Health & Place 21 (2013) 46–51

Contents lists available at SciVerse ScienceDirect

Health & Place

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

Viewpoint

GPS tracking in neighborhood and health studies: A step forward for environmental exposure assessment, a step backward for causal inference?

Basile Chaix [a,b,*], Julie Méline [a,b], Scott Duncan [c], Claire Merrien [a,b], Noëlla Karusisi [a,b], Camille Perchoux [a,b,d], Antoine Lewin [a,b], Karima Labadi [a,b], Yan Kestens [d,**]

[a] Inserm, U707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, 75012 Paris, France
[b] Université Pierre et Marie Curie-Paris6, UMR-S 707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, 75012 Paris, France
[c] Human Potential Centre, Auckland University of Technology, 17 Antares Place, Mairangi Bay, Auckland 0632, New Zealand
[d] Département de Médecine Sociale et Préventive, Université de Montréal, 1430 Boulevard Mont-Royal, Montréal, Québec, Canada H2V 4P3

ARTICLE INFO

Article history:
Received 26 August 2012
Received in revised form
30 December 2012
Accepted 3 January 2013
Available online 17 January 2013

Keywords:
Global positioning system
Environmental exposure assessment
Neighborhood
Selective daily mobility
Transportation and health

ABSTRACT

Recent studies have relied on GPS tracking to assess exposure to environmental characteristics over daily life schedules. Combining GPS and GIS allows for advances in environmental exposure assessment. However, biases related to selective daily mobility preclude assessment of environmental effects, to the extent that these studies may represent a step backward in terms of assessment of causal effects. A solution may be to integrate the Public health / Nutrition approach and the Transportation approach to GPS studies, so as to combine a GPS and accelerometer data collection with an electronic mobility survey. Correcting exposure measures and improving study designs with this approach may permit mitigating biases related to selective daily mobility.

1. GPS tracking for improved assessment of environmental exposures

Recent studies have relied on GPS tracking to assess exposure to environmental characteristics over daily life schedules (Almanza et al., 2012; Elgethun et al., 2003; Rodriguez et al., 2012; Wheeler et al., 2010; Zenk et al., 2011). Combining GPS with Geographic Information Systems offers the opportunity to take a step forward in the measurement of environmental exposures (Duncan et al., 2009; Krenn et al., 2011). However, there are concerns associated with the interpretation of the resulting associations with health outcomes, to the extent that these studies may represent a step backward in terms of assessment of causal environmental effects.

With the growing recognition that most people only spend a limited amount of time each day in their residential environment, there is a large consensus that one of the most serious limitations of neighborhood and health literature to date is its systematic focus on residential neighborhoods (Chaix, 2009; Chaix et al., 2012c; Cummins, 2007; Matthews, 2011; Rainham et al., 2010). Strategies to incorporate daily mobility in neighborhood and health studies include standard mobility surveys (Kestens et al., 2012) or surveys of regular destinations based on electronic mapping tools (Chaix et al., 2012c). Additionally, GPS tracking appears as a way to move environmental exposure assessment from an exclusively residential to a more comprehensive multi-place perspective that accounts for the multiple daily activity places (Zenk et al., 2011).

2. Selective daily mobility as a major source of bias in GPS studies

2.1. A commentary of selected literature

Our aim was to evaluate the methods and the implicit and explicit rationale and objectives in the literature for correlating environmental information around GPS locations with health behaviors and outcomes. Rather than a systematic review that offers a high level of generalization (Krenn et al., 2011), the analytical strategy selected to achieve our aim was to perform a commentary of published articles, which allows for a detailed examination of studies and of the formulations used to report their objectives, analytical design, and interpretation of findings.

* Corresponding author at: Inserm, U707, Faculté de Médecine Saint-Antoine, 27 rue Chaligny, Paris, France. Tel.: +33 1 44 73 86 64; fax: +33 1 44 73 84 62.
** Corresponding author. Tel.: +1 514 890 8000x15900; fax: +1 514 412 7204.
E-mail addresses: chaix@u707.jussieu.fr (B. Chaix), julie.meline@inserm.fr (J. Méline), scott.duncan@aut.ac.nz (S. Duncan), merrien@u707.jussieu.fr (C. Merrien), karusisi@u707.jussieu.fr (N. Karusisi), camille.perchoux@umontreal.ca (C. Perchoux), lewin@u707.jussieu.fr (A. Lewin), labadi@u707.jussieu.fr (K. Labadi), yan.kestens@umontreal.ca (Y. Kestens).

1353-8292/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.healthplace.2013.01.003

The present commentary focuses, not on one article as usual, but on four articles for a more informative analysis, all four articles published in Health and Place (Almanza et al., 2012; Lachowycz et al., 2012; Rodriguez et al., 2012; Zenk et al., 2011). However, the issues discussed in the present article also apply to a number of other GPS studies published in the field of Public health or Nutrition (Duncan and Mummery, 2007; Oliver et al., 2010; Quigg et al., 2010; Wheeler et al., 2010). The four studies were selected for the differences in their objectives (descriptive or inferential) and related interpretation of findings and for the differences in their analytical strategies (GPS point-level analysis or individual-level analysis).

The first reviewed study (Lachowycz et al., 2012) analyzed GPS data collected every 10 s and accelerometer data collected for 10 s epochs (periods of data collection) during four school days and at least one weekend day for 614 children aged 11–12 years (Bristol, UK, PEACH cohort, 2007–2009). The authors performed a "momentary" investigation, i.e., analyzed the data at the epoch level (one statistical observation per 10 s epoch) with a random effect at the individual level. More precisely, we refer to this approach as the "contemporaneous momentary design" because information on the location and related context and on the outcome (accelerometry) was collected at the same moment. The objectives of the study were descriptive, i.e., to "record the environments where different intensities of physical activity take place" and to "investigate the actual use of greenspaces". The authors sought to describe behavioral contexts rather than to perform inferences on the effects of contexts on behavior (the "analysis did not consider how use of green space may be affected by how accessible it is to the child"). In accordance with these descriptive objectives and with their "contemporaneous momentary" analytical strategy, the authors did not report the results as associations that attempt to reflect the causal effects of environments on behavior. Instead, as their main findings, the authors descriptively indicated that the majority of moderate-to-vigorous physical activity took place indoors while a substantial proportion of outdoor physical activity was performed in green spaces.

Commenting on the literature, the authors criticized previous studies on the grounds that they measured exposures in residential environments and were "often unable to consider the actual locations where physical activity takes place". As discussed below, however, assessing where physical activity occurs does not permit causal inference of environmental effects on physical activity. Rather, for such an inferential aim, the challenge is to assess whether physical activity opportunities are accessible from the different geographic contexts visited in daily trajectories.

The second study reviewed here (Rodriguez et al., 2012) analyzed data on 293 adolescent females (15–18 years old) collected for six consecutive days by GPS every 60 s and by accelerometers for 60 s epochs (Minneapolis and San Diego, USA). GPS points located within 50 m of the residence or school were discarded, to exclude activities at home or school. The study relied on a contemporaneous momentary design: the analyses were conducted at the epoch level, considering point-by-point information on the intensity of physical activity and on the built environment in 50 m buffers around each GPS point.

Whereas the previous article (Lachowycz et al., 2012) mostly had descriptive aims, the article by Rodriguez switches between two perspectives: identifying causal environmental effects and describing behavioral contexts. The authors suggested that GPS tracking allows researchers to more accurately identify the environmental opportunities and barriers that influence physical activity. However, when interpreting their findings, they focused more descriptively on behavioral contexts, indicating that "understanding the places were physical activity and sedentary behaviors occur appears to be a promising strategy to clarify relationships". While we agree with this statement, we emphasize below that the sole description of behavioral contexts is not necessarily a step forward towards the appraisal of causal environmental effects on behavior.

The authors reported that, after adjustment, the odds of high physical activity intensity were higher in GPS locations with parks, schools, and high population density, and lower in GPS locations with more roads and food outlets. The descriptive nature of these findings is illustrated, for example, by the argument that the lower odds of intense physical activity near food outlets "may be capturing sedentary behavior, when participants visit malls with outdoor areas, or restaurants with outdoor seating". These findings simply suggest that people are by essence less physically active in specific places (e.g., restaurants, movie theaters, etc.) than in others (e.g., parks).

The third reviewed study (Almanza et al., 2012) relied on GPS and accelerometer data (30 s intervals/epochs) collected for 7 days for 208 children aged 8–14 years from The Preserve smart growth community in California (USA) and six conventional communities situated nearby. Interestingly, the study was designed to rule out selective residential migration biases by comparing families who moved to the smart growth community with families who initially considered moving there but did not. Analytically, the authors compared the contemporaneous momentary analytical design used in the Lachowycz and Rodriguez studies (epoch-level analyses) with a more conventional individual-level analysis.

Contemporaneous momentary analyses revealed a positive relationship between greenness at the GPS point and the likelihood of moderate-to-vigorous physical activity. In individual-level analyses, greenness exposure in the residential neighborhood was defined in two ways: (i) average greenness in the 500 m buffer around the residence and (ii) cumulated time of exposure to greenness at all the GPS points recorded in the residential neighborhood. The association between greenness and physical activity identified in the momentary analysis was retrieved only with the second version of the individual-level greenness exposure variable.

Because of their "spatially-explicit" design (considerable number of locations examined for each participant), contemporaneous momentary analyses were described by the authors as increasing the power to detect associations compared to individual-level analyses. Whether true or not, such simple epoch-level analyses which assess the spatial milieu around individuals at each observation are useful to describe behavioral contexts, but they may be inadequate to assess environmental effects on behavior. For example, such simple contemporaneous momentary analyses are unable to demonstrate that an improved spatial accessibility to greenness causally increases physical activity; they simply highlight that green spaces are a more common place for physical activity than many other places such as railway stations or shopping areas.

The individual-level greenness exposure variable defined in 500 m radius buffers around the residence was qualified as "coarser" than the individual-level variable based on the aggregation of greenness exposure at GPS activity locations. Again, in our view, the latter variable is not only more accurate, its meaning is also qualitatively different: whereas the former variable reflects potential access to green spaces from the residence, the latter captures the actual patterns of use of green spaces in local daily trajectories. As discussed below, such difference has major implications for the interpretation of the associations estimated between the environmental variables and the behavioral or health outcomes.

The standard contemporaneous momentary design was described above as providing descriptive information on behavioral contexts. However, the momentary analysis by Almanza et al. was