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Maternal Perception of Neighborhood Safety as a Predictor of Child Weight Status: The Moderating Effect of Gender and Assessment of Potential Mediators

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Abstract

Objective—To determine if there is a relationship between maternal perception of neighborhood safety in 3rd grade and weight status in 5th grade children, to test if gender moderates this relationship, and to identify potential mediators.

Method—Data from 868 children and their mothers involved in the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD-SECCYD) were used to examine the relationship between maternal perception of neighborhood safety in the 3rd grade and child BMI z-score in the 5th grade. Multiple regression models were used to test this relationship, the effect of gender, and potential mediating variables (time outdoors in neighborhood, television viewing, child behavior problems and puberty status).

Results—Neighborhood safety ratings in the least safe tertile in 3rd grade, compared to the safest tertile, were associated with an increased risk of obesity independent of gender, race and income-to-needs ratio (OR = 1.59; 95% CI 1.03, 2.46), and a higher child BMI z-scores in the 5th grade among girls, but not boys, compared to the safest tertile (β = 0.33; 95% confidence interval, 0.09, 0.57). Neither amount of time spent outdoors in the neighborhood, television viewing, child behavior problems (internalizing or externalizing), nor puberty status altered the relationship.

Conclusions—Maternal perception of the neighborhood as unsafe in 3rd grade independently predicted a higher risk of obesity, and a higher BMI z-score among girls, but not boys, in the 5th grade. The relationship was not explained by several potential mediators. Further investigation is needed to explore these gender differences and potential mediators.

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Keywords

overweight; residence characteristics; neighborhood; safety; physical activity; television; child behavior; puberty

INTRODUCTION

In the context of the present childhood obesity epidemic (1), the relationship between neighborhood characteristics and obesity risk is of increasing interest and has been cited as an important area for future research (2). For example, among school-aged children, parental perception of the neighborhood as unsafe has been independently associated with an increased risk of concurrent overweight in a cross-sectional study (3) and persistent, but not new-onset, overweight in a longitudinal study (4). The relationship between neighborhood safety and children's weight status is complex, however, in that it has not proven to be consistent in younger, preschool-aged children (5) and has been conflicting when the report of neighborhood safety is provided by the child as opposed to a parent (6, 7). In addition, gender may act as a moderator of the relationship, as it has previously been found to moderate the relationship between the neighborhood environment and physical activity (8), and girls may be more vulnerable to neighborhood effects on weight status than boys. Gender as a moderator of the relationship between neighborhood safety and weight status in children, however, has not been previously explored. The relationship between neighborhood safety and increased weight status is further complicated by the number of factors which may serve as mediators, including reduced outdoor physical activity, increased indoor sedentary behaviors, increased behavioral problems and earlier puberty.

We have previously demonstrated an independent association between parental perception of the neighborhood as unsafe and an increased risk of concurrent overweight among U.S. children in first grade (3). The first objective of the present study was, using the same cohort, to test the hypothesis that maternal perception of the neighborhood as unsafe in 3rd grade is independently associated with higher weight status two years later in 5th grade. The second objective was to test the hypothesis that gender will moderate this association, with the effect being more pronounced in girls. The third objective was to test potential mediators of this relationship.

METHODS

The sample was composed of children and their parents enrolled in the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD-SECCYD), a longitudinal study examining the relationships between child behavior and development and key developmental contexts, including the child care experience (9). At birth, 1364 children were enrolled from 10 sites across the United States (10). Of these, 868 children had complete data for the predictor, outcome, and all covariates in our base model, and therefore comprised the primary sample. Children with incomplete data from 3rd and 5th grade (N=496) did not differ from the primary sample with regard to BMI z-score and the Neighborhood Safety Subscale score. Children with incomplete data were more likely to be male (56% vs 49%, $p=0.01$) and less likely to be white (77% vs 82%,

$p=0.04$) compared to the primary sample. This study was approved by the Institutional Review Boards of all pertinent institutions

Perception of Neighborhood Safety

Maternal perception of neighborhood safety was measured using responses from the Neighborhood Safety Subscale (NSS) of the Self-Care Checklist-Parent questionnaire administered during the child's 3rd grade year in school. The Self-Care Checklist-Parent is a 14-item measure of parental perception of neighborhood safety and a child's emotional readiness for self-care that has been used in multiple prior studies and has high internal reliability (11, 12).

The NSS consists of six items: (1) "It is safe for my child to walk around our neighborhood." (2) "It is safe in our neighborhood." (3) "Drug dealers are a problem in our neighborhood." (4) "My child is afraid of the big kids in the neighborhood." (5) "My child feels safe playing outside of our home." and (6) "I worry about people with guns and knives in our neighborhood." Mothers responded on a 5-point Likert scale ranging from 1 ("Not at all true") to 5 ("Really true"). The NSS score was the mean of these 6 items after reversing items (3), (4) and (6). Higher scores represent greater perceived neighborhood safety by the mother. Scores were not normally distributed and NSS tertile was therefore used as the main predictor: Tertile 1 (least safe) = 1.50 to 4.40; Tertile 2 (medium safe) = 4.50 to 4.80; and Tertile 3 (safest) = 4.83 to 5.00.

Weight Status

Height and weight were measured using standardized procedures during study visits in the 5th grade (13). BMI z-scores were calculated based on the U.S. National Center for Health Statistics age- and gender-specific norms.

Covariates

Covariates included child's gender, race/ethnicity (dichotomized as white vs. non-white), and income-to-needs ratio in 3rd grade (as a continuous variable). The income-to needs ratio expresses a family's income as a proportion of the US Census Bureau-based federal poverty line for a family of a particular size. An ITN ratio < 1 is considered "poor". Covariates examined as potential mediators are described below.

Time Outdoors in the Neighborhood—Some (14–16), but not all (5, 7), prior studies have shown an association between unsafe neighborhoods and reduced physical activity, and reduced physical activity is associated with obesity and overweight among youth (17, 18). We therefore sought to examine reduced time spent outdoors in the neighborhood as a potential mediator. Three times during the 3rd grade school year, the After School Time Use interview (19) was administered via telephone. Interviewers asked the child, among other questions, where he/she was for each 15-minute interval during the weekdays from the time of school dismissal until 6:00 pm. The child's responses were categorized into one of 13 different location categories for each of the fifteen minute after-school time intervals. In order to capture the amount of time a child may spend physically active in the neighborhood, we created a variable, Time Outdoors in the Neighborhood, by summing

responses in 2 of the location categories: “Own Home Outdoors” (any activity that took place in the yard of the child’s home or on the grounds of a child’s apartment) and “Neighborhood” (any activity that took place out and about in the neighborhood, such as playing in the street or a sand lot, roller skating down the sidewalk, riding a bike, or sports practices in the field across the street from home).

The number of 15-minute intervals (of a possible 12) spent outdoors in the neighborhood were initially summed and averaged across all interviews completed during the 3rd grade year. Time outdoors in the neighborhood was significantly higher in warmer months (April, May, June, September; $p < .001$). We therefore limited our analysis to include only the responses from interviews conducted during the warmer months of the year in order to capture the time of year when the child would spend the most time outdoors in the neighborhood. Only 41% of the sample reported spending a single 15-minute interval or more outdoors in the neighborhood during warmer months, and we therefore dichotomized time outdoors in the neighborhood as “any” versus “none.” Study site latitude was included *a priori* as a covariate along with time outdoors in the neighborhood given that mean time outdoors in the neighborhood over the course of the year was associated with warmer latitude of the study site ($p < .001$). Complete data for time spent outdoors were available for 770 subjects.

Television Viewing—Some (4, 5), but not all (6), prior studies have shown an association between unsafe neighborhoods and increased sedentary behaviors, and increased sedentary behavior is associated with increased risk of obesity and overweight independent of physical activity (18, 20). We therefore examined television (TV) viewing as a mediator. The Home Literacy Environment Questionnaire, which assesses the amount of time children watch TV (21), was completed by mothers during the child’s 3rd grade year in school. Mothers were asked to report their child’s average amount of TV viewing on weekdays, on Saturday, and on Sunday. Total hours per week were calculated.

Child Behavior Problems—To our knowledge, no study has examined behavioral problems as a potential mediator. Given that living in unsafe neighborhoods has been associated with adverse mental health and behavioral outcomes in children (12, 22) and childhood mental health and behavioral problems are associated with the development of obesity (23, 24), behavior problems could act as a mediator. Mothers completed the Child Behavior Checklist (CBCL) during the child’s 3rd grade school year. The CBCL is the most widely used measure of parent-reported problem behavior in children and has well-established reliability (25) and validity (26). The CBCL consists of 118 items, each scored on a 3-point scale ranging from not true to often true, and generates standardized age- and gender-specific T-scores. The mean (*SD*) T-score is 50 (10), and scores of 60 or above are considered to signify significant behavioral problems (26). The CBCL Internalizing and Externalizing Subscale scores were dichotomized at “>60” versus “≤ 60” and each were tested as potential covariates.

Earlier Puberty—To our knowledge, earlier puberty has not been examined as a potential mediator. Earlier puberty may act as a mediator given that unsafe neighborhoods are associated with increased childhood stress (27), which is associated with earlier puberty,

especially in girls (28, 29), and early puberty in girls has been positively associated with increased weight status (30, 31). Earlier puberty was defined dichotomously based on Tanner staging of breast and pubic hair development at 5th grade, as performed by trained, reliable examiners during a physical examination that was part of the study protocol. Tanner stage >1 for either breast or pubic hair development among girls was defined as “Puberty by 5th grade.”

Data Analysis

All data analysis was performed using SAS 9.1 (SAS Institute Inc., Cary, NC). Bivariate statistics including Chi square, analysis of variance, and t-tests were computed for each covariate to provide a description of the sample by neighborhood safety tertile. Regression analysis was performed with neighborhood safety tertile in 3rd grade as the main predictor and BMI z-score in 5th grade as the outcome. The base model included covariates gender, race/ethnicity, and income-to-needs ratio. The interaction term for gender and neighborhood safety tertile was tested and p-values of less than 0.20 were considered significant (32, 33). Each of the candidate mediator covariates was then tested by entering them one by one and in combination into the base model. If a candidate mediator covariate altered the parameter estimate (β) for neighborhood safety tertile by more than 10%, it was considered a mediating variable (33).

RESULTS

Characteristics of the sample in relation to neighborhood safety tertile are provided in Table 1. Regression analysis demonstrated that maternal perception of neighborhood safety as being in the least safe tertile compared to the safest tertile in 3rd grade predicted higher child BMI z-score in the 5th grade independent of gender, race and income-to-needs ratio (Table 2). We repeated this analysis using the middle safety tertile as the referent. Maternal perception of neighborhood safety as being in the least safe tertile compared to the middle safety tertile again predicted higher BMI z-scores independent of gender, race and income-to-needs ratio, though this did not reach statistical significance (adjusted $\beta = 0.15$; 95% CI $-0.03, 0.33$). No statistically significant association was found between neighborhood safety and BMI z-score when comparing children in the middle safety tertile to children in the highest safety tertile (adjusted $\beta = 0.03$; 95% CI $-0.14, 0.19$). We repeated this analysis using obesity (BMI 95th percentile for age and gender) as an outcome and the results were similar: Maternal perception of neighborhood safety as being in the least safe tertile compared to the highest safety tertile was associated with an increased risk of obesity independent of gender, race and income-to-needs ratio (OR = 1.59; 95% CI 1.03, 2.46).

The interaction term for gender and the least safe versus most safe neighborhood safety tertile was significant in the base model ($p = 0.17$), as was the interaction term for gender and the middle (versus highest) tertile ($p = .09$). We therefore stratified this model on gender (Table 2). Among boys, there was no significant relationship between maternal perception of neighborhood safety and BMI z-score. Among girls, maternal perception of neighborhood safety as being in the least safe tertile compared to the safest tertile in 3rd grade was

associated with a higher BMI z-score in the 5th grade independent of race and income-needs ratio ($\beta = 0.33$; 95% CI, 0.09, 0.57).

Table 3 presents the base model in girls with the inclusion of the five potential mediating covariates concurrently. Neither Time Outdoors in the Neighborhood, TV viewing, CBCL Internalizing or Externalizing Subscale scores, nor puberty status in the 5th grade individually or in combination altered the relationship between maternal perception of neighborhood safety in 3rd grade and BMI z-score in 5th grade. Although in this adjusted model, puberty was significantly independently associated with a higher BMI z-score, the main effect of neighborhood safety remained significant. These results indicate that puberty has a main effect on BMI z-score, but does not act as a mediator of the association between neighborhood safety and BMI z-score.

DISCUSSION

We found that maternal perception of the neighborhood as unsafe in 3rd grade was independently associated with a higher BMI z-score among girls, but not boys, in the 5th grade. The relationship was not explained by less time spent outdoors in the neighborhood, more television viewing, increased behavior problems in the child (internalizing or externalizing), or earlier puberty. The results are consistent with prior cross sectional work with this cohort in 1st grade (3), as well as several other reports in similarly school-aged children in which neighborhood safety was measured by parental report (4, 34).

To our knowledge, this is the first study to demonstrate a moderating effect of gender on the relationship between maternal perception of the neighborhood as unsafe and increased weight status in children. There are several potential reasons we hypothesize that the effect of perceived neighborhood safety on weight status may be stronger in girls than in boys. Living in a neighborhood perceived as unsafe may impact physical activity and sedentary behavior more in girls than in boys, since unsafe neighborhoods have been associated with reduced physical activity among women, but not men (35, 36), and the neighborhood environment affects walking frequency among girls (8). Our analysis, however, did not show reduced physical activity or increased sedentary behavior to mediate the relationship between neighborhood safety and increased weight status in girls. Internalizing and externalizing behavior problems have been found to be associated with increased weight status in girls, but not boys (37). Similarly, increased psychosocial stress, as might result from living in an unsafe neighborhood, can lead to earlier pubertal onset in girls (28, 29) which can result in subsequent weight gain (31). Our analysis, however, did not demonstrate internalizing or externalizing behaviors or earlier puberty to mediate the association between perceived neighborhood safety and body mass index in girls.

Parents of girls in our study did not perceive neighborhoods as less safe than parents of boys, though it is possible that parents may respond to the same level of perceived safety with different restrictions depending on their child's gender. Girls have higher rates of kidnapping and sexual victimization in the U.S. (38), which may cause their parents to be more protective and restrict the activities of their daughters more than those of their sons. Girls also tend to form closer, more communicative relationships with their parents than

boys (39), and thus may be more compliant with parental rules regarding their activities in the neighborhood. Therefore, whether being more restricted or more likely to comply, it is possible that living in an unsafe neighborhood would more negatively affect time spent outdoors in the neighborhood among girls, as compared to boys. We tested the interaction of gender and neighborhood safety on amount of time spent outdoors in the neighborhood, and it did not reach statistical significance, therefore not supporting this hypothesis. Lastly, the associations may be more complex, with gender acting as a moderator of neighborhood safety, race, *and* income as they relate to weight status. Further research is needed to better understand the relationship between neighborhood safety, gender and other variables, as gender differences will be an important part of future childhood obesity prevention and treatment programs.

There are several potential reasons that reduced outdoor physical activity in the neighborhood, increased television viewing, increased behavior problems, or earlier puberty did not act as mediators of the relationship among girls in our sample. First, our measures may not have been sufficiently sensitive or specific. We did not measure whether the child was physically active or not when outside in the neighborhood and it is possible that being outside does not correlate with being physically active. Prior work also has indicated that parental concerns about neighborhood safety play a stronger role in limiting outdoor activities in inner city children, compared to suburban children (15, 16). Our data set did not have information regarding the type of neighborhood, which may have acted as a moderator. Several of our measures may also have had insufficient variability to allow us to detect an effect. For example, the children in this cohort reported very little time outdoors in the neighborhood, regardless of perceived neighborhood safety.

Finally, it is possible that these findings are real, and that the relationship between neighborhood safety and overweight is truly not mediated by physical activity, sedentary behavior, behavioral problems, or earlier puberty but by some unmeasured factor. For instance, it is possible that families living in unsafe neighborhoods have less access to healthy food options and the children therefore have more obesigenic diets. Lower-income and primarily African American neighborhoods in the U.S. have been found to have both fewer supermarkets (40) and more fast-food outlets (41) per capita compared to their wealthier and white counterparts. Families living in unsafe neighborhoods may also be less likely to venture out of their homes to make frequent trips to a supermarket for fresh food. No data regarding dietary intake, supermarket or fast food accessibility were available in our dataset.

This study is limited by several factors. While mothers and children in our study came from 10 different sites across the United States, the proportion of our sample that was of minority ethnicity was somewhat limited, and generalization of these findings to more diverse populations should be done with caution. In addition, the data used in this study were gathered via standardized and validated self-report questionnaires, which are subject to over- or under-estimation.

Implications

The impact of the neighborhood environment has recently garnered attention as a potential target of prevention programs and national public policies directed at reducing childhood obesity (42). A quality neighborhood environment can provide a child with increased opportunities for physical activity and healthy behaviors, as well as improve their emotional and mental health. From a public health and policy perspective, there are many reasons to advocate for safer neighborhoods. However, much additional research is needed to better understand the mechanism linking unsafe neighborhoods with overweight risk. At minimum, our findings suggest that specific obesity prevention programs should be targeted to children living in the least safe neighborhoods given their increased risk for weight gain.

Our study examined the relationship of neighborhood safety and weight status over a period of two years. Future prospective studies should aim to track these variables over a longer period of time, as the neighborhood environment can have implications for health and weight status throughout the life course. In addition, special attention will need to be paid to characterizing the gender differences of this relationship. Once the mechanisms of the relationship are identified, more targeted interventions and specific public policies could be implemented.

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TABLE 1

Characteristics of children by neighborhood safety tertile.

	Total (N=868)	Neighborhood Safety Tertile			p-value
		Lowest (least safe) (N=264)	Middle (N = 279)	Highest (most safe) (N = 325)	
BMI z-score in the 5th Grade, mean (SD)	0.55 (1.06)	0.73 (1.08)	0.50 (1.06)	0.43 (1.04)	.002
Gender, n (%)					0.96
Male	427 (49)	130 (49)	139 (50)	158 (49)	
Female	441 (51)	134 (51)	140 (50)	167 (51)	
Race/ethnicity, n (%)					<.001
White	713 (82)	181 (69)	239 (86)	293 (90)	
Non-white/Other	155 (18)	83 (31)	40 (14)	32 (10)	
Income-to-Needs Ratio in 3rd Grade, mean (SD)	4.2 (3.4)	2.9 (2.7)	4.3 (3.1)	5.0 (3.8)	<.001
Time outdoors in the neighborhood in 3rd Grade, n (%)					0.90
None	455 (59)	127 (58)	152 (60)	176 (59)	
Any	315 (41)	92 (42)	19 (40)	122 (41)	
Television Viewing in 3rd Grade, hours/wk, mean (SD)	15.23(10.01)	17.80 (11.41)	14.75 (9.54)	13.59 (8.70)	<.001
CBCL Internalizing T-score in 3rd Grade, n (%)					<.001
> 60	108 (12)	52 (20)	27 (10)	29 (9)	
60	760 (88)	212 (80)	252 (90)	296 (91)	
CBCL Externalizing T-score in 3rd Grade, n (%)					<.001
> 60	84 (10)	50 (19)	16 (6)	18 (6)	
60	784 (90)	214 (81)	263 (94)	307 (94)	
Puberty by the 5th Grade, girls only, n (%) *					0.28
Yes	277 (79)	89 (82)	79 (74)	109 (80)	
No	74 (21)	19 (18)	28 (26)	27 (20)	

* n = 351, girls only

TABLE 2

Multiple regression models of perceived neighborhood safety in 3rd grade as a predictor of BMI z-score in 5th grade.

	Total (N=868) β (95% CI)	Boys (N=427) β (95% CI)	Girls (N=441) β (95% CI)
Base model			
NSS Tertile 1 (least safe)	0.18 (0.00, 0.36)*	-0.01 (-0.25, 0.27)	0.33 (0.09, 0.57) †
NSS Tertile 2	0.03 (-0.14, 0.19)	0.15 (-0.09, 0.40)	-0.10 (-0.33, 0.12)
NSS Tertile 3 (safest)	Referent	Referent	Referent
Gender (female vs. male)	-0.16 (-0.30, -0.02)*	-	-
Race (non-white vs. white)	0.27 (0.08, 0.46)*	0.30 (0.03, 0.58)*	0.25 (-0.01, 0.51)
Income-to-needs ratio	-0.03 (-0.05, -0.01) †	-0.05 (-0.09, -0.02) †	0.02 (-0.05, 0.01)

* p < .05,

† p < .01

TABLE 3

Multiple regression of potential mediators of relationship between neighborhood safety tertile and BMI z-score among girls (n = 308).

Covariate	β (95% CI)
NSS Tertile 1 (least safe)	0.58 (0.29, 0.87) *
NSS Tertile 2	-0.02 (-0.28, 0.24)
NSS Tertile 3 (safest)	Referent
Race (non-white/other vs. white)	0.11 (-0.21, 0.44)
Income-to-needs ratio	.01 (-0.03, 0.04)
Time Outdoors in the Neighborhood (any vs. none)	-0.05 (-0.28, 0.18)
Latitude	-0.01 (-0.03, 0.02)
Television viewing (hours/week)	0.01 (-0.01, 0.02)
CBCL Internalizing T-score (>60 vs. 60)	-0.20 (-0.57, 0.16)
CBCL Externalizing T-score (>60 vs. 60)	0.15 (-0.25, 0.54)
Puberty by the 5 th grade (yes vs. no)	0.52 (0.25, 0.79) *

*
p < .001