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Stress-Related Eating, Mindfulness, and Obesity

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Objective: This study explored how experiences of stress in adulthood, including the occurrence of stressful life events and psychosocial strains in various life domains, might be related to stress-related eating and indicators of obesity, including body mass index (BMI) and waist circumference. ***Method:*** Cross-sectional data were examined from 3,708 adults in the Midlife in the U.S. study (MIDUS II). ***Results:*** Hierarchical regression analyses indicated that experiences of stress were associated with higher BMI and waist circumference, even after controlling for age, annual household income, education level, race, and sex, although the additional variance accounted for was small. A nonparametric bootstrapping approach indicated that stress-related eating mediated the association between experiences of stress and indicators of obesity. Moderated-mediation analyses indicated that the relationship between experiences of stress and stress-related eating was amplified for women and individuals with obesity in comparison to men and individuals without obesity. Mindfulness did not moderate the experiences of stress and stress-related eating association. ***Conclusions:*** These results provide further evidence of the contributions of psychosocial factors to chronic disease risk.

Keywords: adults, eating, mindfulness, obesity, stress

Approximately 69% of adults in the United States over the age 20 are considered overweight, and 38% are considered obese (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016; Ogden, Carroll, Kit, & Flegal, 2014). Adults with obesity are at higher risk for developing many chronic diseases, including coronary heart disease, Type 2 diabetes, and certain cancers (Esser, Legrand-Poels, Piette, Scheen, & Paquot, 2014; Lavie, Milani, & Ventura, 2009; Wolin, Carson, & Colditz, 2010). *Stress*, defined as a state of emotional tension in response to a difficult experience that also results in expected physiological and behavioral changes (Baum, 1990), has been implicated in increased risk for obesity (Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011). Chronic stress, for instance, is a predictor of elevated body mass index (BMI) and waist circumference in men and women (Brunner, Chandola, & Marmot, 2007). High levels of stress also predict significant weight gain in female university students (Serlachius, Hamer, & Wardle, 2007), Black women (Fowler-Brown et al., 2009), as well as in men and women with already elevated BMIs (Block, He, Zaslavsky, Ding, & Ayanian, 2009). There is also evidence that stress-induced cortisol secretion contributes to abdominal adiposity (Anagnostis, Athyros, Tziomalos, Karagiannis, & Mikhailidis, 2009; Purnell et al., 2009). As such, elevated stress and its physiological consequences may compound the trajectory of excess weight gain, adiposity, and chronic disease risk many adults experience as they age (Hopman et al., 2009; Miller, Chen, & Parker, 2011).

Stress may influence obesity behaviorally through increased "stress-related eating," or the consumption of foods high in fat and sugar as a means of coping with distressful experiences (Adam & Epel, 2007). The use of food to cope with stress is in line with the escape model, which posits that some individuals use eating as a method of escaping emotional distress (Heatherton & Baumeister, 1991). Indeed, individuals who are more reactive to stress, as evidenced by higher levels of the glucocorticoid hormone cortisol, are more likely to engage in stress-related eating (Adam & Epel, 2007; Newman, O'Connor, & Conner, 2007). Moreover, using food in response to stress has been identified as a mediator between early stressful life experiences and adult BMI (Greenfield & Marks, 2009). The presence of daily hassles is also linked with increased consumption of foods that are higher in sugar and fat (O'Connor, Jones, Conner, McMillan, & Ferguson, 2008), as well as increased snacking (Newman et al., 2007). At present, there is a need to better understand whether stress-related eating actually mediates the association between stressful experiences and indicators of obesity. This knowledge would allow for further optimization of evidence-based treatments addressing obesity and weight management. Further research is also needed to examine whether individual factors, like sex and weight status, influence this relationship. For instance, extant data suggest patterns of eating in response to stress may be more common among women and individuals with overweight or obesity (Geliebter & Aversa, 2003; O'Connor et al., 2008; Sims et al., 2008).

Mindfulness is one psychological phenomenon that may mitigate both stress and the unhealthy eating habits that accompany

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some people's stressful experiences (Goldin & Gross, 2010; Katterman, Kleinman, Hood, Nackers, & Corsica, 2014). *Mindfulness* refers to the experience of paying attention to the present moment in a nonjudgmental manner (Kabat-Zinn, 2003). Mindfulness-based interventions teach individuals the skills to notice and experience difficult emotions, rather than engaging in impulsive behaviors (e.g., eating) as a means of reducing the intensity of their emotions (Brown & Ryan, 2003; Kabat-Zinn, 2003). Mindfulness-based strategies have been successfully incorporated into weight loss and weight management interventions (Forman, Butryn, Hoffman, & Herbert, 2009; Godsey, 2013; Katterman et al., 2014; O'Reilly, Cook, Spruijt-Metz, & Black, 2014), grounded in the understanding that mindfulness training enhances the ability to cope with negative emotions and one's awareness of decision-making processes and internal experiences (Forman & Butryn, 2015; Kristeller & Wolever, 2011). It is possible that mindfulness moderates the relationship between stressful experiences and eating in response to stress. More specifically, individuals higher (vs. lower) in mindfulness may report a weaker relationship between stressors and stress-related eating, due to a heightened ability to cope with stress effectively. Extant data indicate that mindfulness is associated with decreased stress (Goyal et al., 2014), as well as eating patterns that often accompany stress, such as binge and emotional eating (O'Reilly, Cook, Spruijt-Metz, & Black, 2014; Ouwens, Schiffer, Visser, Raeijmaekers, & Nyklíček, 2015; Pivarunas et al., 2015). However, these variables have not been studied together, and research is needed to examine whether the relationship between exposure to stressors and stress-related eating is mitigated by mindfulness.

The present study examined how stress in adulthood, including the occurrence of stressful life events and psychosocial strains in various life domains, might be related to stress-related eating and indicators of obesity, including BMI and waist circumference. For the present study, stress was categorized into two types: (1) stressful life events, which include events such as the loss of a job, the loss of a loved one, being the victim of assault, or military deployment and (2) psychosocial strains, which include daily stressors, such as disagreements with family members and difficulties paying monthly bills. It was hypothesized that stressful life events and psychosocial strains would be associated with higher BMI and waist circumference. It was also hypothesized that stress-related eating would mediate the relationship between stressful life events/psychosocial strains and BMI/waist circumference. It was also hypothesized that the mediating effect of stress-related eating on the relationship between stressful life events/psychosocial strains and BMI/waist circumference would be moderated by sex, weight status, and mindfulness, such that women, individuals with obesity, and individuals lower in mindfulness would exhibit a stronger association between stressful life events/psychosocial strains and stress-related eating than men, individuals without obesity, and those higher in mindfulness, respectively. Figure 1 provides a conceptual model of these proposed associations.

Method

Dataset

This study used data from the 2004–2006 National Survey of Midlife Development in the United States (MIDUS II; Ryff et al., 2007). Participants were selected via a nationally representative random-digit phone dialing of noninstitutionalized adults living in the continental United States. MIDUS II followed-up with all participants of the original MIDUS study (1995–1996; Brim, Ryff, & Kessler, 2004), with approximately 70% of the original sample participating in MIDUS II. Participants in MIDUS II completed both a phone interview and a paper-and-pencil survey that included questions regarding height and weight. For the purposes of this study, only participants who completed anthropometric information ($N = 3{,}708$), including height, weight, and waist circumference, were included given that these are the primary indicators of obesity examined. Institutional review board (IRB) approval was not required for the current study, as the MIDUS dataset is publicly available and de-identified. The MIDUS researchers received IRB approval from the University of Wisconsin–Madison, Education and Social/Behavioral Sciences and Health Sciences (Barry, 2014).

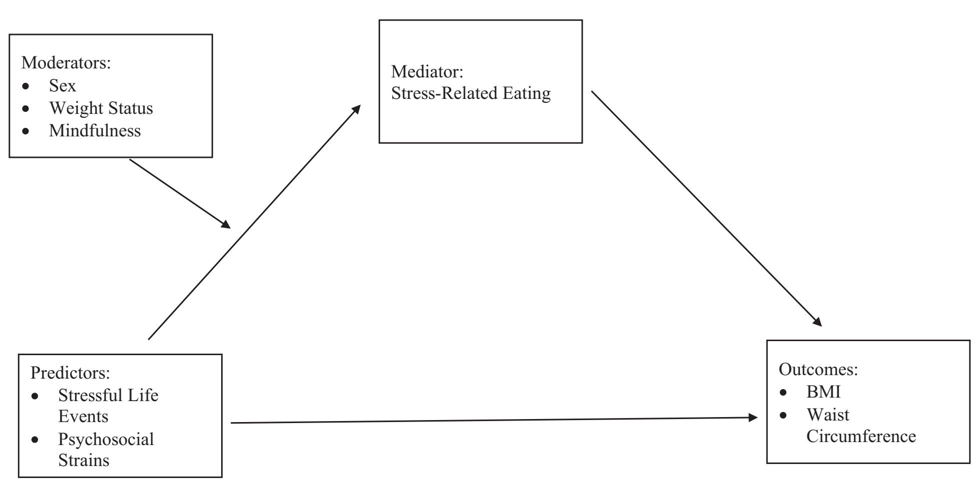

Figure 1. A conceptual model of the proposed relationships between study variables.

Measures

Demographics. Participants were asked to report their date of birth, highest level of education completed, sex, total household income, and race.

Stressful life events. A composite score for stressful life events was created based on the method used by Hostinar, Lachman, Mroczek, Seeman, and Miller (2015). MIDUS participants were asked to report whether they had experienced 20 possible stressful life events during adulthood (fired from a job, loss of a child, loss of a sibling, sexual assault, etc.) and, if yes, to record their age at the time the event occurred. If the event occurred within the last 5 years (by subtracting age at time of event from age at time of MIDUS II survey), it was included in the composite score total for the current study's analyses (M = .36 ± .66; range = 0–6). Hostinar and colleagues' research has linked this 5-year index to increased risk for inflammation in midlife, independent of adverse childhood experiences.

Psychosocial strain. A composite score for psychosocial strain was created using three independent measures of strain experienced in various life domains measured in the MIDUS II survey. These included family strain (four items; e.g., "How often do members of your family let you down when you are counting on them?"; Cronbach's α = .79); friend strain (four items; e.g., "How often do your friends make too many demands on you?"; Cronbach's αa = .79); and financial strain (one item; "How difficult is it for you and your family to pay your monthly bills?). Response options ranged from 1 (*a lot*) to 4 (*not at all*). All items were reverse coded so that a higher score was indicative of greater stress or strain in that particular area. The mean scores across each of the three areas were summed to create a composite score with a possible range of 3 to 12 (M = 5.81 ± 1.42; range = 3–11.5). Cronbach's alpha for the nine items in this sample was .81.

BMI. Participants were asked to report their height and weight. These measurements were used to calculate a BMI score for each participant. Participants were also categorized into weight classes according to the guidelines recommended by the National Heart, Lung, and Blood Institute. A BMI less than 18.5 was considered "underweight," a BMI between 18.5 and 25 was considered "normal weight," a BMI between 25 to 29.99 was considered "overweight," and a BMI of 30 or greater was considered "obese" (M = 27.87 ± 5.75; range = 14.23–82.31).

Waist circumference. Participants were provided a tape measure enclosed with the MIDUS survey, and were asked to measure their waist. Participants were instructed to take their measurement at the level of their naval, while standing, without clothing, and to record their circumference to the nearest quarter inch (M = 37.26 ± 5.86; range = 18–65).

Stress-related eating. MIDUS II participants were asked to respond to items related to their experiences of stress generally (i.e., "Please circle the number that best describes how you experience a stressful event"). Two of the items were as follows: (1) "I eat more than usual" and (2) "I eat more of my favorite foods to make myself feel better." Response options ranged from 1 (*a lot*) to 4 (*not at all*). A summed score (range = 2–8) was created from these two items because they were highly correlated (r = .90). Responses were reverse coded so that higher scores indicated greater use of food to cope with stress (M = 3.72 ± 1.85; range = 2–8).

Mindfulness. Mindfulness was assessed through a 9-item mindfulness subscale, which was part of a 37-item religiosity scale on the self-administered MIDUS II questionnaire. Each item began with the stem, "Because of your religion or spirituality, do you try to be. . .," and the response options were as follows: (a) more engaged in the present moment, (b) more sensitive to the feelings of others, (c) more receptive to new ideas, (d) a better listener, (e) a more patient person, (f) more aware of small changes in my environment, (g) more tolerant of differences, (h) more aware of different ways to solve problems, and (i) more likely to perceive things in new ways. Items were ranked on a 5-point Likert-type scale ranging from 1 (*strongly agree*) to 5 (*strongly disagree*). Items were reversed coded so that higher scores were indicative of greater mindfulness (M = 33.99 ± 6.16; range = 9–45). Cronbach's alpha for the nine items in this sample was .942.

Data Analysis Plan

Hierarchical multiple regression models, cross-tabulation, and Hayes' PROCESS macro were used to examine the hypotheses via IBM SPSS Statistics Version 25 (IBM Corp, 2017). Prior to analyses, variables were examined for skewness and kurtosis. A logarithmic transformation was used to correct skewness in BMI and a Box Cox transformation was used to correct skewness in stressful life events. Age, sex (male = 0, female = 1), race (White = 0, other race = 1), education level, and annual household income were included as covariates in all models, given their link to stress (Baum, Garofalo, & Yali, 1999; Cohen & Janicki-Deverts, 2012; Wang et al., 2007) and weight status (Berry et al., 2010; Molarius, Seidell, Sans, Tuomilehto, & Kuulasmaa, 2000; Ogden et al., 2014). Rates of missing data were minimal. All scales were missing less than 2% of responses, with the exception of household income which was missing 3.85% of responses. This low rate of missingness indicates that the data are unlikely to be biased (Bennett, 2001); therefore, analyses used listwise deletion, in which cases with missing responses on the scales of interest were excluded.

To determine whether stress-related eating differed by weight status and sex, we used analyses of covariance (ANCOVAs). BMI was recoded into a categorical variable based on whether participants' BMI classified them as obese, overweight, normal weight, or underweight. Age, income, education level, and race were entered as covariates for all models. For the model examining differences by sex, BMI was added as a covariate. For the model examining differences by weight status, sex was added as a covariate. To test the hypothesis that experiences with stress are associated with BMI and waist circumference, we ran hierarchical multiple regression models with the control variables of age, sex, race, education level, and household income entered in Step 1 and stressful life events and psychosocial stress entered together in Step 2.

To examine the potential mediating role of stress-related eating in the association between stressful life events/psychosocial strains and BMI/waist circumference, we used Preacher and Hayes' (2004) nonparametric bootstrapping approach for testing mediation. This approach is superior to the traditional approach recommended by Baron and Kenny (1986) because it allows for the examination of the indirect effect through confidence intervals and circumvents problems associated with nonnormality (Zhao, Lynch, & Chen, 2010). Because of this, the nontransformed BMI and stressful life events variables were used in the mediation models for ease of interpretation of coefficients in these analyses. Using the PROCESS SPSS macro, we conducted 5,000 bootstrap resamples testing the mediating role of stress-related eating in the association between stressful life events and BMI, stressful life events and waist circumference, psychosocial strains and BMI, and psychosocial strains and waist circumference. Mediation was determined by assessing whether the confidence intervals for the bootstrapped results contained 0. If the confidence intervals did not contain 0, the indirect effect (or mediation) is considered significant at the .05 level. The strength of each mediating effect was evaluated using the completely standardized indirect effect index (ab_{cs}), which is provided in the PROCESS output and recommended by Preacher and Kelley (2011). This measure provides the amount in standard deviations the dependent variable is expected to change for every one standard deviation increase in the independent variable indirectly through the mediator.

Moderated mediation analyses were conducted to examine the conditional indirect effects of stressful life events/psychosocial strains on BMI/waist circumference through stress-related eating at various levels of three potential moderators: sex, weight status, and mindfulness. Each moderator was examined separately using the PROCESS SPSS macro. Weight status was recoded into a binary variable (obese vs. not obese), given evidence that individuals with obesity are particularly prone to stress-related eating (O'Connor et al., 2008). Continuous independent variables were centered prior to analysis to reduce issues with multicollinearity, and heteroscedasticity-consistent standard errors were used. Age, income, education level, and race were entered as covariates for all models. For the models examining weight status and mindfulness as potential moderators, sex was added as a covariate. The PROCESS macro examines whether an interaction term (created for each moderator by multiplying the predictor and proposed moderator) is associated with a significant additional proportion of variance in stress-related eating beyond stressful life events/psychosocial strains and each proposed moderator separately, as determined by viewing the significance of the R^2 change. The macro also conducts a bias-corrected bootstrapping procedure with 5,000 samples and 95% confidence interval (Hayes, 2012), providing the conditional indirect effects of stressful life events/psychosocial strain on indicators of obesity through stress-related eating, at various levels of the moderators (i.e., two values of a dichotomous moderator and the mean plus/minus 1 standard deviation for continuous variables).

Results

Table 1 provides a summary of the sample characteristics. Participants ranged in age from 30 to 84 ($M = 56.18 \pm 12.29$), and just over half were women (54.4%). This sample was predominantly White (91.9%) and fairly educated (92.5% had at least a high diploma or GED, whereas 39% had a college degree). The average annual household income was $71,722.95 (±60,153.15). The average BMI was 27.87 kg/m^2 (±5.75), with 27.97% of the sample having obesity. A chi-square analysis, $\chi^2(3, 3708) = 154.85$, $p < .001$, indicated that women were more likely to be underweight or normal weight than men, whereas men were more likely to be overweight; there were no significant differences in rates of obesity. A one-way between-groups ANCOVA indicated that rates of stress-related eating differed by sex, $F(1, 3527) = 367.24$, $p < .01$, partial $\eta^2 = .09$, and weight status, $F(3, 3525) = 177.11$, $p < .01$, partial $\eta^2 = .13$. Specifically, women ($M = 4.14 \pm 1.99$) reported higher stress-related eating than men ($M = 3.22 \pm 1.54$); individuals with obesity ($M = 4.63 \pm 2.03$) reported higher stress-related eating than individuals who were overweight ($M = 3.56 \pm 1.75$), normal weight ($M = 3.14 \pm 1.51$), or underweight ($M = 2.73 \pm 1.38$); and individuals who were overweight reported significantly higher stress-related eating than individuals who were normal weight or underweight. Table 2 provides correlations between each of the variables included in the analyses.

After controlling for age, sex, race, education level, and household income, stressful life events and psychosocial strain (entered together in Step 2 of the model) were significantly associated with BMI ($R^2_{\text{change}} = .022$, $F_{\text{change}}(2, 3505) = 40.286$, $p < .001$). In a separate model, these indicators of stress were also significantly associated with waist circumference ($R^2_{\text{change}} = .018$, $F_{\text{change}}(2, 3505) = 36.975$, $p < .001$). Table 3 summarizes the regression results in further detail.

Using 95% confidence intervals, it was found that stress-related eating mediated the relationship between stressful life events and BMI [.089, .324]; stressful life events and waist circumference [.080, .283]; psychosocial strains and BMI [.265, .392]; and psychosocial strains and waist circumference [.227, .339]. Table 4

Table 1
Sample Characteristics

Characteristic	*N* (%)
Age (in years), *M* (*SD*)	56.18 (12.29)
Education level	
Graduate degree	585 (15.78)
4-year college/bachelor's degree	738 (19.90)
2-year college/associate's degree	288 (7.77)
1 to 3 years of college without degree	772 (20.82)
High school diploma	987 (26.62)
Less than high school	213 (5.74)
Sex: female	2019 (54.44)
Annual household income *M* (*SD*)	71722.95 (60153.15)
Race: White	3409 (91.94)
Weight status *N* (%), (% men, % women)	
Underweight	42 (1.1), (.3%, 1.8%)
Normal	1160 (31.38), (22.79%, 38.39%)
Overweight	1469 (39.62), (48.76%, 32.05%)
Obese	1037 (27.97), (28.24%, 27.74%)

Table 2
Correlations Between Study Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Age	—									
2. Education level	−.143**	—								
3. Sex (male reference group)	−.029	−.113**	—							
4. Household income	−.279**	.347**	−.121**	—						
5. Race (White reference group)	−.045**	−.043**	.018	−.051**	—					
6. Stressful life events	−.146**	.014	−.007	−.032	.014	—				
7. Psychosocial strains	−.259**	−.108**	.088**	−.158**	.101**	.163**	—			
8. Body mass index	−.015	−.115**	−.104**	−.054**	.070**	.077**	.147**	—		
9. Waist circumference	.089**	−.095**	−.336**	−.069**	.023	.055**	.091**	.805**	—	
10. Stress-related eating	−.095**	−.001	.247**	−.014	.007	.070**	.225**	.341**	.220**	—
11. Mindfulness	.093**	−.048**	.215**	−.130**	.063**	.013	.038*	−.013	−.075**	.059**

* $p < .05$. ** $p < .01$.

presents the tests of mediation for the associations between stressful life events/psychosocial strains and BMI/waist circumference using the bootstrapped approach recommended by Preacher and Hayes, along with the results of the traditional normal-theory Sobel test. All of the direct effects remained significant after the addition of the indirect effect ($ps \leq .01$), suggesting only partial mediation in each model.

Moderated mediation analysis provided, at the levels of each proposed moderator, the conditional indirect effects of stressful life events/psychosocial strains on BMI/waist circumference through stress-related eating. Analyses indicated that sex moderated the association between psychosocial strains and stress-related eating (B: Psychosocial Strains × Gender = .14, $p < .01$). The conditional indirect effects of psychosocial strains on BMI through stress-related eating were significant for both men and women (men: B = .20, *SE* = .04; 95% CI [.13, .27]; women: B = .34, *SE* = .04; 95% CI [.27, .42]), as were the conditional indirect effects of psychosocial strains on waist circumference for both men and women (men: B = .13, *SE* = .03; 95% CI [.09, .19]; women: B = .23, *SE* = .03; 95% CI [.17, .29]). On the basis of an evaluation of the coefficients, these associations were amplified among women relative to men. No conditional indirect effects were observed for stressful life events on BMI/waist circumference through stress-related eating by sex, as the significance value of the original interaction term was marginally above the cut-off ($p = .0501$).

Weight status also moderated the association between psychosocial strains and stressrelated eating (Psychosocial Strains × Weight Status B = .11, $p = .03$). The conditional indirect effects of psychosocial strains on BMI through stress-related eating were significant for

Table 3
Summary of Hierarchical Regression Analyses for Body Mass Index (BMI) and Waist Circumference

Variable	Model 1			Model 2		
	t	*p*	β	*t*	*p*	β
BMI						
Age	−1.73	.08	−.03	1.33	.18	.02
Education level	−6.36	<.01	−.11	−5.87	<.01	−.10
Sex	−6.36	<.01	−.12	−7.32	<.01	−.12
Household income	−1.92	.06	−.04	−.06	.95	.00
Race (White reference group)	4.07	<.01	.07	3.56	<.01	.06
Stressful life events				3.48	<.01	.06
Psychosocial strains				7.77	<.01	.14
R^2		.03			.02	
F for change in R^2		22.64**			40.29**	
Waist circumference						
Age	3.37	<.01	.06	6.07	<.01	.11
Education level	−5.90	<.01	−.10	−5.41	<.01	−.09
Sex	−22.18	<.01	−.35	−22.64	<.01	−.36
household income	−3.5	<.01	−.06	−1.69	.09	−.03
Race (White reference group)	2.01	.04	.03	1.49	.14	.02
Stressful life events				3.07	<.01	.05
Psychosocial strains				7.58	<.01	.13
R^2		.14			.02	
F for change in R^2		111.83**			36.98**	

** $p < .01$.

Table 4
Mediating Role of Stress-Related Eating on the Relationship Between the Independent Variables of Stressful Life Events and Psychosocial Strains and the Dependent Variables of BMI and Waist Circumference for the Total Sample

Independent variable	Dependent variable	Indirect effect	Bootstrapping (5,000 samples)					Normal theory test for indirect effect			
			Lower	Upper	ab_{cs}	Lower	Upper	Effect	*SE*	*Z*	*p*
Stressful life events	BMI	.206	.089	.324	.024	.010	.037	.206	.059	3.52	<.001
Psychosocial strains	BMI	.323	.265	.392	.074	.061	.089	.323	.032	10.20	<.001
Stressful life events	Waist circumference	.181	.080	.283	.022	.010	.034	.181	.052	3.51	<.001
Psychosocial strains	Waist circumference	.281	.227	.339	.068	.055	.082	.281	.028	10.07	<.001

Note. ab_{cs} = completely standardized indirect effect; BMI = body mass index. Variables controlled for include age, education level, sex, annual household income, and race/ethnicity.

individuals with and without obesity, (not obese: B = .21, *SE* = .03; 95% CI [.15, .26]; obese: B = .33, *SE* = .05; 95% CI [.23, .42]), as were the conditional indirect effects of psychosocial strains on waist circumference through stress-related eating for individuals with and without obesity (not obese: B = .19, *SE* = .03; 95% CI [.14, .24]; obese: B = .29, *SE* = .05; 95% CI [.21, .39]).

On the basis of a comparison of the coefficients, it was determined that the relationship between psychosocial strains and stress-related eating was amplified among those with (vs. without) obesity. No conditional indirect effects were observed for stressful life events on BMI/waist circumference through stress-related eating by weight status, as the significance value of the original interaction term was above the cut-off (p = .49). Mindfulness was not a significant moderator in any of the models examining stressful life events or psychosocial strains (*p*s = .31–.54).

Given the exacerbated associations for women and obesity with stress-related eating, we ran follow-up analyses examining the association between stressful life events/psychosocial strains and BMI/waist circumference through stress-related eating in only those with obesity, with gender as a potential moderator. It was determined that gender had no moderating effect for individuals who were obese (*p*s = .30–.73) in any of the models.

Discussion

Consistent with prior research (Block et al., 2009; Brunner et al., 2007; Korkeila, Kaprio, Rissanen, Koshenvuo, & Sörensen, 1998; Wardle et al., 2011), perceived stressful experiences, including the frequency of stressful events and psychosocial strain (e.g., familial and peer disagreements, recurrent financial concerns), were positively associated with BMI and waist circumference in a large sample of adult men and women. The magnitude of these associations was small, with stressful experiences accounting for approximately 2% of the variance in BMI and waist circumference. In an effort to identify potential behavioral pathways to explain these associations, stress-related eating was examined as a mediator. Indeed, stress-related eating, or the tendency to overeat and/or seek out palatable foods when stressed, partially explained the association between participants' perceptions of their stress and two separate indicators of obesity.

Stress-related eating episodes are generally characterized by increased total caloric intake, as well as the overconsumption of food items high in fat and sugar (Epel, Lapidus, McEwen, & Brownell, 2001; Oliver, Wardle, & Gibson, 2000; Zellner et al., 2006). Consumption of palatable food is, in turn, associated with increased sensitization of the reward networks in the brain (Volkow, Wang, Fowler, Tomasi, & Baler, 2011), rendering anticipated consumption of the same or similar foods as increasingly reinforcing. Acute and chronic stress also inhibit functioning of the prefrontal cortex (Arnsten, 2009), the part of the brain implicated in self-regulation of impulsive, rewarding behavior, such as overeating (Heatherton & Wagner, 2011). Essentially, in times of stress, palatable foods become both increasingly rewarding and particularly difficult to resist. From an energy balance perspective (Rosenbaum, Leibel, & Hirsch, 1997), recurrent instances of using food to cope with stress are likely to lead to excess increases in weight and adiposity.

In support of this potential energy balance explanation, data from the current study also indicated that the link between experiences of stress and stress-related eating was particularly strong among individuals with obesity. Importantly, these associations were only significant for perceived strain related to psychosocial sources, including family, friends and money, but not for the frequency of stressful life events. These findings were unexpected and may be the result of a combination of methodological and/or individual-level factors. Specifically, the measure of psychosocial strain is likely a better indicator of the perceived severity of stress across multiple domains relative to the stressful life events survey, which captures a tally of experiences generally considered stressful, but offers limited insight into their perceived severity according to the individual experiencing them. It may also be the case that psychosocial strain, relative to specific stressful events, are more closely linked to stress-related eating, particularly among adults with obesity. Indeed, in one study of adult men and women, work-related hassles, relative to other sources of stress (e.g., interpersonal, physical), were most predictive of between-meal snacking, and this association was especially robust among participants with obesity (O'Connor et al., 2008). Additional prospective and mechanistic studies are needed to determine whether different sources of stress, as well as the severity of these stressors, uniquely predict both a tendency to eat when stressed and excess weight gain, and whether these experiences differ by weight status or other individual factors.

For instance, although approximately 40% of adults report increased food consumption while stressed, the larger proportion of adults in the United States report no changes or reductions in total caloric consumption when stressed (Block et al., 2009; Pasquali, 2012; Torres & Nowson, 2007). According to data from both the current study and prior research (Grunberg & Straub, 1992; Laitinen, Ek, & Sovio, 2002), adults with obesity and women likely make up a larger percentage of those who turn to food in an effort to cope with perceived stressors. Women who generally work hard to monitor their food intake may be particularly susceptible to overeating when confronted with a stressor (Yeomans & Coughlan, 2009). Women who describe high (vs. low) stress levels also describe feeling hungrier and report more frequent disinhibited eating patterns, including binge eating, even after controlling for age, BMI, income and education (Groesz et al., 2012). As such, among women, perceived levels of stress may be related to elevated BMI and central adiposity not just through stress-related eating, but also a more diverse and pervasive pattern of overeating behaviors. Additional research is needed to determine whether individual variations in eating patterns linked to stress are differentially predictive of obesity-related health outcomes. Unfortunately, in the current study, assessments of hypophagia, or undereating, when stressed, were not available, but would certainly be important to consider in future investigations.

Importantly, although a tendency to eat in response to stress may offer one behavioral explanation for the association between experiences with stress and obesity-related body measurements, there are likely a multitude of other independent and/or co-occurring behavioral and physiological mechanisms at play. For instance, adults who report high levels of stress also frequently experience sleep difficulties, which are associated with obesity (Vgontzas et al., 2008). High (vs. low) levels of stress also predict the onset of physical inactivity in adult men and women (Rod, Grønbaek, Schnohr, Prescott, & Kristensen, 2009). A higher number of daily stressors is also associated with lower levels of postmeal energy expenditure during the subsequent day (Kiecolt-Glaser et al., 2015). Chronic stress is also associated with elevated cortisol reactivity; cortisol exposure, in turn, prompts increased accumulation of adiposity in the abdominal region (Scott, Melhorn, & Sakai, 2012). As such, future research should explore a wider range of behavioral, metabolic, and physiological responses to acute and chronic stress to elucidate the wide variety of potential mechanisms for obesity and central adiposity.

Unexpectedly, mindfulness did not moderate the link between experiences with stress and stress-related eating, as hypothesized. It would be expected that a tendency to practice mindfulness would mitigate the link between stress and eating in response to negative affect given its independent associations with perceived stress (Prakash, Hussain, & Schirda, 2015; Tamagawa et al., 2013), cortisol activity (Garland, Beck, Lipschitz, & Nakamura, 2015), and emotional eating patterns (Masuda, Price, & Latzman, 2012; Ouwens et al., 2015; Pivarunas et al., 2015). Dispositional mindfulness has also been shown to moderate the association between stressful life events in childhood and a range of health outcomes and behaviors (Whitaker et al., 2014) and between perceived stress and perceived health (Bränström, Duncan, & Moskowitz, 2011).

The current study's unexpected findings may be due to the nature of the survey used in the current study. The manner in which the survey items were worded linked mindfulness-based practices explicitly to one's religion or spirituality. Participants who do not identify with any specific religious organization or spiritual group may have not endorsed the items despite practicing mindfulness on a regular basis. The potential underendorsement of mindfulness experiences in the current sample may explain the unexpected null effects. Future research should attempt to replicate the current study's findings with a more general measure of trait mindfulness and should also consider assessing mindful eating practices specifically. It may be the case that a tendency to practice mindfulness while eating is uniquely protective of the effects of stress on eating and weight gain, but this hypothesis has yet to be evaluated with empirical data. However, interventions focused on increasing general and/or eating-specific mindful practices demonstrate promise in reducing stress-related eating patterns, like emotional and binge eating (Levoy, Lazaridou, Brewer, & Fulwiler, 2017), BMI (Godfrey, Gallo, & Afari, 2015; Katterman et al., 2014; Mason et al., 2016; O'Reilly et al., 2014), and perceptions of stress (Palmeira, Pinto-Gouveia, & Cunha, 2017; Ruffault et al., 2017). Additional research is needed to clarify the independent and overlapping roles of trait mindfulness and mindful eating practices in risk for obesity and obesity-related eating patterns. Clarifying the nature of these associations may offer unique intervention points for individuals presenting with different patterns of risk factors.

The current study offers some clarity regarding one behavioral pathway—stress-related eating—explaining the association between perceived stress and obesity-related health variables. Interventions which successfully replace stress-related eating with more adaptive coping strategies may prevent excess weight gain in adulthood, particularly among adults with obesity and women. However, when considering the potential clinical implications of the current study, it is necessary to consider factors that may limit the generalizability of the findings. First, data from the current study are cross-sectional and, as a result, the temporal associations among the study's variables are unknown. For instance, although stress-related eating may prompt excess weight gain, it may also be the case that the psychosocial strain associated with being obese, an overtly stigmatized condition (Tomiyama, 2014), may prompt stress-related eating habits associated with further weight gain and distress. To best inform the development of effective prevention and intervention efforts, prospective data are needed to clarify the nature of the development of these experiences. Additionally, considering the bias associated with self-reported BMI, particularly among those with overweight/obesity (Elgar & Stewart, 2008), future research should include objective measures of both body mass and adiposity. Broader assessments of experiences with stress and stress-related eating are also needed as the current study was limited in its assessment of these constructs. For instance, the measure of psychosocial strain only includes a few items assessing specific domains of distress and the duration of these stressful experiences are unclear. Moreover, a number of other overeating behaviors are closely linked to both stress and obesity risk (Tanofsky-Kraff et al., 2009, 2011). More diverse, well-validated measures of stress and stress-related eating, including surveys and interviews, would strengthen the validity of the current study's conclusions.

Finally, the current study's sample was comprised primarily of older, white non-Hispanic men and women with relatively high levels of education and financial resources. Limited financial means, lower levels of education, and racial/ethnic minority identity are closely linked to both experiences of stress (Lantz, House, Mero, & Williams, 2005) and obesity risk (Robert & Reither, 2004). As such, a sample including individuals with more diverse sociocultural identities and experiences may demonstrate unique patterns as they relate to perceived stress, stress-related eating, and obesity. For these reasons, results from the current study should not be generalized to younger, more diverse samples of men and women. Nonetheless, the current study may have implications for women who are demographically similar to those in the current study. Data from both the current and previous studies (Tryon, DeCant, & Laugero, 2013) suggest that the link between stress and overeating patterns may be particularly salient to women above the age of 50. Given the elevated risk for obesity-related chronic disease and inactivity that accompany aging (Centers for Disease Control and Prevention, 2005; Hopman et al., 2009), interventions focused on older women's experience of stress and stress-related eating may offer particularly robust benefits on this population's health and well-being.

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