



# Objective reports versus subjective perceptions of crime and their relationships to accelerometer-measured physical activity in Hispanic caretaker-child dyads



Margaret van Bakergem<sup>a,\*</sup>, Evan C. Sommer<sup>b</sup>, William J. Heerman<sup>b</sup>, James Aaron Hipp<sup>a</sup>, Shari L. Barkin<sup>b</sup>

<sup>a</sup> Center for Geospatial Analytics and Department of Parks, Recreation and Tourism Management, North Carolina State University, 2820 Faucette Drive, Raleigh, NC 27695, United States

<sup>b</sup> Department of Pediatrics, Vanderbilt University Medical Center, 2146 Belcourt Avenue, Nashville, TN 37212, United States

## ARTICLE INFO

### Article history:

Received 16 May 2016

Received in revised form 30 November 2016

Accepted 1 December 2016

Available online 6 December 2016

### Keywords:

Child  
Crime  
Recreation  
Parents

## ABSTRACT

Crime and safety are commonly cited barriers to physical activity (PA). We had three objectives, 1) describe the association between objective crime measures and perceptions of crime, 2) analyze the relationships between each type of crime and accelerometer-measured physical activity in caretakers and young children (ages 3–5 years), and 3) explore for early gender differences in the relationship between crime and physical activity in young children. Data are from the cross-sectional baseline data of an ongoing randomized controlled trial in Nashville, Tennessee spanning September 2012 through May 2014. Data was analyzed from 480 Hispanic dyads (adult caretaker and 3–5 year old child). Objective crime rate was assessed in ArcGIS and perception of crime was measured by caretaker agreement with the statement “The crime rate in my neighborhood makes it unsafe to go on walks.” The primary outcome was accelerometer-measured physical activity over seven consecutive days. Objective and perceived crime were significantly positively correlated. Caretaker vigorous PA was significantly related to perceptions of crime; however, its relationship to objective crime was not significant. Child PA was not significantly related to caretaker perceptions of crime. However, interactions suggested that the relationship between crime rate and PA was significantly more negative for girls than for boys. Objective and subjective measures of crime rate are expected to be important correlates of PA, but they appear to have complex relationships that are different for adults than they are for young children, as well as for young girls compared to boys, and research has produced conflicting findings.

© 2016 Elsevier Inc. All rights reserved.

## 1. Introduction

While the health benefits of physical activity (PA) are well established, there is evidence that activity levels remain inadequate and vary widely across demographic subgroups. Minority females report the lowest levels of PA and almost half (47.8%) of adult Hispanic women do not engage in leisure time PA compared with 29.2% of non-Hispanic white women (Larsen et al., 2013). This disparity extends to Hispanic children (Gordon-Larsen et al., 2000) as PA levels from racial/ethnic minority groups are generally found to be lower compared to their white counterparts (Whitt-Glover et al., 2009). Within child subgroups, there are also differences between gender as boys are typically more active compared to girls (Gordon-Larsen et al., 2000; Tucker, 2008). Together, these racial/ethnic and gender disparities can lead to

adverse health outcomes, such as obesity and its associated complications (e.g., metabolic and endocrine disorders including glucose intolerance, hypertension, and dyslipidemia) and further, increase the risk of physical inactivity-related complications into adulthood (Whitaker et al., 1997) (e.g., cardiovascular disease and type 2 diabetes (Butte et al., 2007)).

Perceived safety in the built environment is a modifiable facilitator of PA for both children and adults. Research examining neighborhood environments, important venues for outdoor play and PA for children (Carver et al., 2008) and walking for adults (Foster and Giles-Corti, 2008), identifies crime and fear of crime as a potential negative influence on PA. This is especially problematic considering that walking is the most common form of moderate-intensity activity (Foster and Giles-Corti, 2008). In a study examining environmental contexts for PA behaviors in adults wearing accelerometers, results indicate that 30% of all PA episodes were categorized as walking and all walking occurred outdoors (Doherty et al., 2013). Further, Hispanic families are more likely than non-Latino whites to live in low-income urban neighborhoods with higher crime and worse environmental conditions

\* Corresponding author at: Department of Parks, Recreation, and Tourism Management College of Natural Resources, North Carolina State University, United States.  
E-mail address: [mavanbak@ncsu.edu](mailto:mavanbak@ncsu.edu) (M. van Bakergem).

(Larsen et al., 2013) likely exacerbating barriers to being physically active. Related research also suggests that perceptions of safety are rooted in sociohistorical factors related to prejudice and racism, particularly among minority males – an often underexplored issue of criminality in relation to PA in outdoor environments (Gilbert and Ray, 2015). Characterizing the association between crime and PA, especially among low-income Hispanic populations may therefore be an important contribution to combating the rising levels of physical inactivity.

Previous studies examining the relationship between neighborhood crime and PA for adults and children produced conflicting results. One study (Weir et al., 2006) found higher levels of self-reported parental anxiety about neighborhood safety leading to a lower level of children's PA in poor inner city communities compared with middle-class suburban communities. Other U.S. studies found no significant associations between adult perceived crime and PA (Voorhees and Rohm Young, 2003; Wilbur et al., 2003). Additionally, while few studies have investigated the association between objective crime and PA (Foster et al., 2014a), some that did supported the hypothesis that higher objective crime constrained walking and other physical activities (Evenson et al., 2012; McDonald, 2008). Yet, others reported no association between crime and PA (Foster et al., 2014b; Oh et al., 2010) or counter-intuitive positive associations (Mason et al., 2013). To date, however, studies examining perceived and objective crime together with objectively measured PA have not directly focused on Hispanic populations for both adults and young children.

The purpose of this study, therefore, was to characterize the relationships between crime and PA for low-income Hispanic caretaker-child dyads. Exploring this growing population and emphasizing the dyadic relationship between caretakers and children as young as three to five years old may present unique findings that ultimately contribute to understanding behavior and health outcome trajectories for growing children. Using a framework based in the socioecological model where child PA occurs in the context of family and community, we had three objectives: 1) examine the association between objective and perceived measures of crime, 2) analyze the separate relationships of objective and perceived crime with parent and child PA, and 3) use post-hoc exploratory regression analyses to determine whether there were child gender-crime interactions that might be related to child PA. For objective 2, we analyzed sedentary, light, moderate-to-vigorous, and vigorous PA levels, for objective 3, we focused on child moderate-to-vigorous PA (MVPA).

## 2. Methods

### 2.1. Participants

This study was a cross-sectional analysis of data collected prior to randomization from an on-going randomized controlled trial (RCT) of a parent-child intervention designed to prevent childhood obesity in underrepresented, minority communities – primarily Hispanic and African-American neighborhoods (Po'e et al., 2013). In our targeted recruitment zip codes, the 2010 Census reports a range in percent Hispanic or Latino (of any race) from 15.7% to 21.3%, highlighting key underrepresented populations of interest for the ongoing RCT. Our prior research has already shown that parental and child PA is correlated (Ruiz et al., 2011) leading us to focus exclusively on the associations of crime and parental or child PA, separately. Study procedures were approved by the Institutional Review Board of Vanderbilt University Medical Center. The trial is registered at [ClinicalTrials.gov](http://ClinicalTrials.gov) (NCT01316653). Caretaker-child dyads were recruited from Davidson County, TN. Dyads were eligible to participate if they received at least one form of government assistance, spoke English or Spanish, the parent was over 18 years old, the child was between ages three and five and normal weight or overweight (based on body mass index percentile  $\geq 50$ th and  $< 95$ th assessed by trained research staff), and both parent/caretaker and child could participate in PA.

The full trial recruited 610 caretaker-child dyads; however, for the current study we focused on the 555 dyads with a Hispanic caretaker. Due to missing data stemming from several sources (incomplete subjective crime surveys ( $n = 6$ ), incomplete objective crime data ( $n = 26$ ), adults who opted out or did not meet minimum wear time criteria for accelerometry ( $n = 43$ ), and children who did not meet the minimum wear time criteria ( $n = 3$ )), our final analytic sample was 480 for analyses that utilized adult accelerometry and 520 for analyses that utilized child accelerometry.

### 2.2. Measures

The primary exposure variables measured included objective crime counts and caretaker perception of neighborhood crime. The primary outcome variables were PA for both caretakers and children, as measured by accelerometry. Bivariate correlations involving PA utilized percent wear time (as opposed to minutes of wear time) because of the necessity to capture PA with a single variable while still accounting for individual differences in wear time. Regression models used minutes of PA as the outcome and included wear time as a covariate to adjust for differences.

### 2.3. Objective and perceived crime

Objective crime data from 2011 to 2012 was obtained from the Nashville Metropolitan Police Department (NMPD). This dataset consisted of all crimes reported to the police department and crimes were categorized into 74 categories. Crimes were analyzed if they were related to personal safety (e.g., aggravated assault, simple assault, robbery, intimidation, etc.) and if they had an associated address, allowing abstraction of XY coordinates for subsequent geocoding. Exclusion criteria included crime categories not related to personal safety (e.g., bad checks, betting/wagering, embezzlement, found/lost property, etc.) and if crimes did not have XY coordinates. Just over 98,000 total crimes were included in the original NMPD dataset. After removing irrelevant crime categories and those with incomplete addresses, 24,583 of the remaining crimes were geocoded in ArcGIS (v10.3). Final crime distillation included creating a half-mile radial buffer around each dyad's home address and spatially joining a count of reported crimes. Two investigators independently categorized crime data as being related to personal safety and discrepancies were discussed. Inter-rater reliability was high for identifying personal safety categories (IRR = 94%). Fig. 1 shows a consort diagram.

Perceived crime was measured by a single item assessing caretaker agreement with the statement “the crime rate in my neighborhood makes it unsafe to go on walks.” Response options were coded as: 0 = “I disagree” (safe), 1 = “I don't know/am not sure”, and 2 = “I agree” (unsafe). “I don't know/am not sure” was interpreted as an intermediate category between actively disagreeing and agreeing that crime is a problem. Informed consent and all study communication (including survey administration) were conducted in either English or Spanish according to participant preference. Bilingual research assistants administered the survey and all data were collected and stored in REDCap (Harris et al., 2009).

### 2.4. Physical activity

Objective PA was measured using accelerometers (ActiGraph GT3X) worn by both caretakers and children for seven consecutive days. Validation cut-points for four categories of PA (i.e., sedentary, light, moderate or vigorous, and vigorous) were based on previously validated algorithms for both adults and children (Troiano et al., 2008; Trost et al., 2005). Dyads achieved valid wear time if worn for at least three weekdays and one weekend for at least six hours during waking hours (5:00 am to 11:59 pm). Sensitivity analyses compared weekday to

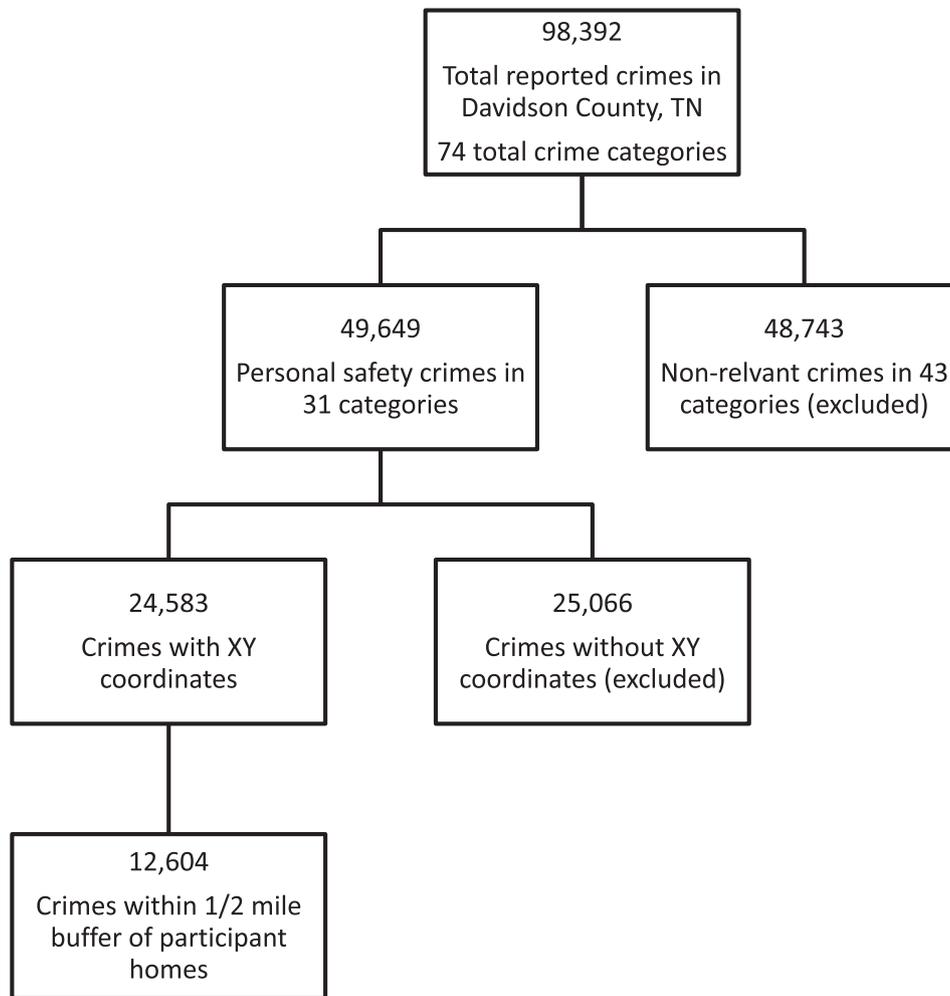


Fig. 1. Consort diagram of crime distillation, Davidson County, TN 2011–2012.

weekend wear time and found no significant differences; therefore, wear time was pooled and averaged per person across all days of the week.

### 2.5. Statistical analyses

Descriptive statistics were calculated for the total Hispanic study sample ( $N = 555$ ), including sociodemographic variables and PA. Non-parametric Spearman correlations were used to explore simple bivariate relationships between objective and perceived measures of crime as well as each measure of crime and different levels of PA using percent wear time to account for individually varying wear times. Correlations are subject to bias from confounders and should not be interpreted as comprehensive models for PA. Accordingly, we conducted post-hoc exploratory analyses to determine if objective or perceived crime had a different relationship to MVPA for boys than for girls. Two separate multivariable regression analyses were conducted predicting average minutes of child MVPA. Covariates in both models included child gender (0 = male, 1 = female), objective crime rate, perceived crime (dummy coded with “disagree” (safe) as the reference group), mean centered wear minutes (to account for differences in wear time), primary caretaker education level (0 = high school incomplete, 1 = high school or more), and mean centered child age in years. The first model contained the gender-objective crime interaction, and

the second model contained the gender-perceived crime interaction. All calculations and analyses were conducted using Stata/SE 14.1.

## 3. Results

### 3.1. Demographics

Table 1 shows participant demographics for the total Hispanic study sample. Average child age was 4.3 years ( $SD = 0.9$ ). Slightly over half of the children were girls (51.4%). The average caretaker age was 32.0 years ( $SD = 5.8$ ). The majority of caretakers were female (99.1%), mothers (98.1%), participated in Women, Infant and Children (WIC) (66.3%), received Supplemental Nutrition Assistance Program (SNAP) (75.5%), and had a total household income ranging from less than \$14,999 to \$24,999 (56.4%).

### 3.2. Objective and perceived crime

The original dataset of objective crime reports provided by the NMPD included 98,392 crimes. After narrowing to 31 crime categories related to personal safety, 12,604 crimes within a half-mile buffer of participants' addresses were successfully joined in ArcGIS. The average number of crime per half-mile home address buffer was 79.2 ( $SD = 52.6$ ) per year. When asked about perceived safety, 56.0% of caretakers

**Table 1**  
Participant demographics: Nashville, TN - September 2012 through May 2014.

Variables	Mean or percent (n = 555)
<i>Child socio-demographic characteristics</i>	
Child age in years, M (SD)	4.3 (0.9)
Child gender (% female)	51.4
<i>Adult socio-demographic characteristics</i>	
Adult age in years, M (SD)	32.0 (5.8)
Adult gender (% female)	(99.1)
Adult education (%)	65.4
Less than high school degree	
High school degree and above	34.6
Women, Infants, and Children (WIC) (%) <sup>a</sup>	66.3
Yes	
No	32.3
No response	1.4
Supplemental Nutrition Assistance Program (SNAP) (%) <sup>b</sup>	
Yes	75.5
No	24.3
No response	0.2
Household income (%)	
\$14,999 or less	27.6
\$15,000–\$24,999	28.8
\$25,000–\$34,999	11.9
≥ \$35,000	2.5
Did not know	28.8
No response	0.4

<sup>a</sup> WIC provides Federal grants to States for supplemental foods, health care referrals, and nutrition education for low-income pregnant, breastfeeding, and non-breastfeeding postpartum women, and to infants and children up to age five who are found to be a nutritional risk.

<sup>b</sup> SNAP offers nutrition assistance to millions of eligible, low-income individuals and families.

disagreed that crime makes it unsafe to go on walks, while 18.3% responded “I don’t know”, and 25.8% agreed that crime makes walks unsafe.

3.3. Physical activity patterns

Table 2 shows the average physical activity patterns based on accelerometer outputs for adults and children in sedentary, light, MVPA and vigorous levels for both average minutes and percent time during waking hours. The majority of time was spent in sedentary behavior, 59.7% (SD = 6.3) per day for children and 61.1% (SD = 9.0) per day for adults. Levels of MVPA for children were 10.8% (SD = 3.4) per day of their wear time and to 2.0% (SD = 2.1) per day for adults. Vigorous PA was generally low, especially for adults who spent on average 0.1% per day (range = 0–24 min) in vigorous activity.

3.4. Objective 1: objective and perceived crime

There was a small, positive correlation between objective and perceived crime, indicating that as crime count increased, so did agreement

**Table 2**  
Physical activity accelerometry results for children and adults: Nashville, TN - September 2012 through May 2014.

Variables	Mean minutes (SD)	Mean percent of wear time (SD)
<i>Child accelerometry</i>		
Sedentary	600.4 (118.3)	59.7 (6.3)
Light	294.9 (59.5)	29.4 (4.2)
MVPA	107.4 (34.9)	10.8 (3.4)
Vigorous	30.6 (14.7)	3.1 (1.5)
<i>Adult accelerometry</i>		
Sedentary	618.4 (138.0)	61.1 (9.0)
Light	370.0 (91.4)	36.9 (7.9)
MVPA	20.2 (20.5)	2.0 (2.1)
Vigorous	0.5 (1.9)	0.1 (0.2)

with the statement that crime makes walking unsafe ( $r_s = 0.14, p = 0.002$ ).

3.5. Objective 2: crime and physical activity

In general, the magnitude of associations between objective crime, perceived crime, and all levels of physical activity were weak. Table 3 highlights associations between objective crime and PA and Table 4 shows associations between perceived crime and PA. These bivariate correlations were used as a starting point for our more robust exploratory analyses; therefore, they should not be interpreted as definitive or conclusive models of PA.

Objective crime and child percent time in light PA had a significant positive correlation ( $r_s = 0.10, p = 0.03$ ). There were no significant relationships between number of crimes and adult PA.

Regarding perceived crime and PA for adult caretakers, agreement that crime is a problem was significantly negatively correlated with percent time per day in vigorous PA ( $r_s = -0.10, p = 0.03$ ). With respect to children, there were no significant correlations between caretaker perceived interpretation of crime and child PA.

3.6. Objective 3: gender-crime interaction and relationship to physical activity

The multivariable regression model containing the gender-crime frequency interaction and predicting average minutes of child MVPA accounted for 17% of the outcome variance (Table 5). Several coefficients were statistically significant, including the gender-crime frequency interaction and its constituent terms. The gender coefficient suggests that girls who lived in neighborhoods with the average crime frequency are predicted to have had 12.69 fewer minutes of MVPA than their male counterparts ( $p < 0.001$ ) while adjusting for wear minutes, perceived crime, caretaker education, and child age. The crime frequency coefficient has a similar contextual interpretation, but indicates that boys are predicted to gain 0.08 min of MVPA for each additional incidence of reported crime ( $p = 0.04$ ). The female-crime frequency interaction coefficient shows that the respective MVPA-crime slope for girls was significantly smaller ( $B = -0.13, p = 0.02$ ). This translates to 0.05 fewer minutes of MVPA per crime for girls ( $0.08 - 0.13 = -0.05$ ). Fig. 2 illustrates the magnitude of this difference in slopes and shows that the gap between girls’ and boys’ average minutes of MVPA continually widens as the frequency of reported crimes increases. Fig. 2 also shows that girls have significantly fewer predicted minutes of MVPA than boys from a crime report frequency of about 50 and higher, with the difference approaching 40 min at a crime report frequency of 300. Note that these relationships were observed while controlling for the other covariates in the model, none of which were significant, with the exception of wear minutes ( $B = 0.07, p < 0.001$ ).

A parallel regression model, replacing the gender-crime frequency interaction with the gender-perceived crime interaction is summarized

**Table 3**  
Association between objective crime and percent time per day in each level of physical activity: Nashville, TN - September 2012 through May 2014.

Variables	Spearman’s ρ	p-Value
<i>Child accelerometry</i>		
Sedentary	-0.08	0.07
Light	0.10	0.03*
MVPA	0.02	0.6
Vigorous	-0.04	0.4
<i>Adult accelerometry</i>		
Sedentary	-0.02	0.7
Light	0.03	0.6
MVPA	<0.01	0.9
Vigorous	0.03	0.5

<sup>†</sup> p-Value < 0.10.

\* p-Value < 0.05.

**Table 4**  
Association between perceived crime and percent time per day in each level of physical activity: Nashville, TN - September 2012 through May 2014.

Variables	Spearman's $\rho$	p-Value
<i>Child accelerometry</i>		
Sedentary	-0.05	0.2
Light	0.03	0.4
MVPA	0.02	0.7
Vigorous	-0.02	0.6
<i>Adult accelerometry</i>		
Sedentary	0.03	0.5
Light	-0.04	0.4
MVPA	-0.03	0.5
Vigorous	-0.10	0.03*

\* p-Value < 0.05.

in Table 6. This model was unable to detect a significant gender-perceived crime interaction, but the main effect of gender was still significant ( $B = -13.41, p < 0.001$ ).

**4. Discussion**

This cross-sectional study investigated associations between crime (objective and perceived) and physical activity for adult caretakers and young children within a Hispanic sub-population of a larger ongoing randomized controlled trial. Results from these initial analyses led to three notable outcomes.

First, objective and perceived measures of crime were significantly positively correlated – as number of crime reports increased, so did caretaker agreement that crime made it unsafe to walk.

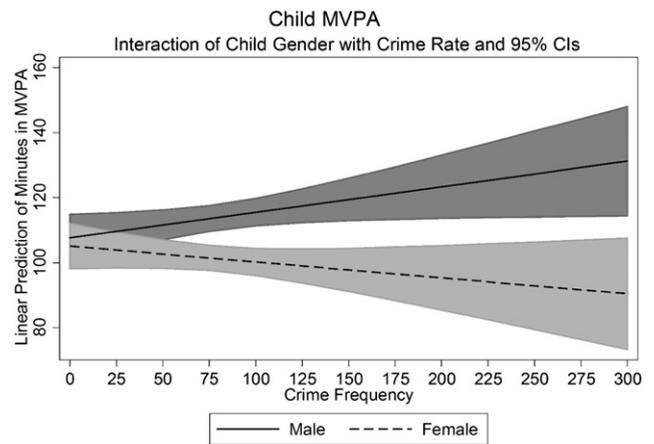
Second, in simple bivariate correlation, only caretaker vigorous PA was significantly related to perceived crime in the expected direction. Conversely and counter to existing literature (Gordon-Larsen et al., 2000; Gomez et al., 2004), child PA was not related to caretaker perceptions of crime in the bivariate correlations nor in the more robust regression models. Evidence suggests that caretakers exert the greatest influence and control over where young, preschool aged children spend time to be active (Lumeng et al., 2006; Valentine and McKendrick, 1997), so it was surprising that our findings found no association between caretaker perceived crime and child MVPA and once again highlights the difficulties in understanding important environmental influences on PA. All bivariate correlations yielded weak relationships and should be interpreted with caution, as these crude measures were not meant to represent comprehensive models. However, these results suggest that crime's relationship to PA may be complex and dependent on other variables.

Third, due to the counter-intuitive relationships between child PA and both types of crime – which suggested that light PA increased as reported crimes increased, and found no simple relationship between PA and perceived crime – we ran more robust regression models to explore the complexities of these potential relationships. We found a significant gender-objective crime interaction effect, suggesting that a high frequency of reported crimes within a half-mile radius of the home was more negatively related to girls' PA than boys'. This interaction was

**Table 5**  
Regression model with a gender-crime frequency interaction predicting average minutes of child MVPA: Nashville, TN - September 2012 through May 2014.

Regression coefficients	B	95% CI	p-Value	Model R <sup>2</sup>
Gender (0 = male, 1 = female)	-12.69	-18.25 - 7.14	<0.001*	0.17
Crime frequency (mean centered)	0.08	0.004 0.15	0.04*	
Female-crime frequency interaction	-0.13	-0.23 -0.02	0.02*	
Wear minutes (mean centered)	0.07	0.06 0.09	<0.001*	
Perceived crime (0 = "safe", 1 = "don't know/not sure")	-4.34	-11.83 3.14	0.3	
Perceived crime (0 = "safe", 2 = "unsafe")	4.78	-1.88 11.44	0.2	
Caretaker education (0 = high school incomplete, 1 = high school or more)	1.96	-3.90 7.83	0.5	
Child age (mean centered years)	0.46	-2.63 3.55	0.8	

\* p-Value < 0.05.



**Fig. 2.** Interaction of child gender and crime frequency predicting minutes of MVPA – Nashville, TN, September 2012 through May 2014.

not mirrored in the gender-perceived crime regression model, indicating that observable and objective elements of home environments (such as crime) may have more powerful relationships to the behaviors of children compared to perceived measures. The gender difference in PA – showing that girls are less active as objectively measured crime increases – aligns with existing literature (Whitt-Glover et al., 2009; Tucker, 2008; Poest et al., 1989; Sallis et al., 2000) and has many implications for future research that are discussed below.

Our study adds to the understanding of crime and its relation to PA in adults and children in multiple ways. First, we explored this relationship in an underserved community at higher risk for obesity. Low PA levels and high inactivity tend to be more prevalent in Hispanic populations (Gordon-Larsen et al., 2003), especially among low SES populations (Day, 2006), both characteristics of our current study population. Caretaker and child PA patterns from this unique sample and the respective associations with both objective and perceived crime, therefore offer a novel insight to an understudied and rapidly growing population. Additionally, our regression analyses revealed that gender gaps in PA can start in children as young as 3–5 years old. The preschool years are a crucial time to study determinants of overweight and obesity as well as associated health behaviors. Not only is this stage in development typically when eating and physical activity habits are becoming established, but it is also recognized as the time period immediately preceding the increase of body mass index (BMI) – known as adiposity rebound (AR) (Trost et al., 2003). This AR period can serve as a precursor towards risk of adverse adolescent and adult health and weight outcomes (Hughes et al., 2014; Peneau et al., 2016). Thus, for underrepresented minority populations, the ability to be physically active from an early age is extremely important, especially for young girls.

The Centers for Disease Control and Prevention advocates positive community-wide programming to reduce chronic diseases associated with increasing sedentary lifestyles (Hipp et al., 2014). This presents one opportunity to address not only physical inactivity, but parents'

**Table 6**

Regression model with a gender-perceived crime interaction predicting average minutes of child MVPA: Nashville, TN - September 2012 through May 2014.

Regression coefficients	B	95% CI	p-Value	Model R <sup>2</sup>	
Gender (0 = male, 1 = female)	−13.41	−20.81	−6.00	<0.001*	0.17
Perceived crime (0 = “safe”, 1 = “don’t know/not sure”)	0.27	−10.45	10.99	0.9	
Perceived crime (0 = “safe”, 2 = “unsafe”)	−0.38	−10.45	9.69	0.9	
Female-perceived crime interaction (0 = “safe”, 1 = “don’t know/not sure”)	−8.22	−23.23	6.78	0.3	
Female-perceived crime interaction (0 = “safe”, 2 = “unsafe”)	8.96	−4.42	22.34	0.2	
Wear minutes (mean centered)	0.08	0.06	0.09	<0.001*	
Crime frequency (mean centered)	0.01	−0.04	0.07	0.6	
Caretaker education (0 = high school incomplete, 1 = high school or more)	2.10	−3.79	7.99	0.5	
Child age (mean centered years)	0.43	−2.67	3.54	0.8	

\* p-Value &lt; 0.05.

unease about safety. By promoting family-friendly, outdoor activities, perceptions may improve and subsequently lead to a decrease in actual crime. Programs such as Open Streets (Hipp et al., 2014) and Play Streets (Wolf et al., 2015) encourage family-friendly activities in a safe, outdoor and familiar environment and increase the likelihood of enhanced community engagement. While it is currently unknown if these types of events have the potential to reduce actual crime, cities that have produced successful programming events, such as Open Streets, garnered support from both community and city official levels and have ultimately moved towards creating a sustained program dedicated to providing safe places for families to be active outdoors together (Kuhlberg et al., 2014). Moreover, given that this current study found girls to be significantly less active compared to boys, programming efforts can specifically include age-appropriate activities for girls, instilling healthy behaviors at an early age.

There were several limitations to this current study. The ActiGraph GT3X accelerometer devices did not have Global Positioning System (GPS) capabilities. Our methodology would be improved if the location of PA was known using GPS technology. Accelerometry data was also collected across all seasons and the effect of seasonality has yet to be investigated. As analysis continues with this study population, future methods will involve stratifying by season as it is well documented that both crime and PA patterns vary accordingly. Another potential limitation is the environmental context for preschool age children's PA is unique, and the context for parental perceived crime might not be a major driver, as this study indicated. Whereas older children and adults often set specific times and places to be physically active, preschool age children obtain PA in bursts throughout an eleven hour period (Ruiz et al., 2013), much of which could occur within or just outside of the home. Additionally, both measures of crime present limitations. The perceived measure of crime was a single item and should not be considered a robust measure. A substantial portion of caretakers (18.3%) responded “I don't know” to whether or not crime made it unsafe to go on walks. We interpreted these responses as participants being between agreement and disagreement that crime is a problem. However, this may point to the possibility that residents do not know how to judge safety; and various contextual cues, emotions, and experiences may make a reliable response challenging. Our objective measure of crime utilized a count of raw crimes and did not adjust for population density. Future studies should utilize more robust measures of perceived and objective crime to better understand the nuances of these overlapping factors. Finally, while this study was cross-sectional, the study population is part of a larger, longitudinal randomized controlled trial. Future analyses will take into account temporality as well as additional covariates that are known to influence physical activity behaviors for both children and adults.

## 5. Conclusions

This was a novel study that characterized the associations between objective and perceived crime and physical activity among a sample of low-income Hispanic caretakers with preschool-aged children. While

the present study replicated prior inconsistent results regarding the relation of crime and physical activity, we were able to contribute unique data on preschool children and provide evidence of early gender-specific differences. Continuing to explore the relationships between crime, caretaker and child physical activity as well as other related built and social environment factors can contribute to the growing body of evidence showcasing how safe neighborhoods can have family-level impacts on health and well-being.

## Acknowledgments

Funding: This research was supported by grants U01 HL103620 with additional support from the remaining members of the COPTR Consortium (U01 HL103561, U01 HL103622, U01 HD068890, U01 HL103629) from the National Heart, Lung, and Blood Institute and the Eunice Kennedy Shriver National Institute of Child Health and Development and the Office of Behavioral and Social Sciences Research (UL1TR000445). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, And Blood Institute, the National Institutes of Health, or the National Institute of Child Health and Development.

Data were managed through REDCap, which is supported from NCATS (UL1 TR000445).

## References

- Butte, N.F., et al., 2007. PA in nonoverweight and overweight Hispanic children and adolescents. *Med. Sci. Sports Exerc.* 39 (8), 1257–1266.
- Carver, A., Timperio, A., Crawford, D., 2008. Playing it safe: the influence of neighbourhood safety on children's PA. A review. *Health Place* 14 (2), 217–227.
- Day, K., 2006. Active living and social justice: planning for physical activity in low-income, Black, and Latino communities. *J. Am. Plan. Assoc.* 72, 88–99.
- Doherty, A.R., Kelly, P., Kerr, J., Marshall, S., Oliver, M., Badland, H., Hamilton, A., Foster, C., 2013. Using wearable cameras to categorise type and context of accelerometer-identified episodes of physical activity. *Int. J. Behav. Nutr. Phys. Act.* 10, 22.
- Evenson, K.R., et al., 2012. Associations of adult PA with perceived safety and police-recorded crime: the Multi-ethnic Study of Atherosclerosis. *Int. J. Behav. Nutr. Phys. Act.* 9, 146.
- Foster, S., Giles-Corti, B., 2008. The built environment, neighborhood crime and constrained PA: an exploration of inconsistent findings. *Prev. Med.* 47 (3), 241–251.
- Foster, S., et al., 2014a. Does walkable neighbourhood design influence the association between objective crime and walking? *Int. J. Behav. Nutr. Phys. Act.* 11, 100.
- Foster, S., et al., 2014b. Do changes in residents' fear of crime impact their walking? Longitudinal results from RESIDE. *Prev. Med.* 62, 161–166.
- Gilbert, K.L., Ray, R., 2015. Why police kill black males with impunity; applying public health critical race praxis (PHCRP) to address the determinants of policing behaviors and “justifiable” homicides in the USA. *Journal of Urban Health* 93, 122–140.
- Gomez, J.E., et al., 2004. Violent crime and outdoor PA among inner-city youth. *Prev. Med.* 39 (5), 876–881.
- Gordon-Larsen, P., McMurray, R.G., Popkin, B.M., 2000. Determinants of adolescent PA and inactivity patterns. *Pediatrics* 105 (6), E83.
- Gordon-Larsen, P., Harris, K.M., Ward, D.S., Popkin, B.M., 2003. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: the National Longitudinal Study of Adolescent Health. *Soc. Sci. Med.* 57, 2023–2034.
- Harris, P.A., et al., 2009. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J. Biomed. Inform.* 42 (2), 377–381.
- Hipp, J.A., et al., 2014. Taking PA to the streets: the popularity of Ciclovía and Open Streets initiatives in the United States. *Am. J. Health Promot.* 28 (3 Suppl), S114–S115.

- Hughes, A.R., Sherriff, A., Ness, A.R., Reilly, J.J., 2014. Timing of adiposity rebound and adiposity in adolescence. *Pediatrics* 134, e1354–e1361.
- Kuhlberg, J.A., et al., 2014. Open streets initiatives in the United States: closed to traffic, open to PA. *J. Phys. Act. Health* 11 (8), 1468–1474.
- Larsen, B.A., et al., 2013. PA in Latinas: social and environmental influences. *Women's Health (Lond. Engl.)* 9 (2), 201–210.
- Lumeng, J.C., et al., 2006. Neighborhood safety and overweight status in children. *Arch Pediatr Adolesc Med* 160 (1), 25–31.
- Mason, P., Kearns, A., Livingston, M., 2013. "Safe Going": the influence of crime rates and perceived crime and safety on walking in deprived neighbourhoods. *Soc. Sci. Med.* 91, 15–24.
- McDonald, N.C., 2008. The effect of objectively measured crime on walking in minority adults. *Am. J. Health Promot.* 22 (6), 433–436.
- Oh, A.Y., et al., 2010. Effects of perceived and objective neighborhood crime on walking frequency among midlife African American women in a home-based walking intervention. *J. Phys. Act. Health* 7 (4), 432–441.
- Peneau, S., Gonzalez-Carrascosa, R., Gusto, G., Goxe, D., Lantieri, O., Fezeu, L., Hercberg, S., Rolland-Cachera, M.F., 2016. Age at adiposity rebound: determinants and association with nutritional status and the metabolic syndrome at adulthood. *Int. J. Obes.* 40, 1150–1156.
- Po'e, E.K., et al., 2013. Growing Right Onto Wellness (GROW): a family-centered, community-based obesity prevention randomized controlled trial for preschool child-parent pairs. *Contemp Clin Trials* 36 (2), 436–449.
- Poest, C.A., et al., 1989. PA patterns of preschool children. *Early Childhood Research Quarterly* 4 (3), 367–376.
- Ruiz, R., Gesell, S.B., Buchowski, M.S., Lambert, W., Barkin, S.L., 2011. The relationship between Hispanic parents and their preschool-aged children's PA. *Pediatrics* 127 (5).
- Ruiz, R., Tracy, D., Sommer, E.C., Barkin, S.L., 2013. A novel approach to characterize PA patterns in preschool-aged children. *Obesity* 21, 2197–2203.
- Sallis, J.F., Prochaska, J.J., Taylor, W.C., 2000. A review of correlates of PA of children and adolescents. *Med. Sci. Sports Exerc.* 32 (5), 963–975.
- Troiano, R.P., et al., 2008. PA in the United States measured by accelerometer. *Med. Sci. Sports Exerc.* 40 (1), 181–188.
- Trost, S.G., Sirard, J.R., Dowda, M., Pfeiffer, K.A., Pate, R.R., 2003. Physical activity in overweight and nonoverweight preschool children. *Int. J. Obes.* 27, 834–839.
- Trost, S.G., McIver, K.L., Pate, R.R., 2005. Conducting accelerometer-based activity assessments in field-based research. *Med. Sci. Sports Exerc.* 37 (11 Suppl), S531–S543.
- Tucker, P., 2008. The PA levels of preschool-aged children: a systematic review. *Early Childhood Research Quarterly* 23 (4), 547–558.
- Valentine, G., McKendrick, J., 1997. Children's outdoor play: exploring parental concerns about children's safety and the changing nature of childhood. *Geoforum* 28 (2), 219–235.
- Voorhees, C.C., Rohm Young, D., 2003. Personal, social, and physical environmental correlates of PA levels in urban Latinas. *Am. J. Prev. Med.* 25 (3 Suppl 1), 61–68.
- Weir, L.A., Etelson, D., Brand, D.A., 2006. Parents' perceptions of neighborhood safety and children's PA. *Prev. Med.* 43 (3), 212–217.
- Whitaker, R.C., et al., 1997. Predicting obesity in young adulthood from childhood and parental obesity. *N. Engl. J. Med.* 337 (13), 869–873.
- Whitt-Glover, M.C., et al., 2009. Disparities in PA and sedentary behaviors among US children and adolescents: prevalence, correlates, and intervention implications. *J. Public Health Policy* 30 (Suppl. 1), S309–S334.
- Wilbur, J., et al., 2003. Correlates of PA in urban Midwestern Latinas. *Am. J. Prev. Med.* 25 (3 Suppl 1), 69–76.
- Wolf, S.A., et al., 2015. The impact of a temporary recurrent street closure on PA in New York City. *J. Urban Health* 92 (2), 230–241.