The Influence of Neighborhood Crime on Increases in Physical Activity during a Pilot Physical Activity Intervention in Children

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ABSTRACT *The purpose of this study was to examine whether neighborhood crime moderated the response (increases in steps) to a pilot intervention to increase physical activity in children. Twenty-seven insufficiently active children aged 6–10 years (mean age = 8.7 years; 56 % female; 59 % African American) were randomly assigned to an intensive intervention group (IIG) or minimal intervention group (MIG). Change in average daily number of steps from baseline was regressed against an index of neighborhood crime in a multilevel repeated-measures model that included a propensity score to reduce confounding. Safer neighborhoods were associated with higher increases in steps during the pilot intervention (interaction $p = 0.008$). Children in the IIG living in low-crime neighborhoods significantly increased their physical activity (5275 ± 1040 steps/day) while those living in high-crime neighborhoods did not (1118 ± 1007) (p for difference = 0.046). In the IIG, the increase in daily steps was highly correlated with neighborhood crime ($r = 0.58$, $p = 0.04$). These findings suggest the need for physical activity interventions to account for participants' environments in their design and/or delivery. To promote healthy behaviors in less-supportive environments, future studies should seek to understand how environments modify intervention response and to identify mediators of the relationship between environment and intervention.*

INTRODUCTION

Because environmental factors appear to be associated with youth physical activity in cross-sectional and longitudinal analyses,¹ it is important to understand whether a child's response to a physical activity intervention may also be influenced by their environment. However, few studies assess the impact of the environment on response to a physical activity intervention.^{2,3} We recently completed a pilot 12-week parent-targeted mobile phone-based intervention to increase a child's daily steps.⁴ Although not designed nor powered to be an effectiveness study, children in the both arms of the intervention significantly increased their average activity. The intervention group in which parents received additional behavioral strategies and text messages (intensive intervention group (IIG)) saw steps/day increases that were twofold greater than steps/day levels in the group receiving only daily monitoring and goal setting (minimal intervention group (MIG)) (2843.9 ± 606.9

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vs. 1425.0 ± 584.7), though this difference was not statistically significant ($p=0.10$).⁴ The purpose of the current study is to investigate the *a priori* hypothesis that neighborhood crime may impact intervention response. Specifically, we hypothesized that children living in lower crime neighborhoods would respond better to the intervention (show larger increases in steps) than children living in higher crime neighborhoods.

METHODS

Participants

Children were required to be 6–10 years old and insufficiently active, defined as <9500 steps/day for girls and <12500 for boys.⁵ A parent or guardian was required to own a mobile phone with text message capabilities and internet access. All study procedures were approved by the Pennington Biomedical Research Center Institutional Review Board.

Intervention

Children were randomly assigned to the MIG or the IIG. Full details about study design and procedures are provided elsewhere.⁴ In brief, all intervention aspects were delivered via mobile phone to the parents. Parents in both groups were asked to increase their child's activity by 6000 steps/day above baseline and to monitor their child's steps daily. Parents in the IIG received additional behavioral strategies and text messages to help achieve this goal.

Measures

Outcome: Change in Daily Steps Over 12 Weeks All children wore a pedometer (New Lifestyles 1000) every day, from waking until sleeping. Parents checked the pedometer at the end of each day and recorded the number of steps on a study-specific website using their mobile phone. Overall, 98 % of step data were successfully recorded by the parent or study coordinator. Daily recorded steps were averaged into weekly values per participant where ≥ 4 days of recorded steps were available. Overall, 349 (99.4 %) participant-weeks of average step data were available for analysis.

Covariate: Neighborhood Crime Participant addresses were collected post-consent and geocoded to Census Block Groups. Using block group to define a child's neighborhood is consistent with other research assessing environmental influences on children's physical activity.⁶ Neighborhood crime was measured by an index of total crime derived from the Uniform Crime Report data (CrimeRisk, Applied Geographic Solutions, 2010). The index is adjusted for population and scaled relative to a national index of 100. Within the sample, neighborhoods (block groups) were dichotomized as high or low crime in comparison to the sample median of 158.

Statistical Analysis

Because of differences in baseline characteristics between participants from high- and low-crime neighborhoods, a propensity score was used to balance covariates, thereby reducing the effects of confounding.⁷ The propensity score

was created as follows: (1) All covariates described in Table 1, and two-way interactions, were considered for inclusion in a model predicting neighborhood crime status. (2) Backwards selection was used to retain all terms showing adjusted associations ($p < 0.4$) with neighborhood crime status. (3) Predicted probabilities from this final model were retained as propensity scores. The model predicting neighborhood crime status showed adequate fit (Hosmer-Lemeshow GOF $p = 0.6139$) and achieved a good balance of covariates across groups (Table 1).

Weekly change in average daily number of steps from baseline was regressed against an index of neighborhood crime in a multilevel repeated-measures model (SAS version 9.3, PROC MIXED). Moderation of the intervention response was assessed via the crime-by-intervention group interaction term in a model that also controlled for propensity score. Denominator degrees of freedom for tests of fixed effects were calculated based on the Kenward-Roger approximation.⁸ Differences between least square means across crime-by-intervention group categories were adjusted for multiple comparisons. Model output was examined for potential violations of distributional assumptions and outliers.⁹

Sensitivity Analyses

The size of this pilot study may render the results more sensitive to outlying values. Although no outliers or violations of distributional assumptions were identified, the data were reanalyzed with the following changes to verify the robustness of the results: (1) the participant with the highest response to the intervention (Δ steps = 8132), who lived in a low-crime neighborhood, was removed from the analysis, and (2) neighborhood crime was re-categorized as high vs. low in comparison to the national index of 100, versus the split at the median.

RESULTS

Twenty-seven children completed the study (Table 1), with 14 randomized to the MIG and 13 to the IIG (data published elsewhere⁴). There were higher proportions of African American children, female children, and obese children living in high-crime neighborhoods; however, propensity score correction appeared to balance all observed covariates across high- and low-crime neighborhoods. The index of total neighborhood crime ranged from 7 to 326 (7–326 % of the national average) across 26 block groups in which the children resided.

The intervention (IIG vs. MIG) resulted in an increase in average number of daily steps, but only in low-crime neighborhoods (Fig. 1, interaction $p = 0.008$). Children in the IIG living in low-crime neighborhoods significantly increased their physical activity (5275 ± 1040 steps/day above baseline) while those living in high-crime neighborhoods did not (1018 ± 1007) (difference $p = 0.046$). In the IIG, the change in daily steps was highly correlated with neighborhood crime ($r = -0.58$, $p = 0.04$) (Fig. 2).

Results remained consistent across the sensitivity analyses. With the most responsive participant removed, the crime-study group interaction was remained significant ($p = 0.022$); however, the effect of crime as a significant predictor of intervention response in the IIG was attenuated ($p = 0.069$). Crime remained a

TABLE 1 Characteristics of participants and neighborhoods and differences in baseline characteristics between participants from low- and high-crime neighborhoods before and after propensity score (PS) correction

	Overall	Low crime	High crime	Before PS correction (<i>p</i> value)	After PS correction (<i>p</i> value)
Individuals					
<i>N</i>	27	13	14		
Age, mean (SD)	8.7 (1.4)	9.1 (1.5)	8.4 (1.3)	0.153	0.989
African American, %	59 %	38 %	79 %	0.041	0.163
Female sex, %	55 %	38 %	71 %	0.092	0.374
Baseline steps, mean (SD)	8622 (1955)	8608 (2190)	8634 (1794)	0.974	0.723
Obesity (% obese)	52 %	31 %	64 %	0.088	0.859
CDI-S, mean (SD)	47.1 (9.2)	46.8 (9.7)	47.3 (9.2)	0.905	0.667
Physical activity enjoyment, mean (SD)	66.6 (7.0)	66.6 (8.5)	66.6 (5.6)	0.987	0.820
Weekday sedentary time (h), mean (SD)	5.1 (4.0)	4.8 (4.4)	5.4 (3.7)	0.740	0.536
Weekend sedentary time (h), mean (SD)	8.3 (5.4)	7.2 (5.0)	9.3 (5.7)	0.326	0.993
Has TV in bedroom, %	59 %	54 %	64 %	0.581	0.509
Neighborhoods (block groups)					
<i>N</i>	26	13	13		
Total crime index, mean (range)	130 (7–326)	56 (11–136)	272 (158–449)

FIG. 1 Differential intervention response between high- and low-crime neighborhoods.

significant moderator of intervention response (interaction $p = 0.018$) even when a different categorization of high versus low crime was considered.

DISCUSSION

This study finds that neighborhood crime appears to moderate increases in daily steps in children, such that children living in low-crime neighborhoods benefitted the

FIG. 2 Correlation between change in steps and neighborhood crime in (*top panel*) the intensive intervention group and (*bottom panel*) the minimal intervention group.

most from a parent-targeted mobile phone-based physical activity intervention. Crime has been associated with lower levels of youth physical activity both cross-sectionally^{10–12} and longitudinally¹¹ and is cited as a barrier to physical activity by parents.^{13–15} These results suggest that a neighborhood environment unsupportive of physical activity may also prevent a child from being able to respond to a physical activity intervention.

Our results support other research exploring the relationship between crime and youth physical activity. In a large sample of 11–15-year-old children, both objectively measured crime and perceived neighborhood safety independently predicted physical activity occurring outside of school hours.¹² Also, parents frequently mention safety concerns as barriers to their children's physical activity,^{13–15} and parental fear about safety has been negatively associated with children's physical activity.^{10,11} Furthermore, our results support that of another study showing environmental modification of a youth-targeted physical activity intervention. In an intervention substituting physical activity for sedentary behavior, children living within 0.5 mi of a park increased their physical activity more than children not living near parks.² The authors hypothesized that the intervention “pushed” children outdoors, and this effect was enhanced by having a nearby park to “pull” children into the neighborhood. Applying this analogy to the current study, crime fails to “pull” children outdoors, while perhaps also creating a barrier to the intervention's “pushing” children outdoors.

Recommendations around environmental support for physical activity are generally based on cross-sectional studies,¹⁶ which cannot establish causal relationships between the environment and physical activity. A particular strength of this study is that the environmental “exposure” temporally precedes the intervention response. Furthermore, this study relied on objective measures of both the outcome (daily steps) and the neighborhood environment measure (crime). The main weakness, however, is that the observed effect of high- versus low-crime neighborhoods could be confounded by other factors that correlate with neighborhood crime. This weakness was addressed using propensity scores, which allow observational studies to achieve a comparable balance in covariates across treatment groups (in this case, neighborhood crime levels) as achieved by randomized studies.^{7,17} Also, using propensity scores allows for control of a large number of variables without overparameterizing the analytic model,¹⁷ which was important because of the small number of children in this pilot study. While the association between neighborhood crime level and intervention response appears to be robust, it is likely that the neighborhood environments differ according to other characteristics besides crime.¹⁸ The small sample precluded control for other neighborhood differences; therefore, these results do not depict the independent effect of crime on intervention response. Weaknesses of the pilot intervention include the lack of a true control group; however, it is unlikely that this biased our results in the direction of finding an association. Furthermore, because these results are based on a small sample of children in a pilot study, it is important that results be explored in larger studies.

These results have implications for behavior change research. Children living in neighborhood environments less-supportive of physical activity are more likely to be racial/ethnic minorities and from lower socioeconomic classes.^{19,20} When both environmentally-advantaged and -disadvantaged groups experience similar health improvements due to a population-based physical activity intervention, absolute differences in health will persist even as overall population health increases. On the

other hand, if physical activity interventions are less effective in less-supportive environments, then environmentally-disadvantaged groups will experience smaller health gains, and health inequalities will increase. In short, if children living in unsupportive neighborhood environments are less likely to benefit from behavioral interventions, then current interventions may contribute to health disparities. To promote healthy behaviors in less-supportive environments, future studies should seek to understand how environments modify intervention response and to identify mediators of the relationship between environment and intervention. Lastly, interventions may need to account for participants' environments in their design or delivery.

AUTHORS' CONTRIBUTIONS

STB conceived of the study, performed the analyses, and drafted the manuscript. RLNJr acquired the data (designing and directing the pilot intervention), aided with interpretation, and critically reviewed the manuscript. KTD, CAM, and AMM helped with data acquisition and critically reviewed the manuscript. TSC aided with interpretation and critically reviewed the manuscript. All authors provided final approval of the manuscript and agree to be to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

COMPLIANCE WITH ETHICAL STANDARDS

Funding Source. This work was supported in part by an American Heart Association grant 11GRNT7750027 (Broyles). RLNJr was supported by unrestricted funds from the Coca-Cola Foundation. The sponsors had no role in the design or conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript.

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