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Research Paper

The relationship between self-reported exposure to greenspace and human stress in Baltimore, MD

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ABSTRACT

Cross-sectional methods were utilized to investigate if greenspace (GS) exposure predicts stress, a known factor affecting health outcomes. Data included publicly accessible Community Statistical Area (CSA) level information and survey (mailed and online) results of residents in Baltimore, Maryland. The convenience sample was recruited in spring 2013 using random (by CSA) and snowball techniques. The survey included demographic information, GS exposure, recent stressful life events, and the validated Perceived Stress Scale (PSS). Individuals reported (hours per week, type) where they see (visual exposure) or spend time in (physical exposure) GS around their home, work and/or school, and during recreation. Duration of GS exposure was defined as hours of visual exposure, hours of physical exposure, and total hours of exposure (both visual and physical). Multivariable linear regression assessed the effect of GS on perceived stress. Respondents (N = 323) reported a mean 25.5 total hours/week exposed to GS. Mean PSS scores were 15.75 for females and 13.45 for males. Controlling for all covariates, there was a statistically significant reduction in PSS score (0.049, p = 0.007) for every hour/week exposed to GS. This means that an individual who spent 25.5 h/week exposed to GS would have a PSS score 3.1% lower than those who were not exposed to GS. Total hours/week exposed to GS, and the individual effects of visual and physical exposure were all statistically significant. These findings indicate the stress reducing effects of GS exposure may be part of complex set of factors behind the relationship between GS and health outcomes.

1. Introduction

Design-related factors shaping where we live, work, and play have become increasingly important considerations in health-related fields. In fact, the World Health Organization has identified the social determinants of health, as “mostly responsible for health inequities – the unfair and avoidable differences in health status seen within and between countries” (“Social determinants of health,” 2013).

Many studies have revealed a protective relationship between the percentage of greenspace (GS) where a person lives and their actual (Maas et al., 2009; Mitchell & Popham, 2008; Takano, Nakamura, & Watanabe, 2002) and perceived health (de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006). Several mechanisms have been postulated to explain the relationship between percentage of neighborhood GS and positive health determinants including relationships between GS and crime, air quality, and stress. However, studies assessing relationships between GS and both crime and air quality report variability due to more detailed factors that could not be assessed using an area- based metric. For example, while greenspace that does not obstruct visibility has been linked to lower crime rates (Donovan & Prestemon, 2012; Troy, Morgan Grove, & O’Neil-Dunne, 2012) as has greening vacant lots (Branas et al., 2011), vegetation that obstructs visibility may invite criminal activity (Donovan & Prestemon, 2012). Similarly, while air quality is a factor affecting health outcomes, and trees can reduce air pollutants (Nowack, 2002), the siting of trees relative to the pollution source and other factors may interact to determine the degree of benefit, if any (Gromke & Ruck, 2009; Nowak, Crane, & Stevens, 2006; Vos, Maiheu, Vankerkom, & Janssen, 2013).

One possible factor that may explain the GS health relationship

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observed at the neighborhood level is stress. Stress is a known factor in both the etiology (cause) of disease and disease prognosis. Stress can affect health through increasing propensity for behavioral risk factors for disease (Glantz & Schwartz, 2008) or through physiologic adaptations caused by the release of stress hormones (Cohen, Janicki-Deverts, & Miller, 2007). Prolonged activation of the stress response increases the risk for permanent effects, contributing to the development of chronic diseases and weakening the body's ability to cope with existing disease (Cohen et al., 2007; Falagas et al., 2007; Ramirez et al., 1989). Increased levels of stress have been reliably linked to incidence of depression, incidence and mortality from cardiovascular disease, and progression of HIV/AIDs (Cohen et al., 2007).

Potential stress mediating effects of exposure to GS have been noted in both experimental and observational studies. In an experimental study, students exposed to a video stressor were divided into groups that either subsequently viewed natural scenes (including vegetation or vegetation and water) or urban scenes (without vegetation or water). Stress recovery, measured through a variety of physiologic measures and a state affect questionnaire, was more rapid and complete in the group that viewed natural scenes (Ulrich et al., 1991). Similarly, students exposed to a stressor while sitting in a room with a view of trees had a more rapid decline in diastolic blood pressure than those who sat in a windowless room (Hartig, Evans, Jamner, Davis, & Garling, 2003). In addition, various physiologic indicators of stress decreased to a greater extent for students when exposed to forested environments than when exposed to urban environments without vegetation (Lee et al., 2011). Residents of neighborhoods with a greater percentage of GS had lower chronic stress as assessed using salivary cortisol levels, and lower self-reported stress, as measured using the Perceived Stress Scale (Ward Thompson et al., 2012). Socioeconomic disparities in all-cause mortality rates and mortality due to circulatory diseases, for which stress is a known factor, were also lower in greener neighborhoods (Mitchell & Popham, 2008).

However, area-based studies cannot capture variability in exposure due to human behavior (i.e. the mere presence of GS does not demonstrate exposure to GS), and experimental studies cannot assess if GS is inversely related to chronic stress during day to day life. In addition, even in experimental studies, the variability in quality, density, and type of GS and any difference in stress response are generally not addressed.

Recent research has investigated the "dose" of nature required to produce these effects. In this developing literature, nature exposure at various doses has been found to be associated with several health outcomes (Barton & Pretty, 2010; Cox et al., 2017; Shanahan et al., 2016). Dose of nature encompasses the aspects of intensity or concentration of vegetation and frequency or duration of exposure (Shanahan, Fuller, Bush, Lin, & Gaston, 2015; Sullivan, Frumkin, Jackson, & Chang, 2014). A recent experimental study has indicated a relationship between stress and an aspect of dose of nature, duration of GS exposure (Jiang, Chang, & Sullivan, 2014); however, the impact of this aspect of dose of nature on stress has yet to be explored in observational research, among individuals accessing GS as typical in their daily lives.

The purpose of this cross-sectional study is to investigate if GS exposure, specifically duration of time spent accessing GS, is statistically significant in predicting stress, a known factor affecting health outcomes, in a non-hospitalized population going about day to day activities without experimental interference in Baltimore, MD.

2. Methods

This study employed an anonymous survey of residents in Baltimore, Maryland, which collected demographic data, measures of exposure to GS, an inventory of recent stressful life events, and incorporated the Perceived Stress Scale (PSS), a 10 question validated survey instrument developed to measure individual variability in stress response due to differences in coping strategies and available resources (Cohen, Kamarck, & Mermelstein, 1983). The institutional review board of SUNY Upstate Medical University (FWA #00005967, IRB #00000391) approved the study following expedited review.

2.1. Location selection

Baltimore was chosen as a study location because it is an urban area with a temperate climate and a wide range of GS availability, as well as documented geographic health disparities (Ames et al., 2011; Iyer et al., 2012). In addition, socio-economic, environmental, and health data are made publicly available from multiple sources using the same geographic units called Community Statistical Areas (CSA's). CSA's are aggregates of demographically similar census blocks grouped by neighborhood, compiled by the Baltimore Neighborhood Indicators Alliance (BNIA) at the University of Baltimore's Jacob France Institute (JFI) (Baltimore Neighborhood Indicators Alliance, Jacob France Institute, & University of Baltimore, 2017).

2.2. Data collection

Data were gathered using a self-administered survey instrument and supplemented with population level data from several sources. Demographic characteristics, including gender, age, race, ethnicity and educational attainment for the City of Baltimore were obtained from the U.S. Census Bureau. CSA level data on percent canopy and percent GS were obtained from the U.S. Forest Service, and CSA level data on race, median income, educational attainment, vacant building density, and homicide rate were obtained from *Baltimore Neighborhood Health Profiles* 2011 (Ames et al., 2011). The survey was designed specifically for this study and was distributed both on paper and online in the spring of 2013. SurveyMonkey® was used to collect and store online survey data.

2.2.1. Survey distribution

The survey was distributed using a combination of random and snowball techniques. To construct the initial invitee list for the survey, an anonymous list of addresses was obtained from the Baltimore city demographer and grouped according to the corresponding CSA. From each of the 55 CSA's located within Baltimore, 30 addresses were randomly selected and mailed the survey packet (N = 1650). To supplement the initial mailing, a list of community organizations, religious institutions, and schools was also obtained from the city demographer and grouped according to the corresponding CSA. One of each per CSA was randomly selected, contacted, and asked to distribute the survey. While these organizations were offered paper copies of the survey for their constituents, all who agreed preferred to distribute a link to the online version. In addition, 600–700 flyers were distributed at public places such as bus stops, telephone poles, laundromats, and nearby businesses near randomly-selected locations. Some subjects were provided a paper copy of the survey during distribution of the flyers. Information given verbally was limited to the contents of the consent document and the recruitment letter distributed in the survey. The Baltimore City Office of Planning was also contacted, along with all of the Baltimore City Council members, some of whom agreed to send the web link to their constituents and community organizations. If people asked, they were instructed that it was permissible to forward the link to other potential respondents via email, Facebook, or other means. The online survey link was also advertised through Facebook and Twitter pages, including a dedicated Facebook page for the study.

To encourage participation, all respondents were offered the opportunity to enter an incentive drawing with one $200 prize, one $100 prize, and four $25 prizes. Identifiable information for the incentive drawing was submitted separately from the de-identified survey response. A power calculation was performed using the G*power 3 calculator (Faul, Erdfelder, Buchner, & Lang, 2009) using the default small,