Actual neighborhood-level crime predicts body mass index z-score changes in a multi-racial/ethnic sample of children☆

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ABSTRACT

Longitudinal studies are warranted to clarify the influence crime has on health outcomes in children especially children representing multiple racial/ethnic backgrounds. To address this need, the current study examined whether neighborhood-level crime predicted changes in body mass index z (BMIz) scores in 373 White (W), 627 African American (AA), 1020 Hispanic (H), and 88 Asian (A), five to ten year-old boys and girls living in urban neighborhoods. Heights and weights were assessed at baseline (2012) and three-years later and used to calculate BMIz scores. Characteristics of zip codes where students lived during the three-year period were obtained at baseline from various sources. The Crime Risk Index (CRI) for each zip code was calculated using actual crime statistics. Multiple linear regression analyses were conducted to examine associations between baseline CRI and follow-up BMIz scores while controlling for other variables including BMIz at baseline. The CRI and BMIz scores differed significantly by race/ethnicity with the highest values for both noted in H. Regression analyses indicated that the CRI accounted for a significant percentage of the variance in follow-up BMIz scores in the overall sample. When race/ethnicity was considered, the CRI predicted follow-up BMIz scores only in W children. The CRI was not significantly associated with BMIz scores in the other races/ethnicities. The impact actual, neighborhood-level crime has on BMI in children is complex. Based on the existing evidence, considering actual crime as a primary target in obesity prevention would be premature especially in racial/ethnicity minority children living in urban areas.

1. Introduction

Obese children, compared to healthy weight children, are at greater risk of becoming obese adults and incurring a disproportionate amount of the burden associated with co-morbidities such as type 2 diabetes, heart disease, and stroke (Kelder et al., 1994; World Health Organization (WHO), n.d.). As obesity in childhood and adolescence serves as a major risk factor for health in later years, it is important that factors influencing weight status in childhood are identified and described in sufficient detail to provide a foundation upon which to build efficacious, effective, and sustainable obesity prevention programs.

Obesity is more prevalent among racial/ethnic minority children (primarily African American and Hispanic minorities) than White children (Ogden et al., 2015). This health disparity is, in part, due to environmental conditions that make it relatively more difficult for minority children to engage in physical activity (PA) and healthy eating behaviors (Baker et al., 2006; Gordon-Larsen et al., 2006). They tend to live in areas where PA opportunities are unavailable/inadequate, street designs and land-use do not support walking and biking, and fast food is readily available (Ding & Gebel, 2011; Lovasi et al., 2009; Humbert et al., 2006; Suminski et al., 2011; Andersen et al., 2015). Further, these effects are amplified if low-income areas are in urban zones which is where a high percentage of the aforementioned racial/ethnic minorities reside (Ding & Gebel, 2011; Zhang et al., 2014).

Crime, including actual crime (e.g., police reported), perceptions of crime, and fear of crime, is one environmental factor that could play a role in the etiology of obesity (Fish et al., 2010). Studies on adults have demonstrated significant relationships between crime-related measures, PA, and body mass index (BMI) (Kerr et al., 2015; Foster et al., 2016; Tamayo et al., 2016; De Bourdeaudhuij et al., 2015). A recent review

found statistically significant associations between crime and PA in 42.7% (38/82) of the studies on adults (Da Silva et al., 2016). Similar outcomes have been shown in adolescents and children (Shinew et al., 2013; Robinson et al., 2016; Kneeshaw-Price et al., 2015; Broyles et al., 2016; Janssen et al., 2014). Beyond this, little evidence exists linking crime to changes in weight and weight status in children. The six longitudinal studies on U.S. children conducted to date are informative, but have methodological weaknesses limiting their utility for providing clarification in this area (McTigue et al., 2015; Gable et al., 2007; Cecil-Karb & Grogan-Kaylor, 2009; Bacha et al., 2010; Datar et al., 2013; Mendoza & Liu, 2014). All used non-validated parental surveys (four had only one item) that asked about neighborhood safety or markers of crime but not crime itself. Although their samples were racial/ethnically diverse, race/ethnicity was used as a control variable and its modifying effects on crime-weight associations were not fully explored. Addressing these limitations would provide additional insight and inform efforts to reduce childhood obesity. Therefore, we examined if actual neighborhood-level (defined by the child's home zip code) crime predicted BMI changes over three years in a multi-racial/ethnic sample of five to 10-year old children living in urban areas. It was hypothesized that higher neighborhood-level crime predicts greater increases in BMI. Because this study was based on ecological models which posit that obesity results from multiple environmental influences, this hypothesis was tested in the context of several other environmental variables (e.g., food and recreational facilities, income) thought to affect weight status in children (Ding & Gebel, 2011; Sallis et al., 2006; Ding, 2013; Dunton et al., 2009; Rahman et al., 2011). We also examined the impact of the child's race/ethnicity on the crime-BMI association given evidence suggesting a key to understanding racial/ethnic health disparities is elucidating the role environmental factors (particularly crime rates which vary significantly across races/ethnicities) play in disease etiology within race/ethnicity (Lovasi et al., 2009; Humbert et al., 2006; Suminski et al., 2011; Andersen et al., 2015; Feldmeyer et al., 2013).

2. Methods

2.1. Procedures

Trained investigators collected baseline (2012) and three-year follow-up data in the fall months (Sept.–Nov.) at 42 public elementary schools located in a large, Midwestern U.S. city. During a data collection session, children reported to a large, common area of the school where assessment stations were setup. The students rotated through each station that included assessments of height and weight and other measures (e.g., blood pressure). Consent was obtained from parents to allow their child to be assessed and have their data used for research purposes. Procedures related to the current study were approved by the Institutional Review Board for the protection of human subjects and were performed in accordance with the ethical standards as per the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

2.2. Participants

A total of 3200 five to 10 year-old children from K-2nd grades were assessed at baseline. To be included in the analyses, a participant had to reside in an urban zip code, attend both baseline and follow-up assessments, and reside in their baseline zip code at follow-up. A zip code was considered "urban" if its total population was > 2500 (United States Census Bureau, 1995). Of the participants measured at baseline, 5.5% ($n = 176/3200$) did not live in an urban zip code, 19.6% ($n = 593/3024$) were lost-to-follow-up, and 13.3% (323/2431) did not reside in their baseline zip code at follow-up. Therefore, a total of 2108 participants from 24 different zip codes who met the inclusion criteria were used in the analyses. Compared to the children not included in the

follow-up assessments due to attrition or moving from their baseline zip code, the study sample was similar with respect to baseline BMIz scores (not included = 0.71 ± 0.99 vs. study sample = 0.73 ± 1.00; $t = 0.64$; $P = 0.53$), and the Crime Risk Index (CRI) (not included 359.0 ± 92.3 vs. study sample 353.6 ± 86.9; $t = -1.49$; $P = 0.14$).

2.3. Measures

2.3.1. Child-level variables

2.3.1.1. Demographics. Sex (male = 0, female = 1), age, the child's home zip code, and race/ethnicity were obtained from school records. Following a given assessment, names of participants were given to the appropriate school official who retrieved the relevant information, entered it next to the participant's name on a data recording sheet, and placed the sheet into a secure envelope which was retrieved by a researcher.

2.3.1.2. Height, weight and BMIz scores. Balance beam scales were used to assess weight to the nearest 0.1 kg, and secured stadiometers were used to measure height to the nearest 0.1 cm. Children removed their shoes and socks before stepping on the scale. Height was measured with the child standing with both heels and buttocks against a vertical stadiometer. Each child's height and weight were assessed twice during a screening session and the average of the two measures was used. A standardized weight was used to calibrate the scales before each screening session. Body mass index standard deviation (BMIz) scores were calculated according to the Centers for Disease Control and Prevention 2000 standards (Kuczmarski et al., 2000). Overweight/obese was defined as BMI ≥ 85th percentile for sex and age.

2.3.2. Zip code-level variables

2.3.2.1. Demographics. The U.S. Census Bureau's American FactFinder was used to obtain baseline, zip code-level data from the American Community Survey on median household income for occupied housing units and educational attainment (% > 18 years of age without a high school degree) (U.S. Census Bureau, n.d.).

2.3.2.2. Crime Risk Index (CRI). The CRI was used as a measure of actual, neighborhood-level crime. This metric was computed by OnBoard Informatics (http://onboardinformatics.com/) and obtained at baseline for each zip code by an author (RSS) using the online portal provided by CLRSearch.com (n.d.). It is a measure of the chance crimes (both personal and property) will be committed in a zip code during a specific time period (e.g., 1 year) when compared to all U.S. zip codes during that same time period. The national CRI average is 100 which is an indication of very low crime. The more a zip code exceeds the national CRI, the greater the chance of crime in that zip code. The CRI is based on extensive statistical analysis of the Federal Bureau of Investigation's (FBI) Uniform Crime Report data which covers roughly 95% of city, county and state law enforcement jurisdictions in the U.S. annually. Additional sources used in creation of the CRI included local and regional law enforcement data. The statistical models used by OnBoard to derive the CRI accounted for the general overall change in crime throughout the U.S., local anomalies, and the size and population of the zip code.

2.3.2.3. Consumer expenditure data. The CLRSearch website was used to determine the percentage of total, yearly retail sales (including food services) per zip code spent by consumers on health and personal care and sporting goods (Clrsearch, n.d.). The data provided on the CLRSearch website were derived from the Consumer Expenditure survey conducted by the Bureau of Labor Statistics at the U.S. Census Bureau, (n.d.). Part one of the survey is a diary in which respondents document purchases for two weeks. Part two is an interview survey which is conducted quarterly for five quarters. Approximately 95% of all expenditures are included in the interview survey.

2.3.2.4. Density of food outlets and places for PA. The number of grocery stores, convenience stores, fast-food outlets, fitness facilities, and parks in each zip code was determined using the Walk Score® search engine (https://www.walkscore.com/). A two-stage process was used to verify the Walk Score data. First, search results were screened to delete blatantly errant data (~2% of identified places). Second, a 10% subsample of the search results was verified in-person to confirm accuracy. No results were altered because of this second stage yielding confidence in the results of the procedure. Density was calculated as: # of each type of facility ÷ zip code area in square miles.

2.4. Statistical analysis

Skewness statistics were within the ± 2 range indicating their distributions were normal (Gravetter & Wallnau, 2014). Baseline BMIz scores and the CRI were compared between children included and not included in the analysis due to attrition or moving from their baseline zip code with Student *t*-tests. A one-way between groups ANOVA with Scheffe post-hoc analysis was used to compare variables between racial/ethnic groups. Pearson Product Moment Correlation coefficients were derived to examine zero-order correlations among variables. Variables significantly correlated with follow-up BMIz scores were included as predictor variables in the multivariate analyses. We used multiple linear regression to explore the independent association between the CRI and follow-up BMIz scores because our examination of multilevel models considering zip code and school effects (random intercept only) indicated that only small percentages of the variance in follow-up BMIz scores was accounted for by zip codes and schools (variance partition coefficient for zip codes = 0.012; variance partition coefficient for schools = 0.025). For the overall sample, the first model created examined the association between the CRI and follow-up BMIz scores in the context of the baseline control variables (BMIz scores, sex, educational attainment, grocery store density, and fitness facility density). The second model used the same control variables, but added race/ethnicity. The four race/ethnicity-specific models also included the baseline control variables BMIz scores, sex, educational attainment, grocery store density, and fitness facility density. Due to multi-collinearity issues, median household income and convenience store density were not included in the models. Chi square with Yate's continuity correction was used to determine if living in low (CRI < 50th percentile) vs. high (CRI > 50th percentile) crime zip codes was associated with becoming obese (follow-up BMI > 95th percentile for sex and age) in White children not obese at baseline. The significance level was set at α < 0.05 and all analyses were conducted using SPSS (SPSS, Rel. 21.0. 2015. Chicago: SPSS Inc.).

3. Results

Half the children were female (50.5%) and 34.5% and 41.6% were overweight/obese in 2012 and 2015, respectively. Further, 62.2% of the children lived in the same zip code where they attended school, 82.1% remained at the same school during the study period, and 17.9% switched to another school outside of their home zip code during the study period. Sample demographics are presented for the overall sample and by race/ethnicity in Table 1. Baseline [F(3,2104) = 17.6; $P < 0.001$; $\eta^2 = 0.02$] and follow-up BMIz scores [F(3,2104) = 22.4; $P < 0.001$; $\eta^2 = 0.03$] differed across the racial/ethnic groups ($P < 0.001$). Post-hoc analyses indicated that at baseline, BMIz scores were higher in Hispanics (0.88 ± 1.01) than Whites (0.51 ± 0.95) and African Americans (0.58 ± 1.04) (*all* $P < 0.001$). At follow-up, BMIz scores remained higher in Hispanics (0.98 ± 1.03) than Whites (0.50 ± 1.03) and African Americans (0.72 ± 1.00) (*all* $P < 0.001$). In addition, the African Americans' BMIz scores exceeded those of the Whites at follow-up ($P < 0.05$). This is reflected in the BMIz score changes (follow-up – baseline). Whites experienced a drop in BMIz scores of 0.01 over the three-year study period while African Americans

(+0.13) and Hispanics (+0.10) saw gains during this time. The CRI also varied by race/ethnicity [F(3,2104) = 356.2; $P < 0.001$; $\eta^2 = 0.34$]. According to the post-hoc analyses, the CRI was lower in Whites (249.8 ± 118.4) than the other races/ethnicities (*all* $P < 0.001$). All of the other variables differed across the racial/ethnic groups ($P < 0.001$ for all F tests).

Zero-order correlations are presented in Table 2. Baseline BMIz scores were highly correlated with follow-up BMIz scores ($r = 0.83$; $P < 0.001$). In addition, a higher CRI ($r = 0.11$; $P < 0.001$), a greater percentage of the zip code population without a HS degree ($r = 0.12$; $P < 0.01$), and greater densities of grocery stores ($r = 0.05$; $P < 0.05$) and convenience stores ($r = 0.04$; $P < 0.05$) were related to higher follow-up BMIz scores. Conversely, being male ($r = -0.06$; $P < 0.01$), lower median household incomes ($r = -0.10$; $P < 0.005$), and fewer fitness facilities per square mile ($r = -0.05$; $P < 0.05$) were correlated with higher follow-up BMIz scores.

Multiple linear regression results are shown for the overall sample in Table 3. Model 1 containing the CRI and control variables was significant [F(6,2101) = 781.9; $P < 0.001$, $R^2 = 0.691$] accounting for 69.1% of the total variance in follow-up BMIz scores. In this model, the CRI was significantly associated with follow-up BMIz scores ($t = 3.77$; $P < 0.001$) with a one SD change in the CRI predicting a 0.06 unit change in follow-up BMIz scores holding control variables in the model constant. The addition of race/ethnicity to Model 1 to create Model 2, did not significantly alter model parameters [F(7,2100) = 671.4; $P < 0.001$, $R^2 = 0.691$]; however, it did lower the standardized Beta for the CRI by 20% (0.056 to 0.045) suggesting a modifying role for race/ethnicity in terms of the association between the CRI and follow-up BMIz scores (Cohen, 1988).

Multiple linear regression results for each race/ethnicity are in Table 4. The models for Whites [F(6,363) = 115.3; $P < 0.001$, $R^2 = 0.650$], African Americans [F(6,621) = 201.0; $P < 0.001$, $R^2 = 0.657$], Hispanics [F(6,1014) = 422.2; $P < 0.001$, $R^2 = 0.712$], and Asians [F(6,82) = 29.9; $P < 0.001$, $R^2 = 0.663$] were significant. In all models, baseline BMIz scores were the strongest predictor of follow-up BMIz scores. However, the CRI was predictive of follow-up BMIz scores only in Whites ($t = 2.23$; $P < 0.05$). For each one SD change in the CRI, a 0.11 unit change in follow-up BMIz scores would be expected if other variables in the model were held constant. The only other significant predictors of follow-up BMIz scores in White children were education level ($t = -2.28$; $P < 0.05$) and fitness facility density ($t = -2.46$; $P < 0.05$). According to the Chi-square test, non-obese, White children who lived in higher compared to lower CRI zip codes, were significantly more likely to become obese at follow-up ($\chi^2(1,328) = 6.43$; $P < 0.05$). Only 2.5% (2/158) of the White children living the lower CRI zip codes became obese, whereas 10.0% (17/170) of the White children living in higher CRI zip codes became obese.

4. Discussion

Results of this study support the hypothesis that higher neighborhood-level crime predicts greater increases in BMI. This is consistent with some, but not all previous longitudinal studies on U.S. children (McTigue et al., 2015; Gable et al., 2007; Cecil-Karb & Grogan-Kaylor, 2009; Bacha et al., 2010; Datar et al., 2013). The reasons for the mixed findings are most likely due to different methodological approaches taken especially with the crime measures. Other studies used parental surveys to assess neighborhood characteristics. Although perceptions of crime correlate with weight status, the surveys used previously assessed parental perceptions of neighborhood safety and not necessarily crime (Forsyth et al., 2015). Furthermore, four of the six studies used only one question ("How safe is it for children to play outside during the day in your neighborhood?"). We used the CRI as a measure of crime which is based on FBI crime statistics, includes local and regional law enforcement data, considers other relevant variables (e.g., population size) and is scaled to the zip code level. This improvement adds credence to the

Table 1
Descriptive statistics for the overall sample and for each race/ethnicity group.

	White (n = 373)	African American (n = 627)	Hispanic (n = 1020)	Asian (n = 88)	Overall (n = 2108)
	M(SD)	M(SD)	M(SD)	M(SD)	M(SD)
Child-level variables					
Follow-up BMIz score (2015)[a,b]	0.50(1.03)	0.72(1.00)	0.98(1.03)	0.69(1.03)	0.80(1.04)
Baseline BMIz score (2012)[c]	0.51(0.95)	0.58(1.04)	0.88(1.01)	0.67(1.08)	0.72(1.02)
BMIz change (follow-up – baseline)[a]	−0.01(0.62)	0.13(0.63)	0.10 (0.57)	0.02(0.63)	0.09(0.60)
Age (y)[d]	7.36(1.39)	6.72(0.95)	6.84(1.03)	6.87(1.09)	6.90(1.10)
Zip code-level variables					
CRI (national average = 100)[e,f]	249.8(118.4)	353.4(65.4)	389.9(45.0)	369.3(71.7)	353.6(86.9)
Education (% < HS diploma)[b,e,g]	16.53(9.40)	20.17(9.11)	27.30(7.81)	27.71(8.21)	23.30(9.59)
Median household income ($)[d,h]	48,433(15,447)	37,130(8553)	35,268(7226)	34,593(6282)	38,105(10,673)
Race/ethnicity (%)					
White	65.8(29.2)	17.4(19.4)	14.9(16.8)	1.9(1.8)	36.4(23.5)
African American	28.1 (18.0)	51.2(25.4)	18.3(16.0)	2.5(1.9)	32.3(24.1)
Hispanic	31.6(15.2)	25.9(16.8)	38.4(11.9)	4.0(1.9)	28.1(17.8)
Asian	30.4(16.4)	33.2(22.6)	32.5(16.5)	3.9(2.2)	3.2(2.1)
Health & personal sales (% total sales)[c]	4.91(4.16)	4.75(3.88)	6.32(5.20)	5.25(3.75)	5.56(4.67)
Sporting good sales (% total sales)[a,f,i]	0.51(0.60)	1.03(1.13)	0.80(0.97)	0.45(0.62)	0.80(0.98)
Grocery store D (#/sq. mi.)[b,e,g]	0.76(1.23)	1.15(1.43)	1.61(1.60)	1.33(1.54)	1.33(1.54)
Convenience store D (#/sq. mi.)[e]	0.62(1.23)	1.19(1.44)	1.41(1.70)	1.60(2.02)	1.22(1.59)
Fast-food outlet D (#/sq. mi.)[e]	0.60(0.88)	1.15(1.39)	1.18(1.12)	1.17(1.16)	1.07(1.19)
Fitness facility D (#/sq. mi.)[h,j]	0.25(0.59)	0.59(1.04)	0.24(0.57)	0.15(0.34)	0.34(0.75)
Park D (#/sq. mi.)[e]	0.43(0.73)	0.79(0.90)	0.85(0.79)	0.79(0.81)	0.75(0.83)

M – mean, SD – standard deviation, BMI – body mass index, CRI – crime risk index, HS – high school, D – density, sq. mi. – square mile.
Significant post-hoc differences:
[a] Whites < African Americans and Hispanics.
[b] African Americans < Hispanics.
[c] Hispanics < Whites and African Americans.
[d] Whites > African Americans, Hispanics, Asians.
[e] Whites < African Americans, Hispanics, and Asians.
[f] Asians > Hispanics.
[g] African Americans < Asians.
[h] African Americans > Hispanics and Asians.
[i] Asians < African Americans.
[j] African Americans > Whites.

Table 2
Correlates of Follow-up (2015) BMIz scores (Pearson's r in table).

	Overall (n = 2108)
2012 BMIz score	0.83***
CRI	0.11***
Age (y)	−0.02
Sex (male = 0; female = 1)	−0.06**
Education (% < HS diploma)	0.12***
Median household income ($)	−0.10***
Health and personal sales (% of total sales)	0.001
Sporting good sales (% of total sales)	−0.03
Grocery store D (#/sq. mi.)	0.05*
Convenience store D (#/sq. mi.)	0.04*
Fast-food outlet D (#/sq. mi.)	0.02
Fitness facility D (#/sq. mi.)	−0.05*
Park D (#/sq. mi.)	0.01

BMI – body mass index, CRI – crime risk index, HS – high school, D – density, sq. mi. – square mile.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Table 3
Multivariate analysis predicting follow-up (2015) BMIz scores in the overall sample.

	Unstandardized Coefficients				95% CI for β	
	β	Std. Error	Std. Beta	t value	Lower	Upper
Model 1						
Constant	0.044	0.056		−0.79	−0.066	0.155
BMIz baseline	0.839	0.012	0.826	67.47***	0.815	0.864
CRI	0.001	0.000	0.056	3.77***	0.000	0.001
% < HS	−0.003	0.002	−0.028	−1.31	−0.008	0.002
Fitness facility D	−0.036	0.025	−0.026	−1.48	−0.085	0.012
Grocery D	0.010	0.012	0.015	0.85	−0.014	0.034
Sex	−0.016	0.025	−0.008	−0.64	−0.066	0.033
Model 2						
Constant	0.026	0.111		−0.623	−0.287	0.149
BMIz baseline	0.838	0.057	0.824	67.09***	0.813	0.862
CRI	0.001	< 0.000	0.045	2.82**	0.000	0.001
% < HS	−0.004	0.002	−0.035	−1.58	−0.008	0.001
Fitness facility D	−0.036	0.025	−0.026	−1.45	−084	0.013
Grocery D	0.010	0.012	0.015	0.82	−0.014	0.034
Sex	−0.016	0.025	−0.008	−0.641	−0.066	0.033
Race/ethnicity	0.034	0.019	0.027	1.82	−0.003	0.071

Std. – standardized; CI – confidence interval; BMI – body mass index; CRI – crime risk index; HS – high school; D – density.
** $P < 0.01$.
*** $P < 0.001$.

contention that neighborhood-level crime plays a role in the etiology of overweight/obesity among children living in urban areas.

When the analysis was stratified by race/ethnicity, the association between the CRI and follow-up BMIz scores was modified. The CRI predicted BMIz score changes over a three-year period only in White children. This was the case even though the CRI was significantly lower in Whites than the other races/ethnicities. This might be related to different perceptions, attitudes, and cultural influences related to crime existing across racial/ethnic groups. For instance, Whites are more

likely to overestimate the likelihood they will be a victim of crime and the amount of crime committed by non-Whites by roughly 25% (Pickett et al., 2012). These views are often reinforced by media crime coverage

Table 4
Multiple linear regression results predicting follow-up (2015) BMIz scores by race/ethnicity.

	Unstandardized coefficients				95% CI for β	
	β	Std. error	Std. Beta	t value	Lower	Upper
White						
Constant	0.110	0.092		1.19	−0.071	0.292
BMIz baseline	0.865	0.034	0.798	25.37**	0.798	0.932
CRI	0.001	0.000	0.113	2.23*	0.000	0.002
% < HS	−0.016	0.007	−0.148	−2.28*	−0.030	−0.002
Fitness facility D	−0.238	0.097	−0.137	−2.46*	−0.429	−0.048
Grocery D	0.078	0.045	0.093	1.72	−0.011	0.167
Sex	−0.047	0.064	−0.023	−0.74	−0.172	0.078
African American						
Constant	0.242	0.135		1.80	−0.023	0.507
BMIz baseline	0.782	0.023	0.809	34.52**	0.737	0.826
CRI	0.000	0.000	0.028	1.10	0.000	0.001
% < HS	−0.007	0.004	−0.060	−1.71	−0.014	0.001
Fitness facility D	−0.047	0.036	−0.048	−1.28	−0.118	0.025
Grocery D	0.000	0.024	0.000	−0.01	−0.048	0.048
Sex	0.048	0.047	0.024	1.03	−0.044	0.141
Hispanic						
Constant	0.065	0.165		0.396	−0.258	0.389
BMIz baseline	0.863	0.017	0.841	49.64**	0.829	0.897
CRI	0.000	0.000	0.013	0.73	0.000	0.001
% < HS	0.002	0.004	0.015	0.57	−0.005	0.009
Fitness facility D	0.014	0.042	0.008	0.34	−0.069	0.097
Grocery D	0.006	0.016	0.009	0.35	−0.026	0.037
Sex	−0.043	0.035	−0.021	−1.22	−0.111	0.026
Asians						
Constant	−0.187	0.383		−0.489	−0.949	0.574
BMIz baseline	0.783	0.060	0.824	13.16**	0.665	0.902
CRI	0.001	0.001	0.078	1.14	−0.001	0.003
% < HS	0.000	0.014	−0.001	−0.01	−0.029	0.028
Fitness facility D	0.145	0.217	0.048	0.67	−0.288	0.577
Grocery D	−0.055	0.059	−0.097	−0.92	−0.173	0.063
Sex	0.033	0.128	0.016	0.26	−0.222	0.288

B-unstandardized beta, SE-Standard Error, SB – standardized beta, CI – confidence interval, SEE – standard error of the estimate, BMI – body mass index, CRI – crime risk index, HS – high school, D - density.

* $P < 0.05$.
** $P < 0.001$.

which creates misconceptions about people of color and crime (Dorfman & Schiraldo, 2001). In relation to our findings, it is possible parents of White children (who likely controlled their child's behaviors) misinterpreted the crime environment, and thus, placed excessive limitations on their child's lifestyle activities leading to extra weight gain. Alternatively, hypersensitivity to crime may be less related to race/ethnicity than to the actual crime environment. As Broyles et al. (Broyles et al., 2016) demonstrated, children, regardless of race/ethnicity, become more physically active when crime rates decrease only if they live in relatively lower crime areas. If this is the case, then crime effects on BMI are more global and may become manifest in racial/ethnic minorities when they reside in relatively lower crime neighborhoods. Future studies are needed to explore whether crime and BMI are related in racial/ethnicity minorities exposed to low-crime environments.

The finding that neighborhood-level crime was not associated with BMIz scores in African American and Hispanic children is important and somewhat contradicts outcomes from other studies looking at PA and crime (Shinew et al., 2013; Broyles et al., 2016). In prior studies, crime was related to less outdoor activity and suppressed levels of PA. Opposite the "hypersensitivity to crime in low crime areas" explanation given above, it is possible residents of neighborhoods where crime is ever present develop, overtime, an ability to "block out" crime activity and go about normal, daily activities (Cooley-Quille & Lorion, 1999; Fitzpatrick & Boldizar, 1993; McCart et al., 2007; Mrug et al., 2008).

Individuals, including children, may adapt to violence by adjusting emotionally and physiologically allowing them to accept violence as normal. This has been shown in African American children who are relatively more likely to have early life experiences with violent crime at home which can translate to ambivalence to violence later in life (Mrug & Windle, 2010). As with previous research, we found that African American and Hispanic children, compared with White children, lived in areas with significantly higher crime (Lipton et al., 2013). Therefore, they (along with their parents) may have become "desensitized" or "hyposensitized" to high crime. In this scenario, crime and lifestyle behaviors (e.g., outdoor play) would become decoupled or unrelated which would also lead to a decoupling between crime and weight changes. However, we still observed relatively high BMIz scores in the African Americans and Hispanics suggesting the presence of factors other than crime that impacted their weight. Previous research has shown that low-income, racial/ethnic minority children tend to live in obeseogenic environments - neighborhoods with few PA opportunities and more unhealthy food choices (Suminski et al., 2011; Hilmers et al., 2012; Moore et al., 2008).

Although environmental correlates of weight status have been examined in Taiwanese children and Asian American adolescents, ours is the first study to look at the association between crime and weight changes in Asian American children (Duncan et al., 2012; PH1 et al., 2011). For the most part, the Asian children in the current study displayed characteristics very similar to the African American and Hispanic children (e.g., high BMIz scores and the CRI relative to Whites). However, as in African American and Hispanic children, the CRI did not predict changes in BMIz scores. Obviously, more research on the effects of crime on weight status/changes in Asian American children is needed.

A major strength of this study was the use of an indicator of crime based on actual crime rates. As stated previously, none of the longitudinal studies in this area conducted with U.S. children used a credible measure of neighborhood crime. Another strength was our ability to measure heights and weights on a large cohort of racially/ethnically diverse children. Measured heights and weights, while difficult to obtain, are more accurate than self-reported heights and weights in youth (B1 et al., 2007). Further, the children in the current study were measured over a three-year period while living in the same area. Finally, we considered other environmental factors thought to be related to weight status in children such as the presence of various food outlets and recreational facilities. None of these other factors predicted changes in BMIz scores which contradicts findings from previous studies (Ding & Gebel, 2011; Sallis et al., 2006; Ding, 2013; Dunton et al., 2009; Rahman et al., 2011). This could be due to differences in study design (cross-sectional vs. longitudinal), geographical study areas examined (home vs. school zip codes), and/or other study design nuances.

This study also has weaknesses that should be considered. We only used one measure of overall crime. Obtaining additional information on children's and parent's perceptions of crime, fear of crime, the type of crime (e.g., violent vs. property), and changes in crime rates may provide a richer view of crime's impact on weight status/changes. Also, additional data at the individual-level (e.g., PA levels) and/or the use of school-level or other neighborhood-level variables could provide more insight.

In conclusion, the findings of this study extend our understanding about weight status in children by providing evidence that actual, neighborhood-level crime predicts changes in BMIz scores and that this relationship varies as a function of race/ethnicity. Future research examining crime's impact on BMI in racial/ethnic minority children living in relatively low crime areas is warranted. In addition, there are existing initiatives that could provide "real world" accounts of how crime prevention affects health. For instance, Crime Prevention Through Environmental Design is an approach to reducing crime through built/social environmental changes which also correlate with PA behavior (Ding & Gebel, 2011; Lovasi et al., 2009; Cozens & Love, 2015).

Disclosure of potential conflicts of interest

The authors declare that they have no conflict of interest.

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