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A comparison of road- and footpath-based walkability indices and their associations with active travel

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ABSTRACT

Background: Many studies have used the concept of 'walkability' to assess how conducive a neighbourhood is to physical activity, especially active travel. Studies in the United States and Australia have traditionally used a road-based network system of intersection density to derive a walkability index. However, other studies suggest that analyses based on footpath networks may provide a more robust basis for assessing the walkability of built environments in the European context as they better capture alternative opportunities for physical activity such as parks and greenways. To date, no studies have examined whether a road- or footpath-based network is more closely related to actual physical activity behaviour. Therefore, the aims of this paper were to examine associations between active travel and walkability indices based on both road- and footpath-based intersection density and to establish which measure provided the best fit to the data.

Methods: Cross-sectional survey and geographical information system (GIS) data were collected from February 2010-January 2011. A series of crude and fully adjusted zero-inflated negative binomial regression analyses examined associations between road- and footpath-based walkability and the average minutes per week of active travel.

Results: Model fit indices suggested that the models using road-based walkability provided a marginally better fit. However, regression results indicated similar findings with respect to the effect of road- and footpath-based walkability on active travel.

Conclusion: Results suggest that footpath-based indices of walkability are comparable to road-based indices in their associations with active travel and are an alternative model, particularly for assessing environmental change in non-road-based built environment interventions.

1. Introduction

Recent studies have suggested that certain aspects of the built environment can influence levels of physical activity (Sallis et al., 2012). In particular, the concept of 'walkability' has been used as a means of assessing how conducive a neighbourhood is to walking,

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and more generally, physical activity. Walkability has been defined as "the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort and offering visual interest in journeys throughout the network" (Southworth, 2005, p. 248). Attempts have been made to capture those built environment characteristics that are associated with this in the form of a single walkability index. This single indicator allows for the capture of a range of built environment attributes known to support walking behaviour, their variation across space, and links with other factors, such as physical activity, for the purposes of research or planning. The most widely used walkability index (see Section 2 for how it is calculated) (Adams et al., 2014; Frank et al., 2010; Leslie et al., 2007) combines the following four components:

1. Residential density, residents per km (Adams et al., 2014);
2. Retail floor area ratio, representing the retail building floor area divided by the retail land site area;
3. Land use mix, based on five categories (residential, retail, entertainment, office, and institutional) and calculated using an entropy equation whose normalised outcome was between 0 (single use) and 1 (complete even distribution of land use categories); and
4. Street connectivity, calculated using intersection density based on road centre lines calculated as the ratio between the number of road intersections of three or more legs and the land area.

Intersection density (ID) appears to have the greatest influence over active travel (Leslie et al., 2007; Ellis et al., 2016).

The connectivity of any built environment relates to how easy it is to get from point A to point B, and is largely derived from the morphological characteristics of the urban form, including block size and density of streets and paths. It has been suggested that the more connected an urban area, the more conducive it will be to physical activity, independent of other variables (Berrigan et al., 2010). As a result, improving connectivity has become a focus for active travel interventions (Goodman et al., 2014), and it should, therefore, be possible to associate improvement in connectivity with active travel outcomes. Connectivity measures included in the index have conventionally been derived from the networks formed by the road centre lines and as such, are essentially only *proxies* for connectivity of pedestrian infrastructure. Furthermore, it has been noted that there are a series of common errors in road networks (Frizelle et al., 2009), examples of which are noted in Fig. 1. There is, however, almost universal availability of road network data and they are utilised on the assumption that pedestrians primarily use footpaths that run parallel to roads, thus neglecting the influence of non-motorised networks such as footbridges, paths through parks, etc. Indeed, this could mean that road-based walkability indices are not useful at capturing change in non-road based opportunities for physical activity, such as parks, footbridges, greenways, and cycle lanes. Recent guidelines on the environment and physical activity from the National Institute for Health and Care Excellence (NICE, 2008) in the UK have identified the need for the creation of appropriate methodologies to measure how environmental policies and projects can help increase people's physical activity levels. Therefore, the creation of indices that better capture the types of environmental features targeted in these interventions are required, demonstrating the need to assess a footpath-based walkability index. Given the need for built environment interventions (Hunter et al., 2015), such a model would have important implications for assessing non-road-based environmental change interventions.

Some studies (Chin et al., 2008; Ellis et al., 2016; Tal and Handy, 2012) have suggested that a network that reflects all potential route choices for pedestrians has a much greater resolution and potentially provides a better representation of connectivity, which intuitively should offer a more accurate basis for determining the walkability of built environments than those based on road centre lines alone. One study (Ellis et al., 2016) has tested how different measures of connectivity should be used in footpath-based assessments of walkability and has concluded that intersection density is as applicable for measuring connectivity in footpath networks as it is for road networks.

To the best of our knowledge, Ellis et al. (2016) remains the only study to date that has used both non-motorised networks and actual observed physical activity data to empirically test these relationships. However, there are still no studies to date that have empirically compared road- and footpath-based walkability indices and their associations with physical activity. Therefore, the key aim of this paper was to examine associations between active travel and walkability indices based on both road- and footpath-based intersection density and to establish which measure provides the best fit to the data.

2. Methods

2.1. Respondents

A cross-sectional, interviewer-administered self-report survey was conducted and geographical data collected during the period February 2010 to January 2011 as part of a natural experiment examining the health and health behaviours of a sample population experiencing a programme of urban regeneration in East Belfast, Northern Ireland (Tully et al., 2013). A representative stratified random sampling of 1209 households (representative of the Northern Ireland population based on age, gender, and 2001 Census deprivation indicators), resulted in one adult in the household (aged 16 and over) being randomly selected and surveyed (see Tully et al., 2013), for further details of sampling and recruitment). The survey will be repeated in 2017 following the construction of 9 km of new greenway infrastructure that includes footbridges, pedestrian paths, and road crossings.