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Violence exposure and adolescents' same-day obesogenic behaviors: New findings and a replication

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Abstract

Objective—To test whether exposure to violence is associated with same-day increases in obesogenic behaviors among young adolescents, including unhealthy food and beverage consumption, poor quality sleep, and lack of physical activity.

Methods—Young at-risk adolescents between 12 and 15 years of age were recruited via telephone screening from low-income neighborhoods. Adolescents and their parents completed in-person assessments, followed by Ecological Momentary Assessment (EMA) delivered to 151 adolescents' mobile phones three times a day for 30 days (4329 person days). Three obesogenic behaviors – unhealthy food consumption, poor sleep quality, and lack of physical activity – and violence exposure were assessed daily. Adolescents' body mass index (BMI) was assessed prior to the EMA and 18 months later. A replication was performed among 395 adolescents from a population-representative sample (with 5276 EMA person days).

Results—On days that at-risk adolescents were exposed versus not exposed to violence, they were more likely to consume unhealthy foods and beverages ($b = 0.12$, $p = 0.01$), report feeling tired the next morning ($OR = 1.58$, $p < 0.01$), and to be active ($OR = 1.61$, $p < 0.01$). At-risk adolescents who reported higher consumption of soda and caffeinated beverages during the 30-day EMA were more likely to experience increases in BMI in later adolescence. Findings related to sleep and activity were supported in the population-based replication sample; however, no

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significant same-day associations were found between violence exposure and unhealthy dietary consumption.

Conclusions—This study provides evidence that exposure to violence is associated with same-day unhealthy dietary consumption among at-risk adolescents and next-day tiredness related to sleep quality among adolescents from both at-risk and normative populations. Findings also point to unhealthy soda consumption during early adolescence as an important predictor of weight gain among at-risk adolescents.

Keywords

Childhood obesity; Exposure to violence; Health behaviors; Ecological Momentary Assessment

1. Introduction

Childhood obesity is currently one of the most pressing health concerns in the United States. With one in every three children now classified as overweight or obese (Ogden et al., 2014) it is predicted that we may witness a *decline* in average life expectancy for this generation (Olshansky et al., 2005). Children from minority and low socioeconomic status (SES) families are disproportionately affected (Ogden et al., 2010; Rossen, 2014; Vieweg et al., 2007). For example, a recent study found that by kindergarten entry 18% of low-income children versus 7% of children from more affluent families were classified as obese (Datar and Chung, 2015). By adolescence, over 20% of adolescents aged 12 to 19 in the US are classified as obese, with the highest rates of obesity observed among Hispanic and Non-Hispanic Black adolescents (Ogden et al., 2015). Disparities in obesity rates between children from high versus low-SES households are also widening over time (Datar and Chung, 2015).

Exposure to adversity and stressors accompanying low-income environments are reliably associated with children's health (Evans, 2004). Results from large-scale cohort studies (Boynton-Jarrett et al., 2010) and meta-analyses (Danese and Tan, 2014; Hemmingsson et al., 2014) demonstrate a robust relationship between exposure to maltreatment, violence, and obesity risk during both childhood and adulthood (Bosch et al., 2015; Clark et al., 2014; Midei and Matthews, 2011). Prior research suggests both direct and indirect effects of exposure to childhood violence on obesity. Explanations range from the influence that family violence and related stressors may have on diet and exercise patterns (for a review see Midei and Matthews, 2011) to more direct biological theories of influence. For example, violence exposure may increase obesity risk by triggering unhealthy food consumption or disordered eating or by disrupting sleep (Bosch et al., 2015; Lissau and Sorensen, 1994). The effects of violence exposure on obesity risk may also be driven by stress-related abnormalities in biological pathways, including the hypothalamic-pituitary-adrenal (HPA) axis (Adam and Epel, 2007; Heim et al., 2008) and via heightened inflammation (Danese et al., 2007; Hotamisligil, 2006). In the former case, chronic stimulation of the HPA-axis due to stressors is hypothesized to increase obesity risk by elevating cortisol levels and promoting visceral fat accumulation and/or dysregulating neuroendocrine mediators of the reward pathway (Rutters et al., 2010).

Lower physical activity is also associated with increased risk of overweight status among youth (Janssen et al., 2005) and children growing up in violent neighborhoods may engage in reduced physical activity as they lack safe places to exercise and play. Consistent with this mechanism, adolescents participating in the Project on Human Development in Chicago Neighborhoods, who lived in neighborhoods with higher levels of social disorder and lower neighborhood safety, averaged fewer hours in recreational programming than their peers living in safer and less disordered neighborhoods (Molnar et al., 2004). Similar associations between higher neighborhood violent crime levels and reduced outdoor physical activity have been documented among Mexican-American adolescent girls (Gomez et al., 2004). However, not all studies have found that adolescents living in unsafe neighborhoods engage in decreased physical activity (see for example: Lee and Cubbin, 2002).

Unfortunately, few studies have been able to isolate exactly *how* witnessing and experiencing violence influences young people's day-to-day health behaviors related to weight status. In this study we used Ecological Momentary Assessment (EMA) via mobile phones to collect daily measures of violence exposure and obesogenic behaviors for 30 consecutive days and address the following three questions: First, are there daily associations between exposure to violence and obesogenic behaviors? That is, on days that adolescents are exposed versus not exposed to violence, do they consume unhealthier food and beverages? Are violence exposure, versus non-exposure, days more likely to be followed by disrupted sleep and next day fatigue and tiredness? Second, are some adolescents (e.g., girls, racial/ethnic minorities) more "reactive" to daily violence exposure (the term "reactivity" is used to refer to the strength of the *same-day association or coupling* between violence exposure and obesogenic behaviors versus referencing a causal association)? Third, does daily violence exposure, unhealthy food consumption, or sleep disruption predict increases in adolescents' BMI or changes in overweight or obesity status across early adolescence?

This study is unique in that it employed an intensive assessment strategy where each adolescent is used as his/her own control when testing whether violence exposure was associated with *within-individual* elevations in risk for same-day obesogenic behaviors. This approach facilitates causal inference by holding constant all time-invariant factors within the adolescent. Although not sufficient to establish a causal connection, it represents a strong test of whether there are unique associations between violence exposure and behaviors that cannot otherwise be explained by often powerful invariant and potentially confounding factors, including sex, age, and socioeconomic status.

2. Method

2.1. Participants

The miLife Study used EMA via mobile phones to track daily experiences, health behaviors, and emotions of young adolescents (N = 151) living in low-income neighborhoods in California. Adolescents were, on average, 13 years of age (range = 11–15 years, SD = 0.91). Males and females were equally represented in the sample (48.3% female) and 42.7% of adolescents identified as belonging to an ethnic minority group (non-white ethnicity, primarily Latino). Parental reports (89% biological mother) were collected for 93% of the adolescents in the sample via in-person interviews (*N* = 141). The University of California Irvine Institutional Review Board and the Duke University Institutional Review Board approved all measures and procedures in the studies.

2.2. Procedures

Adolescents from low-SES neighborhoods were recruited via telephone screening. Full details of the recruitment, sample demographics, eligibility, and procedures are described in full detail elsewhere (Russell et al., 2015). Briefly, adolescents at risk for behavioral, school-related, or mental health problems based on parent reports were eligible for inclusion in the study.

Baseline assessment—Adolescents attended an in-person assessment with at least one parent. In private interview rooms, both the parent and the adolescent completed self-report inventories on laptop computers that assessed baseline height, weight, diet and exercise.

30-day EMA field-study—Following the baseline assessments, adolescents were provided with smart phones individually programmed with each adolescent's normal waking hours and schedules to "beep" three times a day for approximately 30 consecutive days. The morning survey occurred between 7 and 10 a.m. (average time 2.3 min), the afternoon survey occurred between 2 and 5 p.m. (average time of 3.8 min) and the PM survey between 5 p.m. and midnight (average time of 8.3 min). A case manager monitored incoming data, tracked response rates, and sent a text message reminder when more than two consecutive sessions were missed. On average, adolescents responded to 92% of the surveys across the 30-day assessment (resulting in over 12,400 completed surveys and over 4300 person-days; *M* = 38.0, *SD* = 13.5).

Follow-up assessment—Eighteen months later, 93% of adolescents completed an in-person follow-up assessment and a second measure of self-reported BMI was obtained for 91% of these adolescents.

EMA replication sample—We also tested whether our findings replicated in the Research on Adaptive Interests, Skills, and Environments (RAISE) study which consisted of a sample of 395 adolescents aged 11–15 assessed via EMA three times a day over 14-consecutive days. Demographics for the replication sample are provided in Supplemental Table 1 and illustrate that the EMA sample approximately represents the larger population of same-aged children attending public schools in the state of North Carolina. Respondents answered 80% of survey prompts, resulting in 13,017 total observations. As a subsample, some adolescents were also provided with wearable devices, which collected objective data on sleep duration and steps taken throughout the day (*N* = 272). Full details of the replication sample are described elsewhere (Rivenbark et al., *submitted*). As described below, similar daily measures of exposure to violence and obesogenic behaviors were collected in this study.

2.3. Measures

The daily prevalence of violence exposure and obesogenic daily outcomes across the two samples are reported in Table 1 along with the intraclass correlation coefficients (ICCs) for each measure.

Exposure to violence—Exposure to violence was measured each day in the evening survey by asking whether adolescents witnessed people fighting: at home, in school, in their neighborhoods, or "somewhere else" ("Yes" or "No"). Each day was coded as "Yes" (1) if violence exposure occurred in any context, and "No" (0) if violence exposure did not occur that day. Adolescents, on average, witnessed violence on approximately 10% of study days (N = 4329 person days). Violence exposure was most frequently reported outside (8%) versus inside the home (4%). Girls versus boys were slightly more likely to be exposed to violence (10.7% vs. 8.8%, respectively). ICCs were calculated using multilevel models to partition the variance in each outcome into its between- and within-person components. The ICC for exposure to violence was 0.20, indicating that 20% of the variance in exposure to violence was between adolescents, whereas the remaining 80% of the variance was within adolescents over time.

In the replication sample, exposure to violence was measured using a set of items that captured whether the adolescent had seen people "arguing" in their neighborhoods, homes, schools or somewhere else throughout the day (14% of study days, ICC = 0.26) and a set of items asking whether the adolescent had seen anyone "physically fighting" in their neighborhoods, homes, schools, or somewhere else throughout the day (4% of study days, ICC = 0.27). Two separate measures of exposure to violence are reported: (1) exposure to *any* violence (*arguing* and *physical fighting* combined), and (2) exposure to *physical fighting* each day, which most closely resembles the measure used in the original study with at-risk adolescents.

Obesogenic behaviors—Obesogenic behaviors were measured each day via reports of three behaviors: unhealthy consumption of food and beverages, perceived sleep quality, and physical activity. *Unhealthy dietary consumption* was measured based on the adolescents' reported daily intake of fast food, caffeinated drinks (including soda and sweet tea), not consuming any fruit, and not consuming any vegetables. Adolescents were given a "1" if they engaged in that behavior on a given day and a "0" if they did not. A composite score indexing *unhealthy food consumption* was computed for each person for each day of the study that counted the total number of behaviors. The mean unhealthy dietary consumption score was 1.26 with a standard deviation of 1.05 (N = 4330 person days), meaning that adolescents engaged in an average of 1.26 unhealthy behaviors per day. In the replication sample, adolescents reported on their daily consumption of fast food, soda and caffeinated beverages, as well as whether or not they had "healthy food" each day (descriptives for the replication sample are included Table 1).

Sleep—Sleep was measured in the morning survey when adolescents reported on the number of hours slept, their perceived sleep quality, and whether they "felt tired" (0 = No; 1 = Yes). Adolescents reported feeling tired in the morning on 61% of study days (N = 4323 person days). The mean number of sleep hours reported on study days was 8.5 (*SD* = 1.6) and adolescents reported receiving "poor" sleep on 8% of study days. Sleep was measured using the same measures in the replication sample, however adolescents were allowed to rate how tired they were on a sliding scale from 1 to 100 anchored at "Not at all" and "Very" (*M* = 44.68, *SD* = 33.2).

Participants also reported on their *duration of physical activity* for the day and were considered *physically active* if they reported engaging in 30 min or more of physical activity for a given day (1 = physically active; 0 = inactive). Adolescents reported being inactive on 68% of study days (*N* = 4245 person days). In the replication sample, physical activity was assessed via a self-reported measure of the number of minutes that the study member was physically active for, defined as a period of "increased heart rate" and having to "breathe hard some of the time." Adolescents reported being physically active for 30 min or more on 54% of study days. A subsample of 272 adolescents in the replication sample (*N* = 1147 person days) wore a wearable fitness band that monitored the number of steps taken each day (*M* = 5,762, *SD* = 3834.89: range = 120-21,521).

Obesity and overweight status—Obesity and overweight status at baseline and the 18-month follow-up was calculated by computing each adolescent's BMI based on their self-reported weight, height, gender and age (at the baseline and follow-up) based on the Centers for Disease Control and Prevention (2010) recommended guidelines. Prior work shows that adolescents' self-reported BMI can be reliably measured and used for comparisons across grade, sex, and racially and ethnically diverse subpopulations of adolescents, although it may be a more conservative measure as it is likely to underestimate the prevalence of obesity (Perez et al., 2015). Adolescents with a BMI percentile of 95 or above were considered "obese" (9% of the CA sample) and adolescents with a BMI percentile of 85 or above were considered "overweight" (14% of the CA sample). For the population representative replication sample drawn in NC, BMI was assessed in a home visit by directly measuring height and weight. Almost 21% of the replication sample was considered "obese" and 12% were considered "overweight." These differences likely reflect state differences in childhood obesity rates. For the follow-up analyses the BMI percentile measure was used as a continuous measure. No follow-up data were available for the replication sample.

2.4. Analytic strategy and statistical models

Together the studies include over 25,000 total assessments and over 9,500 person days (miLife = 4,300, RAISE = 5,276) with daily reports nested within over 540 adolescents. All models were run separately for the two samples. Multilevel models (MLMs; Raudenbush and Bryk, 2002) were used test whether adolescents were more likely to engage in obesogenic behaviors on days when they were versus were not exposed to violence (Level 1, within adolescents). We also tested whether the within-person relationship between violence exposure and obesogenic behaviors was stronger for some adolescents than others (e.g. Level 2, testing for differences in "reactivity" across racial/ethnic groups or by gender). All MLMs used a spatial power autocorrelation structure to model residual dependence over time; logistic MLMs (for tired and physical activity outcomes) also included a dispersion parameter (Bolger and Laurenceau, 2013). For linear MLM, standardized effect sizes (β) were calculated using the formula $\beta = (b^{*}s_x)/(s_y)$, where b is the unstandardized regression coefficient and s_x and s_y are the standard deviations of the predictor and outcome, respectively (Hox, 2002). Odds ratios (ORs) were estimated for logistic MLMs by exponentiating regression coefficients (e^b). Pseudo-R^2 measures for MLMs were calculated by correlating model estimates with the original outcome variables (Pampel, 2000; Singer and Willett, 2003). Both models used maximum likelihood to handle missing data, so multiple imputation is not used (see Allison, 2012).

In the miLife study regression models were used to test whether daily levels of violence exposure or obesogenic behaviors (unhealthy dietary consumption, lack of sleep, inactivity) captured during the EMA in early adolescence predicted overweight status in later adolescence using a logistic regression model (18 months following the initial assessment) or increases in BMI percentile rank over time using traditional ordinary least squares regression models.

3. Results

Do adolescents engage in more obesogenic behaviors on days when they are exposed versus not exposed to violence?

miLife Study results

Table 2 shows the results for the multilevel model examining the association between daily violence exposure and unhealthy dietary consumption, next day reports of feeling tired, and engaging in no or low levels of physical activity. Findings in Table 2 illustrate three main findings. First, adolescents engaged in unhealthier dietary consumption on days when they were versus were not exposed to violence ($\beta = 0.03$, $p = 0.01$). Second, adolescents were also more likely to report feeling tired on mornings following violence exposure days, as compared to themselves on mornings following non-violence exposure days ($OR = 1.58$, $p = 0.01$) despite no significant association between violence exposure and the number of hours slept or self-reported quality of sleep. Third, adolescents were *more* likely to be physically active on violence exposure versus non exposure days (as indicated by a positive *OR* for this outcome, $OR = 1.61$, $p = 0.01$). We found no evidence that the daily relationship between exposure to violence and obesogenic behaviors differed for girls or those who identified as belonging to an ethnic minority group.

Replication sample results

Results from the MLMs from the population-representative replication sample illustrated three main findings. First, similar to the original study, adolescents reported feeling more tired on days following violence exposure days, as compared to themselves on days following non-violence exposure days ($b = 3.3$, $p = 0.02$). Among minority-status adolescents, days with versus without reports of exposure to physical fighting were also followed by reports of poorer sleep quality ($b = 0.64$, $p = 0.04$). Second, in contrast to findings with at-risk adolescents, no statistically significant daily associations between unhealthy dietary consumption and exposure to violence were found. Third, similar to the original study, we found evidence that adolescents were more active on violence exposure versus non-exposure days, with adolescents taking more steps (as detected by a wearable device) on days were exposure to physical fighting was reported versus not reported ($b = 1118.69$, $p = 0.056$); this association was driven primarily by higher step-counts among minority-status adolescents who took, on average, 2046.66 ($p = 0.01$) more steps on physical fighting exposure versus non-exposure days. No significant associations were found between violence exposure and step counts among white adolescents ($b = 172.64$, $p = 0.83$). The interaction between minority status and exposure to physical fighting was statistically significant ($p = 0.049$). No significant associations between violence exposure and daily *self-reports* of physical activity were found in the replication sample.

Do daily violence exposure and obesogenic behaviors during early adolescence predict changes in BMI and/or becoming overweight or obese later in adolescence?

The number of days that at-risk adolescents in the original study reported consuming soda and/or caffeinated beverages during the 30-day EMA predicted higher BMI by later adolescence ($b = 2.71$, $p = 0.04$), changes in BMI from early to later adolescence ($b = 1.99$, $p = 0.03$) and, at the $p = 0.10$ level, an increased likelihood of being classified as obese or overweight by later adolescence (unadjusted model: $OR = 4.94$, 95% $CI = 1.19$ to 20.56, $p = 0.067$; adjusted model controlling for baseline BMI: $OR = 5.40$, 95% *CI*s = 1.02 to 8.6, $p = 0.096$, $N = 151$). The association between soda consumption and changes in BMI remained statistically significant when controlling for family socioeconomic status, sex, food insecurity, and reported physical activity levels. There was no association between reported exposure to violence, tiredness due to poor sleep, unhealthy dietary consumption, and physical activity across the EMA period with changes in BMI or later obesity status. Longer-term follow-up data were not available for the replication sample.

4. Discussion

Childhood obesity remains a significant threat to the health of young people. It is well documented that children exposed to violence are at increased risk for obesity (Danese and Tan, 2014). However, it is unclear whether or how violence exposure *per se* (versus other correlated factors) influences obesity risk. This study leverages high-resolution measures of adolescents' daily lives and provides evidence that violence exposure is associated with *same-day* increases in obesogenic behaviors during early adolescence. This finding is important as early adolescence is a key period for the development of obesogenic behaviors (Birch et al., 2007; Munoz et al., 1997) and strategies for coping with stressful life events (Jaaskelainen et al., 2014). Our findings are consistent with the hypothesis that violence exposure and obesity may be related, in part, through changes in health-risk behaviors in response to violent events (Boynton-Jarrett et al., 2010; Clark et al., 2014).

Violence exposure was associated with same-day increases in a number of unhealthy dietary consumption behaviors in the original sample of at-risk adolescents. At-risk adolescents' consumption of soda/caffeinated beverages was the strongest same-day correlate of exposure to violence. Furthermore, daily consumption of these beverages also predicted higher BMI in later adolescence, increases in BMI across early adolescence, and a trend towards increased overweight/obese status by later adolescence. This finding is consistent with research showing that increased soda consumption has been a strong driver of increased obesity and poor health outcomes (Vartanian et al., 2007). Our findings also inform current policy discussions related to the potential benefits of enacting policies aimed at decreasing soda consumption, particularly among adolescents (Andreyeva et al., 2011; Brownell et al., 2009; Novak and Brownell, 2011) and suggest that interventions aimed at reducing soda consumption may also need to consider environments and stressful social experiences that may increase consumption.

In both the original and replication studies we found associations between exposure to violence and next-day reports of tiredness. However, in the replication sample, we did not see evidence that violence exposure was associated with same-day elevations in unhealthy eating or soda consumption. The discrepancy in findings across studies could be due to the fact that fast food and soda consumption were more normative in the replication sample, occurring on 32% versus 59% of study days, respectively. These differences are consistent with geographic variation in childhood obesity rates across the two states from which the adolescents were sampled, with higher rates of obesity (Singh et al., 2010) and higher rates of sugary beverage consumption (Park et al., 2015) in Southern versus Western States. It is also possible that the same-day coupling between exposure to violence and unhealthy dietary consumption is only observed among adolescents with existing mental health problems (as was the case in the miLife sample of at-risk adolescents).

Obesogenic behavior changes for a given individual on violence exposure versus non-exposure days were not different for boys versus girls in our original study, despite the increased exposure to violence among girls in our study and their heightened risk for obesity in studies examining younger children (Boynton-Jarrett et al., 2010). Surprisingly, adolescents were more likely to be physically active on violence exposure versus non-exposure days. This finding was supported in study 1, based on at-risk adolescents' reports of minutes spent being physically active each day, and, again in study 2, where more steps were detected on the wearable devices on violence exposure versus non-exposure days. Given that most of the violence exposure occurred outside of the home, it is possible that spending more time outside of the home and being more mobile led to both greater violence exposure and to more physical activity on a given day. Alternatively, violence exposure may result in a "flight or fight response" that spurs more physical activity following or during a violent event. Unfortunately, adolescents reported on both physical activity and exposure to violence in the evening, and we were unable to disentangle the temporal relationship between these occurrences within the day. In the replication sample we also found that the link between greater activity and violence exposure was primarily driven by a strong association among minority-status adolescents. Future research that uses more fine-grained measures of physical activity and violence exposure, and incorporates more objective measures of physical activity, is required to further test this association.

Interestingly, among at-risk adolescents, the amount of physical activity during the 30 day EMA was not associated wtih later BMI, but the consumption of soda/caffeinated beverages was predictive of these later outcomes. Such findings are consistent with the finding that unhealthy consumption of food and beverages is a stronger predictor of weight status than physical activity among adults (Thomas et al., 2012). With respect to the role of daily violence exposure in weight status, among at-risk adolescents we find that exposure to violence is associated with same-day increases in unhealthy dietary consumption (a within-person association). However, we did not find evidence that average levels of exposure to violence during the 30-day period were associated with initial BMI or obesity status or that they predicted increased weight gain during the early adolescent period (*a between person association*). Instead, the most powerful "between" person predictor of at-risk adolescents' weight gain was their average level of soda consumption across the EMA period. The lack of an association between average violence exposure over the 30-day period and BMI at follow-up may be due the fact that violence exposure occurred only on 10% of study days; therefore, small increases in obesogenic behaviors associated with ETV may not translate into weight gain across the 18-month period we observed. In addition, most prior research has documented differences in obesity rates across "maltreated" versus "non-maltreated" children, often based on a single exposure or a cumulative polyvictimization index. This approach classifies people as either exposed versus non-exposed (a between-person approach), in contrast to our within-person approach, which examines violence as witnessed over the course of daily life and across diverse contexts. Finally, because we find similar ICCs for violence exposure in our at-risk (ICC = 0.20) and general population replication sample (ICC = 0.28), we see little evidence that the high-risk nature of our original sample restricted the between-person variability in violence exposure in a way that would limit an observation of significant between-person associations between exposure to violence across the EMA and later obesity status.

4.1. Limitations

These st0udies also had limitations. First, the EMA relied on daily self-reports of exposure to violence and obesogenic outcomes. Future research incorporating more objective and fine-grained measures, including wireless sensors, activity monitors, and daily logs of diet and physical activity, such as the wearable devices used in the replication sample, is required. Second, specific forms of violence exposure were not measured, apart from reports of witnessing "physical fighting" versus "arguing" in the replication study. Future research is required to test for the effects of multiple forms of violence exposure across the day, including exposure to violence in television, video games, and other forms of digital media. Third, adolescents in this sample were relatively young, between the ages of 11 and 15, and tests of whether these associations exist in older populations of adolescents and hold among adolescents living in areas where more extreme forms of violence (e.g., gunshots, violent street-crime) are common are required. Fourth, results did not perfectly replicate across samples. Evidence was found for an association between exposure to violence and next-day tiredness and same-day mobility across both samples. However, same-day associations between exposure to violence and unhealthy food consumption were not found in the replication sample. Future research is needed to understand how daily violence exposure is associated with a wide-range of health-risk behaviors across diverse populations. Given the time-intensive nature of these assessments, standardized protocols should be used across studies to facilitate replication attempts and data harmonization.

5. Conclusion

Childhood obesity is a serious health concern that disproportionately impacts young people from low socioeconomic families and communities, who are also more likely to be exposed to violence. This study provides evidence that violence exposure is associated with same-day increases in the consumption of unhealthy foods and beverages among at-risk adolescents, and next day reports of sleep quality among adolescents from both at-risk and representative populations, two known predictors of children's weight status. Our findings also illustrate that the consumption of soda/caffeinated beverages during early adolescence predicts both higher BMI by later adolescence and greater increases in BMI during this period. Understanding how daily exposure to violence increases risk for obesity, and obesity related behaviors, is an important next step in addressing growing health disparities and improving children's future health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2017.07.004.

References

Adam TC, Epel ES. Stress, eating and the reward system. Physiol Behav. 2007; 91:449–458. [PubMed: 17543357]

Allison PD. Handling missing data by maximum likelihood. SAS Global Forum. 2012 Apr.23

Andreyeva T, Chaloupka FJ, Brownell KD. Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue. Prev Med. 2011; 52:413–416. [PubMed: 21443899]

Birch L, Savage JS, Ventura A. Influences on the development of Children's eating behaviours: from infancy to adolescence. Can J Diet Pract Res. 2007; 68:s1–s56. [PubMed: 19430591]

Bolger, N., Laurenceau, JP. Intensive Longtiudinal Methods: an Introduction to Diary and Experience Sampling Research. Guilford Press; New York: 2013.

Bosch J, Weaver TL, Arnold LD, Clark EM. The impact of intimate partner violence on Women's physical health: findings from the Missouri behavioral risk factor surveillance system. J Interpers Violence. 2015 Advance online publication.

Boynton-Jarrett R, Fargnoli J, Suglia SF, Zuckerman B, Wright RJ. Association between maternal intimate partner violence and incident obesity in preschool-aged children: results from the Fragile Families and Child Well-being Study. Arch Pediatr Adolesc Med. 2010; 164:540–546. [PubMed: 20530304]

Brownell KD, Farley T, Willett WC, Popkin BM, Chaloupka FJ, Thompson JW, et al. The public health and economic benefits of taxing sugar-sweetened beverages. N Engl J Med. 2009; 361:1599–1605. [PubMed: 19759377]

Centers for Disease Control and Prevention. Body Mass Index for Age Tables, Children Ages 2-20 Years. CDC/National Center for Health Statistics; 2010.

Clark CJ, Spencer RA, Everson-Rose SA, Brady SS, Mason SM, Connett JE, et al. Dating violence, childhood maltreatment, and BMI from adolescence to young adulthood. Pediatr. 2014; 134:678–685.

Danese A, Pariante CM, Caspi A, Taylor A, Poulton R. Childhood maltreatment predicts adult inflammation in a life-course study. Proc Natl Acad Sci U S A. 2007; 104:1319–1324. [PubMed: 17229839]

Danese A, Tan M. Childhood maltreatment and obesity: systematic review and meta-analysis. Mol Psychiatry. 2014; 19:544–554. [PubMed: 23689533]

Datar A, Chung PJ. Changes in socioeconomic, racial/ethnic, and sex disparities in childhood obesity at school entry in the United States. JAMA Pediatr. 2015 Jul.169:696–697. [PubMed: 25984706]

Evans GW. The environment of childhood poverty. Am Psychol. 2004; 59:77–92. [PubMed: 14992634]

Gémez JE, Johnson BA, Selva M, Sallis JF. Violent crime and outdoor physical activity among inner-city youth. Prev Med. 2004; 39:876–881. [PubMed: 15475019]

Heim C, Newport DJ, Mletzko T, Miller AH, Nemeroff CB. The link between childhood trauma and depression: insights from HPA axis studies in humans. Psychoneuroendocrinology. 2008; 33:693–710. [PubMed: 18602762]

Hemmingsson E, Johansson K, Reynisdottir S. Effects of childhood abuse on adult obesity: a systematic review and meta-analysis. Obes Rev. 2014; 15:882–893. [PubMed: 25123205]

Hotamisligil GS. Inflammation and metabolic disorders. Nature. 2006; 444:860–867. [PubMed: 17167474]

Hox, J. Multilevel Analysis: Techniques and Applications. Lawrence Erlbaum Associates; Mahwah, New Jersey: 2002.

Jaaskelainen A, Nevanpera N, Remes J, Rahkonen F, Jarvelin MR, Laitinen J. Stress-related eating, obesity and associated behavioural traits in adolescents: a prospective population-based cohort study. Bmc Public Health. 2014; 14:321. [PubMed: 24708823]

Janssen I, Katzmarzyk PT, Boyce WF, Vereecken C, Mulvihill C, Roberts C, Currie C, Pickett W, The Health Behaviour in School-Aged Children Obesity Working, G. Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. Obes Rev. 2005; 6:123–132. [PubMed: 15836463]

Lee RE, Cubbin C. Neighborhood context and youth cardiovascular health behaviors. Am J Public Health. 2002; 92:428–436. [PubMed: 11867325]

Lissau I, Sorensen TIA. Parental neglect during childhood and increased risk of obesity in young adulthood. Lancet. 1994; 343:324–327. [PubMed: 7905145]

Midei AJ, Matthews KA. Interpersonal violence in childhood as a risk factor for obesity: a systematic review of the literature and proposed pathways. Obes Rev. 2011; 12:e159–172. [PubMed: 21401850]

Molnar BE, Gortmaker SL, Bull FC, Buka SL. Unsafe to Play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. Am J Health Promot. 2004; 18:378–386. [PubMed: 15163139]

Munoz KA, Krebs-Smith SM, Ballard-Barbash R, Cleveland LE. Food intakes of US children and adolescents compared with recommendations. Pediatr. 1997; 100:323–329.

Novak NL, Brownell KD. Taxation as prevention and as a treatment for obesity: the case of sugar-sweetened beverages. Curr Pharm Des. 2011; 17:1218–1222. [PubMed: 21492083]

Ogden CL, Carroll MD, Fryar CD, Flegal KM. Prevalence of obesity among adults and youth: United States, 2011–2014. NCHS Data Brief. 2015; 219:1–8.

Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014; 311:806–814. [PubMed: 24570244]

Ogden CL, Lamb MM, Carroll MD, Flegal KM. Obesity and socioeconomic status in children and adolescents: United States, 2005-2008. NCHS Data Brief. 2010:1–8.

Olshansky SJ, Passaro DJ, Hershow RC, Layden J, Carnes BA, Brody J, et al. A potential decline in life expectancy in the United States in the 21st century. N Engl J Med. 2005; 352:1138–1145. [PubMed: 15784668]

Pampel, FC. Logistic Regression: a Primer. Sage Publications; Thousand Oaks, CA: 2000.

Park S, McGuire LC, Galuska DA. Regional differences in sugar-sweetened beverage intake among US adults. J Acad Nutr Diet. 2015; 115:1996–2002. [PubMed: 26231057]

Perez A, Gabriel K, Nehme EK, Mandell DJ, Hoelscher DM. Measuring the bias, precision, accuracy, and validity of self-reported height and weight in assessing overweight and obesity status among adolescents using a surveillance system. Int J Behav Nutr Phys Act. 2015; 12:S2. [PubMed: 26222612]

Raudenbush, SW., Bryk, AS. Hierarchical Linear Models : Applications and Data Analysis Methods. Sage Publications; Thousand Oaks: 2002.

Rivenbark JG, Copeland WE, Davisson EK, Gassman-Pines A, Hoyle RH, Piontak JR, Russell MA, Odgers CL. Adolescents' Social Standing and Mental Health: Evidence from Census Data to Cellphones. (submitted).

Rossen LM. Neighbourhood economic deprivation explains racial/ethnic disparities in overweight and obesity among children and adolescents in the USA. J Epidemiol Community Health. 2014; 68:123–129. [PubMed: 24072744]

Russell MA, Wang L, Odgers CL. Witnessing substance use increases same-day antisocial behavior among at-risk adolescents: gene-environment interaction in a 30-day ecological momentary assessment study. Dev Psychopathol. 2015:1–16.

Rutters F, Nieuwenhuizen AG, Lemmens SGT, Born JM, Westerterp-Plantenga MS. Hypothalamic–Pituitary–Adrenal (HPA) axis functioning in relation to body fat distribution. Clin Endocrinol. 2010; 72:738–743.

Singer, JD., Willett, JB. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. Oxford University Press; New York: 2003.

Singh GK, Kogan MD, van Dyck PC. Changes in state-specific childhood obesity and overweight prevalence in the United States from 2003 to 2007. Arch Pediatr Adolesc Med. 2010; 164:598–607. [PubMed: 20603458]

Thomas DM, Bouchard C, Church T, Slentz C, Kraus WE, Redman LM, et al. Why do individuals not lose more weight from an exercise intervention at a defined dose? An energy balance analysis. Obes Rev. 2012; 13:835–847. [PubMed: 22681398]

Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. Am J Public Health. 2007; 97:667–675. [PubMed: 17329656]

Vieweg VR, Johnston CH, Lanier JO, Fernandez A, Pandurangi AK. Correlation between high risk obesity groups and low socioeconomic status in school children. South Med J. 2007; 100:8–13. [PubMed: 17269519]

Table 1

Daily measures of obesogenic behaviors and violence exposure in Ecological Momentary Assessment studies.

Type of Unit	Milife Study			RAISE EMA Study		
Assessments	12,400			13,028		
Person days	4300			5276		
Persons	151			395		
Measures	Scale	Mean (*SD*)	*ICC*	Scale	Mean (*SD*)	*ICC*
Exposure to violence days	0–1	0.10 (0.30)	0.20	0–1	0.16 (0.36)	0.28
Unhealthy dietary consumption	0–4	1.26 (1.05)	0.37	0–3	1.29 (0.95)	0.44
Ate fast food	0–1	0.20 (0.40)	0.09	0–1	0.32 (0.47)	0.23
Had soda	0–1	0.33 (0.47)	0.28	0–1	0.59 (0.49)	0.42
No fruit	0–1	0.33 (0.47)	0.35	n/a	n/a	n/a
No vegetables	0–1	0.41 (0.49)	0.40	n/a	n/a	n/a
No healthy food	n/a	n/a	n/a	0–1	0.39 (0.49)	0.46
Next day “tired”	0–1	0.61 (0.41)	0.33	0–100	44.7 (33)	0.48
Physically active days	0–1	0.68 (0.02)	0.27	0–1	0.46 (0.50)	0.29

Table 2

Multilevel models testing exposure to violence on daily obesogenic behaviors.

	Daily Obesogenic Outcomes					
Statistic	**Unhealthy Dietary Consumption**		**Feeling Tired**		**Physically Active**	
Fixed Effects (intercepts, slopes)	*b* (*SE*)	*OR*	*b* (*SE*)	*OR*	*b* (*SE*)	*OR*
Exposure to Violence (ETV)	0.12** (0.05)	0.03	0.46** (0.16)	1.58	0.48** (0.14)	1.61
Percentage of Days ETV (Person Level)	0.002 (0.004)	0.02	?0.002 (0.01)	1.00	0.002 (0.01)	1.00
Intercept	1.24*** (0.05)	–	0.57*** (0.14)	1.77	0.94*** (0.13)	2.57
Random Effects (variances, covariances)	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	0.41***	0.05	2.45***	0.36	2.00***	0.30
Autocorrelation	0.15***	0.02	0.11***	0.02	0.17***	0.02
Residual[a]	0.70***	0.02	0.87+		0.85+	
Variance Explained	Estimate		Estimate		Estimate	
R^2_{f}	0.2%		0.1%		0.3%	
R^2_{fr}	39.4%		36.3%		29.0%	

Note. OR=Odds ratio from a multilevel logistic model. b = unstandardized logit regression coefficient, VAR = variance parameter, COV = covariance parameter, CORR = correlation. R^2_f = Pseudo R^2 for full model using fixed effects; R^2_{fr} = Pseudo R^2 for full model using fixed and random effects.

*** $p < 0.001$,

** $p < 0.01$,

* $p < 0.05$.

[a] For logistic models, the residual is a dispersion parameter tested against 1. Models where the 95% confidence interval for the dispersion parameter does not include 1 are marked with a +.