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Neighborhood walkability, deprivation and incidence of type 2 diabetes: A population-based study on 512,061 Swedish adults

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ABSTRACT

Neighborhood walkability has been associated with increased physical activity, but only a few studies have explored the association between walkability and health outcomes related to physical activity, such as type 2 diabetes. The aim of this study was to investigate the association between objectively assessed neighborhood walkability and the 4-year incidence of type 2 diabetes in a sample of 512,061 Swedish adults aged 18 years and older. Neighborhoods were defined by 408 administratively defined geographical areas in the city of Stockholm. We found a negative association between walkability and type 2 diabetes (OR = 1.33, 95% CI = 1.13–1.55) that remained significant after adjusting for neighborhood deprivation. This association, however, no longer remained statistically significant after adjusting for individual socio-demographic factors. These results were also confirmed using a co-sibling design. Future studies are encouraged to further explore the potential effect of a broader array of the neighborhood built environment on health outcomes related to physical activity.

1. Introduction

Research on environmental correlates of physical activity has gained increasing interest during the last decade. Neighborhood walkability, a physical environmental characteristic, has been investigated in several studies and it has become one of the most consistent environmental correlates of physical activity in Europe (Sundquist et al., 2011; Van Holle et al., 2012) and worldwide (Owen et al., 2007; Sallis et al., 2009; Bauman et al., 2012).

Previous research on neighborhood walkability has primarily addressed the hypothesis that more walkable environments result in higher levels of physical activity, which in turn may decrease the public health burden of non-communicative diseases such as hypertension, type 2 diabetes, cardiovascular disease and depression (Frank et al., 2006; Owen et al., 2007; Sallis et al., 2009). Most studies have investigated the association between neighborhood walkability and walking and/or total physical activity (Owen et al., 2007; Sallis et al., 2009; Sundquist et al., 2011; Van Dyck et al., 2010a). For example, results from the Swedish Neighborhood and Physical Activity study showed that participants living in highly walkable neighborhoods reported 50 min more of walking for transportation per week and had about 21 more minutes of moderate to vigorous physical activity per week (Sundquist et al., 2011). Only a few studies have, however, investigated the association between neighborhood walkability and other types of health-related outcomes and even fewer have used a longitudinal study design. Many of the studies on walkability and health-related outcomes have used body mass index (BMI) as an outcome (Frank et al., 2007; Gebel et al., 2011; Sallis et al., 2009; Van Dyck et al., 2010b), while others were based on mental and physical quality of life (Sallis et al., 2009). The results have often shown that more walkable environments may have a beneficial effect on certain health-related outcomes but not on others, i.e., living in walkable neighborhoods is associated with more physical activity and lower overweight/obesity rates but not with better quality of life.

The worldwide prevalence of type 1 and type 2 diabetes in the adult population is about 6.4% (285 million people) and it is estimated to increase to 7.7% (439 million adults) by 2030 (Shaw et al., 2010). Insufficient levels of physical activity are estimated to cause 27% of the type 2 diabetes burden worldwide (WHO, 2009). Despite the obviously beneficial effects of physical activity in the prevention of type 2 diabetes (Colberg et al., 2010), a majority of individuals at risk of developing type 2 diabetes are not sufficiently physically active (at least 150 min of moderate to vigorous

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physical activity per week) (Morrato et al., 2007). There is also evidence that walking specifically improves 24 h glycemic control in people at risk for type 2 diabetes (DiPietro et al., 2013).

Walkable neighborhoods have therefore been suggested as a potentially preventive factor for type 2 diabetes in the population (Pasala et al., 2010) and self-reported neighborhood resources for physical activity, such as perceived ease of walking and availability of exercise facilities, were shown to be negatively associated with type 2 diabetes in a study of 2285 adults in the U.S. (Auchincloss et al., 2009). However, while the association between objectively measured neighborhood walkability and physical activity is relatively established, no previous study has investigated the potential association between objectively measured neighborhood walkability and the incidence of type 2 diabetes in the entire adult population of a large city. In addition, previous research has highlighted the importance of objectively assessing walkability; in a recent report that used both objective and subjective assessments of walkability, one-third of individuals in neighborhoods with high objective walkability misperceived it as low (Arvidsson et al., 2012b).

Neighborhood deprivation is an important variable to consider in studies of the potential association between neighborhood characteristics and type 2 diabetes as previous studies have documented associations between neighborhood deprivation and type 2 diabetes, physical activity and diet (Cubbin et al., 2006; Mezuk et al., 2013). Neighborhood walkability was a strong predictor of type 2 diabetes incidence independent of neighborhood deprivation in a large study from Canada. Coexisting poverty and recent immigrant status modified these effects (Booth et al., 2013). Finally, previous research has argued that there is a need to examine whether individual and neighborhood characteristics may modify the association between the built environment, i.e., neighborhood walkability, and health-related behaviors (Lovasi et al., 2009). This is because socioeconomically disadvantaged individuals may be less likely to respond positively to walkable neighborhoods due to lack of financial and other resources.

The first aim of this study was to investigate the association between objectively assessed neighborhood walkability and the incidence of type 2 diabetes, independently of neighborhood – and individual-level potential confounders, in a sample of 512,061 Swedish adults. The second aim was to investigate the potential interactions, i.e., moderating effects of individual socioeconomic characteristics and neighborhood deprivation on this hypothesized association. To gain further insight into the nature of the association between walkability and diabetes, we also used a co-sibling design that allowed us to assess the degree to which the possible association observed in the population might be causal or due to confounding from genetic and/or familial-environmental factors.

2. Methods

Our study used linked data from multiple Swedish nationwide registries and healthcare data. Linking was achieved via the unique individual 10-digit personal ID number assigned at birth or immigration to all Swedish residents. This ID number was replaced by a serial number, in order to preserve confidentiality. The following sources were used to create our dataset: the Total Population Register, containing annual individual-level sociodemographic data; the Multi-Generation Register, providing information on family relations; the Swedish Hospital Discharge Register, containing all hospitalizations for all Swedish residents; the Swedish Prescribed Drug Register, containing all prescriptions in Sweden picked up by patients; the Swedish Mortality Register, containing causes of death, and; the Longitudinal Integration Database for Health Insurance and Labor Market Studies (LISA), containing annual information on socioeconomic factors on all individuals from 16 years of age. The data were provided to us by Statistics Sweden (the Swedish Government-owned Statistics Bureau) and the National Board of Health and Welfare. All socioeconomic data used in the present study were obtained from national registers maintained by Statistics Sweden, who in turn receives data on the socioeconomic variables from different authorities. For example, the income data comes from the tax authorities and the education data comes from schools and universities. Self-report survey measures are only used for educational level in those immigrants who have not studied in Sweden (Statistics Sweden).

We secured ethical approval for this study from the Regional Ethical Review Board of Lund University (No. 2008/409).

2.1. Outcome variable

Clinically diagnosed type 2 diabetes was identified in the Swedish Prescribed Drug Register by ATC codes A10A (insulin and analogs to insulin), A10B (blood glucose lowering drugs, excluding insulins) and A10 × (other drugs used in diabetes). Individuals were considered to have their first recorded event of type 2 diabetes in our analyses if they had collected a prescribed drug classified from the above ATC codes during the period January 1, 2007–December 31, 2010. Insulin and anti-diabetic agents are almost exclusively prescribed for individuals with a diagnosis of diabetes mellitus, which means that the use of ATC-codes will not include other types of diseases. Swedish doctors follow national guidelines in the diagnosis of type 2 diabetes (Läkemedelsverket, 2014), which are based on expert consensus from the WHO. Missing data in the Swedish Prescribed Drug Register varies between 0.02% and 0.6% according to the National Board of Health and Welfare (National Board of Health and Welfare). In addition, the National Diabetes Register in Sweden has used the Swedish Prescribed Drug Register to validate their own data and found that the correspondence between the two registers is high (Nationella Diabetesregistret, 2013).

2.2. Samples

The city of Stockholm is divided into 408 geographic areas, created for administrative purposes. The mean number of individuals living in these areas is 1890 (range 1–8790). The mean size of the areas is 0.53 km^2 (range 0.01–3.81), which corresponds well with other studies' definitions of neighborhoods used to estimate walkability indices (Forsyth, 2007).

From the population residing in the 408 geographical areas on December 31, 2005, we identified all individuals born 1988 or earlier ($n=634{,}214$). This age restriction ensures that the vast majority of identified incident cases are of type 2 diabetes (Thunander et al., 2008). We excluded individuals who had collected a prescribed drug classified from the above ATC codes from January 1, 2006 – December 31, 2006 in order to increase the probability that our analysis was restricted to incident cases; all drugs in Sweden are prescribed for a period of three months, which means this 12-month wash-out period covered four possible prescriptions. Remaining individuals were followed for the outcome variable described above from 1st Jan 2007 to 31st Dec 2010. We also excluded those individuals hospitalized for cardiovascular diseases (CVDs) during the years 2000–2006 in order to minimize confounding due to CVD. CVD was defined according to the following ICD10 codes: I10–I15, I20–I25, and I60–I69. Other exclusions were individuals who died ($n=28{,}336$) or emigrated ($n=22{,}998$) during the follow-up period. Individuals lacking information on residential location were also excluded ($n=3777$). Furthermore, we excluded 67 geographic areas with less than 50 individuals due to unstable statistical estimates. In total, 1869 eligible individuals were lost due to this restriction. In the final analyses, 512,061 individuals from 341 geographical areas were included. In a second step, by means of the Swedish