yet other studies focus on the biological response to stress (i.e., cortisol dysregulation) (11, 12).

Experiences of stress stemming from exposure to negative life events (i.e., job loss, violence, divorce) have been associated with obesity in some studies while others have noted no associations between stress and obesity (5). Perceived stress construed as the perception of feeling hopeless or out of control has been associated with numerous health outcomes (e.g. blood pressure, heart disease, anxiety, depression, infection) (13) and in some studies with obesity (14).

Sex differences in the relation between stress and obesity have also been documented in this literature (15), with noted associations among women but not men (15). Differential behavioral responses and/or physiological mechanisms may contribute to potential sex differences. Women may be more likely to cope with stress by exhibiting behaviors that are obesogenic (e.g. consuming higher caloric and dense foods, increasing sedentary behaviors) while men may be more likely to cope by expressing non-obesity promoting behaviors (e.g. smoking, increasing physical activity) (16). Differential responses to stress for example in relation to appetite have been examined, with some studies noting an increased appetite in response to stress among women only with no noted associations between increased eating and stress among men (17).

We expand upon existing research and explore the association between perceived stress and adiposity (BMI and waist circumference) among a large sample of young adults in a nationally representative cohort. Given that young adults may be experiencing stressors across multiple domains dependent on their life circumstances (i.e., job, school, family-parent, family-spouse) we focus on the perception of stress which more likely encompasses experiences of stressors in multiple domains and may thus shape behavioral and biological responses. Given the documented potential for differential effects of perceived stress on adiposity, we explicitly examine whether the associations differ by sex.

Methods

Study Population

Data for this study came from the National Longitudinal Study of Adolescent to Adult Health (18). Add Health is a school-based, longitudinal study following a nationally representative sample in addition to a select oversampling of minority groups, from adolescence through early adulthood (18). High schools were selected via a stratified random sampling of US high schools. The schools were stratified into clusters based on their representativeness of the US in terms of region, urbanicity, size, type (public, private, parochial), and ethnicity, from which 80 high schools were ultimately selected. Included schools all met the inclusion criteria of having an 11th grade and more than 30 enrolled students. Those schools that did not meet inclusion criteria were replaced by comparable schools. A feeder school (a middle/junior high that was likely to send at least 5 students in the following year) was selected for each high school. Twenty high schools were their own feeder school as their schools included 7th and 8th grades. In total, 145 schools participated. Students enrolled in grades 7–12 during the 1994–1995 school-year were stratified by age and sex, and interviewed at baseline using an in-school questionnaire. Subsequently, four waves of follow-up were conducted by way of in-home interviews (Wave 1, 1995; wave 2, 1996; wave 3, 2001–2002; wave 4, 2008–2009). Details of the Add Health study design have been reported in greater detail previously (18). Among the 20,745 respondents, between the ages of 12 and 18 years old, 1,185 were declared ineligible for wave 4; either because they were out of the country during the data collection, were active duty military, were not accessible by the field interviewers, or had become deceased. The remaining 19,560 participants were eligible for the wave 4 survey, of which 15,701 completed the interview. Participants without sampling weights (n=901), or pregnant during the wave 4 in-home interview (n=487), or missing BMI data (n=229), waist circumference measurements (n=12), perceived stress data (n=26), or education data (n=2) were excluded from the sample, leaving 14,044 as the sample size for these analyses. Data collection procedures of the Add Health study were approved by the Institutional Review Board of the University of North Carolina, Chapel Hill. Analyses for this study were approved by the Institutional Review Board of Columbia University, New York.

Perceived Stress

As part of the Wave 4 in-home interview, participants were asked a series of 4 questions that comprise the Cohen 4-item Perceived Stress Scale (PSS-4) (19, 20). Each of the four items was asked regarding the past 30 days and were worded as follows: *how often have you felt that you were unable to control the important things in your life, how often have you felt confident in your ability to handle your personal problem, how often have you felt that things were going your way, how often have you felt that difficulties were piling up so high that you could not overcome them*. Participants were asked to respond to each item along a 5-level Likert scale with responses ranging from never to very often. For analysis purposes, Add Health provided a constructed perceived stress scale variable which is the sum of the responses of each of the four items, with the 2nd and 3rd items reverse coded.

Anthropometric Data

During the wave 4 in-home assessment, height and weight of the participants were both measured. BMI for each participant was calculated from measured height and weight values (kg/m^2), collected during the wave 4 in-home visits. Additionally, waist circumference was measured to the nearest 0.5 cm at the superior border of the iliac crest as recommended by the National Cholesterol Education Program Third Adult Treatment Panel, (21) during the wave 4 in-home assessment.

Covariates

Information on socio-demographic factors, such as age, sex, race/ethnicity, and educational attainment was collected through in-home questionnaires, as was self-report data on physical activity, smoking status, average duration of sleep, and depressive symptomatology. Race/ethnicity was operationalized as a 5-level, categorical variable: non-Hispanic white (referred to from here on out as White), non-Hispanic black (referred to from here on out as Black), Hispanic origin, Asian, and other. Education was based on the highest education level attained and categorized into 4 levels, less than a high school education, high school graduate or vocational school, some college, and college graduate or graduate education. To assess physical activity, participants were asked how often they had engaged in a number of physical activities for any duration of time in the past seven days. These activities included bicycling, skateboarding, dancing, hiking, hunting, doing yard work, roller blading/skating, skiing/snowboarding, playing racquet sports, doing aerobics, playing strenuous team sports, participating in individual sports, doing gymnastics, weight lifting, strength training, playing golf, going fishing, or walking for exercise. Physically active events were summed across all categories for each participant. High physical activity was defined as 5 or more physically active events in a week. Smoking status was operationalized as a 3-level categorical variable. Individuals who reported never smoking at least one cigarette a day for 30 consecutive days were labeled as never smokers. Those who reported at some point smoking at least 1 cigarette a day for 30 consecutive days but reported not smoking at least 1 cigarette in the previous 30 days were labeled as former smokers. Individuals who reported at some point smoking at least 1 cigarette a day for 30 consecutive days and reported smoking 1 or more cigarettes in the past 30 days were labeled as current smokers. Sleep duration was categorized into 3 categories, 6 hours of sleep or less a night, 7–8 hours of sleep a night, and more than 8 hours of sleep a night. The 10-item CES-D scale was administered to assess depressive symptomatology during the wave 4 in-home visits. The CES-D is a widely-used measure with well-documented reliability and validity (22, 23). Depression symptoms were characterized as either high depressive symptomatology (score of 11 or above for CESD-10) or none/low depressive symptomatology, according to established guidelines (23).

Data Analysis

We used multiple linear regression models to estimate the relationship between perceived stress and BMI, and perceived stress and waist circumference in a partially adjusted model for demographic variables (sex, race/ethnicity, age, and education). We then examined a fully adjusted model, which controlled for health behaviors (physical activity and smoking status), sleep duration, and depressive symptoms, in addition to the demographic variables.

Additionally, a cross product term was created to test whether sex modified the relationship between perceived stress and BMI or waist circumference. Furthermore, three sets of models stratified by sex were estimated for each outcome variable, adjusting for 1) sociodemographic factors; 2) sociodemographic factors and sleep and depressive symptoms; 3) sociodemographic factors, sleep and depressive symptoms, and health behaviors. All analyses were conducted using survey weighting procedures and populations weights provided by Add Health. Data analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

Results

The demographic breakdown of the sample is shown in Table 1. The study sample was 52% male, 69% completed college or had some college education as their highest form of educational attainment and 65% were White. Scores on the perceived stress scale for the sample ranged from 0 to 16, with a mean score of 4.86 (SE: 0.05). Mean BMI was 29 for both men and women (SE_{men}: 0.13; SE_{women}: 0.21) and mean waist circumference was 99 cm (SE: 0.30) and 97 cm (SE: 0.48) for men and women respectively. Overall, 34.8% (SE: 0.83) of the sample was obese as determined by a BMI > 30 (data not shown).

Perceived stress was not significantly associated with BMI in the partially adjusted model (adjusting for sex, race/ethnicity, age, and education) or the fully adjusted model (adjusting for sex, race/ethnicity, age, physical activity, smoking, education, sleep, and depressive symptomatology). However, when the cross-product term for the interaction between perceived stress and sex was included into the fully adjusted model, the association between perceived stress and BMI was significant (B: -0.35, SE: 0.09, $p < .0001$) (data not shown). Similarly, the association between perceived stress and waist circumference was not significant in the partially adjusted or fully adjusted models, but was significant (B: -0.80, SE: 0.19, $p < .0001$) when the cross-product term for the interaction of perceived stress and sex was included (data not shown). Both models provided evidence for sex modifying the relationship between perceived stress and either BMI or waist circumference (BMI [$\beta_{PSS \times Gender}$: 0.19, SE: 0.06]; WC [$\beta_{PSS \times Gender}$: 0.48, SE: 0.12]). As noted in Figures 1 and 2, as perceived stress increases, BMI and waist circumference decrease for both men and women but a steeper decrease was noted among men compared to women, therefore additional models were stratified by sex (Tables 2, 3).

Among men, for every unit increase in perceived stress, BMI decreases by 0.12 points (SE = 0.04) when adjusting for race/ethnicity, age, and level of education (Table 2). Holding height constant, a 0.12 point change in BMI is equivalent to a change in weight of 0.85 pounds. Conversely, perceived stress and BMI were not significantly associated in women (B: -0.001 SE: 0.05) when adjusting for race/ethnicity, age, and level of education. Neither of these results changed when adjusting for sleep duration and depressive symptomatology (Men [B: -0.11 SE: 0.05]; Women [B: -0.05 SE: 0.05]), or when additionally adjusting for physical activity and smoking (Men [B: -0.09 SE: 0.05]; Women [B: -0.03 SE: 0.05]). The 0.09 point change in BMI among men in the fully adjusted model is equivalent to a 0.60 pound change in weight, when holding height constant. Similarly, for every unit increase in perceived stress among men, waist circumference decreased 0.21 cm (SE = 0.10), when

adjusting for race/ethnicity, age, and education (Table 3). Again, this association was not significant among women ($B = 0.10$ SE = 0.05). Further adjusting for sleep duration and depressive symptoms did not change the results for waist circumference among men or women (Men [$B: -0.21$ SE: 0.10]; Women [$B: 0.001$ SE: 0.12]), however the association was no longer significant in men when further adjusting for physical activity and smoking ($B: -0.18$ SE: 0.10).

Discussion

In this nationally representative sample of young adults we note that perceived stress is associated with BMI and waist circumference among men, in that higher perceived stress levels were associated with lower BMI and lower waist circumference. However, we noted no statistically significant relation between perceived stress and BMI or waist circumference among women.

Evidence for a relation between perceived stress and BMI has been mixed. While some studies have noted no associations between perceived stress and adiposity (24, 25) other studies have noted a significant positive relation among both men and women (26, 27) and yet others have noted positive associations among women but not men (1, 28, 29). For example, in the Pitt County Study, African-American women who reported higher levels of perceived stress at baseline had higher percentage increases in BMI over a 13 year follow-up period compared to women at lower stress levels. Among Black men however, no associations between stress and BMI change were noted (30). It is also plausible that noted differences across studies could be reflective of age differences. Previous studies have noted a relation between stress and obesity to be 'stronger' among older women compared to younger women (30). However, most studies have focused on adult populations, and are thus unable to determine whether the relation between stress and BMI is modified by age. Our study differs in that we focus on a narrow age range of young adults; in this younger population, perceptions of stress may lead to different coping measures as well as different behavioral changes compared to older adults (31).

Longitudinal studies, examining the role of work stress, have noted that increases in BMI over time are associated with work stress only among people who are overweight or obese. Using data from the MIDUS study, Block and colleagues noted that among both men and women, work stress was associated with greater weight gain over time among participants with higher baseline body mass index (32). In the Whitehall II Study a bidirectional effect of work stress was noted only among men, in that work stress increased weight gain among those with a higher BMI, however among leaner men, work stress predicted weight loss over time (33). This is comparable to our findings where we note perceived stress to be associated with lower BMI and waist circumference among men only. We are limited however by the cross-sectional nature of our data and cannot examine changes in BMI and waist circumference over time. While stress has been shown to increase caloric intake and in particular intake of high fat and calorie dense foods, for some, stress causes a decrease in appetite resulting in potential weight loss (29, 33–35). Stress can suppress or alter appetite hormones; furthermore, in animal studies the stress-eating response is altered by the type of food available (36–38). Behavioral factors could thus explain the noted relation between

high levels of stress and lower BMI and lower waist circumference among men in the Add Health Study. In addition to suppressed eating, high levels of stress have been associated with increased smoking and alcohol use. In the Copenhagen City Heart Study, for example, perceived stress was associated with smoking and high alcohol use (28). In our analyses, we note that physical activity, smoking, alcohol use and short sleep duration explain the noted associations between perceived stress and waist circumference however they, did not attenuate the previously noted results for BMI.

While these analyses are conducted within a nationally representative sample of young adults, we acknowledge our measure of perceived stress was assessed at the same time as our measures of BMI and waist circumference, thus we cannot establish temporality. While we adjusted for behavioral factors such as physical activity, smoking, alcohol, and sleep duration, we have no information on diet, which was not assessed in this study and could partly explain the noted relations. Furthermore, some of the behavioral factors (i.e., physical activity) were assessed through self-report.

Conclusion

In this nationally representative sample of US adults we note an inverse relation between perceived stress and adiposity only among men. Future work should consider the potential for a relation between stress and adiposity that may be dependent on sex, age, stress levels or adiposity level. Longitudinal studies are also needed to understand how the relation between stress and adiposity changes over time and with age. Coping measures as well as behavioral mechanisms should be explored to determine their role as well as how they can be targeted for potential intervention efforts.

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Abbreviations

BMI	Body Mass Index
Add Health	National Longitudinal Study of Adolescent Health
PR	Prevalence Ratio
RR	Risk Ratio
CI	Confidence Interval

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- Perceived stress and adiposity were examined in a nationally representative sample
- Perceived stress is negatively associated with BMI and waist circumference in men
- No associations were noted among women

Figure 1. Perceived Stress and BMI among men and women in the Add Health Study (N=14,044), linear regression adjusted analyses

The relationship between perceived stress and BMI, modified by sex.

Figure 2. Perceived Stress and waist circumference among men and women in the Add Health Study (N=14,044), linear regression adjusted analyses

The relationship between perceived stress and waist circumference, modified by sex.

Table 1

Sample characteristics, Add Health Study (N=14,044)

	n (%)
Age mean (SE)	29.0 (0.03)
Gender	
Male	6,799 (52.3)
Female	7,245 (47.7)
Race	
white	7,470 (65.4)
black	3,061 (16.1)
hispanic	2,235 (12.1)
asian	895 (3.4)
other	383 (3)
Education	
< High School	1,095 (9.3)
High School	2,784 (21.6)
Some College	5,712 (39.5)
College	4,453 (29.7)
Physical Activity	
High	3,562 (28.6)
Low	10,842 (71.4)
Smoking	
Current	3,040 (21.6)
Former	3,088 (22)
Never	7,916 (56.4)
Sleep	
<= 6 hrs	1,386 (10)
7–8 hrs	7,659 (53.9)
>8 hrs	4,999 (36.2)
Depressive Symptoms	
High	2,262 (16.5)
Low	11,782 (83.5)
Perceived Stress mean (SE)	4.86 (0.05)

Depressive symptoms were dichotomized as a score greater than or equal to an 11 on the CES-D. High physical activity was categorized as 5 or more activities in a week.

Table 2

Linear regression analyses of perceived stress and BMI, stratified by sex, Add Health Study (N=14,044)

	BMI					
	Model 1		Model 2		Model 3	
	MEN	WOMEN	MEN	WOMEN	MEN	WOMEN
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Perceived Stress	-.12 (.04) *	-0.001 (.05)	-.11 (.05) *	-.05 (.05)	-.09 (.05) *	-.03 (.05)
Race/Ethnicity						
Black	.17 (.30)	3.51 (.36) *	.11 (.30)	3.46 (.36) *	-.14 (.28)	3.16 (.36) *
Hispanic	1.11 (.41) *	1.08 (.38) *	1.1 (.42) *	1.06 (.39) *	.78 (.4)	.77 (.4)
Asian	-.55 (.63)	-2.40 (.72) *	-.68 (.65)	-2.42 (.73) *	-.72 (.67)	-2.6 (.73) *
Other	.97 (.83)	-.02 (1.0)	.86 (.83)	-.02 (1.0)	.92 (.81)	-.04 (.97)
White	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Age	.15 (.07) *	.21 (.08) *	.14 (.07) *	.21 (.08) *	.11 (.07)	.20 (.08) *
Education						
Less than HS	1.02 (.39) *	2.31 (.5) *	1.04 (.40) *	2.32 (.49) *	1.68 (.42) *	2.72 (.51) *
High School	1.14 (.32) *	4.12 (.49) *	1.14 (.33) *	4.11 (.48) *	1.5 (.35) *	4.39 (.5) *
Some College	1.73 (.32) *	2.6 (.33) *	1.68 (.33) *	2.58 (.33) *	1.98 (.33) *	2.81 (.34) *
College	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Sleep Duration						
<= 6 hrs			1.5 (.42) *	1.76 (.50) *	1.66 (.41) *	1.86 (.50) *
7-8 hrs			.53 (.25) *	.64 (.30) *	.58 (.25) *	.7 (.3) *
>8 hrs			0 (ref)	0 (ref)	0 (ref)	0 (ref)
High Depression			-.26 (.40)	.54 (.39)	-.24 (.40)	.52 (.39)
Physical Activity					-.84 (.24) *	-.11 (.28)
Smoking Status						
Current					-1.91 (.33) *	-1.16 (.35) *
Former					-.55 (.31)	-.49 (.33)
Never					0 (ref)	0 (ref)

Depressive symptoms were dichotomized as a score greater than or equal to an 11 on the CES-D. Physical activity was characterized as 5 or more activities in a week relative to less than 5 activities in a week.

* Denotes that Beta coefficient is statistically significantly different than 0 at a 5% level of significance.

Table 3

Linear regression analyses of perceived stress and waist circumference, stratified by sex, Add Health Study (N=14,044)

	Waist Circumference					
	Model 1		Model 2		Model 3	
	MEN	WOMEN	MEN	WOMEN	MEN	WOMEN
	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)	B (SE)
Perceived Stress	-.21 (.09)*	.10 (.11)	-.21 (.10)*	0.001 (.12)	-.18 (.10)	.01 (.12)
Race/Ethnicity						
Black	-1.56 (.62)*	5.09 (.74)*	-1.59 (.61)*	5.0 (.73)*	-1.94 (.63)*	4.66 (.72)*
Hispanic	1.12 (.89)	-.12 (.94)	1.15 (.89)	-.16 (.94)	.73 (.87)	-.48 (.95)
Asian	-5.35 (1.31)*	-6.44 (1.63)*	-5.55 (1.32)*	-6.48 (1.63)*	-5.51 (1.38)*	-6.67 (1.65)*
Other	.78 (1.74)	-1.06 (2.48)	.67 (1.74)	-1.07 (2.48)	.78 (1.69)	-1.08 (2.45)
White	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Age	.37 (.15)*	.50 (.19)*	.34 (.15)*	.48 (.19)*	.27 (.15)	.47 (.19)*
Education						
Less than HS	3.25 (.93)*	7.26 (1.16)*	3.32 (.95)*	7.23 (1.15)*	4.13 (.98)*	7.56 (1.2)*
High School	2.89 (.75)*	10.36 (.99)*	2.95 (.77)*	10.31 (.97)*	3.36 (.8)*	10.51 (.98)*
Some College	3.63 (.64)*	6.45 (.72)*	3.59 (.65)*	6.4 (.73)*	3.95 (.67)*	6.58 (.74)*
College	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)	0 (ref)
Sleep Duration						
<= 6 hrs			2.06 (.89)*	2.94 (1.25)*	2.34 (.88)*	3.08 (1.23)*
7-8 hrs			1.36 (.60)*	.97 (.69)	1.48 (.6)*	1.05 (.68)
>8 hrs						
High Depression			-.04 (.94)	1.17 (.90)	-.03 (.93)	1.16 (.9)
Physical Activity					-3.02 (.55)*	-.72 (.6)
Smoking Status						
Current					-3.13 (.66)*	-1.17 (.71)
Former					-.59 (.72)	-.24 (.75)
Never					0 (ref)	0 (ref)

Depressive symptoms were dichotomized as a score greater than or equal to an 11 on the CES-D. Physical activity was characterized as 5 or more activities in a week relative to less than 5 activities in a week.

* Denotes that Beta coefficient is statistically significantly different than 0 at a 5% level of significance.