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Urban greenness and physical activity in a national survey of Canadians

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ABSTRACT

Recent research suggests that urban greenness has important beneficial effects on health. While some epidemiological studies have investigated associations between measures of greenness and participation in physical activities, the findings have been inconsistent and several have relied on self-reported rather than objectively determined measures of greenness. Further, there have been few national studies. Our aim was to characterize associations between residential measures of greenness and physical activity within a nationally representative sample of Canadians. Moreover, we sought to determine to what extent these associations were modified by age, sex and income. Our analyses are based on data collected from participants of the 2001 Canadian Community Health Survey. Analyses were restricted to 69,910 individuals who were: 20 years of age and older, lived in urban areas, and for whom a residential measure of greenness could be assigned. The Normalised Difference Vegetation Index (NDVI), which is an objectively defined measure of greenness based on satellite imaging, was assigned to the residential addresses of the participants. Our NDVI values were based on 30 m and 500 m buffers from the centroid of the provided postal codes. Logistic regression was used to estimate odds ratios (ORs) and their 95% confidence intervals to describe associations between greenness and several measures of physical activity. The ORs were adjusted for age, sex, smoking status, marital status, and income. We found that participants who resided in the highest quartile of greenness, based on a 500 m buffer, were more likely to participate in leisure-time physical activity (adjusted OR=1.34, 95% CI=1.25–1.44) when compared to those in the lowest quartile. Positive associations were observed between greenness and physical activity in all income groupings. A key finding was the observation of a stronger association between greenness and measures of physical activity among younger adults, especially women. Our findings have important public health implications as they suggest that access to urban green environments contributes to increased participation in leisure-time physical activity which has demonstrable health benefits.

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1. Introduction

Recent research suggests that greenness (sometimes referred to as green space or natural environments) plays a beneficial role in the health of urbanites. Greenness typically includes open and undeveloped land with natural vegetation, including parks, playing fields and forests (Mitchell and Popham, 2008) or lawns, golf courses and wetlands (Richardson et al., 2012). The benefits of greenness are varied and range from fostering social connections and positive effects on mental and physical health (Kaczynski et al., 2009; Schipperijn et al., 2013), improving sleep quality (Astell-Burt et al., 2013), and lowering mortality rates for stroke (Lee and Maheswaran, 2011), and other causes of death (Mitchell and Popham, 2008; Villeneuve et al., 2012).

While the health benefits of greenness have been documented in several studies, the biological pathways that confer these benefits are less well understood. It has been suggested that the health improvements occur, in part, because access to green spaces promotes physical activity (Mytton et al., 2012). Physical activity has been shown to reduce the risk of cardiovascular disease, osteoporosis, mortality, and some forms of cancer (Warburton et al., 2006). Canadians are largely sedentary, and recent estimates suggest that only 15% of adults meet government recommended physical activity guidelines of 150 min of activity per week (Colley et al., 2011).

The studies that have investigated urban greenness and physical activity have produced mixed results with positive associations observed in some (Cohen et al., 2007; Coombes et al., 2010; Kaczynski et al., 2009; Mytton et al., 2012), but not other studies (Maas et al., 2008; Ord et al., 2013; Schipperijn et al., 2013; Witten et al., 2008). Of the these studies, only four have been national in

scale; three in Europe (Maas et al., 2008; Mytton et al., 2012; Ord et al., 2013) and one in New Zealand (Witten et al., 2008). The lack of consistency across these studies may be partly due to differences in the methods used to characterize greenness and physical activity. For example, some studies relied on self-reported measures of the number of nearby trees and parks (Takano et al., 2002), while others used community-area or county measures of greenness (Mytton et al., 2012; Ord et al., 2013). Measures of greenness that are better able to describe greenness in close proximity to individuals' homes may be necessary to detect subtle associations. The greenness measure that we used in this study has a higher spatial resolution (< 500 m) relative to most other studies that investigated associated with physical activity. Differences between studies may also be influenced by the different approaches used to measure participants' levels of physical activity. Our study was able to model associations using several metrics of physical activity that captured participation in a variety of leisure-time activities in the past three months.

The socio-ecological framework (Mytton et al., 2012) recognises that social determinants and the environment interact to influence behaviour and health. These social determinants include several characteristics such as income, education, age, gender, and ethnicity (Lachowycz and Jones, 2011). In the context of epidemiological studies of greenness, it is important to evaluate whether associations with health measures are either modified or confounded by socio-demographic factors (Schipperijn et al., 2013). This is salient in Canada because previous research has shown that those who are more affluent, on average, are more likely to reside in greener areas (Villeneuve et al., 2012).

2. Methods and materials

2.1. Study population

This study used data from the 2001 Canadian Community Health Survey (CCHS). The CCHS is a national scale, cross-sectional voluntary survey that was developed primarily for health surveillance and population health research (Statistics Canada, 2013). The survey was designed to collect information from a nationally representative sample of Canadians and recruited participants in all provinces and territories. The target population was Canadians, aged 12 and older, who were non-institutionalized, not a member of the armed forces, and not living on aboriginal reserves (Statistics Canada, 2013). After applying these exclusion criteria, the sampling frame of the survey was deemed to be representative of approximately 97% of Canadian residents (Statistics Canada, 2013). This survey was conducted over the course of the calendar year, and the estimated response rate was approximately 80% (Statistics Canada, 2013). In total, nearly 130,000 Canadians completed the 2001 CCHS. We made use of the private use version of the survey that was further restricted to include only those participants who consented to allowing their place of residence data to be used in research ($n = 125{,}574$).

We limited analyses to adults (i.e., those who were 20 years of age and older). We excluded data from those less than 20 years of age for two reasons. First, survey data for younger participants were often supplied by proxy responses provided by their parents. Second, younger participants are more likely to have regimented physical activities built into school routines, which could obscure associations with residentially based measures of greenness.

2.1.1. Assessment of physical activity

The CCHS collected information on many aspects of physical activity. To comprehensively evaluate associations between green space and physical activity, we performed analyses using six

Table 1
Physical activity variables analysed in (and derived from) the 2001 Canadian Community Health Survey.

Physical activity (PA) variable	Variable type	Description
Level of PA for a usual day	• 4 level categorical	"Thinking back over the past 3 months, which of the following best describes your usual daily activities or work habits? " 1. Usually sit and don't walk much 2. Stand or walk quite a lot but no heavy lifting 3. Usually lift or carry light loads, climb hills or stairs often 4. Heavy work or carries very heavy loads
Participation in leisure time PA	• Dichotomous categorical • Derived from responses to multiple questions	• Yes or no based upon participation in any leisure PA in the previous 3 months from a range of 21 activities.
Monthly frequency of PA > 15 min	• Continuous • Derived from responses to multiple questions	• Number of times individual was active for > 15 min in past 3 months; this was then divided by 3 to provide a monthly measure
Overall frequency of PA	• 3 level categorical • Derived from responses to multiple questions	• Grouped ranking of monthly frequency of PA • High ≥ 12 • Medium ≥ 4 and < 12 • Low < 4
Daily energy expenditure	• Continuous • Derived from responses to multiple questions	• Kilocalories burned per kilogram of bodyweight per day
Physical activity index	• 3 level categorical • Derived from responses to multiple questions	• 3 level categorical variable based on participation in 21 different activities • Active: ≥ 3 Kcal/kg/day • Moderate: 1.5 to < 3 Kcal/kg/day • Inactive: < 1.5 Kcal/kg/day