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Sensitive Periods for the Association between Childhood Maltreatment and BMI

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Abstract

Introduction: Although previous research has suggested a positive association between child maltreatment and body mass index (BMI) over the life course, it is unclear when the relationship develops.

Methods: The authors used time-varying effect models and data from a nationally representative, longitudinal, cohort study (Add Health), to test how childhood physical, sexual, and emotional abuse uniquely varied in associations with BMI from age 13–28, and whether different patterns existed for males and females. Add Health collected data from 1994–2008, and present analyses occurred in 2018.

Results: 18 years was the earliest age when a relationship between maltreatment and BMI emerged for either sex. Child sexual abuse was negatively associated with BMI among males from 18.5–20 years but positively associated with BMI among females from 19–24.5 years, and childhood emotional abuse was positively associated with BMI among females from 18–28 years.

Conclusions: The relationship between child maltreatment and BMI varies as a function of maltreatment type, sex, and time. Notably, associations between maltreatment and BMI did not emerge until young adulthood. Future research should investigate mechanisms by which the association between maltreatment and BMI changes over time to identify trauma-informed intervention targets for improving weight outcomes.

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INTRODUCTION

According to the Fourth National Incidence Study of Child Abuse and Neglect, nearly one in 25 children in the United States experiences maltreatment by caregivers annually,¹ and self-report studies suggest this prevalence is an underestimate.^{2,3} Beyond placing children in immediate harm, maltreatment presents long-term adverse health effects.⁴⁻⁷ One important outcome is body mass index (BMI). Excess BMI (i.e., >25 kg/m² for adults) is a main driver of rising medical expenditures,⁸ associated with a reduced quality of life,⁹ and is disproportionately high among those who have experienced child maltreatment.^{10,11} Previous research has suggested a positive association between child maltreatment and BMI in adulthood,⁴ but it is unclear when the relationship develops.

The World Health Organization defines child maltreatment as: “[a]ll forms of physical and/or emotional ill-treatment, sexual abuse, neglect or negligent treatment [...], resulting in actual or potential harm to the child’s health, survival, development or dignity in the context of a relationship of responsibility, trust or power.”¹² Formal definitions vary between countries, states, and studies. The present analyses focus on three maltreatment types: sexual, physical, and emotional abuse. These typologies do not encompass all maltreatment, but understanding how three types relate to BMI over time may help inform timing for obesity prevention interventions for some individuals who experienced early trauma.

No research has evaluated the time-varying effect of maltreatment throughout adolescence and young adulthood. It is critical to evaluate risk factors for elevated BMI during this time, as this is a sensitive period for the development of obesity.^{13,14} In this study, the time-varying effect model (TVEM) uncovers when associations between child maltreatment types and BMI appear.

Although a recent meta-analysis found child maltreatment was associated with elevated risk of developing obesity over the life-course,⁴ findings differ across studies. Thus, experts argue that the nature of the association between child maltreatment and BMI from adolescence to adulthood is inconclusive.¹⁵ For example, in one cross-sectional study, adolescent boys with a neglect allegation had a higher obesity risk compared with adolescent boys with a physical abuse allegation, and adolescent girls with a history of any maltreatment investigation had a greater obesity risk than those without a history.¹⁶ In the first prospective study using child welfare records to investigate this relationship, however, physical abuse was associated with high BMI in adulthood 30 years later, and childhood sexual abuse and neglect were not predictors of adult BMI.¹⁷ Yet in a different prospective study using child welfare records in a female sample, sexually abused girls had steeper BMI growth from childhood to adulthood than non-abused girls, although obesity rates were not different until ages 20–27.¹⁸

These varying effects may be due to maltreatment type and biological sex, but they could also be artifacts of the investigated ages and when the relationship between maltreatment and BMI emerges. Previous research investigating the longitudinal relationship between child maltreatment and BMI has evaluated whether maltreatment alters an individual’s BMI trajectory.^{15,19–21} However, prior studies have not considered how the association between

maltreatment and BMI changes as individuals age. This study used data from the National Longitudinal Study of Adolescent to Adult Health (Add Health) to test when the associations between types of child maltreatment (i.e., physical, sexual, and emotional abuse) and BMI are strongest between 13 to 28 years, and whether different patterns exist for males and females.

METHODS

Data Source

This study used Add Health data (P01-HD31921), a longitudinal, nationally representative study of 20,745 adolescents in grades 7–12 in the U.S. during 1994–95 (analyzed 2018) followed into adulthood.²² This study used Wave I (ages 11–21), II (collected ~1 year later, ages 13–21), III (ages 18–28), and IV (ages 24–34). Wave I provided information on time-invariant covariates, Waves II–IV provided information on measured BMI, and Wave IV provided retrospective information on child maltreatment experienced prior to age 17. The investigators' IRB granted exemption from human subjects' research approval.

Data were structured in long form so there were multiple rows of data per respondent—a row per each age between 13 and 28 years—each row known as a 'person-year.' Ages were restricted to 13–28 due to sparse data outside this range. For the analysis, person-years from any measurement occasion when an individual had information on the outcome (i.e., BMI), predictors (i.e., covariates and maltreatment variables), and complex survey design variables, were included, regardless of later attrition, as the TVEM can accommodate different numbers and spacing of measurement occasions. Age in years was used as the time variable. All measurement occasions where an individual was pregnant were excluded, as correlates of BMI are unique for pregnant women. The analytic sample contained 9,837 individuals (51% male), which included 20,138 person-years (males: 9,583 person-years; females: 10,555 person-years).

Measures

Body mass index.—Study staff measured height and weight in Waves II–IV, and BMI was calculated as kilogram (kg)/meter (m)².

Child maltreatment.—At Wave IV, respondents were asked questions retrospectively about child maltreatment experienced prior to age 18. These questions asked about physical abuse (i.e. How often did a parent or adult caregiver hit you with a fist, kick you, or throw you down on the floor, into a wall, or down stairs?), sexual abuse (i.e. How often did a parent or other adult caregiver touch you in a sexual way, force you to touch him or her in a sexual way, or force you to have sexual relations?), and emotional abuse (i.e. How often did a parent or other adult caregiver say things that really hurt your feelings or made you feel like you were not wanted or loved?). An endorsement of 1 occurrence was considered maltreatment exposure. Additional questions asked about the age (i.e., 0–17) at which each of these maltreatment types started. Indicator variables for each maltreatment type were created, and indicator variables switched from a value of 0 to 1 at the age a respondent reported first experiencing a specific maltreatment type, and it remained a value of 1 for

subsequent ages. Thus, each maltreatment variable captured whether a respondent had ever experienced specific types of child maltreatment, and the values of the maltreatment variables could change as respondents aged. For example, if an individual experienced their first physical abuse encounter at age 7, then they would have a value of 1 for the physical abuse indicator for ages 13–28; if an individual experienced their first physical abuse encounter at age 16, then they would have a value of 0 for the physical abuse indicator for ages 13–15, and a value of 1 for the physical abuse indicator for 16–28.

Covariates.—Authors' previously developed Directed Acyclic Graph (DAG) that depicted the casual relationship between child maltreatment and longitudinal weight outcomes informed covariates.²³ This study controlled for factors known to influence BMI and child maltreatment, but it did not include variables on the causal path between maltreatment and BMI, such as diet or physical activity.²⁴ Covariates included race/ethnicity (non-Hispanic Black, non-Hispanic White, Hispanic, other), parent education (less than high school, high school, some college, college graduate), parent employment (employed or unemployed), birthweight (in ounces, meancentered), if a child was exclusively breastfed for 6+ months, if a child was born in the United States, and if a biological mother or father was obese.^{24–26} Add Health assessed these variables at Wave I, and assessments carried forward to all waves because these covariates were either timestable or only assessed at Wave I (e.g., parent obesity status).

Statistical analysis.—Authors used TVEMs to examine how three types of child maltreatment were associated with BMI over time (i.e., from ages 13–28). TVEMs estimate how associations between predictors and an outcome change over time without assuming associations follow parametric functions of time; for example, TVEM does not force an estimated curve to be linear or quadratic.²⁷ All three maltreatment types were included in one model, but analyses were stratified by biological sex to allow time-varying sex differences. All maltreatment types were included in one model, rather than estimating three separate models, as previous ordinary least squares regressions indicated low multicollinearity of maltreatment types predicting BMI. Moreover, the study aimed to quantify the unique effect of specific maltreatment types on BMI—net the presence of other maltreatment types—which necessitated including physical, sexual, and emotional abuse in a single model. Because respondents reported the age at which maltreatment began, analyses estimated time-varying coefficients of the time-varying maltreatment predictors. Due to the coding of maltreatment, coefficients were interpreted as associations between having ever experienced maltreatment up to a given age and BMI at that age. All analyses also controlled for the above covariates as time-invariant predictors with time-invariant coefficients. All TVEMs were fit using the % *WeightedTVEMSAS* macro, available at methodology.psu.edu.²⁸ The % *WeightedTVEM* macro accommodates survey weights and clustering; this feature allowed accounting for the Add Health complex study design.

RESULTS

Table 1 presents descriptive statistics by sex. Table 2 presents the prevalence of ever having experienced maltreatment from 13–28 years, stratified by sex. For males by age 17, 38% had experienced emotional abuse, 16% physical abuse, and 2.1% sexual abuse. For females by

age 17, 50% had experienced emotional abuse, 16% physical abuse, and 6.8% sexual abuse. Among males and females, 13% and 17% had experienced 2 types of maltreatment by 17 years, respectively. As evidenced by the plot of BMI across age (Figure 1), BMI increased from 13 (males: 22.2 kg/m²; females: 21.6 kg/m²) to 28 years (males: 28.8 kg/m²; females: 29.4 kg/m²).

Figure 2 presents TVEM results of examining associations between maltreatment types and BMI over ages 13–28. The solid black curves in the figure correspond to coefficient estimates of the association between maltreatment and BMI across time (i.e., age), and shaded regions correspond to the 95% confidence intervals of the coefficient estimates across time. Confidence intervals not containing 0 indicate an association between the maltreatment type and BMI at a particular age. Note that, although the analytic model included all maltreatment forms simultaneously, the % *WeightedTVEM* macro provides a separate figure for each maltreatment type's time varying effect on BMI.

The unique association between ever having experienced physical abuse and BMI was not present at any age for males or females. Ever having experienced sexual abuse was uniquely associated with a lower BMI compared to never having experienced sexual abuse for males ages 18.5–20—over and above experiencing other types of maltreatment—with a maximum association of -2.2 kg/m^2 at 19.2 years (95% CI: $-4.08, -0.31$). For a 19-year old male with average height for sex and age according to the sample (i.e., 5 feet, 10 inches), 2.2 kg/m^2 corresponds to 15 pounds. For females, however, the relationship between sexual abuse and BMI was positive from ages 19 to 24.5, with a maximum association of 1.93 kg/m^2 at 22.7 years (95% CI: 0.60, 3.25). For a 23-year old female with average height for sex and age according to the sample (i.e., 5 feet, 4 inches), 1.93 kg/m^2 corresponds to 11.3 pounds.

Ever having experienced child emotional abuse was not uniquely associated with BMI at any age for males. For females, the unique association between ever having experienced emotional abuse and BMI was positive from ages 18 to 28, with a maximum association of 1.6 kg/m^2 at 26.2 years (95% CI: 0.44, 2.71). For a 26-year old female with average height for sex and age according to the sample (i.e., 5 feet, 4 inches), 1.6 kg/m^2 corresponds to 9.5 pounds.

DISCUSSION

The present analyses demonstrate the relationship between child maltreatment and BMI varies as a function of maltreatment type, biological sex, and time. With respect to time, 18 years was the earliest age when a relationship between maltreatment and BMI for either sex emerged. There are several explanations for why the associations between maltreatment and BMI may not appear until young adulthood. First, it may be that individuals do not have the ability to internalize maltreatment experiences until later in adolescence and young adulthood,²⁹ at which time they cope with the memory via poor health behaviors, such as binge eating, bulimia, emotional eating, or eating in absence of hunger.^{30,31}

An alternative explanation for why the association between maltreatment and BMI emerges in young adulthood could be that early maltreatment experiences alter the developing brain

and change the way individuals cope with subsequent stress.^{32,33} The toxic stress framework suggests early life adversity may result in persistent activation of the stress response system and thereby cause dysregulation of the hypothalamic-pituitary-adrenal axis.^{34,35} Due to this chronic activation of the stress response system, later in young adulthood when individuals experience different life stressors they may have a lower tolerance for stress,³⁶ be more prone to engaging in poor health behaviors to cope,^{37,38} and/or more easily retain excess weight.³⁹ It remains unclear which mechanisms—or combinations of mechanisms—are responsible for the changing association between maltreatment and BMI over adolescence to early adulthood. Future work should explore what mechanisms exist to inform obesity prevention interventions for this population.

Analyses suggested distinct patterns for males and females. Although there was no unique association between child emotional abuse and BMI for males at any age, females who had experienced emotional abuse exhibited a higher BMI between the 18 to 28 years compared to females who had never experienced emotional abuse. Perhaps most notably, whereas ever having experienced sexual abuse was associated with a higher BMI for females in early adulthood, the relationship was in the opposite direction for males during this time. This finding is in contrast to previous research that suggests either a positive^{20,40} or null^{15,17,21,41,42} association between sexual abuse and BMI among males. The discrepancy between previous and present research could be credited to how present analyses estimated the association between maltreatment and BMI. Previous work either (1) has evaluated the relationship between maltreatment and BMI at snapshots in time; or (2) has restricted the association between maltreatment and BMI to have a parametric relationship with time (e.g., the association between maltreatment and BMI growth is stable across time). The present analyses, however, investigated how the association between maltreatment and BMI evolves over continuous time while allowing the relationship to take a non-parametric form. If present analyses had evaluated the relationship between childhood sexual maltreatment and BMI at an age prior to 18.5 or after 20 instead of evaluating the time-varying effect of maltreatment, there would have been a null association for males. Moreover, because the association between sexual abuse and male BMI was null for the majority of the time, if analyses had evaluated the association between sexual abuse and the rate of change in BMI, there also would have been a null association similar to the results of Shin and colleagues.²¹ Estimating the time-varying effect of child sexual abuse on BMI allowed for uncovering a developmental period when the association is negative for males.

The opposing patterns between males and females may be due to different eating-related behaviors displayed during early adulthood by men and women with a history of child maltreatment. For example, using data from a nationally representative study of adults in the United States, Afifi and colleagues found that men who experienced sexual abuse in childhood were more likely to exhibit bulimia nervosa—but not binge eating disorder—compared to men who had not experienced sexual abuse, but women who experienced sexual abuse in childhood were more likely to exhibit binge eating disorder—but not bulimia nervosa—compared to women who had not experienced sexual abuse.³¹

The longitudinal, observational, nature of the Add Health data set—coupled with applying a TVEM—allowed for exploring how the relationship between child maltreatment experiences

and longitudinal weight outcomes evolves over the span of adolescence through young adulthood in a nationally representative sample. Because maltreatment was self-reported by respondents, Add Health did not need to rely on child welfare data that largely underestimate maltreatment cases.¹ Due to the data and nature of the models, the present analysis assessed only the association of having experienced maltreatment or not and BMI without capturing the intensity or duration of maltreatment, which may conceal important nuances in the relationship between child maltreatment and BMI over time.

Add Health data are subject to self-reporting bias. For instance, a respondent may recall maltreatment started at age 16 when it actually started at 14. This would result in incorrect maltreatment variable values for ages 14 and 15, but values would be correct for subsequent ages. The possibility for incorrect maltreatment variable values provides lower confidence in results for ages 13–17 when the values of the maltreatment variables can change with time; this could mean the association may begin during the teen years but analyses are not identifying it because of error in reporting ages. After age 17, however, the values for child maltreatment variables are ‘locked in’ because, by definition, child maltreatment cannot begin in adulthood. Because associations between maltreatment and BMI did not appear until after the window of possible child maltreatment, i.e., after 18, the impact that reporting-bias would have on the pattern of results in adulthood is not concerning.

Because this study focused on child maltreatment as the exposure, analyses did not consider relationships between other trauma and BMI over time, such as peer victimization or intimate partner violence. Likewise, analyses did not include potential additional adversities that occurred between ages 18–28 years. This omission was intentional because child maltreatment predisposes an individual to subsequent adversity,^{43,44} creating the potential that adversity in young adulthood mediates—rather than confounds—the relationship between child maltreatment and BMI. Given that trauma external to child maltreatment is associated with well-being,^{45–48} however, future studies should consider associations between a wider array of trauma forms and BMI over time. Moreover, the present analyses focused on unique associations between child maltreatment types and BMI over time; evaluating relationships between co-occurring maltreatment and BMI would add nuance to these investigated associations.

CONCLUSIONS

The relationship between child maltreatment and BMI varies by maltreatment type, sex, and time. Specifically, sexual abuse was negatively associated with BMI in young adulthood among males but positively associated with BMI in young adulthood among females, and emotional abuse was positively associated with BMI in young adulthood among females. Young adulthood has not been a traditional stage for delivering treatment associated with child maltreatment, but this time could be a critical window for intervention. Future research should investigate the mechanisms by which associations between maltreatment and BMI change over time in an effort to identify effective intervention targets for improving weight outcomes for this population.

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Figure 1.

Average body mass index across ages 13–28 years with 95% confidence intervals of the means, stratified by biological sex.

Figure 2.

Plots of the associations between ever having experienced (a) physical abuse, (b) sexual abuse, and (c) emotional abuse, and BMI from 13 to 28 years old, and 95% confidence interval of the association, stratified by sex and controlling for potential confounders.

Table 1.

Time-invariant covariate descriptive statistics of the sample from the National Longitudinal Study of Adolescent to Adult Health ($N = 9,837$), stratified by biological sex.

Variable	Males, $\bar{x}$ or %	Females, $\bar{x}$ or %
Parental obesity	23%	26%
Birthweight (ounces)	121.7 (0.45)	117.2 (0.45)
Breastfed	20%	20%
US born	96%	96%
Parent employment	79%	79%
Race/ethnicity		
White	73%	71%
Hispanic	10%	10%
Black	12%	14%
Other	5%	5%
Parent education		
< High school	9%	10%
High school	26%	28%
Some college	32%	31%
College graduate	33%	31%
<i>n</i>	4,767	5,070

Note: Descriptive statistics account for survey weighting and clustering.

Table 2.

Prevalence of ever having experienced child maltreatment by age and stratified by sex, from the National Longitudinal Study of Adolescent to Adult Health ($N = 9,837$).

Child maltreatment type	13 years	14 years	15 years	16 years	17 years
Males ($n = 4,767$)					
Physical abuse	11%	13%	14%	15%	16%
Sexual abuse	1.7%	1.9%	1.9%	1.9%	2.1%
Emotional abuse	23%	26%	30%	34%	38%
Females ($n = 5,070$)					
Physical abuse	10%	12%	13%	15%	16%
Sexual abuse	6.1%	6.3%	6.5%	6.7%	6.8%
Emotional abuse	30%	34%	40%	46%	50%

Note: Descriptive statistics account for survey weighting and clustering.