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Spatial analysis of crime incidence and adolescent physical activity

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ABSTRACT

Objectives. Adolescents do not achieve recommended levels of physical activity. Crime is believed to be a barrier to physical activity among youth, but findings are inconsistent. This study compares the spatial distribution of crime incidences and moderate-to-vigorous physical activity (MVPA) among adolescents in Massachusetts between 2011 and 2012, and examines the correlation between crime and MVPA.

Methods. Eighty adolescents provided objective physical activity (accelerometer) and location (Global Positioning Systems) data. Crime report data were obtained from the city police department. Data were mapped using geographic information systems, and crime and MVPA densities were calculated using kernel density estimations. Spearman's correlation tested for associations between crime and MVPA.

Results. Overall, 1694 reported crimes and 16,702 min of MVPA were included in analyses. A strong positive correlation was present between crime and adolescent MVPA ($\rho = 0.72$, $p < 0.0001$). Crime remained positively associated with MVPA in locations falling within the lowest quartile ($\rho = 0.43$, $p < 0.0001$) and highest quartile ($\rho = 0.32$, $p < 0.0001$) of crime density.

Conclusions. This study found a strong positive association between crime and adolescent MVPA, despite research suggesting the opposite relationship. This counterintuitive finding may be explained by the logic of a common destination: neighborhood spaces which are desirable destinations and promote physical activity may likewise attract crime.

Introduction

Adolescents do not achieve recommended levels of physical activity, despite known health benefits. Research has shown that health-enhancing physical activity behaviors may be influenced by certain aspects of the neighborhood environment, including availability of parks and green space, walkability, and crime and safety (Handy et al., 2002; Oreskovic et al., 2015).

Although neighborhood crime is believed to be a barrier to physical activity, research in both adult and pediatric populations has produced mixed findings. While several studies have found that higher crime rates and lower reported safety are associated with lower levels of physical activity (Gomez et al., 2004; Gordon-Larsen et al., 2000), other studies have found null associations (Prince et al., 2011). One recent study in adults found that an increase in objectively measured crime was associated with increased walking frequency (Foster et al., 2014). Furthermore, some evidence suggests that the relationship between crime and physical activity may vary depending on crime severity (Kerr et al., 2015). Together these findings suggest that the relationship between crime and safety and physical activity is more complex than previously believed.

Prior mixed findings may be explained by inconsistencies as well as limitations in the measurement of both crime and physical activity. Past research has often focused on perceptions of crime and safety, a measure that may not reflect actual crime patterns (Carver et al., 2008). Similarly, physical activity is frequently measured using self-report and questionnaire data, despite advances in more objective methods for quantifying physical activity, such as accelerometry. Reviews of the physical activity literature have highlighted the shortcomings of self-reported physical activity (Biddle et al., 2011). Furthermore, studies that do use objectively measured crime and physical data are limited by the operationalization of the neighborhood environment or daily activity space, focusing on geographic proxies such as the area immediately surrounding the home (Janssen, 2014) or census units (O'Connor et al., 2014). However, research has consistently shown that such

Abbreviations: MVPA, Moderate-to-vigorous physical activity; GPS, Global Positioning System; GIS, Geographic Information System.

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geographic proxies do not necessarily represent the spaces that individuals are exposed to, let alone those in which individuals engage in physical activity (Robinson and Oreskovic, 2013). This study sought to compare the spatial relationship between local crime and objectively measured adolescent moderate-to-vigorous physical activity (MVPA), and to examine the statistical correlation between crime density and physical activity density.

Methods

Participants and setting

We recruited 80 adolescents aged 11–14 years living in the greater Boston, Massachusetts area. Subjects were recruited from a local community health center and a community recreation center. Participants reported age (date of birth), sex, race/ethnicity, and highest level of parent education. We collected home and school addresses from each subject. This study was approved by the Partners HealthCare Institutional Review Board.

Measures

Physical activity data

Physical activity data were collected as part of a larger study assessing adolescent use of the built environment for physical activity (Oreskovic et al., 2015). Each subject wore an elastic belt around the hip equipped with a GPS receiving unit (QStarz BT-Q1000XT) to record location and an accelerometer (GT3X; ActiGraph LLC) to record physical activity. Adolescents were instructed to wear the belt at all times except during water activities (e.g. bathing, swimming, etc.) and sleep hours, and to charge the GPS unit overnight. We asked subjects to wear the belt for two separate weeks between May 2011–2012, during both a warm and cold season.

GPS and accelerometer data were reviewed upon return to ensure that each subject provided adequate data for analysis. The two files were joined and location and physical activity data were matched based on date and time. Joined datasets were validated and cleaned using a multistep approach previously described (Robinson and Oreskovic, 2013). Activity intensity was calculated for accelerometer data with MVPA defined as activity at or above a threshold of 2296 counts per minute, in accordance with age appropriate guidelines (Evenson et al., 2008). As this study was primarily interested in the locations of health-enhancing physical activity (i.e. MVPA), all non-MVPA activity data were removed from the final dataset prior to analysis.

Crime data

One year of contemporaneous crime report data was collected from the local city police department. Crime data were collected approximately one year after the study conclusion to allow for sufficient time for reported crimes to be entered in the police database. Crime data included crime type (e.g. robbery, assault, etc.), date and time of the reported crime, and address at which the crime occurred. The crime dataset was cleaned to remove crimes that were reported in duplicate. Crimes were then further categorized as serious crimes (aggravated assault, arson & bombing, burglary (B&E), forcible rape, homicide, kidnapping/abduction, robbery) and minor crimes (disorderly conduct, destruction/damage/vandalism, drugs/narcotics violations, drunkenness, liquor law violation, stolen property offenses, weapon laws violation, intimidation).

Spatial analysis

All GIS analyses were conducted using ArcGIS version 10.1 (ESRI, Redlands, California). Crime and adolescent physical activity locations were geocoded and mapped. Additionally, subjects' home and school addresses were geocoded and mapped. Physical activity data were then categorized as taking place in one of the following built environment categories: home, school, parks, playgrounds, streets/sidewalks, and other. Details of the GIS methodology used to make these classifications are described elsewhere (Oreskovic et al., 2015). In this study, physical activity data points that fell outside of the study area (city boundaries) were removed from analysis, as we did not have corresponding crime data. After mapping the physical activity and crime locations, we measured the densities of adolescent physical activity and crime incidences using kernel density estimation. Kernel density is a method of estimating the density of an event across a geographic area by creating a continuous density surface (Thornton et al., 2011). Unlike simple density measurements which account only for data or events that occur immediately within a geographic area, kernel density provides a more practical density measure by accounting for events that occur not only within, but also around, an area. While events that occur in closer proximity are weighted more heavily, events within a specified radius are also incorporated into the density measurement (Smiley et al., 2010).

We conducted kernel density analysis using several different parameters, in order to select those most appropriate for our dataset. The study area was divided into 50 m (option 1) and 100 m (option 2) grid cells. We then ran kernel density estimations for crime and physical activity using 400 m (option 1a and 2a), 800 m (1b and 2b), and 1600 m (1c and 2c) bandwidths. We selected 50 m grid cells and 400 m bandwidth, as these parameters best captured variation in our dataset without over- or under-smoothing. Kernel densities for both crime and physical activity were then transformed to a 0–1 scale. We removed crime and MVPA kernel density data for grid cells that covered land use areas deemed unusable/inaccessible, such as bodies of water (including lakes and wetlands) and waste disposal sites, identified using the MassGIS land use layer (Massachusetts Office of Geographic Information). These areas are unlikely to contain incidences of either physical activity or crime, and retaining these spaces in the analyses would have produced zero values for the grid cells contained within those spaces, potentially biasing the results. We then adjusted for population density by averaging kernel density values for both crime and physical activity to a census block group level, the smallest census unit available in US population data.

Crime severity analysis. Given some existing evidence that severity of crimes may differentially influence physical activity behaviors, we conducted additional kernel density estimations for crimes categorized as serious and minor, respectively. Crime severity subanalyses were conducted using 50 m cells and 400 m bandwidth.

Built environment analysis. The presence of crime, as well as other neighborhood characteristics, may influence a child or family's decision to engage certain built environments differently than others. Specifically, there are certain built environments that children and/or families generally make an active choice to engage (or avoid), such playgrounds and sidewalks. Other built environments in which children and adolescents spend time, namely home and school, are not actively chosen. Adolescents are typically not free to choose which school they attend or control where their home is located. For this reason, it is possible that neighborhood characteristics may play a partial role in an adolescent's decision to spend time in these spaces or be active in these spaces. To account for potential differences in these built environments, we dichotomized physical activity locations into “non-optional” built environments (home and school) and “optional” built environments (parks, playgrounds, streets/sidewalks, and other). Built environment subanalyses were conducted using 50 m cells and 400 m bandwidth.

Statistical analysis

Descriptive statistics were calculated for the study sample, MVPA, and crime. Non-parametric Spearman correlation analyses were used to test for associations between overall crime densities and MVPA densities. We also ran Spearman correlation analyses on locations falling within the lowest crime density quartile and highest crime density quartile. Regression analyses tested for associations between overall crime and health-enhancing physical activity, controlling for population density. In subanalyses, Spearman correlations tested the association between MVPA densities and serious crime and minor crime densities Spearman correlation also tested the associations between crime densities and MVPA densities in non-optional built environments and optional built environments.

Results

Study participants and setting

The study city is located about eight kilometers northeast of Boston, Massachusetts and has three subway stations which are part of the Boston public transportation system. During the study period, the city had a population of approximately 52,000 people and was 62.4% non-Hispanic white, 4.3% non-Hispanic black, 5.6% Asian and 24.4% Hispanic or Latino. The city is home to a significant immigrant population, with 30.5% of residents born outside the United States and 42.8% speaking a language other than English at home. The median household income was $51,863 with 15.4% of residents living below the poverty level