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Body mass index trajectory throughout adolescence: a comparison of maltreated adolescents by maltreatment type to a community sample

J. U. Schneiderman¹, S. Negri¹, M. Peckins², F. E. Mennen¹, and P. K. Trickett¹

¹School of Social Work, University of Southern California, Los Angeles, CA, USA

²Department of Human Development and Family Studies, Pennsylvania State University, University Park, PA, USA

Summary

Background—Childhood maltreatment is associated with adult obesity, but there is conflicting evidence regarding the relationship between childhood maltreatment and obesity during adolescence.

Objectives—To compare the body mass index (BMI) trajectory of adolescents with a specific type of maltreatment (sexual abuse, physical abuse, emotional abuse or neglect) to adolescents with another type of maltreatment (maltreated sample $n = 303$) and to a comparison group ($n = 151$).

Methods—Individual growth models were used to estimate average growth trajectories of BMI percentile separately by sex (ages 9 to 22 years). Unconditional and conditional linear and quadratic growth models were estimated and maltreatment types were added before including covariates (ethnicity, anxiety, depression and pubertal stage).

Results—BMI growth trajectories of sexually abused girls and neglected girls were significantly different from comparison girls. Comparison girls had a growth trajectory that reached its apex at 15 years and then began to decline, whereas sexually abused girls and neglected girls had lower BMI than comparison girls until age 16–17 years when their BMI was higher than comparison girls.

Conclusions—Late adolescence appears to be the developmental period during which differences in BMI percentiles become pronounced between girls with sexual abuse or with neglect vs. comparison girls.

Keywords

Body mass index trajectory; female adolescents; neglect; sexual abuse

Address for correspondence: Dr JU Schneiderman, School of Social Work, University of Southern California, 669 West 34th Street; Los Angeles, CA 90089-0411, USA. juschnei@usc.edu.

Conflict of interest statement

No conflict of interest was declared.

Introduction

In 2011, child protective services in the United States received an estimated 3.7 million reports of abuse and neglect, and of those reports, an estimated 681 000 children (9.1 per 1000 children) were victims of maltreatment (1). International studies have found that approximately 20% of women and 5% to 10% of men report being sexually abused as children, whereas 25% to 50% of all children report being physically abused (2). A meta-analysis of 41 studies found that childhood maltreatment was associated with elevated risk of developing obesity during the life course but not specifically in childhood, although only nine of the studies included children (3). The toxic stress framework suggests that adversity experienced during youth, such as child maltreatment, may result in frequent or prolonged activation of the stress response system (4), which may increase the risk of obesity (5). Research on adverse childhood experiences, including maltreatment, has supported the toxic stress hypothesis. Adverse childhood experiences have been shown to increase health risk behaviours among adults such as substance use and smoking, as well as negative health consequences such as cardiovascular disease and obesity (6).

Despite evidence linking early life stress with health problems, the extant research on the association between child maltreatment and body mass index (BMI) has been inconclusive. In the first prospective study using child welfare records of maltreatment, Bentley and Widom (7) found that although physical abuse was associated with high BMI in adulthood, childhood sexual abuse and neglect were not significant predictors of adult BMI. In another prospective longitudinal study using child welfare maltreatment records, sexually abused girls had a steeper rate of BMI growth than a comparable group of non-abused girls, although obesity rates between groups were not different until early adulthood (8). Two studies explored BMI over time using data from the National Longitudinal Study of Adolescent Health (9,10). The first study found that the presence of childhood neglect predicted faster growth in BMI compared with those with no maltreatment (9). The second found that the combination of childhood physical abuse and sexual abuse was related to extreme obesity among non-minority adults compared with those without maltreatment (10). However, the first study (9) used self-reported height and weight, which has been found to be inaccurate (11), and both studies used a self-reported measure of maltreatment that did not represent all types of maltreatment. Two studies that used prospective analysis with child welfare documentation of maltreatment found different relationships between maltreatment types and high BMI, although one was a 30-year follow-up of maltreated children and did not examine BMI growth over time (7) and the other only examined sexually abused girls (8).

To address the limitations of previous research, the present study used a prospective design with child welfare documentation of all types of maltreatment and included measured height and weight to examine changes in BMI throughout adolescence. By identifying which childhood maltreatment experiences contribute to particular trajectories of BMI growth, interventions can be strategically targeted. This study used four waves of data, arrayed by age (9 to 22 years), from a longitudinal study on the effects of maltreatment on adolescent development. The study examined boys and girls separately and compared the BMI trajectory for adolescents with a specific type of maltreatment (sexual abuse, physical abuse,

emotional abuse or neglect) to adolescents with a different type of maltreatment as well as to a comparison group living in the same community.

Methods

Setting and selection of participants

The maltreated sample ($n = 303$) was referred by the Los Angeles County Department of Children and Family Services (DCFS). Inclusion criteria were (i) a new referral and investigation of maltreatment by DCFS within the past 30 days; (ii) the child was 9–12 years old; (iii) the child was Black, Latino or White and (iv) the child lived within specified zip codes in urban Los Angeles, California. The maltreated sample included 152 boys and 151 girls; 77% of the sample experienced neglect, 51% experienced emotional abuse, 51% experienced physical abuse and 20% experienced sexual abuse (Table 1). The total percentages in Table 1 add up to more than 100% because 76% of adolescents experienced more than one type of maltreatment. Adolescents in the maltreatment group had an average of 3.7 maltreatment investigations by DCFS.

Comparison youth ($n = 151$) from the same age group, race/ethnicity and zip codes were recruited from lists generated by a direct marketing firm. Letters inviting potential caregivers were mailed with a postage-paid return postcard indicating their willingness to participate. If we did not receive a postcard within a week, we telephoned caregivers to inquire about their willingness to participate. Of the families referred by DCFS, 77% agreed to participate in the study, whereas 50% of the comparison families contacted agreed to participate. Caregivers gave consent and the youth gave assent to participate. Comparison families were asked about any previous experience with child welfare and none of the families identified any previous or ongoing involvement with child welfare. The study received human subjects' approvals from DCFS, the juvenile court and the institutional review board of the affiliated university.

Upon enrolment in the study, the maltreatment and comparison groups were compared based on demographic variables. The two groups were similar in age ($M = 10.93$ years, $SD = 1.16$), gender (53% male) and neighbourhood characteristics (based on census block information). The comparison group had more Latinos than the maltreatment group (Table 2). Between 2002 and 2005, the children and their caretakers came to the research office and completed a 3–4 h interview protocol (Time 1). Time 2, 3 and 4 interviews occurred approximately 1, 2.5 and 4.5 years after Time 1 (Table 2). During each interview, caregivers and children were given remuneration compatible with National Institutes of Health's standard compensation rate for healthy volunteers. The measures used in the following analyses represent a subset of the questionnaires administered.

Measures

Body mass index—Participants were weighed and measured for height during the interviews. Trained graduate student assistants took weight and height measurements using a Healthometer scale (Global Industrial, Port Washington, New York, 11050, USA) after asking each child to remove shoes and any large bulky outerwear. Weight was measured

three times (to the nearest 0.5 pounds) and height was measured twice (to the nearest 0.25 inch). The measurements were averaged, converted to metric scale and used to calculate BMI percentile using the Centers for Disease Control and Prevention gender-specific percentiles.

Maltreatment classification—Data were obtained from child welfare case records that described the maltreatment experiences of participants. After permission was received from the juvenile court, these records were abstracted to classify the types of maltreatment the children experienced, as detailed elsewhere (12). For the purposes of the present analyses, maltreatment categories were developed based on a hierarchy of stress reactions in children with different types of maltreatment. The experience of sexual abuse and physical abuse have been found to be more stressful than emotional abuse and neglect, and these types of maltreatment have been linked to attenuated diurnal decrease in cortisol, a type of dysregulation of the stress response (13). Based on this literature, independent maltreatment categories were created by identifying all youth with a history of sexual abuse (including those with co-occurring maltreatment types) to populate the sexual abuse category. Among the remaining youth, those who experienced physical abuse (including those with emotional abuse, neglect or both) were identified to determine the physical abuse category. For the emotional abuse category, remaining youth with emotional abuse (including those with neglect) were identified. All remaining youth had only experienced neglect. This resulted in four mutually exclusive maltreatment categories with no youth being placed in more than one category (see Table 1).

Covariates were chosen based on factors that are known to predict BMI in adolescents including demographics (age, gender and ethnicity), development (puberty) and psychological functioning (anxiety and depression) (14,15). The analysis is stratified by gender because both before and after puberty, males and females differ in patterns of weight gain, body composition and the susceptibility to social and environmental factors (16).

Demographics—Characteristics included age, gender and race/ ethnicity.

Pubertal stage—Participants self-reported on their stage of pubertal development using Tanner criteria, in which five stages of pubertal development are represented by sets of serial line drawings that depict the development of two different secondary sexual characteristics from pre-pubertal (stage 1) to post-pubertal (stage 5) (17). Self-report on Tanner stages is highly correlated with physician assessment and sufficient when approximate estimation of pubertal stage is adequate.

Psychological functioning—Depressive symptoms were measured using the 27-item Children's Depression Inventory (18). The range of possible scores is 0 to 54. Test-retest for the Children's Depression Inventory has been adequate in various samples and the instrument has been shown to correlate strongly with other measures of childhood depressive symptoms (18). Internal consistency in this sample across all four waves averaged 0.84 with a range of 0.83 to 0.86.

Anxiety was measured with the 39-item Multidimensional Anxiety Scale for Children (19). Test-retest reliability ranged from 0.70 to 0.93 and the measure has shown good discriminant validity (19). Internal consistency in this sample for all four waves averaged 0.91 with a range of 0.90 to 0.91.

Data analysis

The effect of maltreatment on BMI growth trajectory was investigated separately by gender in two ways: (i) by comparing a specific maltreatment type vs. another specific maltreatment type (e.g., sexual abuse vs. physical abuse, sexual abuse vs. emotional abuse, sexual abuse vs. neglect, etc.) and (ii) by comparing maltreated and comparison adolescents (sexual abuse vs. comparison, physical abuse vs. comparison, emotional abuse vs. comparison and neglect vs. comparison). Individual growth models were estimated using BMI percentiles. Individual growth models via the SAS/MIXED procedure were used to estimate average growth trajectories of BMI percentiles arrayed by age. Model estimates using maximum likelihood estimation were compared with those obtained with restricted maximum likelihood estimation. Because the results were not substantially different, the reported results were based on maximum likelihood estimation to remain consistent with Singer and Willett's work (20). Following the steps outlined by Singer and Willett (20), an unconditional linear growth model was fit, followed by conditional linear and quadratic growth models. Next, maltreatment type was added to test whether there were any main effects, linear effects or quadratic effects for BMI on maltreatment type. Lastly, the time-invariant (ethnicity) and time-varying (depression, anxiety and pubertal stage) covariates were added to the multivariable model. In an age-based design, unobserved data are missing by design and both linear and quadratic models can be estimated. The advantages of using the individual growth models via the SAS/MIXED procedure to fit the longitudinal data include (i) the ability to use all available data at any time point and (ii) the ability to use multiple observations for each participant over time while adjusting for the correlated nature of the data. This procedure allows the use of data from participants who may have only one data point (7%) as well as those who have all four data points (61%).

Results

The only significant effects in the models were for females (see Table 3). There was a significant difference in linear slope between neglected females and physically abused females (referent) ($\beta = -4.70$, standard error [SE] = 2.05, $P < 0.05$). When comparing a specific maltreatment type to another type of maltreatment, the quadratic effects (differences in quadratic slopes) included: (i) neglected females vs. physically abused females ($\beta = 0.37$, SE = 0.16, $P < 0.05$) and (ii) physically abused girls vs. sexually abused girls ($\beta = -0.33$, SE = 0.16, $P < 0.05$). When comparing maltreated adolescents to the comparison adolescents, the quadratic effects (differences in quadratic slopes) included: (i) neglected females vs. comparison females ($\beta = 0.33$, SE = 0.16, $P < 0.05$) and (ii) sexually abused girls vs. comparison girls ($\beta = 0.29$, SE = 0.14, $P < 0.05$). All models controlled for covariates.

Figure 1 shows the quadratic BMI percentile trajectories and raw data for girls with each type of maltreatment and the comparison group. Girls with physical abuse had a BMI

trajectory that reached its apex at 16–17 years old and then declined, whereas girls with sexual abuse and girls with neglect had a smaller and later decline in BMI than girls with physical abuse. The results also indicated that girls in the comparison group had a growth trajectory that reached its apex between 14 and 15 years and then began to decline, whereas sexually abused girls and neglected girls had a slower increase in their BMI percentile than comparison girls until age 16–17 years, at which point their BMI percentile was higher than comparison girls.

Discussion

The results of this study showed that girls with sexual abuse and girls with neglect had different growth trajectories than the comparison girls after controlling for ethnicity, anxiety, depression and pubertal stage. Comparison girls had a BMI growth trajectory that was slightly higher between 9 and 15 years of age than either girls with neglect or girls with sexual abuse, but around 15–16 years old, the comparison girls' BMI trajectory decreased and the girls with neglect or sexual abuse were higher and decreased only slightly. Also, growth trajectories were not equivalent for all types of maltreatment for girls, but they were in the boys. Although retrospective research has shown that adult obesity is related to maltreatment in general (3), we found that girls with a history of maltreatment but who were not sexually abused or neglected (without any other type of maltreatment) and boys with a history of maltreatment had BMI growth curves equivalent to comparison adolescents.

The BMI trajectory of neglected girls showed a very slight decrease in later adolescence compared with the larger decrease in comparison adolescents, whereas sexually abused girls had a consistent slight BMI increase with a small decline at age 22 years. Studies have found that childhood neglect and sexual abuse are related to elevated risk of eating disorders, and specifically, physical neglect was related to obesity in adolescence (21,22). Binge eating syndrome is associated with both sexual abuse and neglect, while night eating syndrome is associated with childhood neglect (23). Nationally, binge eating disorder is more common in adolescent girls than in adolescent boys (24). The lack of any substantial decrease in BMI found for neglected girls or sexually abused girls in late adolescence may be a result of difficulty with regulating their eating.

The results from this study for sexually abused girls are similar to a prospective study in which sexually abused girls had an accelerated BMI trajectory in early adulthood compared with non-abused girls (8). Preventing continued increase in BMI in late adolescence may be especially important for sexually abused girls, given that treatment for obesity in adults with a history of childhood sexual abuse is difficult. Adults with a history of sexual abuse who enrolled in weight-loss programmes using a low-calorie diet lost less weight and reported more non-adherence than those without sexual abuse histories (25). Similarly, adults with sexual abuse history who lost weight using a programme including a low-calorie diet were more likely to regain weight after 18 months than adults without a sexual abuse history (26). Adults with childhood sexual abuse may have difficulty losing weight using a behavioural intervention, but surgical interventions have been successful with this population. A significant minority of adults undergoing bariatric surgery (17% of women and 11.5% of men) reported a history of sexual abuse (27). Yet, 2 years after gastric bypass surgery, there

were no differences in the ability to maintain weight loss for adults with childhood sexual abuse compared with adults without sexual abuse (28).

Limitations

Generalizability is limited because of the dense urban sample population and results cannot be extended to non-urban populations. We were unable to control for parental weight status, a predictor of child and adolescent obesity. We also could not control for caregiver income or education, which are also predictors of adolescent obesity, because our adolescent sample population was mobile; more than 20% of the sample changed caregivers from Time 1 to Time 3. Therefore, if we had used the initial caregiver's information, it would have not accurately reflected the longitudinal home environment of the adolescents. The use of official child welfare reports of maltreatment captured only what professionals noted in their investigations and official reports, and thus may not capture the totality of each child's experience. Upon enrolment, no comparison adolescents identified involvement with DCFS, but this does not preclude experiencing maltreatment not reported to DCFS. The limited number of adolescents in each maltreatment type, especially sexually abused boys and emotionally abused boys and girls, as well as the loss to follow-up may have limited our ability to test for BMI growth differences. Also, we ran our final model with 'number of maltreatment types' in place of 'maltreatment type' and there were no significant findings, meaning that experiencing a higher number of maltreatment types did not explain our findings.

Conclusion

Although this study did not establish a causal linkage of childhood sexual abuse or neglect among girls and higher in BMI in late adolescence, it did illustrate differences in BMI trajectories between sexually abused girls and neglected girls compared with girls who were not maltreated. While not all sexually abused or neglected girls are obese, those in this study clearly showed BMI trajectories that were higher in late adolescence than comparison adolescents. Further research is needed to see if results are similar in other populations of maltreated youth, with the recognition that BMI trajectories may differ by maltreatment type. This study suggests that healthcare clinicians and child welfare workers need to concentrate more on monitoring weight gain among girls than boys, especially girls with sexual abuse or neglect, explore weight concerns and support appropriate lifestyle changes including healthy eating and physical activity. Childhood sexual abuse prevalence has been estimated to be as high as 20% for women internationally (2) and childhood neglect is estimated at between 6% and 11% cumulative prevalence in the United States and the United Kingdom (29). Clinicians need to be aware of the prevalence of sexual abuse or neglect among female clients and that sexual abuse or neglect may be a factor in continued high BMI or BMI growth during late adolescence.

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Figure 1.

Body mass index (BMI) percentile trajectories (females).

Note: Quadratic effect of BMI percentile modelled. The percentage of female adolescents in each category who have BMI percentile data points at age 18 or above are: comparison = 57%; neglect = 57%; emotional Abuse = 48%; physical abuse = 57%; sexual abuse = 63%.

Table 1

Frequency and percentage of co-occurring maltreatment within each maltreatment category

Maltreatment category	Sexual abuse	Physical abuse	Emotional abuse	Neglect
Sexual abuse				
Boys	20 (100%)	15 (75%)	12 (60%)	19 (95%)
Girls	40 (100%)	20 (50%)	19 (48%)	30 (75%)
Physical abuse				
Boys	0 (0%)	74 (100%)	43 (58%)	59 (80%)
Girls	0 (0%)	47 (100%)	37 (79%)	33 (70%)
Emotional abuse				
Boys	0 (0%)	0 (0%)	18 (100%)	14 (78%)
Girls	0 (0%)	0 (0%)	27 (100%)	20 (74%)
Neglect				
Boys	0 (0%)	0 (0%)	0 (0%)	29 (100%)
Girls	0 (0%)	0 (0%)	0 (0%)	28 (100%)
Total				
Boys	20 (13%)	89 (60%)	73 (30%)	121 (81%)
Girls	40 (27%)	67 (45%)	83 (55%)	111 (74%)

Categories of maltreatment groups used for growth curve analysis are in bold face and include number of participants. Total percentages add up to more than 100% because 76% of adolescents experienced more than one type of maltreatment. Twenty subjects (7%) did not have a type of maltreatment noted because of the lack of evidence in the Department of Children and Family Services case records (one girl and three boys) or categorization as 'at risk' for maltreatment (eight boys and eight girls).

Table 2

Sample characteristics for time 1, 2, 3 and 4

Demographic variable	Group		Comparison			
	Maltreated		Time 1	Time 2	Time 3	Time 4
<i>n</i>	Time 1	Time 2	Time 3	Time 4	Time 1	Time 2
	303	250	191	222	151	128
Age (standard deviation)	10.84 (1.15)	12.02 (1.21)	13.85 (1.48)	18.28 (1.41)	11.11 (1.15)	12.28 (1.26)
Gender (%)						
Male	50	48	46	47	60	57
Female	50	52	54	53	40	43
Ethnicity (%)						
African American	40	40	47	43	32	34
Latino	35	36	29	34	47	45
White	12	11	8	10	10	11
Mixed biracial	13	13	16	13	11	12
Living arrangement (%)						
With parent	52	63	62	56	93	94
Foster care or extended family	48	37	38	24	7	6
Without caregiver	n/a	n/a	n/a	20	n/a	n/a

Time 2 interviews occurred approximately 1 year after Time 1 (with a range of 8 months to 3.3 years); Time 3 interviews occurred approximately 1.5 years after Time 2 (with a range of 8 months to 4.2 years) and Time 4 interviews occurred approximately 4.5 years after Time 3 (with a range of 1.6 years to 6.8 years). The interval between Time 1 to Time 4 ranged from 4.8 years to 9.8 years. n/a, not applicable.

Table 3

Quadratic growth models of body mass index percentile among girls

Measure	Comparison Estimate (SE)	Neglect Estimate (SE)	Physical abuse Estimate (SE)	Sexual abuse Estimate (SE)
Fixed effects				
Intercept	77.50 ** (8.39)	81.13 ** (9.63)	66.00 ** (8.50)	74.60 ** (9.07)
Linear slope	0.62 (2.91)	-2.73 (3.36)	1.98 (2.96)	-1.55 (3.13)
Quadratic slope	-0.24 (0.34)	0.09 (0.36)	-0.28 (0.34)	0.05 (0.35)
Maltreatment type				
Comparison	—	-3.62 (6.86)	11.50 * (5.62)	2.90 (6.03)
Emotional abuse	3.74 (6.76)	0.11 (8.13)	15.24 * (7.13)	6.64 (7.42)
Neglect	3.62 (6.86)	—	15.13 * (7.16)	6.53 (7.42)
Physical abuse	-11.50 * (5.62)	-15.13 * (7.16)	—	-8.60 (6.35)
Sexual abuse	-2.90 (6.03)	-6.53 (7.42)	8.60 (6.35)	—
Linear slope of maltreatment type				
Comparison	—	3.34 (1.93)	-1.34 (1.54)	2.16 (1.66)
Emotional abuse	-2.32 (1.81)	1.02 (2.28)	-3.68 (1.97)	-0.16 (2.07)
Neglect	-3.34 (1.93)	—	-4.70 * (2.05)	-1.18 (2.14)
Physical abuse	1.36 (1.54)	4.70 * (2.05)	—	3.52 (1.80)
Sexual abuse	-2.16 (1.66)	1.18 (2.14)	-3.52 (1.80)	—
Quadratic slope of maltreatment type				
Comparison	—	-0.33 (0.16)	0.04 (0.13)	-0.29 * (0.14)
Emotional abuse	0.23 (0.16)	-0.10 (0.20)	0.27 (0.18)	-0.06 (0.18)
Neglect	0.33 * (0.16)	—	0.37 * (0.17)	0.04 (0.18)
Physical abuse	-0.04 (0.13)	-0.37 * (0.17)	—	-0.33 * (0.16)
Sexual abuse	0.29 * (0.14)	-0.04 (0.18)	0.33 * (0.16)	—
Random effects				
Variance intercept	551.82 ** (63.76)	—	—	—
Variance slope	3.31 ** (0.63)	—	—	—
Covariance intercept, slope	-18.03 ** (5.25)	—	—	—
Residual variance	50.94 ** (4.19)	—	—	—
Indices of fit				
-2 log likelihood	5339.4	—	—	—
AIC	5413.4	—	—	—
BIC	5535.8	—	—	—

Findings for covariates are not presented.

* $P < 0.05$;** $P < 0.01$.

AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; SE, standard error.