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Exposure to violence in childhood is associated with higher body mass index in adolescence

Holly C. Gooding[a,b,*], Carly Milliren[c], S. Bryn Austin[a,b,d], Margaret A. Sheridan[b,e], Katie A. McLaughlin[f]

[a] Division of Adolescent and Young Adult Medicine, Boston Children's Hospital, USA
[b] Department of Pediatrics, Harvard Medical School, USA
[c] Clinical Research Center, Boston Children's Hospital, USA
[d] Department of Social and Behavioral Sciences, Harvard School of Public Health, USA
[e] Division of Developmental Medicine, Boston Children's Hospital, USA
[f] Department of Psychology, University of Washington, USA

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ABSTRACT

To determine whether different types of childhood adversity are associated with body mass index (BMI) in adolescence, we studied 147 adolescents aged 13–17 years, 41% of whom reported exposure to at least one adversity (maltreatment, abuse, peer victimization, or witness to community or domestic violence). We examined associations between adversity type and age- and sex-specific BMI *z*-scores using linear regression and overweight and obese status using logistic regression. We adjusted for potential socio-demographic, behavioral, and psychological confounders and tested for effect modification by gender. Adolescents with a history of sexual abuse, emotional abuse, or peer victimization did not have significantly different BMI *z*-scores than those without exposure ($p > 0.05$ for all comparisons). BMI *z*-scores were higher in adolescents who had experienced physical abuse ($\beta = 0.50$, 95% CI 0.12–0.91) or witnessed domestic violence ($\beta = 0.85$, 95% CI 0.30–1.40). Participants who witnessed domestic violence had almost 6 times the odds of being overweight or obese (95% CI: 1.09–30.7), even after adjustment for potential confounders. No gender-by-adversity interactions were found. Exposure to violence in childhood is associated with higher adolescent BMI. This finding highlights the importance of screening for violence in pediatric practice and providing obesity prevention counseling for youth.

Introduction

Adverse childhood experiences, including exposure to interpersonal violence, have been associated with obesity in children (Whitaker, Phillips, Orzol, & Burdette, 2007), adolescents (Burke, Hellman, Scott, Weems, & Carrion, 2011; Jun et al., 2012; Shin & Miller, 2012), and adults (Bentley & Widom, 2009; Boynton-Jarrett, Rosenberg, Palmer, Boggs, & Wise, 2012; Midei & Matthews, 2011; Thomas, Hypponen, & Power, 2008; Vamosi, Heitmann, & Kyvik, 2009). While there has been an increasing awareness of the impact of childhood adversity generally on adult health and chronic disease (Gilbert et al., 2015), important questions remain about the types of adversity associated with health outcomes, including obesity, and the

* Corresponding author at: Division of Adolescent and Young Adult Medicine, Boston Children's Hospital, 300 Longwood Avenue, Boston, MA 02115, USA.

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varying effects across the life course and by gender. In this study we report relationships between six types of childhood adversity and weight composition in adolescents participating in a study of the effects of child maltreatment and examine for differential associations in boys and girls.

Mechanisms linking early life adversity to later life obesity are complex and are an active area of investigation (Vamosi et al., 2009). Existing conceptual frameworks explaining the lasting impact of childhood adversity on health outcomes posit that exposure to adverse and stressful environments early in development leads to lasting alterations in systems that regulate responses to the environment, including the autonomic nervous system (ANS), the hypothalamic-pituitary-adrenal (HPA) axis, the immune system, and the metabolic system (Gunnar & Quevedo, 2007; Lupien, McEwen, Gunnar, & Heim, 2009; Miller, Chen, & Parker, 2011; Shonkoff & Garner, 2012). Indeed, exposure to childhood adversity has been associated with changes in the regulation of the ANS and HPA axis and hormones involved in energy metabolism in numerous studies (Danese et al., 2014; Heim et al., 2000; Joung et al., 2014; Taylor, 2010), each of which play a role in the regulation of appetite and metabolism. Changes in these neurobiological systems might lead individuals to experience intense emotional responses to future stressors (Glaser, van Os, Portegijs, & Myin-Germeys, 2006; McLaughlin, Conron, Koenen, & Gilman, 2010; Wichers et al., 2009), which may in turn increase risk for internalizing problems (McLaughlin et al., 2010; Moylan et al., 2010) such as anxiety and depression. In order to cope with these repeated negative emotions, individuals with a history of childhood adversity may engage in emotional eating or binge eating of high-calorie foods (Dallman et al., 2003; Greenfield & Marks, 2009; Nguyen-Rodriguez, Chou, Unger, & Spruijt-Metz, 2008). Dysregulation of these systems may also lead directly to obesity via changes in body composition, including the tendency to store visceral fat (Midei & Matthews, 2011). Other behavioral factors associated with childhood adversity, including physical inactivity, generally poor dietary habits, and tobacco use (Bellis, Hughes, Leckenby, Perkins, & Lowey, 2014; Halonen et al., 2014; Kestila et al., 2006), may also be part of the maladaptive response to repeated stress or may simply be more common in environments with high adversity exposure, and thus may either contribute to or confound the relationship between childhood adversity and weight.

Adolescence is a particularly vulnerable time for the confluence of adverse childhood experiences, dysregulation in the stress response, and weight accumulation. Increased physiologic reactivity to psychosocial stressors – in both the ANS and HPA axis – occurs during adolescence (Gunnar & Quevedo, 2007; Stroud et al., 2009). There are rapid changes in growth and development occurring simultaneously with socially influenced behavior patterns that favor weight gain, including decreased physical activity (Allison, Adlaf, Dwyer, Lysy, & Irving, 2007) and increased consumption of high-calorie foods, including sugar-sweetened beverages (Berkey, Rockett, Field, Gillman, & Colditz, 2004; Taveras et al., 2005). One retrospective study of adults found that the transition from adolescence to young adulthood was a particularly sensitive time for increased weight gain in women exposed to childhood abuse (Noll, Zeller, Trickett, & Putnam, 2007).

Clarification of the types of childhood adversity most strongly associated with a higher body mass index (BMI) in adolescence is important for the design of prevention programs aimed at mitigating the effects of childhood adversity on adult obesity and chronic disease. Therefore the purpose of the current study was to investigate associations between six types of childhood adversities, including multiple forms of interpersonal violence and victimization, and BMI in adolescence. As some studies have found a stronger association between childhood adversity and obesity in women compared to men (Mamun et al., 2007), we also aimed to assess whether any associations differed by gender. We hypothesized that adolescents with a history of interpersonal violence, including sexual abuse, physical abuse, and domestic violence, would have higher BMI *z*-scores compared to adolescents without a history of interpersonal violence or those exposed only to community violence or peer victimization due to heightened perception of individual threat. We also hypothesized that these associations would be stronger in adolescent girls compared to adolescent boys based on findings from the adult literature (Mamun et al., 2007). We assessed for a number of potential confounders of any relationship between these childhood adversities and BMI, including sociodemographic factors, dietary factors (fast food and sugar sweetened beverage consumption), physical activity, smoking, and internalizing problems.

Methods

Study Population

A community-based sample of 168 adolescents aged 13–17 years was recruited from schools, after-school programs, medical clinics, and the general community in Boston and Cambridge, MA in 2010–2011. Participants were recruited for a parent study of stress reactivity after childhood maltreatment (McLaughlin, Sheridan, Alves, & Mendes, 2014). We purposefully targeted recruitment from neighborhoods with a high prevalence of violence and from clinics serving a predominantly low income area in order to identify a sample in which approximately half of participants had exposure to childhood adversity. Therefore the sample is not representative of the local population. Participants were told this was a study of emotional experiences, emotions, and health and were reimbursed $50 for their participation. No participant was currently experiencing maltreatment, and the proper authorities were contacted in cases where there were safety concerns. Informed consent was obtained from the parent/guardian who attended the session, and assent was provided by adolescents. This study was approved by the Boston Children's Hospital Office of Clinical Investigation. We report data on the 147 participants with self-reported height and weight and complete data on all demographic covariates and potential confounders.

Childhood Adversity Variables

Physical, *sexual*, and *emotional abuse* were assessed using a self-report questionnaire and an interview. First, we administered the Childhood Trauma Questionnaire (CTQ) (Bernstein, Ahluvalia, Pogge, & Handelsman, 1997). The CTQ is a 28-item scale that assesses the frequency of maltreatment exposure during childhood and adolescence, including physical, sexual, and emotional abuse and physical and emotional neglect. The CTQ has excellent psychometric properties including internal consistency, test-retest reliability, and convergent and discriminant validity with interviews and clinician reports of maltreatment (Bernstein et al., 1997; Bernstein, Fink, Hondelsman, Foote, & Lovejoy, 1994). Second, we administered the Childhood Experiences of Care and Abuse (CECA) interview (Bifulco, Brown, & Harris, 1994; Bifulco, Brown, Lillie, & Jarvis, 1997). The CECA assesses multiple aspects of caregiving experiences, including abuse and neglect. Inter-rater reliability for maltreatment reports is excellent, and multiple validation studies suggest high agreement between siblings on reports of caregiver behaviors and maltreatment (Bifulco et al., 1994, 1997). We used the CECA and the CTQ to create dichotomous indicators of exposure to physical abuse, sexual abuse, and emotional abuse based on previously identified thresholds (Walker et al., 1999). Finally, we used these dichotomous variables to create an overall indicator of exposure to *any* abuse (physical, sexual, or emotional), and we created an abuse severity score by summing items from each of the three CTQ abuse subscales. This composite score ranged from 15 to 52, with higher scores indicating greater abuse severity. The abuse composite score demonstrated good reliability in our sample ($\alpha = 0.88$).

Domestic Violence Exposure was coded as present if the participant reported on the CECA ever witnessing "parents or caregivers hit each other repeatedly with something (like a belt or stick) or hit, punch, kick, or burn each other" or witnessing another adult do any one of these things to the parent or caregiver.

Community Violence Exposure was assessed using the Screen for Adolescent Violence Exposure (SAVE) (Hastings & Kelley, 1997). The SAVE is a 32-item measure assessing violence exposure in school, home, and neighborhood contexts. Only items assessing school and neighborhood violence were considered to avoid overlap with the CTQ with regard to experiences of child abuse. Respondents rate the frequency of exposure to indirect violence (e.g., "I have heard about someone getting shot") as well as being the victim of violence (e.g., "Someone has pulled a knife on me") on a 5-point Likert scale ranging from 1 (never) to 5 (almost always). The SAVE has demonstrated good reliability and validity in prior studies of adolescents (Hastings & Kelley, 1997). The SAVE total violence exposure scale ranged from 32 to 92, with higher scores indicating higher violence exposure. The total violence exposure scale demonstrated excellent internal consistency in this sample ($\alpha = 0.89$).

Peer Victimization experiences were assessed using The Revised Peer Experiences Questionnaire (RPEQ) (Prinstein, Boergers, & Vernberg, 2001). The RPEQ was developed from the Peer Experiences Questionnaire (Vernberg, Jacobs, & Hershberger, 1999) and assesses overt, relational, and reputational victimization by peers. The questionnaire includes 18 items that ask participants to rate how often an aggressive behavior was directed toward them in the past year on a 5-point Likert scale ranging from never (1) to a few times a week (5). Example items include: "A kid threatened to hurt or beat me up" (overt); "To get back at me, another kid told me that he or she would not be my friend"(relational); and "A kid gossiped about me so that others would not like me" (reputational). The original and revised measure has demonstrated good test-retest reliability, internal consistency, and convergent validity (Prinstein et al., 2001; Vernberg, Fonagy, & Twemlow, 2000). We created a total victimization score by summing all victimization items. The RPEQ total victimization scale ranged from 0 to 33, with higher scores indicating higher exposure. The total victimization scale demonstrated good internal consistency in this sample ($\alpha = 0.87$).

Body Mass Index

Participants were asked to self-report their height in inches and weight in pounds. The BMI for each participant was calculated as [(weight in pounds/(height in inches $\times$ height in inches)) $\times$ 703]. Age- and sex-specific BMI *z*-scores were created using Centers for Disease Control standard growth charts (Kuczmarski et al., 2002). BMI *z*-score was used as the primary outcome to account for the expected changes in growth and development for adolescents ages 13–17 years. Participants were considered overweight if their BMI was $\geq$85th% but <95th%, and obese if their BMI was $\geq$95th% for age and sex.

Covariates and Potential Confounders

Participants self-reported their race and whether they were of Hispanic/Latino origin. Parents self-reported the highest parental education achieved by the primary caregiver/guardian and partner. Participants were asked "Are you a current smoker, ex-smoker, or have you ever smoked?" and were designated smokers if they reported any current smoking. Being physically active was recorded as reporting vigorous physical exercise that lasts for 15 min or longer at least once a week or more or light or moderate physical exercise for 30 min or more at least several times a week. Participants were coded to be frequent consumers of fast food if they reported eating meals from a fast food restaurant several times a week or more and frequent consumers of sugar sweetened beverages (SSBs) if they reported drinking soda several times a week or more. Internalizing behaviors were assessed using the Youth Self Report form of the Child Behavior Checklist (CBCL) (Achenbach, 1991; Achenbach & Rescorla, 2001), which uses extensive normative data to generate age-standardized estimates of the severity of internalizing problems including anxiety/depression, withdrawal, and somatic complaints.

Statistical Analysis

We used chi-square and *t*-tests to assess for differences in adversity exposures by gender and for associations between the adversity exposures and each of the covariates and potential confounders. We used multivariate linear regression to test for associations between each adversity exposure separately and BMI *z*-score and created interaction terms to assess for each potential gender-by-adversity interaction. Additionally, we tested for associations between each adversity exposure and overweight or obesity status using multivariate logistic regression. We present unadjusted findings (Model 1) followed by models adjusted for sociodemographic characteristics (race/ethnicity and parental education, Model 2) and for potential confounders (physical activity, SSB consumption, smoking, and internalizing behaviors, Model 3). All analyses were conducted in STATA version 13 (College Station, TX).

Results

The mean age of participants was 14.9 years (*SD* = 1.3) and 58% (*n* = 86) were female. All females were post-menarchal. Additional sociodemographic, behavioral, and psychological characteristics of the sample, stratified by gender, are found in Table 1. Mean BMI was 22.3 kg/m^2 (*SD* = 5.0) and mean BMI *z*-score was 0.44 (*SD* = 0.95, range −2.97 to +3.13). Mean BMI *z*-scores were not significantly different between males (0.41, *SD* 1.10) and females (0.46, *SD* 0.83; $p = 0.75$). Eleven percent of participants were overweight and an additional 10% were obese. A total of 26% of males were overweight or obese compared to 17% of females; however, there was no statistically significant difference in overweight/obesity prevalence by gender ($p = 0.20$).

Table 2 depicts differences in exposure to the 6 childhood adversities, as well as the composite abuse variable and abuse severity scores, for males and females. Emotional abuse was the most common type of abuse history reported by teens of both genders, followed by physical abuse and then sexual abuse. Forty-five percent (*n* = 39) of females reported a history of some type of physical, emotional, or sexual abuse, compared to 31% (*n* = 19) of males ($p = 0.08$). Differences between boys and girls in the prevalence of specific abuse types or in scores on the total abuse, community violence, or peer victimization scales did not reach statistical significance, although females reported higher prevalence for most types of adversity.

In analysis unadjusted for demographic factors, higher fast food consumption was associated with physical abuse and community violence exposure. Current smoking was associated with emotional abuse, sexual abuse, community violence and peer victimization. Internalizing behaviors were associated with emotional abuse, sexual abuse, community violence, domestic violence, and peer victimization. However, none of these potential confounders was associated with BMI *z*-score.

Table 1
Characteristics of adolescents ages 13–17 years in the Developmental Origins of Health Disparities Study (*n* = 147).

	Males (*n* = 61)		Females (*n* = 86)	
	Mean	(SD)	Mean	(SD)
Age, years	15.1	(1.4)	14.8	(1.3)
BMI *z*-score	0.41	(1.1)	0.46	(0.83)
Internalizing behaviors (CBCL score)	52.6	(9.9)	53.6	(9.9)

	Males (*n* = 61)		Females (*n* = 86)	
	n	%	*n*	%
Race/ethnicity				
White	30	49	33	38
Black	10	16	16	19
Latino	10	16	15	17
Other	11	18	22	26
Parental education				
Less than High School	31	51	32	37
High school	11	18	11	13
Some college	9	15	18	21
College graduate	9	15	20	23
Refused/Don't Know	1	2	5	6
Smoker	18	30	16	19
Physically active	46	75	71	83
Frequent fast food consumption	11	18	13	15
Frequent sugar sweetened beverage consumption	31	51	30	35
BMI category				
Healthy weight	45	74	71	83
Overweight	9	15	7	8
Obese	7	11	8	9

There were no significant differences between males and females ($p > 0.05$ for all comparisons using chi-square and *t*-tests).

Table 2
Distribution of childhood adversity by gender in a sample of adolescents ages 13–17 years ($n = 147$).

	Males ($n = 61$)		Females ($n = 86$)		p-Value
	n	%	n	%	
Childhood adversity history					
Physical abuse	10	16	16	19	0.73
Emotional abuse	15	25	29	34	0.23
Sexual abuse	5	8	12	14	0.28
Any abuse	19	31	39	45	0.08
Domestic violence	4	7	8	9	0.55
	Males ($n = 61$)		Females ($n = 86$)		p-Value
	Mean	(SD)	Mean	(SD)	
Abuse severity score	18.7	(6.6)	20.3	(7.1)	0.16
Community violence	51.4	(14.6)	49.7	(10.0)	0.39
Peer victimization	8.5	(7.4)	8.2	(6.8)	0.78

p-Values are from chi-square and t-tests of differences in adversity exposure by gender.

Table 3
Associations between childhood adversity and body mass index z-score in a sample of adolescents ages 13–17 years ($n = 147$).

Childhood adversity	Model 1			Model 2[b]			Model 3[c]		
	β	(95% CI)	p-Value	β	(95% CI)	p-Value	β	(95% CI)	p-Value
Categorical									
Physical abuse[a]	**0.52**	**(0.12, 0.91)**	**0.01**	0.26	(−0.17, 0.70)	0.23	0.29	(−0.14, 0.72)	0.19
Emotional abuse[a]	0.16	(−0.18, 0.49)	0.36	0.10	(−0.23, 0.44)	0.55	0.07	(−0.29, 0.42)	0.72
Sexual abuse[a]	0.36	(−0.12, 0.84)	0.14	0.26	(−0.22, 0.74)	0.29	0.29	(−0.22, 0.80)	0.27
Any abuse[a]	0.20	(−0.12, 0.51)	0.22	0.09	(−0.23, 0.42)	0.56	0.11	(−0.23, 0.45)	0.52
Domestic violence[a]	**0.85**	**(0.30, 1.40)**	**<0.01**	**0.72**	**(0.16, 1.28)**	**0.01**	**0.75**	**(0.17, 1.32)**	**0.01**
Continuous									
Abuse severity score	0.018	(−0.004, 0.04)	0.11	0.008	(−0.01, 0.03)	0.48	0.009	(−0.02, 0.03)	0.48
Community violence	0.012	(−0.001, 0.02)	0.07	0.003	(−0.01, 0.02)	0.62	0.007	(−0.01, 0.02)	0.36
Peer victimization	0.014	(−0.01, 0.04)	0.21	0.010	(−0.01, 0.03)	0.34	0.014	(−0.01, 0.04)	0.26

β = change per one unit in BMI z-score. 95% CI = 95% confidence interval.
[a] Referent group is non-exposed to each individual adversity. Differences significant at $p < 0.05$ are in bold.
[b] Adjusted for race/ethnicity, parental education.
[c] Adjusted for race/ethnicity, parental education, smoking status, fast food consumption, sugar sweetened beverage consumption, physical activity, and internalizing behavior.

Not being physically active was associated with mean higher BMI z-score, although physical activity was not associated with any of the adversity variables.

Participants who had witnessed domestic violence or experienced physical abuse had significantly higher BMI z-scores compared to those who had not, and the relationship between community violence exposure and BMI z-scores was marginally significant (Table 3). The associations between community violence and physical abuse history were attenuated after adjustment for race/ethnicity and parental education. However, participants who had witnessed DV had higher BMI z-scores compared to those had not even after adjustment for demographic variables and potential confounders ($\beta = 0.75$, 95% CI: 0.17–1.32, $p = 0.011$). The mean BMI percentile for those exposed to domestic violence was 81.1 (range 37.4–99.9), compared to 61.3 (range 0.15–98.9) for those not exposed to domestic violence. Formal testing for gender by adversity interactions did not reveal any statistical differential association between any childhood adversity and BMI z-score in boys and girls.

Participants who had witnessed domestic violence or experienced emotional abuse were more likely to be overweight or obese compared to those who had not experienced these adversities and the relationship between community violence exposure and weight status was marginally significant (Table 4). The associations between community violence and emotional abuse history were attenuated after adjustment for race/ethnicity and parental education. Participants who witnessed DV had 5.78 times the odds of being overweight or obese (95% CI: 1.09–30.7) even after adjustment for demographics and potential confounders.

Discussion

In a community-based sample of adolescents purposely sampled for a high prevalence of exposure to a number of childhood adversities, exposure to domestic violence was associated with a significantly higher BMI z-score and odds of overweight and obesity in adolescence. Other forms of violence exposure, including physical abuse and community violence,

Table 4
Associations between childhood adversity and overweight/obesity status in a sample of adolescents ages 13–17 years ($n = 147$).

Childhood adversity	Model 1			Model 2[b]			Model 3[c]		
	OR	(95% CI)	*p*-Value	OR	(95% CI)	*p*-Value	OR	(95% CI)	*p*-Value
Categorical									
Physical abuse[a]	2.38	(0.94, 6.04)	0.07	1.39	(0.46, 4.20)	0.56	1.51	(0.49, 4.67)	0.48
Emotional abuse[a]	**2.36**	**(1.04, 5.36)**	**0.04**	2.33	(0.93, 5.82)	0.07	2.08	(0.76, 5.73)	0.16
Sexual abuse[a]	1.67	(0.54, 5.15)	0.38	1.36	(0.38, 4.89)	0.63	1.00	(0.24, 4.19)	0.99
Any abuse[a]	2.22	(0.99, 4.96)	0.05	2.03	(0.82, 5.04)	0.13	2.03	(0.75, 5.49)	0.16
Domestic violence[a]	**4.40**	**(1.31, 14.8)**	**0.017**	**5.15**	**(1.15, 23.1)**	**0.03**	**5.78**	**(1.09, 30.7)**	**0.04**
Continuous									
Abuse severity score	1.03	(0.98, 1.08)	0.29	1.01	(0.95, 1.07)	0.86	0.99	(0.93, 1.06)	0.80
Community violence	**1.03**	**(1.00, 1.07)**	**0.047**	1.02	(0.98, 1.06)	0.32	1.02	(0.98, 1.06)	0.31
Peer victimization	1.04	(0.98, 1.09)	0.18	1.04	(0.98, 1.11)	0.19	1.04	(0.97, 1.12)	0.26

β = change per one unit in BMI *z*-score. 95% CI = 95% confidence interval.
[a] Referent group is non-exposed to each individual adversity. Differences significant at $p < 0.05$ are in bold.
[b] Adjusted for race/ethnicity, parental education.
[c] Adjusted for race/ethnicity, parental education, smoking status, fast food consumption, sugar sweetened beverage consumption, physical activity, and internalizing behavior.

were marginally associated with BMI, as was emotional abuse. The associations between physical abuse, community violence exposure, emotional abuse and BMI or weight status were partly explained by race/ethnicity and parental education; the association between DV and BMI persisted after controlling for these demographic variables and potential confounders known to be associated with both childhood adversity and BMI. The BMI *z*-score of youth exposed to DV was 0.7 points higher than those not exposed. This corresponds to approximately a 20 unit difference in BMI percentiles, and youth exposed to DV were almost 6 times more likely than those without DV exposure to be overweight or obese. Although our study was cross-sectional, persistently increased BMI *z*-scores in those exposed to DV in childhood could lead to significant morbidity from being overweight and obese in adulthood.

There are several possible mechanisms for our findings linking violence exposure and weight. Children exposed to DV are at heightened risk for negative affect and internalizing disorders (McLaughlin et al., 2012; Moylan et al., 2010), which may contribute to binge eating and other disordered eating behaviors (Midei & Matthews, 2011). This association could be the result of dysregulation in physiological systems that regulate responses to environmental stress, such as the ANS or HPA axis (Gunnar & Quevedo, 2007; Lupien et al., 2009) or increased emotional reactivity (Glaser et al., 2006; McLaughlin et al., 2010; Wichers et al., 2009) that contributes to maladaptive behavioral patterns, including poor dietary choices (Dallman et al., 2003). Although internalizing problems were significantly associated with most of child maltreatment variables in our study including DV, they were not associated with BMI *z*-score and did not appear to alter the relationship between DV and BMI. However, we did not assess specifically for disordered eating behaviors. Alternatively, DV is highly correlated with food insecurity (Chilton, Rabinowich, & Woolf, 2014; Hernandez, Marshall, & Mineo, 2013), which itself is correlated with obesity in children (Casey et al., 2006) and adults (Gooding, Walls, & Richmond, 2012). The attenuation of our findings linking physical abuse and community violence exposure to BMI after adjustment for parental education, a marker of socioeconomic status, may indeed reflect the food insecurity pathway. Additional factors, such as poor family relationships and alterations in stress hormones, are also likely to play a role in the relationship between DV and BMI. Further study of food availability, food choices, and eating behaviors in children exposed to violence are potential avenues for further research.

Contrary to our hypotheses, we did not find a relationship between other forms of childhood adversity commonly associated with obesity in prior studies (i.e., sexual abuse) and adolescent BMI. It is possible that domestic violence exposure was more persistent and therefore had greater emotional and physiological consequences. However, our group has previously reported that individuals in this study with a history of physical, sexual, or emotional abuse have substantially altered patterns of physiological reactivity in response to a laboratory stressor and heightened internalizing and externalizing psychopathology (McLaughlin et al., 2014). Therefore it is possible that the violence and BMI association reported here is more representative of structural factors that underpin both family and community violence and obesity, such as food insecurity.

We also did not find any differential association between childhood adversity and BMI among adolescent boys and girls in this sample. While it is possible our sample size was not large enough to find an interaction between gender and abuse, it is also possible that prior studies that found associations between child maltreatment and BMI only in females may reflect differences in the type, severity, and/or frequency of adversity experienced by women compared to men (Cappelleri, Eckenrode, & Powers, 1993). Indeed in our study, while adolescent girls generally reported higher levels of adversity exposure than boys, this difference was not statistically significant. Future studies should aim to investigate relationships between childhood adversity and adult outcomes in diverse samples that optimize accurate reporting of adversity exposures in both genders to minimize possible sampling bias.

Our study has several important limitations. We did not have robust measures of childhood neglect, and were unable to investigate this important adversity which has been linked to the development of adolescent obesity in other studies (Shin & Miller, 2012). Future studies should continue to collect detailed information on neglect and other childhood adversities

as researchers work to unravel mechanisms linking different forms of childhood adversity to adult disease. Height and weight were self-reported, and participants may have underestimated their weight or overestimated their height, thus falsely lowering BMI *z*-scores. Indeed, the prevalence of overweight and obesity in our sample was less than the national average (Ogden, Carroll, Kit, & Flegal, 2014). However, we do not have reason to suspect this difference in reporting would have preferentially occurred in those exposed vs. not exposed to childhood adversity. Our study sample is small, and may be underpowered to detect clinically meaningful differences in BMI *z*-scores or the prevalence of overweight and obesity. Finally, the cross-sectional nature of the study does not allow us to conclude that DV causes an increase in BMI.

Despite these limitations, our findings are important because they highlight a population that might be at increased risk for excessive weight gain in adolescence and the development of obesity in adulthood. Pediatric providers should screen for interpersonal violence when treating adolescent patients, and consider metabolic effects in addition to psychological effects in those with a history of domestic violence exposure. In addition to securing appropriate safety and mental health resources for these patients, issues surrounding food insecurity and eating behaviors should also be addressed.

Author's Contributions

HG and KM conceptualized and designed this study. MS and KM conceived and designed the original parent study. CM carried out the initial analyses and interpretation of data. SA critically interpreted the data and supervised the analyses. HG conducted the literature review and drafted the initial manuscript. All authors reviewed and revised the manuscript and approved the final manuscript as submitted

Conflict of Interest

The authors have no competing interests.

Financial Disclosure

The authors have no financial relationships relevant to this article to disclose.

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