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Walkability and cardiometabolic risk factors: Cross-sectional and longitudinal associations from the Multi-Ethnic Study of Atherosclerosis

Lindsay M. Braun[a,*], Daniel A. Rodríguez[a], Kelly R. Evenson[b], Jana A. Hirsch[c], Kari A. Moore[d], Ana V. Diez Roux[d]

[a] Department of City and Regional Planning, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[b] Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[c] Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[d] Dornsife School of Public Health, Drexel University, Philadelphia, PA, United States

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ABSTRACT

We used data from 3227 older adults in the Multi-Ethnic Study of Atherosclerosis (2004–2012) to explore cross-sectional and longitudinal associations between walkability and cardiometabolic risk factors. In cross-sectional analyses, linear regression was used to estimate associations of Street Smart Walk Score® with glucose, triglycerides, HDL and LDL cholesterol, systolic and diastolic blood pressure, and waist circumference, while logistic regression was used to estimate associations with odds of metabolic syndrome. Econometric fixed effects models were used to estimate longitudinal associations of changes in walkability with changes in each risk factor among participants who moved residential locations between 2004 and 2012 ($n=583$). Most cross-sectional and longitudinal associations were small and statistically non-significant. We found limited evidence that higher walkability was cross-sectionally associated with lower blood pressure but that increases in walkability were associated with increases in triglycerides and blood pressure over time. Further research over longer time periods is needed to understand the potential for built environment interventions to improve cardiometabolic health.

1. Introduction

Heart disease, stroke, and diabetes are three of the leading causes of death worldwide, resulting in approximately 16.7 million deaths (nearly 30 percent of all global deaths) in 2012 with even greater rates in high-income countries (World Health Organization, 2014). Cardiometabolic risk factors, including elevated lipids, glucose, and hypertension, are projected to continue to rise, especially as the population ages and increasingly in middle- to low-income countries (Smith et al., 2012). Thus, identifying population-level strategies to reduce cardiometabolic risk is a global public health priority.

While individual and pharmaceutical-related interventions play a role in reducing cardiometabolic risk (National Center for Health Statistics, 2011), place-based strategies have the potential to improve population health outcomes on a broader scale. In line with this notion, a growing body of literature has explored the relationship between the built environment and cardiovascular health. Typically operationalized using measures of density, land use mix, and street connectivity (Saelens et al., 2003), walkable built environments have been found in cross-sectional studies to be positively associated with walking (Van Dyck et al., 2010; Witten et al., 2012; Li et al., 2005) and physical activity (Van Dyck et al., 2010; Witten et al., 2012; Hoehner et al., 2011; Berke et al., 2007; Li et al., 2008; Garden and Jalaludin, 2008; King et al., 2005; Frank et al., 2004) and inversely associated with body mass index (BMI) (Hoehner et al., 2011; Berke et al., 2007; Li et al., 2008; Garden and Jalaludin, 2008; Frank et al., 2004; Joshu et al., 2008; Rundle et al., 2007). More recently, longitudinal evidence has suggested similar associations between the built environment and walking (Hirsch et al., 2014a; Giles-Corti et al., 2013; Gebel et al., 2011; Mumford et al., 2011; Michael et al., 2010), cycling (Beenackers et al., 2012), overall physical activity (Gebel et al., 2011; McAlexander et al., 2011; Calise et al., 2012), and BMI (Hirsch et al., 2014a, 2014b; Berry et al., 2010). These findings, derived from studies in the United States, Canada, Europe, Australia, and New Zealand, suggest that the settings in which people live may influence proximal behaviors that

* Correspondence to: Campus Box 3140, New East Building, Chapel Hill, NC 27599-3140, United States.
E-mail address: maurerbraun@unc.edu (L.M. Braun).

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in turn influence health.

Physical activity and normal body weight have a variety of cardiometabolic benefits, suggesting that the built environment—through its documented relationships with physical activity and BMI—may also be associated with more distal health outcomes such as glucose, triglycerides, cholesterol, and blood pressure. Regular physical activity can reduce fasting glucose levels, and thus reduce the risk of type 2 diabetes, by facilitating the uptake, transport, and regulation of muscle glucose (Goodyear and Kahn, 1998; Hayes and Kriska, 2008; Sigal et al., 2004; Goodpaster and Brown, 2005). Through its influence on lipid metabolism (Pires et al., 2012), physical activity can lead to improved lipid profiles including lower triglyceride levels (Pires et al., 2012; Green et al., 2014; Gordon-Larsen et al., 2009), greater high-density lipoprotein cholesterol levels (Pires et al., 2012; Donnelly et al., 2000; Murphy et al., 2002), lower total cholesterol levels (Murphy et al., 2002), and lower lipid accumulation (Green et al., 2014). The cardiovascular benefits of physical activity also include improved blood pressure, and past research has found moderate activities such as active commuting (walking or cycling to work) (Gordon-Larsen et al., 2009) and daily walking (Moreau et al., 2001) to be associated with lower diastolic (Gordon-Larsen et al., 2009) and systolic (Moreau et al., 2001) blood pressure. Additionally, the converse of physical activity—sedentary time—is an independent risk factor for adverse cardiometabolic health (Green et al., 2014; Sugiyama et al., 2016). These biological mechanisms suggest potential pathways through which the built environment, as a facilitator of or barrier to physical activity, may influence downstream cardiometabolic risk factors.

Limited research has been conducted to date on the relationship between the built environment and cardiometabolic risk (Leal and Chaix, 2011). Two recent cross-sectional analyses in the United States and Australia found that neighborhood physical activity resources (Auchincloss et al., 2008) and walkability (Müller-Riemenschneider et al., 2013) were associated with lower insulin resistance and lower risk of type 2 diabetes. Baldock et al. (2012) found perceived neighborhood land use mix, aesthetics, and pedestrian infrastructure to be correlated with lower risk of metabolic syndrome among adults in Australia. Two cross-sectional studies in France and the Netherlands found measures of population and housing density (Chaix et al., 2008; Agyemang et al., 2007) and green space quality (Agyemang et al., 2007) to be correlated with lower systolic blood pressure. Mujahid et al. (2008) recorded an association between higher neighborhood walkability and lower prevalence of hypertension among older adults in the United States, although this association was not robust to adjustment for race. A small number of studies in the United States and Australia have analyzed composite cardiometabolic risk measures (Coffee et al., 2013; Dengel et al., 2009), providing some cross-sectional evidence of a positive association between walkable built environments and improved cardiometabolic profiles.

Even fewer studies have examined this relationship longitudinally (Leal and Chaix, 2011). Li et al. (2009) found higher neighborhood walkability to be associated with decreases in systolic and diastolic blood pressure over a one-year period among middle-aged and older adults in Portland, Oregon. Auchincloss et al. (2009) examined the role of healthy food sources and recreational facilities, finding greater availability of both to be associated with lower diabetes incidence over a five-year period among older adults in the United States. Paquet et al. (2014) found the risk of developing pre-diabetes or diabetes to be lower among Australian adults living in areas with larger public open spaces and higher walkability, although no such relationships were observed for the risk of hypertension or dyslipidemia. Sundquist et al. (2015) observed an association between higher walkability and lower incidence of type 2 diabetes over a three-year follow-up period in Swedish adults, but this relationship did not persist after controlling for individual-level sociodemographic characteristics. Examining older adults in the United States over a 10-year period, Christine et al. (2015) found a lower incidence of type 2 diabetes among those with greater access to healthy food and physical activity resources.

While these longitudinal studies have explored the incidence of cardiometabolic risk factors over time, only Christine et al. (2015) related these changes to time-varying built environment exposures. Thus, there is a critical need for further research on the relationship between *changes* in the built environment and *changes* in cardiometabolic health. Because changes to the built environment often occur over long time frames, one useful research design is to examine changes in health among individuals who move residential locations and are therefore exposed to a new and potentially distinct neighborhood environment. This approach, which has been used in previous studies to examine longitudinal associations of the built environment with physical activity, walking, and BMI (Hirsch et al., 2014a; Giles-Corti et al., 2013; Mumford et al., 2011; Handy et al., 2008; Lee et al., 2009; Wells and Yang, 2008; Christian et al., 2013), has the potential to provide a more thorough understanding of the relationship between the built environment and cardiometabolic health.

Given the emerging nature of this evidence base, there is a need for both cross-sectional and longitudinal research to extend these findings to different populations and contexts. The present study responds to this need by exploring cross-sectional and longitudinal associations between the neighborhood built environment and cardiometabolic risk factors in the Multi-Ethnic Study of Atherosclerosis (MESA). As previous work in this sample has indicated a relationship between changes in the built environment and changes in both walking and obesity (Hirsch et al., 2014a, 2014b, 2014c), this paper considers associations of the neighborhood walking environment with cardiometabolic risk factors potentially affected by physical activity and body weight. The longitudinal portion of the study focuses on respondents who move residential locations in order to assess changes in both environment and health. Through this multifaceted approach, we contribute to an enhanced understanding of the potential connections between modifications that planners and policy makers can make to the built environment and a wider set of health outcomes.

2. Methods

2.1. Sample

The sample for this analysis was from MESA, a longitudinal study with racially and ethnically diverse participants recruited from six regions across the United States (Forsyth County, North Carolina; New York, New York; Baltimore, Maryland; St. Paul, Minnesota; Chicago, Illinois; Los Angeles, California) beginning in 2000. MESA respondents are a population-based sample of 6814 men and women who were 45–84 years of age and had no history of clinical cardiovascular disease at baseline (Bild et al., 2002).

This analysis used data from exam 3 (January 2004–September 2005) and exam 5 (April 2010–February 2012). The cross-sectional sample consisted of respondents who participated in the Neighborhood Ancillary Study and gave complete information on all variables of interest at exam 5. Respondents with diabetes mellitus (DM) at exam 5 were also excluded from the cross-sectional analysis given the focus on metabolic syndrome, the interpretation of which is not as meaningful in the presence of DM. Among the 4622 individuals who completed exam 5, 621 were excluded for missing data and an additional 774 were excluded for having DM,