Urban Forestry & Urban Greening 26 (2017) 1–10

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

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

Original article

Varying age-gender associations between body mass index and urban greenspace

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ARTICLE INFO

Keywords:
Urban greenspace
Body mass index
Obesity

ABSTRACT

Urban greenspace benefits urbanites in numerous ways ranging from regulating flooding, air quality, and local climate to providing opportunities for exercise and relaxation. These benefits may influence human health. Greenspace, for example, may facilitate exercise, thereby helping to reduce body mass index (BMI) and combat obesity, a current epidemic of great public health concern. Little evidence exists to support this assertion, however, and we lack a full understanding of the mechanisms whereby this relationship operates, the populations for whom greenspace is linked to weight status, and the aspects of urban greenspace that are linked to weight status. This study seeks to identify relationships among the composition and arrangement of greenspace and BMI for different populations using regression models for eight age and gender groups in Cleveland, Ohio, US. We find that several greenspace variables are related to BMI for women under 65 years and males under 51 years, but not for older groups, and that the aspects and types of greenspace that are significantly related to BMI vary among groups. Relationships between greenspace attributes and BMI are generally stronger for female groups and for younger groups. Providing access to greenspace with particular attributes such as greenspaces with water, canopy cover, or connected greenspaces could support a healthy weight status for some populations, but these attributes are not consistent across age and gender groups. These results could help to inform policy aimed at designing urban greenspace to benefit the health of different population subgroups.

1. Introduction

Over half of the human population lives in cities, a number expected to rise to nearly three-quarters by mid-century (UNPD, 2012). Health concerns for this increasingly urban population include sedentary lifestyles that contribute to obesity and associated illnesses (e.g., diabetes, hypertension, cardiovascular disease) (Tamosiunas et al., 2014; Tseng et al., 2014; Groth et al., 2015; Koohsari et al., 2015). Urban greenspaces may influence weight status and are increasingly identified as valuable resources for supporting active lifestyles and enhancing health. Evidence supporting this association exists, but is inconsistent (Hartig et al., 2011; De Vries et al., 2011; Groenewegen et al., 2012; Hartig et al., 2014), restricting management of urban greenspaces as public health resources and venues for behavioral intervention.

Obesity rates rose dramatically in the last fifty years and obesity is considered a global epidemic linked to numerous health conditions, including cardiovascular illness (Richardson et al., 2013; Tamosiunas et al., 2014; Bixby et al., 2015; Nayyar and Hwang, 2015), diabetes (Astell-Burt et al., 2014), and hypertension (Bassett et al., 2002). Obesity results from a complex, multi-causal process. Urban living, which limits physical activity due to sedentary lifestyles and reduced locations for outdoor activities, is among the myriad contributing factors to obesity (Caballero, 2007). Urban greenspace may influence obesity directly via enhanced opportunities for physical exercise (Hartig et al., 2011; De Vries et al., 2011; Groenewegen et al., 2012; Hartig et al., 2014; Villanueva et al., 2015), or indirectly by providing areas for building social connections (Hartig et al., 2014), reducing stress (Groenewegen et al., 2012; Hartig et al., 2014), and attention restoration (Berman et al., 2008; Berman et al., 2012; Hartig et al., 2014; Kaplan, 1995). These benefits may further influence willingness to exercise or overall quality of life and thus obesity. Obesity itself may impact ability and willingness to participate in physical activity, and, at least in children, increased adiposity may reduce physical activity (Richmond et al., 2014).

Studies indicate positive associations between greenspace availability and physical activity (Kaczynski and Henderson, 2007; Jiang et al., 2016) and qualitative studies suggest that greenspace attributes (e.g., safety, aesthetics, amenities, maintenance) influence physical

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http://dx.doi.org/10.1016/j.ufug.2017.05.016
Received 29 November 2016; Received in revised form 22 May 2017; Accepted 28 May 2017
Available online 03 June 2017
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activity (Mccormack et al., 2011; Koohsari et al., 2015). Recent studies found inverse relationships between urban parks and natural amenities and weight status such that locations with greater access experienced lower body mass indices (BMI) (Pitts et al., 2013; Rundle et al., 2013; Stark et al., 2014; Boncinelli et al., 2015; Xu et al., 2015). Several studies, however, found no or a positive relationship between greenspace exposure and weight status (Rundle et al., 2013; Lachowycz and Jones, 2011). As contact with urban nature may encourage physical activity and healthy lifestyles that could reduce obesity (Hartig et al., 2014), better understanding the relationships among obesity and greenspace could improve management of urban environments to reduce obesity rates.

A number of factors may contribute to inconsistencies observed in the relationships between greenspace and obesity, including inadequate adjustment for socioeconomic factors and reliance on self-reported measures of obesity and physical activity and crude greenspace metrics (Lachowycz and Jones, 2011; Koohsari et al., 2015; Van Den Berg et al., 2015). Relationships between greenspace and weight status may also vary demographically (e.g., with age, gender, race/ethnicity) (Van Den Berg et al., 2015). These relationships have received little study, but evidence suggests that greenspaces reduce the odds of overweight/obesity for women generally (Veitch et al., 2016) and for women of color, over 40-years old, and without college degrees (Ransdell and Wells, 1998; Bassett et al., 2002), but not for men (Veitch et al., 2016; Astell-Burt et al., 2014). Some studies found relationships between greenspace attributes and weight status, with publicly-owned (Ghimire et al., 2017), cleaner (Stark et al., 2014), larger (Rundle et al., 2013), and forested (Ghimire et al., 2017) greenspaces and greenspaces that provide resources for outdoor recreation such as biking and hiking trails (Ghimire et al., 2017) exhibiting a significant relationship to weight status not observed for other greenspaces. As such, the current literature suggests that relationships between greenspace and weight status vary among population subgroups and with greenspace attributes, but does not definitively identify these differences or the factors that contribute to them.

Previous studies leave critical questions regarding relationships between urban greenspace and weight status unanswered. These questions relate particularly to identifying 'where' and for 'whom' weight status is associated with greenspace, 'what' greenspace characteristics are correlated with weight status, and mechanisms whereby associations occur (Lachowycz and Jones, 2011; Lachowycz and Jones, 2013). We seek to identify relationships among weight status and greenspace type, composition, and spatial arrangement ('what'/'where'), and variation in these relationships with age and gender ('for whom') while adjusting for population attributes (e.g., wealth, education, race/ethnicity) previously found to impact health (Kaczynski and Henderson, 2007; Lachowycz and Jones, 2011; Koohsari et al., 2015).

2. Methods

We focus on 546 US Census block groups in Cleveland, Ohio, USA (Fig. 1) ranging in area from 0.65 km^2–2152.42 km^2 (mean = 3.92 km^2, SD = 4.98). In 2009, 35% of Cleveland adults were obese (Bruckman et al., 2012), with higher rates for women (41%) than men (32%). Rates were lowest in the 18–29 year-old age group (29%) and highest amongst individuals aged 30–49 (41%).

2.1. Body mass index

We measured weight status using BMI, a summary measure of height and weight that is commonly-used for monitoring prevalence of overweight/obesity at individual and population levels. We estimated BMI using the US Centers for Disease Control's algorithm by dividing an individual's weight (kg) by the square of their height (m) (http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html#Interpreted) and data from the Ohio Bureau of Motor Vehicles (BMV) state driver's license and identification card applications. This dataset included age, gender, self-reported height and weight, and residential location for Cleveland residents aged 18–84 years with driver's licenses or state identification cards between January, 2010 and December, 2012 (305,295 individuals, 149,797 males, 155,498 females). Ohio BMV data may be seen as generally representative of Ohio's overall population as 87.2% of Ohio's driving-age population possess driver's licenses and overall proportions of male and female licensed drivers correspond closely to the gender composition of the state's driving-age population (US Department of Transportation Federal High Administration, 2010). Some groups (e.g., the elderly, very poor, disabled, undocumented) are less likely to possess driver's licenses. Including data from state identification cards enhances representativeness of these groups as individuals without driving licenses require an identification card to access services. As a result of the large size of this dataset and its coverage of a very large proportion of the population, we consider this dataset to provide a general representation of the overall Cleveland population, but acknowledge that some groups may be less well-represented.

We used GIS functions to calculate average block group male and female BMI for the following age groups: 18–29 (young adult), 30–50 (middle adult), 51–65 (older adult), and 65–84 (retiree). We aggregated to this level because, while the agreement with the BMV allows individual-level analysis, reporting must occur at aggregated scales. Smaller aggregation units (e.g., Census blocks) would threaten confidentiality. We included only block groups with over ten individuals per group. Additionally, to facilitate comparison with US Census-derived variables, we excluded individuals under 18 and over 84 years from analysis.

2.2. Greenspace variables

Cleveland supports 143.20 km^2 of protected greenspace: conservation lands (47.84 km^2), recreational parks (71.69 km^2), and cemeteries (23.67 km^2). All conservation lands and recreational parks included in this analysis were publicly-accessible. Cemeteries were semi-accessible (i.e., publicly-accessible during the day on most days, but typically gated and closed at other times). We identified greenspace locations and types using parcel data from the Cuyahoga County Geographical Information Systems Department (CCGISD) and used ten variables in four groups to quantify greenspace attributes. The first group included three variables that identify greenspace exposure as the percentage of block group area occupied by each greenspace type. The second group quantified greenspace connectivity which might facilitate activities requiring larger extents (e.g., walking, jogging, cycling). We included two connectivity variables, collective recreational park and conservation land contiguity and contiguity of cemetery. These variables were calculated using the contiguity index, a common landscape metric that identifies spatial connectedness, using Fragstats version 4.2 (McGarigal et al., 2012). This index ranges from 0 to 1. Zero values indicate either low connectedness or the absence of a greenspace type, values near 1 indicate high connectedness of that type.

Greenspace land-cover composition and arrangement may influence usage. To measure greenspace composition, we calculated two groups of variables. First, we estimated the percentage of greenspace in each block group covered by water, forest, impervious surfaces, and grass using 2011, high-resolution (1-m) land-cover data from the CCGISD. Second, we calculated mean block group greenspace percent canopy coverage using the 2011 National Landcover Dataset (NLCD) Tree Canopy product (Homer et al., 2015). Canopy coverage is distinct from forest as it includes canopy over pavement and grass rather than contiguous forest.

2.3. Socio-economic variables

Using 2010 US Census data, we identified block group percent

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