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Research Paper

Understanding spatial variation of physical inactivity across the continental United States

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ABSTRACT

Physical inactivity lies at the heart of the public health crisis in the United States (U.S.). Research on the factors that contribute to inactivity is vast and growing; however, most of this work focuses on individual rather than community-level dynamics such as socio-economics, access to resources, and features of the physical environment. Moreover, few studies have tested spatial relationships between the prevalence of physical inactivity and multiple explanatory variables to identify potential sources of social and environmental justice at the community level of analysis. To address these gaps in previous research, this study drew on an array of secondary data sources to: 1) identify factors that contribute to levels of physical inactivity; 2) examine how these factors affect spatial inequalities; and 3) compare model performance between conventional ordinary least squares regression models and geographically weighted regression (GWR) to predict physical inactivity among U.S. residents. Our findings indicate that multiple variables predict physical inactivity, particularly access to infrastructure, expenditures on recreational activities, and poverty within disenfranchised segments of the population. Given that improvements in our model performance detected non-stationary spatial relationships and reduced the autocorrelation of residual variables, we contend that this technique accounts for greater variation than ordinary least squares regression. Thus, this study provides a comprehensive basis for informing urban and landscape planning decisions across spatial and regional scales.

1. Introduction

1.1. A short background on physical activity

Physical inactivity has been widely recognized as a public health crisis. Particularly in the United States (U.S.), obesity rates are rapidly increasing due to an array of factors such as diet, decreases in leisure-time, and lack of access to healthy foods (Fung & Lo, 2000; Ladabaum, Mannalithara, Myer, & Singh, 2014; Walker, Keane, & Burke, 2010). Intervention programs designed to increase physical activity have been limited to a small number of people who are rarely tracked over space and time (Trost, Owen, Bauman, Sallis, & Brown, 2002; Sugiyama, Leslie, Giles-Corti, & Owen, 2009). This is problematic because most people who start physical activity programs discontinue involvement within the first six months (Stetson et al., 2005), and most interventions do not lead to long-term participation (Lee, Djoussé, Sesso, Wang, & Burning, 2010; Sun, Norman, & While, 2013; Sugiyama et al., 2009; Trost et al., 2002). Moreover, a bulk of research in this area has focused on why individuals (dis)engage in physical activity (Ball et al., 2008; Crespo, Smit, Andersen, Carter-Pokras, & Ainsworth, 2000; Seefeldt, Malina, & Clark, 2002) despite the importance of considering group-level dynamics. That is, multiple levels of social, economic, and environmental determinants should be factored into decisions about landscape and urban planning to identify the reasons why individuals and groups settle into sedentary lifestyles. In response to these knowledge gaps, past research has indicated proximity to green space and access to programs that encourage recreational pursuits are crucial for fostering constructive behavioral outcomes (Norman et al., 2006; Veitch et al., 2014). In this sense, individual use of everyday landscapes is nested within broader contexts and macro-level dynamics that govern healthy lifestyles (Dahmann et. al., 2010; Giles-Corti & Donovan, 2002; Liechty, Genoe, & Marston, 2017; Macintyre, MacIver, & Sooman, 1993).

The architecture and design of landscapes has bearing on levels of physical activity, and in turn, human well-being and quality of life for diverse populations (Wilhelm Stanis, Schneider, Chavez, & Shinew, 2009). In particular, various aspects of the built environment, including

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degrees of development, transportation networks, and access to food distribution points are associated with health disparities and fitness (Sallis & Glanz, 2009). For instance, previous research has indicated that maintaining sufficiently wide, illuminated and well-designed sidewalks, minimizing traffic and creating pedestrian-friendly spaces will stimulate and redirect use of an environment that is accessible to all members of a community (Berrigan & Troiano, 2002). The National Research Council (2005, p.7) has reinforced this point and noted that human movement patterns are exceedingly complex, particularly in urban contexts, and require consideration of indirect and mediating factors for diverse populations. Despite this complexity, landscape architecture research has tended to focus more on design principles than human behavior. Although helpful, this focus has created a need for sound theoretical frameworks and more complete research designs (Lachowycz & Jones, 2013; Qviström & Vicenzotti, 2016; Silva & Teixeira, 2012; Taylor, 2016; Wylie, 2007). Along with the built environment, the natural world has differential effects on human behavior, health and well-being (Littenberg et al., 2015). A natural amenity scale was developed to measure these effects and test whether people are attracted to areas with varied topography, bodies of water, warmer climates, and low humidity (USDA ERS, 2004). Applications of this scale have laid the groundwork for future research and indicated there are inverse relationships between obesity rates and natural amenities at a national level (Jilcott et al., 2013).

Previous research has examined the spatial distribution of public recreation programs that encourage active living and reduce health problems (see Dahmann, Wolch, Joassart-Marcelli, Reynolds, & Jerrett, 2010). However, fewer studies have examined parks and open spaces as contexts for physical activity (e.g., Kaczynski & Henderson, 2007). This is an important area of inquiry because presence or absence of these settings influence the prevalence of chronic diseases such as obesity across spatial scales. For example, Myers, Slack, Martin, Broyles, and Heymsfield (2015) used spatial cluster analysis to show that physical inactivity was positively associated with obesity prevalence. These authors provided insight into which segments of society accessed open spaces and identified locations most likely to foster healthy lifestyles. Similarly, Black (2014) adopted Geographically Weighted Regression (GWR) rather than traditional aspatial regression to detect locational differences in obesity rates across the U.S. Results revealed a positive correlation between adult obesity and physical inactivity at the county-level and illustrated how the local environment was related to obesity prevalence across spatial scales. Thus, geospatial modeling such as GWR has emerged as a promising method to advance knowledge of the causes and consequences of physical activity in landscape and urban planning. Therefore, this study examined the spatially varying relationships between physical inactivity and both natural and built environments (heretofore referred to as the “physical environment”), as well as socio-economic variables at the county level using geocoded secondary data.

1.2. Application of opportunity theory to understand physical activity

Opportunity theory can be used to guide research focused on the association between health problems such as obesity prevalence and physical activity (Rosenberger, Bergerson, & Kline, 2009; Wells, Ashdown, Davies, Cowett, & Yang, 2007). This conceptual framework postulates, “All things being equal, individuals from different segments of society have the propensity to participate in recreation activities” (Romsa & Hoffman, 1980, p.322). Recreation participation relies on the extent to which recreation resources are accessible and financially available (Hendee, 1969). Although there are a range of psycho-social variables that can be used to understand why people do or do not engage in physical activity, public environments such as parks and related recreation areas are important features of urban settings that stimulate human movement (Koohsari et al., 2015). Residents’ proximity to management infrastructure has garnered research attention to document the health benefits of nature and provide implications for land use planning and management agencies (Scott, 2013). Previous research has indicated that racial and ethnic minorities such as African Americans from lower income households and rural environments tend to be less physically active and overweight when recreation amenities are lacking (Gordon-Larsen, Nelson, Page, & Popkin, 2006; Nelson, Gordon-Larsen, Song, & Popkin, 2006; Patterson, Moore, Probst, & Shinogle, 2004). Moreover, in a meta-analysis conducted by Doucouliagos and Hall (2010), multiple socio-economic variables were identified to anticipate barriers that impeded activity engagement. The authors found that income was a particularly strong predictor of physical activity, which could be used to anticipate use of recreation resources.

Opportunity theory has been applied in numerous contexts (e.g., Congdon, 2016; Edwards, Jilcott, Floyd, & Moore, 2011; Scott & Munson, 1994; Sylvester, 2015; Tilley & Sidebottom, 2015; Troy, Nunery, & Grove, 2016). Many of these studies exploring recreation participation have used cross-sectional research designs (Andkjaer & Arvidsen, 2015), thus showing limited generalizability. Differences in the association between socio-economics and recreation participation have yet to be tested on regional or national levels. This gap in previous research calls to question issues of housing, the location of recreation resources and social justice for diverse populations (Dahmann et. al., 2010). If recreation resources are not readily available or affordable, limited opportunity exists to participate (Joassart-Marcelli, 2010). This situation presents a challenge for research to guide planning and management across spatial scales on a national level. A substantive body of previous research on the relationship between physical activity and self-reported wellness has indicated that numerous health-related problems (e.g., stress, obesity) can be influenced by participation, proximity and access to resources (Driver, 1985; Godbey, Graefe, & James, 1992; Kaczynski & Henderson, 2008; Snodgrass & Tinsley, 2010; Godbey, 2009; Rosenberger et al., 2009). Health disparities and perceptions of the neighborhood environment are priorities for funding agencies and those entities focused on promoting health, well-being, and quality of life (Giles-Corti & Donovan, 2002).

1.3. Effects of the physical environment

Previous research has established a broad understanding of how physical activity and related chronic diseases develop across spatial scales using techniques such as multivariate regression analysis. For example, Rosenberger et al. (2009) found a negative relationship between opportunities for recreation and rates of physical inactivity in Oregon. Also using multilevel regression models, Jilcott et al. (2013) demonstrated that natural amenities and the density of recreation facilities were negatively related to obesity rates in the U.S. However, these two previous studies suffered from methodological limitations − namely, variation in the relationships among different physical environments were unaccounted for in their models. Given that physical activity takes place in different activity domains (e.g., household, living environments, and leisure) that are influenced by a variety of determinants (Sugiyama et al., 2009), future research should prioritize consideration of these domains to refine knowledge of the physical attributes that influence engagement.

The effects of physical activity on human health and well-being has been well documented in previous research (Hardman & Stensel, 2009; Kaczynski & Henderson, 2007; Leslie et al., 1999; Stanis et al., 2009). Regional-level assessments of activity engagement have provided particularly valuable insights into the role of physical environments in the provision of opportunities for people to experience open spaces. The location and expanse of infrastructure (e.g., recreation facilities), for example, have been examined to identify availability and access to resources developed to suit individual needs (Roubal, Jovaag, Park, & Gennuso, 2014). Many regional-level planning and