Health & Place 45 (2017) 181–188

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Are buffers around home representative of physical activity spaces among adults?

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ARTICLE INFO

Keywords:
Physical activity
Accelerometry
Activity space
Global positioning systems
Residential buffers

ABSTRACT

Residential buffers are frequently used to assess built environment characteristics relevant to physical activity (PA), yet little is known about how well they represent the spatial areas in which individuals undertake PA. We used System for Observing Play and Recreation in Communities data for 217 adults from five US states who wore an accelerometer and a GPS for three weeks to create newly defined PA-specific activity spaces. These PA spaces were based on PA occurring in bouts of ≥10 min and were defined as 1) the single minimum convex polygon (MCP) containing all of a participant's PA bout minutes and 2) the combination of many MCPs constructed using each PA bout independently. Participants spent a large proportion of their PA bout time outside of 0.5, 1, and 5 mile residential buffers, and these residential buffers were a poor approximation of the spatial areas in which PA bouts occurred. The newly proposed GPS-based PA spaces can be used in future studies in place of the more general concept of activity space to better approximate built environments experienced during PA.

1. Introduction

Theoretical frameworks suggest that built environment characteristics may be points of intervention for developing physical activity (PA) health promotion programs at the population level (McLeroy et al., 1988; Kersell and Milsum, 1985). These built environment characteristics, including attributes of urban design, land use, and transportation systems (Handy et al., 2002), are often assigned based solely on the location of a participant's home, without regard to where their PA actually occurs. Indeed, a systematic review of the literature as of 2009 indicated that 90% of studies on the relationship between the contextual built environment and cardiometabolic risk factors focused solely on the residential environment (Leal and Chaix, 2011), although some recent literature has moved away from this practice (e.g. Rodriguez et al. (2012)). This study therefore examines the relationship between the spatial locations of participant PA and their home addresses to quantitatively evaluate the appropriateness of residential-based built environment exposures for PA behaviors.

Residential-based assignment methods are at odds with the concept of activity space, which represents the overall geographical area in which individuals spend time in their day-to-day lives (Thornton et al., 2011). Many authors have therefore been critical of the use of residential-based demarcations, indicating that it allows for substantial measurement error of built environment attributes (Rainham et al., 2010; Perchoux et al., 2013). Further, residential-based assignment methods have received criticism from both the geography and public health fields, being called, for example, “place-based” instead of “people-based” (Miller, 2007) and the “local” (Cummins, 2007) or “residential” (Chaix et al., 2009) “trap”, indicating their failure to measure exposures from the locations in which people actually spend time. Given these various criticisms, many authors have suggested that location-enabled devices could be used to more accurately measure these environmental contexts (Rainham et al., 2010; Kerr et al., 2011; Boruff et al., 2012), particularly for physical activity (Krenn et al., 2011; Maddison and Ni Mhurchu, 2009). Despite this consensus, many researchers still rely on residential-based assignment methods as studies involving global positioning systems (GPS) can be costly, time-intensive, and introduce advanced data management and manipulation challenges.

Understanding the proportion of PA time spent in residential

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http://dx.doi.org/10.1016/j.healthplace.2017.03.013
Received 30 September 2016; Received in revised form 13 February 2017; Accepted 23 March 2017
Available online 06 April 2017
1353-8292/

buffers is therefore an important step in assessing the accuracy of studies focused solely on the residential environment. Specifically, it will inform the validity of the assumption that the home neighborhood accurately represents built environment characteristics encountered during PA and will provide guidance on whether or not measurement error may be of concern. This study therefore 1) assessed the percent of PA time spent within residential buffers, 2) proposed two new definitions of PA-specific activity space, in contrast to the more general concept of activity space, to represent the spatial areas in which individuals completed bouts of PA measured by GPS over a three-week period, and 3) examined the degree of spatial overlap between these PA activity spaces and traditional residential-defined buffers. Further, differences by sociodemographic characteristics were examined given that these factors may affect how near to home one engages in PA.

2. Methods

2.1. Study population

This study used data collected as part of the System for Observing Play and Recreation in Communities (SOPARC) GPS sub-study. The initial data collection involved recruitment of participants from key parks within five communities (Los Angeles, California; Albuquerque, New Mexico; Chapel Hill and Durham, North Carolina; Columbus, Ohio; and Philadelphia, Pennsylvania) as well as from residences within one mile of the parks. Participants were eligible for the study if they were ≥18 years old, English-speaking, and ambulatory. Sociodemographic data (age, sex, race/ethnicity, and highest level of education achieved) were collected through a questionnaire. Study staff used a Tanita Bc551 scale and a Seca Portable Stadiometer to measure weight and height of participants at enrollment, respectively, allowing classification of body mass index (BMI, kg/m^2) into categories of normal weight ($< 25\ kg/m^2$), overweight (≥ 25 to $< 30\ kg/m^2$), or obese ($\geq 30\ kg/m^2$).

Participants were asked to concurrently wear an accelerometer to measure PA and a GPS to measure location for three consecutive 1-week periods during the spring, summer, or fall of 2009–2011. Details of the accelerometer and GPS are discussed in detail below. Further participant recruitment and study details are available elsewhere (Evenson et al., 2013a, 2013b; Cohen et al., 2013). Study protocols were approved by appropriate study site affiliated institutional review boards and participants provided written informed consent.

2.2. Physical activity assessment

Participants wore an ActiGraph (model GT1M; ActiGraph LLC, Pensacola, Florida) accelerometer on the right hip for three consecutive 1-week periods (Evenson et al., 2013b). The accelerometer recorded PA in 1-min epochs and has demonstrated validity (Van Remoortel et al., 2012). Accelerometer non-wear time was identified as ≥90 min of consecutive zero counts, allowing for up to two minutes of nonzero counts if the 30 min before and after the nonzero counts contain no positive counts (Choi et al., 2011). Counts for these non-wear minutes were flagged as missing. The GPS data were then merged with the accelerometer data, including the accelerometer minutes flagged as non-wear, by timestamp.

Moderate to vigorous PA bouts (MVPA-Bs) of at least ten minutes were used to conform with the 2008 PA Guidelines for Americans and the World Health Organization PA recommendations (US Department of Health and Human Services, 2008; World Health Organization, 2010) and to better visualize PA that occurs together spatially. MVPA-Bs were identified based on the Matthews' cut-point (MVPA ≥760 counts/min) (Matthews, 2005), allowing for 20% of the minutes to fall below the cut-point. In addition, a bout had to begin and end with a physically active minute and could not contain more than four consecutive minutes below the cut-point. The analysis considered wearing the accelerometer for at least four, ten-hour days as compliant (Ward et al., 2005), although participants contributed a median (IQR) of 17 (13-20) days of compliant wear.

2.3. Physical activity location monitoring

Geographic location of participants was tracked using a Qstarz BT-Q1000X portable GPS unit (weight, 65 g; dimensions, 72×46×20 mm) with Wide Area Augmentation System (WAAS) enabled to improve accuracy (Evenson et al., 2013a, 2013b). GPS points were recorded in one minute epochs. Participants were asked to wear GPS units concurrently with the ActiGraph GT1M accelerometers for three consecutive one-week periods.

2.4. Residential buffer area creation

Participant home addresses were used to define several residence-based buffers in ArcGIS 10.3.1 (ESRI 2015, Redlands, CA) that span those commonly used in the literature. Home addresses were first geocoded using the 2010 TIGER/Line shape files in ArcGIS 10 and unmatched addresses were geocoded with electronic maps as needed (Evenson et al., 2013b). Residence-based buffers were created with the geoprocessing buffer tool (0.5, 1, and 5 mile circular buffers, encompassing all area 0.5, 1, and 5 miles in Euclidian (straight-line) distance from the home address) and network analyst service areas (0.5, 1, and 5 mile road network buffers, encompassing all area 0.5, 1, and 5 miles in road network distance from the home address). The 0.5 and 1 mile buffers were chosen as they are commonly used in the literature. The 5 mile buffer represents a larger and more inclusive buffer in order to determine which buffer size best captured PA.

2.5. Physical activity space creation

MVPA GPS points that were part of an MVPA-B were used to create two new measures of MVPA space: an overall MVPA space and an independent bout-based MVPA space. These measures were derived from the general concept of activity space, which seeks to describe the space in which individuals conduct day-to-day activities regardless of PA level (Thornton et al., 2011). Typically, activity space is constructed by mapping all of the locations in which a person experiences time during the day. In these analyses, the measures have been adjusted to represent only the space in which individuals were physically active. Specifically, all MVPA GPS points that were part of a MVPA-B during the three weeks were used to create a single overall minimum convex polygon space for each participant (Fig. 1). The minimum convex polygon (convex hull) is the smallest polygon containing all points.

In addition to the overall minimum convex polygon, a MVPA space layer was created for each participant based on their independent MVPA-Bs (Fig. 2). In this case, instead of using all MVPA-B points to create a single, overall MVPA space for each participant, the minimum convex polygon tool in ArcGIS was used to create a space for each MVPA-B separately. These individual bout MVPA spaces were created in a single layer and dissolved by participant (removing double counting of overlapping land area across the bouts) to use in comparison with the residential-based buffers.

The bout-based method is proposed as an alternative to the single, overall MVPA space to potentially limit inclusion of large sections of land unused for PA between MVPA-B locations as could occur in creating overall MVPA spaces (Figs. 1 and 2) and is therefore thought to be more representative of the spatial areas in which participants engage in MVPA-Bs. This approach has been previously proposed for summarizing spatial data that is unevenly distributed (Bachi, 1962). In all cases of MVPA space creation, the data were first cleaned to remove bouts that were unreasonably far (> 35 miles) from the participant's home address, allowing a PA location to require travel up to twice the average daily distance traveled in the five study states (US Department