

Sensitive Periods for the Association Between Childhood Maltreatment and BMI



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Introduction: Although previous research has suggested a positive association between child maltreatment and BMI over the life course, it is unclear when this 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 to 28 years, and whether different patterns existed for male and female participants. Add Health collected data from 1994 to 2008, and the present analyses took place in 2018.

Results: Age 18 years was the earliest that a relationship between maltreatment and BMI emerged for either sex. Child sexual abuse was negatively associated with BMI among male participants from 18.5 to 20 years, but positively associated with BMI among female participants from 19 to 24.5 years, and childhood emotional abuse was positively associated with BMI among female participants from 18 to 28 years.

Conclusions: The relationship between child maltreatment and BMI varies as a function of type of maltreatment, 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 1 in 25 children in the U.S. experiences maltreatment by caregivers annually,¹ and self-report studies suggest that 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 BMI. Excess BMI (i.e., >25 kg/m² for adults) is a main driver of increasing medical expenditures,⁸ is 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 this develops.

WHO 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

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between countries, states, and studies. The present analyses focus on 3 types of maltreatment: sexual, physical, and emotional abuse. These typologies do not encompass all maltreatment, but understanding how 3 types relate to BMI over time may help inform timing for obesity prevention interventions for people who experienced trauma early in life.

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) reveals when associations between types of child maltreatment and BMI appear.

Although a recent meta-analysis found that child maltreatment was associated with increased 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 1 cross-sectional study, adolescent boys who had alleged neglect had a higher obesity risk compared with adolescent boys who had alleged physical abuse, and adolescent girls with a history of any investigation of maltreatment had a greater risk of obesity than those without such 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 nonabused girls, although obesity rates were not different until age 20–27 years.¹⁸

These varying effects may be because of type of maltreatment 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, previous 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 the ages of 13 and 28 years, and whether different patterns exist for male and female participants.

METHODS

Study Sample

This study used data from Add Health (P01-HD31921), a longitudinal, nationally representative study of 20,745 adolescents in Grades 7–12 in the U.S. from 1994 to 1995 (analyzed in 2018) followed into adulthood.²² This study used Wave I (aged 11–21 years), Wave II (collected ~1 year later, aged 13–21 years), Wave III (aged 18–28 years), and Wave IV (aged 24–34 years). 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 before the age of 17 years. The investigators' IRB granted exemption from human subjects' research approval.

Data were structured in long form so that there were multiple rows of data per respondent—a row per year between the ages of 13 and 28 years—each row known as a “person-year.” Ages were restricted to 13–28 years owing 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, because the TVEM can accommodate different numbers and spacing of measurement occasions. Age in years was used as the time variable. All measurement occasions when an individual was pregnant were excluded, because correlates of BMI are unique for pregnant women. The analytic sample comprised 9,837 participants (51% male), which included 20,138 person-years (male participants, 9,583 person-years; female participants, 10,555 person-years).

Measures

Study staff measured height and weight in Waves II–IV, and BMI was calculated as kg/m². At Wave IV, respondents were asked questions retrospectively about child maltreatment experienced before age 18 years. 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 at least 1 occurrence was considered exposure. Additional questions asked about the age (i.e., 0–17 years) at which each of these types of maltreatment began. Indicator variables for each type of maltreatment were created, and indicator variables switched from a value of 0 to 1 at the age at which a respondent reported first experiencing a specific type of maltreatment, and it remained as a value of 1 for subsequent ages. Thus, each maltreatment variable captured whether a respondent had ever experienced specific types of 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 the age of 7 years, then they would have a value of 1 for the physical abuse indicator for ages 13–28 years; if an individual experienced their first physical abuse encounter at age 16 years, then they would have a value of 0 for the physical abuse indicator for ages 13–15 years, and a value of 1 for the physical abuse indicator for ages 16–28 years.

The authors previously developed a Directed Acyclic Graph that depicted the causal relationship between child maltreatment and longitudinal weight outcomes, which informed covariates (RLS, unpublished observations, 2019). That study controlled for factors known to influence BMI and child maltreatment, but did not include variables on the causal path between maltreatment and BMI, such as diet or physical activity.²³ 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, mean-centered), if a child was exclusively breastfed for ≥ 6 months, if a child was born in the U.S., and if a biological mother or father was obese.^{23–25} Add Health assessed these variables at Wave I, and assessments carried forward to all Waves because these covariates were either time-stable or only assessed at Wave I (e.g., parent obesity status).

Statistical Analysis

The authors used TVEMs to examine how 3 types of child maltreatment were associated with BMI over time (i.e., from age 13 to 28 years). TVEMs estimate how associations between predictors and an outcome change over time without assuming that associations follow parametric functions of time; for example, TVEM does not force an estimated curve to be linear or quadratic.²⁶ All 3 types of maltreatment were included in 1 model, but analyses were stratified by biological sex to allow time-varying sex differences. All types of maltreatment were included in 1 model, rather than estimating 3 separate models, as previous ordinary least-squares regressions indicated low multicollinearity of types of maltreatment predicting BMI. Moreover, the study aimed to quantify the unique effect of specific types of maltreatment on BMI—not the presence of other types of maltreatment—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. Owing 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 %WeightedTVEM SAS macro, available at methodology.psu.edu.²⁷ 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 age 13 to 28 years, stratified by sex. For male participants, by age 17 years, 38% had experienced emotional abuse, 16% physical abuse, and 2.1% sexual abuse. For female participants by age 17 years, 50% had experienced emotional abuse, 16% physical abuse, and 6.8% sexual abuse. Among male and female participants, 13% and 17% had experienced 2 or more types of maltreatment by age 17 years, respectively. As demonstrated by the plot of BMI across age (Figure 1), BMI increased

from 13 years (male participants, 22.2 kg/m²; female participants, 21.6 kg/m²) to 28 years (male participants, 28.8 kg/m²; female participants, 29.4 kg/m²).

Figure 2 presents TVEM results of examining associations between types of maltreatment and BMI over the ages from 13 to 28 years. 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% CIs of the coefficient estimates across time. CIs not containing 0 indicate an association between the type of maltreatment 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 type of maltreatment's time-varying effect on BMI.

The unique association between ever having experienced physical abuse and BMI was not present at any age for male or female participants. Ever having experienced sexual abuse was uniquely associated with a lower BMI compared with never having experienced sexual abuse for male participants aged 18.5–20 years—over and above experiencing other types of maltreatment—with a maximum association of -2.2 kg/m² at age 19.2 years (95% CI = $-4.08, -0.31$). For a 19-year-old male participant with average height for sex and age according to the sample (i.e., 5 feet, 10 inches), 2.2 kg/m² corresponds to 15 pounds. For female participants, however, the relationship between sexual abuse and BMI was positive from ages 19 to 24.5 years, with a maximum association of 1.93 kg/m² at age 22.7 years (95% CI = $0.60, 3.25$). For

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 Biologic Sex

Variable	Males	Females
Parental obesity, %	23	26
Birthweight (ounces), sample mean	121.7 (0.45)	117.2 (0.45)
Breastfed, %	20	20
U.S. born, %	96	96
Parent employment, %	79	79
Race/ethnicity, %		
White	73	71
Hispanic	10	10
Black	12	14
Other	5	5
Parent education, %		
Less than high school	9	10
High school	26	28
Some college	32	31
College graduate	33	31
N	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 type of maltreatment	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.

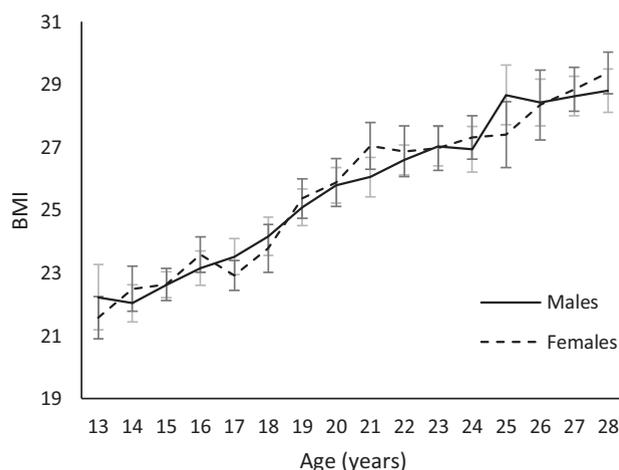


Figure 1. Average BMI across ages 13–28 years with 95% CIs of the means, stratified by biologic sex. Male error bars, gray; female error bars, black.

a 23-year-old female participant with average height for sex and age according to the sample (i.e., 5 feet, 4 inches), 1.93 kg/m² corresponds to 11.3 pounds.

Ever having experienced child emotional abuse was not uniquely associated with BMI at any age for male participants. For female participants, the unique association between ever having experienced emotional abuse and BMI was positive from ages 18 to 28 years, with a maximum association of 1.6 kg/m² at age 26.2 years (95% CI=0.44, 2.71). For a 26-year-old female participant with average height for sex and age according to the sample (i.e., 5 feet, 4 inches), 1.6 kg/m² corresponds to 9.5 pounds.

DISCUSSION

The present analyses demonstrate that the relationship between child maltreatment and BMI varies as a function of type of maltreatment, biological sex, and time.

With respect to time, age 18 years was the earliest that a relationship between maltreatment and BMI for either sex emerged. There are several explanations as to 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,²⁸ 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.^{29,30}

An alternative explanation for why the association between maltreatment and BMI emerges in young adulthood could be that early experiences of maltreatment alter the developing brain and change the way individuals cope with subsequent stress.^{31,32} The toxic stress framework suggests that early life adversity may result in persistent activation of the stress-response system and thereby cause dysregulation of the hypothalamic–pituitary–adrenal axis.^{33,34} Owing 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,³⁵ be more prone to engaging in poor health behaviors to cope,^{36,37} and more easily retain excess weight.³⁸ 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 male and female adults. Although there was no unique association between child emotional abuse and BMI for male participants at any age, female participants who had experienced emotional abuse exhibited a higher BMI between the ages of 18 and 28 years compared with those who had never experienced emotional abuse. Perhaps most notably, whereas ever having experienced

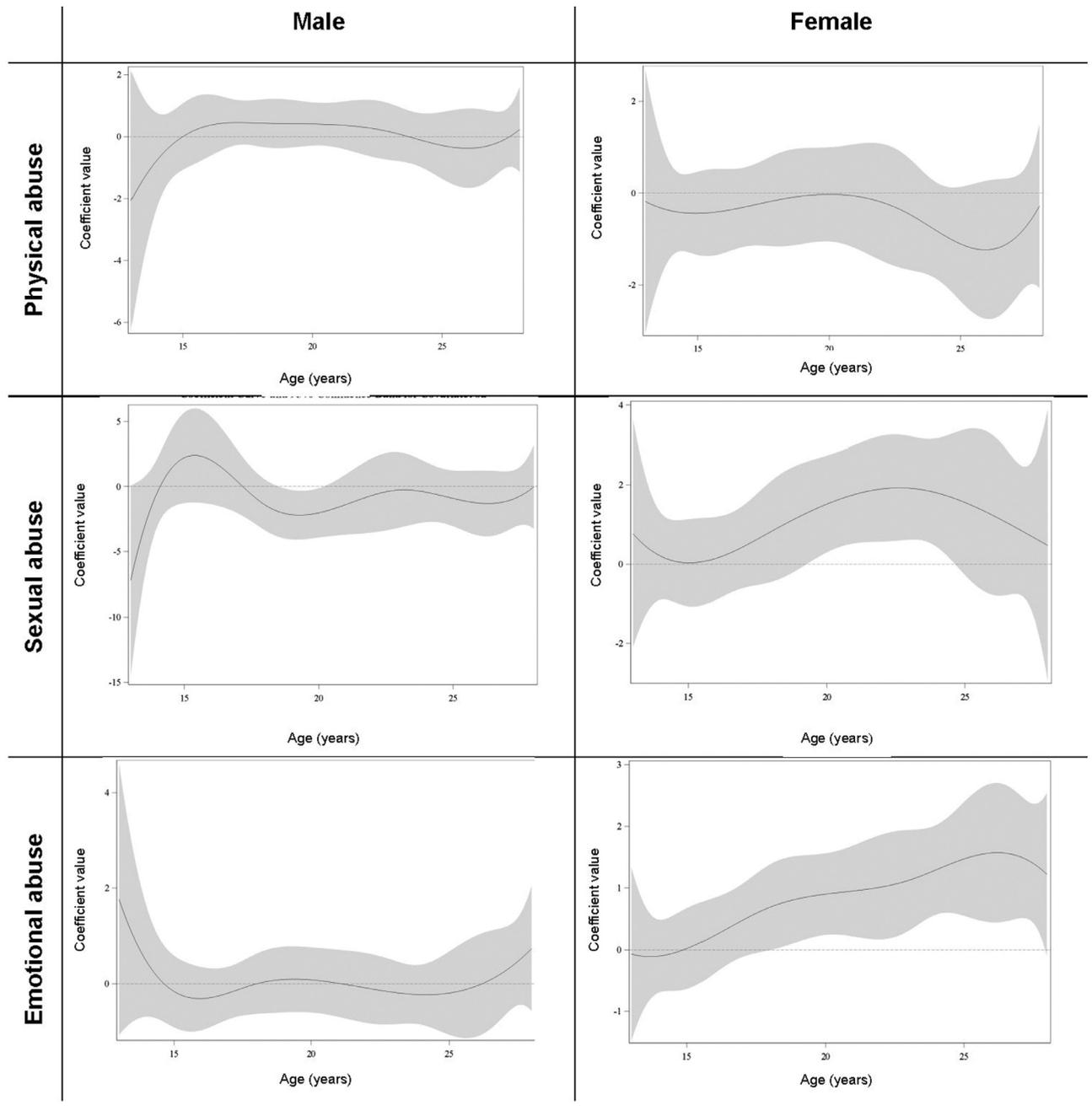


Figure 2. Plots of the associations between ever having experienced (1) physical abuse, (2) sexual abuse, and (3) emotional abuse, and BMI from age 13 to 28 years, and 95% CI of the association, stratified by sex and controlling for potential confounders.

Note: Scaling differs between plots. Solid black curves correspond to coefficient estimates of the association between maltreatment and BMI across age (in years). Shaded regions correspond to the 95% CIs of the coefficient estimates across ages.

sexual abuse was associated with a higher BMI for female participants in early adulthood, the relationship was the opposite for male participants during this time. This finding is in contrast to previous research that suggests either a positive^{20,39} or null^{15,17,21,40,41} association between sexual abuse and BMI among male individuals. 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 nonparametric form. If the present analyses had evaluated the relationship between childhood sexual maltreatment and BMI before the age of 18.5 or after 20 years, instead of evaluating the time-varying effect of maltreatment, there would have been a null association for male participants. Moreover, because the association between sexual abuse and male BMI was null most 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 Miller.²¹ Estimating the time-varying effect of child sexual abuse on BMI allowed for uncovering a developmental period when the association is negative for male individuals.

The opposing patterns between male and female adults may be due to different eating-related behaviors displayed during early adulthood by men and women with a history of maltreatment as children. For example, using data from a nationally representative study of adults in the U.S., Afifi et al.³⁰ found that men who experienced sexual abuse in childhood were more likely to exhibit bulimia nervosa—but not binge eating disorder—compared with 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 with women who had not experienced sexual abuse.

The longitudinal, observational, nature of the Add Health data set—coupled with applying a TVEM—allowed for exploration of 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 cases of maltreatment.¹ Owing to the data and the 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.

Limitations

Add Health data are subject to self-reporting bias. For instance, a respondent may recall maltreatment started at age 16 years when it actually started at age 14 years. This would result in incorrect maltreatment variable values for ages 14 and 15 years, but values would be correct for

subsequent ages. The possibility for incorrect maltreatment variable values provides lower confidence in results for ages 13–17 years when the values of the maltreatment variables can change with time; this could mean that the association may begin during the teenage years, but analyses do not identify it because of error in reporting ages. After age 17 years, 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 age 18 years), the impact that reporting bias would have on the pattern of results in adulthood is not of concern.

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 the ages of 18 and 28 years. This omission was intentional because child maltreatment predisposes an individual to subsequent adversity,^{42,43} 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,^{44–47} 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 types of maltreatment 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 type of maltreatment, sex, and time. Specifically, sexual abuse was negatively associated with BMI in young adulthood among male participants, but positively associated with BMI in young adulthood among female participants, and emotional abuse was positively associated with BMI in young adulthood among female participants. Young adulthood has not been a traditional stage for delivering treatment associated with child maltreatment, but this age 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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RLS identified the research question and led analyses and writing, STE supervised the work and provided writing revisions. NCG helped develop the statistical plan and provided statistical support and writing revisions. JMP, CTH, MES, and EBF helped develop the analysis plan and provided writing revisions.

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