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## Neighborhood Crime-Related Safety and Its Relation to Children's Physical Activity

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**ABSTRACT** *Crime is both a societal safety and public health issue. Examining different measures and aspects of crime-related safety and their correlations may provide insight into the unclear relationship between crime and children's physical activity. We evaluated five neighborhood crime-related safety measures to determine how they were interrelated. We then explored which crime-related safety measures were associated with children's total moderate-to-vigorous physical activity (MVPA) and MVPA in their neighborhoods. Significant positive correlations between observed neighborhood incivilities and parents' perceptions of general crime and disorder were found ( $r=0.30$ ,  $p=0.0002$ ), as were associations between parents' perceptions of general crime and disorder and perceptions of stranger danger ( $r=0.30$ ,  $p=0.0002$ ). Parent report of prior crime victimization in their neighborhood was associated with observed neighborhood incivilities ( $r=0.22$ ,  $p=0.007$ ) and their perceptions of both stranger danger ( $r=0.24$ ,  $p=0.003$ ) and general crime and disorder ( $r=0.37$ ,  $p<0.0001$ ). After accounting for covariates, police-reported crime within the census block group in which children lived was associated with less physical activity, both total and in their neighborhood ( $\beta=-0.09$ ,  $p=0.005$ ,  $\beta=-0.01$ ,  $p=0.02$ , respectively). Neighborhood-active children living in the lowest crime-quartile neighborhoods based on police reports had 40 min more of total MVPA on average compared to neighborhood-active children living in the highest crime-quartile neighborhoods. Findings suggest that police reports of neighborhood crime may be contributing to lower children's physical activity.*

**KEYWORDS** *Crime, Neighborhood, Children, Physical activity*

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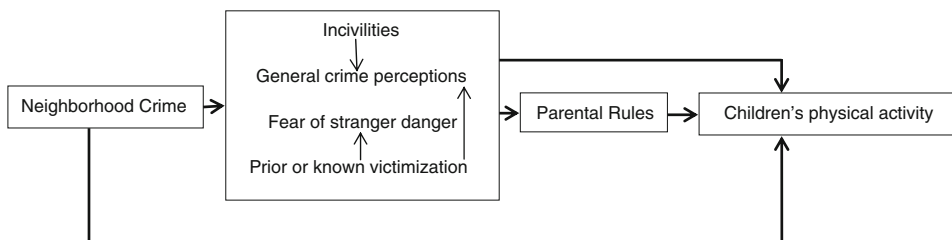
## INTRODUCTION

Neighborhood crime is both a societal safety and public health issue. Not only can it directly harm residents through its violent manifestations but also it can indirectly harm residents through stress and impacts on health behaviors. In particular, higher crime or lower safety (perceived and actual) may impede physical activity, particularly in urban neighborhoods.<sup>1-13</sup> Issues of crime-related safety may be especially pertinent to children's physical activity. Through parent supervision and control, children may be precluded from moving freely through areas perceived as unsafe.

Research on crime and parents' perceptions of crime and children's physical activity remains mixed with most studies finding no relationship.<sup>14-16</sup> Some have suggested that measurement differences may play a role in these mixed findings,<sup>6,15,17</sup> while others have noted little variation or perhaps limited sensitivity in their crime measures.<sup>17,18</sup> Furthermore, crime can be considered a component of the broader construct of safety that can include traffic and poorly maintained playground equipment, and different measures of safety and crime may not be correlated with one another. For example, gang-related activity and auto traffic both can influence the safety of a neighborhood but may not be correlated. These measures in turn may have distinct associations with physical activity. There are multiple dimensions of crime-related safety, and it is important to examine the associations between multiple dimensions of crime-related safety and children's physical activity. For example, few studies have examined both official crime statistics and residents' safety perceptions in relation to physical activity.<sup>2,5-7,19</sup>

Figure 1 presents a conceptual model depicting possible relationships between several dimensions of neighborhood crime-related safety and children's physical activity. First, high rates of crime in a child's neighborhood may directly inhibit children's physical activity through increased exposure to crime including victimization and witnessing or hearing about victimization.<sup>3,6,9,12,20-23</sup> Crime victims may have a stronger negative perception of neighborhood crime and violence than those who have never been victimized or do not know anyone personally who was previously victimized.<sup>3,20-22</sup> This increased exposure or victimization may in turn heighten parents' fears of crimes occurring against their children, reducing the likelihood of letting children be active in their neighborhood.

Second, neighborhood crime may impinge on children's physical activity through indications of its presence, even without direct observation of criminal behavior. Signs of crime (often termed "incivilities") such as graffiti, broken glass, and other indicators of social or physical disorder may increase parents' perceptions of the



**FIG. 1** Proposed conceptual model of relationship between crime and children's physical activity. (Originally published in Kneeshaw-Price SH. Safe streets are healthy streets: The role of crime and traffic in neighborhood health. Transportation Alternatives Web site. [http://www.transalt.org/files/newsroom/reports/2012/Safe\\_Streets\\_are\\_Healthy\\_Streets.pdf](http://www.transalt.org/files/newsroom/reports/2012/Safe_Streets_are_Healthy_Streets.pdf). Published December 2012.)

presence of crime and diminished sense of safety.<sup>6,9,12,20,21,24,25</sup> In addition, incivilities may directly discourage children's physical activity by creating an aesthetically unpleasant environment or increasing child's safety risk (e.g., broken glass and drug paraphernalia).<sup>8</sup> Consistent presence of incivilities in the neighborhood may heighten parents' fears that crime is "just around the corner" and that children lack judgment about dangerous situations and are without means to defend themselves.<sup>20,23,24</sup> Parents who worry about children's safety from crime and incivilities keep a watchful eye on children and often limit children being outside the confines of their home, perhaps resulting in higher sedentary behavior (i.e., "screen time") and lower physical activity as a consequence.<sup>8,23,25-27</sup> Thus, not only may crime and its indicators directly deter children's physical activity in their neighborhood, parents' perceptions and rules may also be a key pathway in this relationship.

Safety can be conceptualized through multiple perspectives and measured in several ways. The present study examined five dimensions of crime-related safety, including criminal behavior reported to law enforcement, incivilities measured via pedestrian audits, and parent report of three aspects of crime and victimization. The study aims were to determine the inter-relatedness among the crime-related safety measures and their relations to children's physical activity.

## METHODS

### Study Design

The current study used baseline data from a cohort of 6–11-year-old children living in the city of San Diego, CA, from an observational prospective cohort study, Neighborhood Impact on Kids (NIK). The NIK Study examined neighborhood and individual factors related to weight, physical activity, and nutrition behaviors.<sup>28</sup>

This study was approved by the Institutional Review Boards at Seattle Children's Hospital and San Diego State University. Adults and children gave consent and assent, respectively.

### Neighborhood Selection

Details of neighborhood selection in NIK are described elsewhere,<sup>29</sup> but briefly, neighborhood was defined as a census block group. Prior to participant recruitment, neighborhoods were evaluated based on several built (e.g., availability of higher quality parks) and nutrition (e.g., presence of a grocery store or supermarket) environment characteristics in King County, WA, and San Diego County, CA, using information brought into a Geographic Information System (GIS). Neighborhoods were divided into one of four quadrants based on the presence and quality of environmental characteristics believed to be either supportive or unsupportive of physical activity and/or healthy nutrition: high physical activity environment (PAE)/high nutrition environment (NE); high PAE/low NE; low PAE/high NE; and low PAE/low NE. Neighborhood PAE was dichotomized into high physical activity environment or low physical activity environment and combined across levels of nutrition environment in the present study. For reasons described below only participants from the City of San Diego are included in the present analyses.

## Participants and Recruitment

NIK recruitment and data collection procedures have previously been described in detail.<sup>28</sup> Briefly, between September 2007 and January 2009, participants were contacted and recruited from households within the identified neighborhoods. Children were 6–11 years old, able to engage in moderate-to-vigorous physical activity, did not have a medical condition or treatment that impacted growth, were above the 10th BMI percentile for age and sex based on parent report of child weight and height, and had a parent or legal guardian willing to participate. Only one child per household was permitted to participate.<sup>28</sup>

An additional inclusion criterion for present analyses was that participants must reside in the City of San Diego, because police reports of crime were only available for this jurisdiction. One hundred fifty participants living within 103 census block groups had geocoded police-reported crime data. Of those 150 participants, 5 participants did not have corresponding parent-reported “place logs” for their physical activity (described below), resulting in a final sample of 145 participants within 99 census block groups. Table 1 provides information about these participants and their respective families and neighborhoods.

## Measures

*Field-Based Observation to Measure Neighborhood Qualities and Incivilities* Based on existing pedestrian audit tools, the research team developed an audit tool to examine community- and street-scale factors relevant to participants' neighborhood built and social environments.<sup>30</sup> For each participant, a one-fourth-mile route was selected originating from the participant's home address

**TABLE 1** Characteristics of children living in San Diego and their families and neighborhoods, 2007–2009: descriptive statistics

Demographics		
Age <sup>a</sup> , years, mean (SD)		9.2 (1.6)
Sex, <i>n</i> , (%)	Male	71 (49.0)
	Female	74 (51.0)
Race/ethnicity, <i>n</i> , (%)	Non-Hispanic white	82 (56.6)
	Hispanic	42 (29.0)
	Non-Hispanic non-white	21 (14.5)
Household income <sup>a</sup> , <i>n</i> , (%)	<\$50,000	30 (21.4)
	\$50–100,000	54 (38.6)
	>\$100,000	56 (40.0)
Neighborhood physical activity environment (PAE), <i>n</i> , (%)	Low PAE	68 (46.9)
	High PAE	77 (53.1)
Daily MVPA <sup>b</sup> , minutes, mean (SD)	Range 29.6–302.6	135.9 (49.4)
Daily neighborhood MVPA, min, mean (SD)	Range 0–39.2	1.7 (5.8)
Children with any neighborhood MVPA, <i>n</i> , (%)		29 (20.0)
Daily neighborhood MVPA for “neighborhood-active” children, min, mean (SD)	Range 0.3–39.2	8.3 (10.9)

SD standard deviation, PAE physical activity environment, MVPA moderate-to-vigorous physical activity

<sup>a</sup>*n*=145 participants, full sample size

<sup>b</sup>*n*=140 participants whose parents reported household income

<sup>c</sup>*n*=142 participants who met valid accelerometer wear time criteria

and heading in the direction of the closest commercial destination or park. Trained staff conducted these field-based audits between June 2009 and November 2009.

Several audit items proposed to represent incivilities were chosen for the present analyses a priori based on the literature.<sup>6,10</sup> The presence of liquor/alcohol stores, abandoned buildings, and unmaintained lot/field (response options 0, 1, 2+ were recoded into 0, 1, or 2) yielded a possible score of 0 to 6. Streetlights along the route were assessed as either being not present, some (e.g., overhead street lights on utility poles with wide spacing), or ample (e.g., regularly spaced pedestrian lampposts). This item was reverse scored (e.g., no lights present was assigned a 2). The presence of ten indicators of physical disorders (yes/no) were graffiti/tagging (not murals), abandoned cars, buildings with broken/boarded windows, drug paraphernalia, broken glass, beer/liquor bottle/cans, litter in yards, noticeable/excessive litter in street/sidewalk, neighborhood watch signs, and signage for commercial destinations or parks. All items were assigned a score of 0 if absent, 1 if present, with the exception of neighborhood watch signs and signage for commercial destinations or parks, which were reverse scored, giving this section a possible score of 0 to 10. Finally, ratings for the extent of both overall physical (listed above) and social disorder (e.g., stray dogs, gangs, prostitution, hostile behaviors, drug dealing, panhandlers, etc.) present were assessed separately as none (0), a little (1), some (2), or a lot (3), resulting in a possible score of 0 to 6. Scores were summed to create a total incivilities score, with higher scores indicating a greater presence of incivilities (scale of 0 to 24).

*Geocoding Police-Reported Crime Data* The City of San Diego's Police Department provided nearest cross-streets for crimes reported between 2007 and 2009, with a total of 245,174 crimes during that period. For the present paper, all types of crime were included in the measure, which included violent crimes like murder and rape, property crimes like car theft, and fraud. Nearest cross-streets of where crimes occurred were geocoded using ArcGIS v.10, with an initial match rate of 92 % (224,693 police-reported crime point data), 1 % tied (1252 point data), and 8 % unmatched (19,229 point data). Tied and unmatched police-reported point data were reviewed for spelling and ambiguous addresses and geocoded again, yielding a final match rate of 97.6 % (239,268 police-reported crime point data). X and Y coordinates of the final matched police-reported crime point data were obtained using the geometry calculator in ArcGIS, converting the geocoded point data into X and Y coordinates in 1984 World Geodetic System (WGS) decimal degrees.

Year 2000 census block group boundaries for San Diego County were retrieved to aggregate crime data to the block group level.<sup>31</sup> For each year (i.e., 2007–2009), geocoded police-reported crime point data were matched to their respective census block group using the spatial join function in ArcGIS. Crime frequencies were averaged over the 3 years to obtain an estimate of crimes for each census block group.

*Parents' Perceptions of Neighborhood Crime: Stranger Danger and General Crime and Disorder* Parents completed a survey (online or paper) that included items about neighborhood perceptions and household, parent, and child demographics. Parents' perceptions of neighborhood crime were assessed by nine items, such as "I am afraid of my child being taken or hurt by a stranger on local streets" and "There is a high crime rate [in my neighborhood]" with four possible responses ranging from strongly disagree to strongly agree (see Table 2). Items were taken from the

**TABLE 2** Factor analysis and reliability coefficients of items measuring perceptions of crime

Items from parent questionnaire	Factor	
	Stranger danger	General crime and disorder
Parents were asked to rate their agreement on potential crime/safety concerns and barriers to children's activity in their neighborhood. All questions below refer to the child's neighborhood unless otherwise specified (e.g., local park)		
I'm afraid of my child being taken or hurt by a stranger on local streets	0.86	0.02
I'm afraid of my child being taken or hurt by a stranger in my yard, driveway, or common area	0.84	-0.01
I'm afraid of my child being taken or hurt by a stranger in a local park	0.82	-0.05
I'm afraid of my child being taken or hurt by a known "bad" person (adult or child) in my neighborhood	0.70	0.07
There is nowhere to leave a bike safely	-0.19	0.76
My child would have to walk/bike through places to get there that were unsafe	0.09	0.75
There are stray dogs	-0.11	0.74
It is not safe because of crime (strangers, gangs, drugs)	0.18	0.71
There is a high crime rate	0.24	0.54
% of variance accounted for	42.60	17.03
Cumulative % of variance	42.60	59.62
Cronbach's alpha	0.84	0.77

Neighborhood Environment Walkability Scale<sup>32</sup> and the Active Where? Study.<sup>33</sup> A principal component factor analysis was performed on the full NIK sample ( $n=730$ ), with an oblique rotation (assuming that any factors that loaded were correlated with one another). This resulted in two parent safety perception factors with eigenvalues greater than 1.0, which we titled *stranger danger* and *general crime and disorder*. These factors were found to have good and acceptable internal consistency, respectively (see Table 2). Fear of stranger danger has further been studied using these items and found to be reliable using a different youth sample.<sup>33</sup> Responses for items on each factor were averaged to create summary variables, with higher scores indicating a higher parental concern for that safety factor in the neighborhood.

*Prior Crime Victimization* Parents responded to two survey questions asking if they (1) had ever been a victim of crime in their neighborhood and (2) if they knew someone who had been a victim of crime in their neighborhood, with responses on a four-point Likert scale ranging from "strongly disagree" to "strongly agree." Based on prior work by Foster and colleagues,<sup>34</sup> the dichotomized "any prior victimization variable" was created, considered present if parents responded with "somewhat agree" or "strongly agree" to either or both questions.

*Physical Activity* Children's physical activity was measured by the GT1M Actigraph accelerometer. The Actigraph has been validated and calibrated for use among children.<sup>35</sup> Accelerometers were initialized to sample and store activity counts in 30-s epochs beginning at 00:00:01 (i.e., 12:00:01 a.m.) on the first day of expected wearing. Participants were asked to wear the accelerometer for 7 days, for at least 10 h per day, during their waking hours. Upon return, the accelerometer was downloaded and screened for completeness and possible irregularities or malfunc-

tion. Participants were asked to re-wear the accelerometer if it was not worn for enough valid hours on at least 6 days. A valid hour was defined as one that had no more than 20 min of consecutive zero counts.

Age-specific cut points were employed, with moderate-to-vigorous physical activity (MVPA) defined as 3+ METs.<sup>36</sup> Participants' ages were rounded to the nearest half-year. Daily MVPA was estimated by averaging MVPA across valid days (defined as 8+ valid hours). Only participants with at least three valid days of 10+h were included ( $n=142$ ) in the present analysis.

Daily neighborhood MVPA was the average MVPA during the time children spent in their neighborhood, outside of their home, based on parent-reported place logs. In the place log instructions, neighborhood was defined as an area around the home or neighborhood but was not a specific place with an address (e.g., a friend's house). Children's yards (e.g., front and/or backyards) were considered part of their "home" location. Methods for linking MVPA to locations in NIK are described elsewhere.<sup>37</sup> The valid wear time criterion described for total average daily MVPA was relaxed to determine daily neighborhood MVPA, and all participants with physical activity by location data were included in this measure ( $n=145$ ). Of the three children not meeting the three 10+ valid hour criterion, one child had one 10+ valid hour day and five 8+ (but less than 10) valid hour days; a second child had two 10+ valid hour days and three 8+ valid hour days; and the third child had no 10+ valid hour days, three 8+ valid hour days, and 5 days with less than 8 valid hours.

*Demographic Covariates* Demographic variables included child's age, sex, race/ethnicity (categorized into non-Hispanic white, Hispanic, and non-Hispanic non-white), and household income (categorized into <\$50,000, \$50–100,000, and >\$100,000).

*Collective Efficacy* A single summary variable comprised of two scales, social cohesion and informal social control, was created to evaluate collective efficacy.<sup>38</sup> Items were reverse coded where necessary with higher values representing higher collective efficacy, and the summary variable was the average of 11 items such as "people in my neighborhood can be trusted" and how likely would neighbors respond if "they witness a crime in progress." These scales have been found to represent similar constructs and were combined by their originators.<sup>38</sup> They also have been found to have acceptable to good internal reliability.<sup>39</sup> Collective efficacy may discourage neighborhood crime (e.g., neighbors do not hesitate to alert authorities should they witness a crime in progress)<sup>6,8,20,22,25,38</sup> and increase children's physical activity (e.g., parents allow their children to play in the neighborhood partially because of the knowledge that there are other adults available to supervise children).<sup>40</sup>

*Data Analyses* All analyses were conducted using STATA 11 SE. Descriptive statistics for demographics, crime measures, and collective efficacy were calculated. Pearson's product-moment correlations among the measures of crime-related safety and with MVPA were conducted.

Two multilevel linear random effects models using robust standard errors with two levels (child and census block group as the clustering variable) were estimated to explore whether any of the crime and safety measures were significantly associated with child total MVPA and child neighborhood MVPA in minutes. Statistical models were based on principles of ecological models suggesting distal environmental

factors' associations with child physical activity may be mediated by more proximal parents' perceptions and prior crime victimization. The mixed models were run in five stages, with the environmental factor furthest away from the individual entered first (i.e., police-reported crime) and the most conceptually proximal crime measure entered last (i.e., prior crime victimization). This allowed us to view any association of these individual-level crime covariates as they were entered into the model on the environmental factors' coefficients. The five stages were as follows: (1) police-reported crime alone as the exposure of interest; (2) police-reported crime and neighborhood incivilities; (3) police-reported crime, incivilities, and parents' perceptions of crime; (4) police-reported crime, incivilities, parents' perceptions of crime, and prior crime victimization; and (5) all crime-related measures with adjustment for collective efficacy and demographic covariates. Children's total and neighborhood MVPA by police-reported crime quartiles were examined for illustrative purposes. All significance levels were set at  $\alpha < 0.05$ .

## RESULTS

Twenty percent of the full sample accrued any MVPA in the neighborhood (see Table 1). Neighborhood incivilities identified by the audit tool were generally low, as were parents' perceptions of stranger danger and general crime and disorder. However, more than 25 % of the sample reported experiencing or knowing someone who experienced victimization in their neighborhood. Parents also perceived a relatively high collective efficacy in their neighborhood (see Table 3).

There were several significant correlations among crime-related variables (range  $r = 0.17$ – $0.37$ ; see Table 4). Parents' perceptions of general crime and disorder were positively associated with parents' concerns about stranger danger. Prior crime victimization was positively associated with audit-based neighborhood incivilities and parent concerns about stranger danger and general crime and disorder. More audit-measured neighborhood incivilities were associated with higher parent perceptions of general crime and disorder. It was notable that police-reported crime was not statistically significantly related to any of the parent-reported safety variables or the audit-based incivilities measure.

After accounting for all other crime-related measures and covariates, one additional police-reported crime in the census block group was associated with a significant 0.09 min less of total MVPA ( $p = 0.005$ ) (Table 5). Putting this estimate

**TABLE 3** Descriptive statistics for crime measures and collective efficacy, San Diego

Description		
Police-reported crimes per year for 2007–2009 by census block group <sup>a</sup> , mean (SD)	Range 0.3–454.3	87.7 (98.0)
Total number of neighborhood incivilities, audit-based, mean (SD)	Range 0–12	3.2 (1.8)
Stranger danger perception, parent report, mean (SD)	Range 1–4	2.2 (0.8)
General crime and disorder perception, parent report, mean (SD)	Range 1–3.4	1.7 (0.6)
Prior victimization, parent report, <i>n</i> (%)	Yes	39 (27.1)
	No	105 (72.9)
Collective efficacy perception, parent report, mean (SD)	Range 2.1–5	3.9 (0.7)

SD standard deviation

<sup>a</sup> $n = 145$  participants, full sample size



**TABLE 4** Bivariate correlations between neighborhood crime measures and children's moderate-to-vigorous physical activity (MVPA), Pearson's  $r$  ( $p$  value)

	Police-reported crimes	Neighborhood incivilities	Stranger danger perception	General crime and disorder perception	Prior crime victimization	Mean daily MVPA (min)	Mean daily neighborhood MVPA (min)
Police-reported crimes	1.00						
Neighborhood incivilities	0.003 (0.97)	1.00					
Stranger danger perception	0.05 (0.53)	0.12 (0.16)	1.00				
General crime and disorder perception	-0.02 (0.82)	0.30 ( <b>0.0002</b> )	0.30 ( <b>0.0002</b> )	1.00			
Prior crime victimization	-0.05 (0.53)	0.22 ( <b>0.007</b> )	0.24 ( <b>0.003</b> )	0.37 ( <b>&lt;0.0001</b> )	1.00		
Mean daily MVPA (min)	-0.13 (0.13)	0.02 (0.80)	-0.03 (0.69)	0.02 (0.85)	0.01 (0.88)	1.00	
Mean daily neighborhood MVPA (min)	-0.12 (0.15)	-0.07 (0.43)	-0.11 (0.21)	-0.02 (0.83)	-0.08 (0.36)	0.17 ( <b>0.04</b> )	1.00

Correlations that were statistically significant were indicated in bold

**TABLE 5 Multilevel regression coefficients (95 % CI) of mean daily MVPA (min) for children living in San Diego, 2007–2009**

	Model 1: police-reported crime <sup>a</sup>	Model 2: police- reported crime + incivilities	Model 3: police-reported crime + incivilities + parents' perceptions of crime	Model 4: police-reported crime + incivilities + parents' perceptions of crime + prior crime victimization	Model 5: full, adjusted model <sup>b</sup>
Police-reported crime by census block group	-0.07 (-0.15, 0.02)	-0.07 (-0.15, 0.02)	-0.07 (-0.15, 0.02)	-0.06 (-0.15, 0.02)	-0.09 (-0.15, -0.03)*
Neighborhood incivilities	-	0.68 (-3.75, 5.12)	0.66 (-3.99, 5.31)	0.71 (-3.96, 5.38)	-0.71 (-3.81, 2.40)
Stranger danger perception	-	-	-2.41 (-13.05, 8.23)	-3.40 (-14.25, 7.45)	-1.29 (-7.95, 5.37)
General crime and disorder perception	-	-	1.58 (-12.67, 15.84)	1.33 (-13.50, 16.16)	3.02 (-6.73, 12.77)
Prior crime victimization <sup>c</sup>	-	-	-	1.01 (-18.90, 20.92)	2.74 (-9.62, 15.11)

CI confidence interval, MVPA moderate-to-vigorous physical activity

\*Significant,  $p=0.005$

<sup>a</sup> $n=142$  participants who met valid accelerometer wear time criteria

<sup>b</sup>Adjusted for child's age, sex, race/ethnicity, household income, collective efficacy, and neighborhood physical activity environment

<sup>c</sup>Referent category = no prior victimization

into context, the average difference between a child living in a neighborhood where police-reported crime was in the 25th percentile relative to a child living in a neighborhood in the 75th percentile would be approximately 11.8 min higher per day. None of the other crime-related measures were independently related to total MVPA.

After accounting for all other crime-related safety measures and covariates, children's neighborhood MVPA was significantly lower by 0.01 min for each additional police-reported crime ( $p=0.02$ ), which also could be interpreted as 1 min less of MVPA per 100 additional crimes (Table 6). Again, no other crime-related safety measure was independently related to children's neighborhood MVPA.

Children living in neighborhoods in the lowest crime quartile based on police reports had the highest total and neighborhood MVPA, while children in the highest crime quartile had the lowest total and neighborhood MVPA (Table 7). However, there was not a consistent linear trend in total or neighborhood MVPA across the middle quartiles. Interestingly, when children were further divided into those who had no versus any neighborhood MVPA, children in the highest crime quartile neighborhoods that had any physical activity in their neighborhood had the lowest total MVPA. The results highlight almost a 40-min-per-day lower total MVPA between children with any neighborhood activity in the highest versus lowest crime quartiles based on police reports.

## DISCUSSION

### Correlations among Crime-Related Measures

Bivariate findings suggested the presence of incivilities within a neighborhood may not go unnoticed by parents, because they were associated with parents' perceptions of greater crime and disorder in their neighborhoods. This supports a "disorder model," which posits the presence of incivilities, signals a general breakdown of the neighborhood, and symbolizes potential threats to personal safety, in turn increasing perceptions and fear of crime and social disorder.<sup>20</sup> Prior victimization may impact perceptions of safety, with more concerns about safety in the neighborhood present among those who have experienced or know someone who has experienced crime victimization, as previously demonstrated.<sup>34</sup>

### Neighborhood Crime-Related Safety and Children's Physical Activity

The only measure of crime and safety related to children's MVPA was police-reported crime. No parent-reported or audit-based measures were related to MVPA. Higher crime close to where youth lives was associated with lower MVPA after accounting for various other aspects of crime-related safety, including audit-based incivilities, parent's perceptions of safety, and demographics. Lower total MVPA was found among the highest compared to the lowest neighborhood crime areas in this study. Parents' perceptions have been found to serve as a gatekeeper for their children's physical activity in previous studies.<sup>41</sup> The lack of statistically significant findings for the other measures of safety included in the study in their associations with child physical activity may be an issue of lack of variability, as previously noted.<sup>17,18</sup> In the present study, neighborhood incivilities and parents' crime perceptions were low on average within their potential range, with relatively low variability across neighborhoods. By contrast, there was greater variability across

**TABLE 6 Multilevel regression coefficients (95 % CI) of mean daily neighborhood MVPA (min) for children living in San Diego, 2007–2009**

	Model 1: police-reported crime <sup>a</sup>	Model 2: police-reported crime + incivilities	Model 3: police-reported crime + incivilities + parents' perceptions of crime	Model 4: police-reported crime + incivilities + parents' perceptions of crime + prior crime victimization	Model 5: full, adjusted model <sup>b</sup>
Police-reported crime by census block group	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.03, -0.002)*
Neighborhood incivilities	-	-0.21 (-0.73, 0.30)	-0.20 (-0.74, 0.34)	-0.18 (-0.72, 0.37)	-0.35 (-0.95, 0.25)
Stranger danger perception	-	-	-0.74 (-1.99, 0.50)	-0.65 (-1.92, 0.61)	-0.65 (-1.88, 0.58)
General crime and disorder perception	-	-	0.28 (-1.39, 1.95)	0.47 (-1.27, 2.21)	0.42 (-1.40, 2.24)
Prior crime victimization <sup>c</sup>	-	-	-	-0.88 (-3.20, 1.43)	-0.73 (-3.02, 1.57)

CI confidence interval, MVPA moderate-to-vigorous physical activity

\*Significant  $p=0.02$

<sup>a</sup> $n=145$  participants, full sample size

<sup>b</sup>Adjusted for child's age, sex, race/ethnicity, household income, collective efficacy, and neighborhood physical activity environment

<sup>c</sup>Referent category = no prior victimization

**TABLE 7 San Diego children's total & neighborhood daily Moderate-to-Vigorous Physical Activity (MVPA) by police-reported crime quartiles, 2007–2009**

	Police-reported crime range	All children	Children getting any neighborhood physical activity	Children getting no neighborhood physical activity <sup>a</sup>
≤25th Percentile	Daily MVPA <sup>b</sup> , min (SD) Daily neighborhood MVPA <sup>c</sup> , min (SD)	0.3–25.7 144.8 (52.6) 3.3 (8.4)	151.4 (68.8) 10.9 (12.6)	141.8 (45.1) 0
>25th–50th Percentile	Police-reported crime range Daily MVPA <sup>b</sup> , min (SD) Daily neighborhood MVPA <sup>c</sup> , min (SD)	26.0–58.3 131.4 (43.6) 0.6 (1.9)	151.5 (66.6) 4.5 (2.8)	128.0 (39.2) 0
>50th–75th Percentile	Police-reported crime range Daily MVPA <sup>b</sup> , min (SD) Daily neighborhood MVPA <sup>c</sup> , min (SD)	58.7–103.3 142.1 (49.5) 2.2 (7.4)	134.7 (41.9) 9.2 (13.2)	144.6 (52.2) 0
>75th Percentile	Police-reported crime range Daily MVPA <sup>b</sup> , min (SD) Daily neighborhood MVPA <sup>c</sup> , min (SD)	103.7–454.3 124.9 (50.8) 0.4 (1.6)	111.8 (41.8) 3.7 (4.1)	126.2 (52.0) 0

SD standard deviation, MVPA moderate-to-vigorous physical activity

<sup>a</sup>Any versus no neighborhood physical activity across the entire time wearing the accelerometer; note: 80 % of the sample accrued no neighborhood MVPA

<sup>b</sup>n=142 participants who met valid accelerometer wear time criteria

<sup>c</sup>n=145 participants, full sample size

neighborhoods in the crime measure based on police reports. Future studies that select participants' neighborhood based on higher variability in these crime measures may provide different effect estimates.

### **Strengths and Limitations**

Strengths of the present study included assessment of five dimensions of crime-related safety, two objective (i.e., police-reported crime and incivilities measured by audit), two subjective (i.e., parents' perceptions of stranger danger and general crime and disorder), and prior victimization status. Specificity of construct measurement was aided by factor analysis that suggested parents' perceptions of general crime and disorder differed from perceptions of stranger danger. Consistent with recommendations, our approach provided greater detail of how neighborhood crime may manifest itself compared to a general safety measure.<sup>6,15</sup> These crime-related factors did not seem to be different measures of the single construct, based on the moderate correlations. Thus, it may be useful to include multiple crime-related measures in studies to improve understanding of the role they play in health outcomes and behaviors like physical activity.

Three years of local-level police-reported crime data likely provided more stable estimates than single years. It is also possible that the present study had more precision in the assignment of crime data to individuals by having aggregation to the census block group, which is smaller than police precinct level<sup>10</sup> or county data<sup>42</sup> that have been used in prior studies. A limitation to this measure in the current study, however, is that all police-reported crimes were included, some of which may not have as great of an impact on children's physical activity (e.g., fraud). Past studies have noted that the types of crime and the potential risks they pose to a child's safety (e.g., illegal gambling vs. aggravated assaults) may influence the degree of fear a parent experiences and in turn limits their child's activity.<sup>20,21,23,26</sup> However, there has been little examination of how various types of crime are related to physical activity, so the decision was made to include all crimes in present analyses. Future studies distinguishing between types of crime are warranted. It may be prudent to conduct a qualitative study specifically asking parents about various types of crimes and which and at what level they feel would concern them enough to restrict their children's time in the neighborhood.

The "on the ground" pedestrian audits of incivilities were participant specific, so they should be highly relevant to parent perceptions of crime and safety. One limitation is that some audits may have extended beyond the census block group, creating a mismatch between the geography of audits and police-reported crime. In addition, since the audits only measured one route and direction for each child, it is possible that crime-related safety concerns that were present within the neighborhood may not have been captured.

Another strength was that objective measures of physical activity were used, which provides several advantages over self-reported physical activity measures.<sup>43</sup> Some argue that wearing a device that measures physical activity may influence the amount of activity a child accrues while wearing it (e.g., curiosity, competition, social desirability bias). Researchers in Switzerland recently estimated that children between the ages of 7 and 11 years old (the approximate age range of the current study's sample) may have up to 5 % of "reactivity" to wearing an accelerometer on the first day of wear.<sup>44</sup> This small but potentially significant bias may influence the estimate of physical activity measured using accelerometer. Further study into this matter may be warranted, but the accelerometer continues to be a heavily favored method for measuring children's physical activity objectively. Unique to the present

study was the measure of objective physical activity in the neighborhood, using parent-reported place logs. Although validity has not yet been established for this parent-reported place log, excellent inter-rater reliability has been demonstrated.<sup>37</sup> This measurement method was expected to enhance the ability to detect associations between neighborhood crime-related measures and neighborhood physical activity. Contrary to expectations, the association of police-reported crime was stronger for total physical activity, so this question requires further study.

An important limitation was the use of cross-sectional data, so causality cannot be inferred. The generalizability of these findings is also limited; participants were able-bodied children ages 6–11 years old residing in a single US city. Children were also primarily non-Hispanic white, with less than a quarter living in households with incomes <\$50,000. The modest sample size also may have contributed to a relatively low statistical power.

The main finding of the present study was a relatively strong association of police-reported crime with children's total and neighborhood physical activity but no significant associations involving any of the perceived or observed crime-related measures. Present findings do not resolve the notable inconsistencies in studies of crime and children's physical activity<sup>33</sup> but point to the value of expanding conceptual models of crime and physical activity and continuing to explore objective crime measures.

Future studies that systematically select participants and study areas based on wider income and crime variability may provide additional understanding of how various aspects of crime and safety play a role in children's physical activity and other health outcomes and behaviors. Community-based participatory research (CBPR) may be an additional valid approach to further understanding the role of crime and parents' perceptions of safety within the neighborhood on children's physical activity (e.g., Kneeshaw-Price, 2012).<sup>45</sup> Further and larger studies of crime that incorporates and/or controls for other safety factors (e.g., traffic safety, bullying, assessment of specific local gangs) are needed to better inform policy and environmental changes that will support increases in children's physical activity. For example, it may be particularly useful to evaluate "natural experiments" of geographically targeted crime reduction efforts on parent perceptions of crime-related safety and children's physical activity. Reducing violence perpetuated by neighborhood crime is gaining relevance as a target for improving children's health behaviors including physical activity and decreasing risk for related chronic illnesses.<sup>46</sup> Recommendations for addressing the link between crime and active neighborhood living include championing the importance of addressing this relationship and community partnering with residents and professionals across public health, planning, and criminology, among other disciplines.

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