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Built environmental correlates of cycling for transport across Europe

Lieze Mertens[a], Sofie Compernolle[a], Benedicte Deforche[b,c], Joreintje D. Mackenbach[d], Jeroen Lakerveld[d], Johannes Brug[d], Célina Roda[e], Thierry Feuillet[e], Jean-Michel Oppert[e,f], Ketevan Glonti[g], Harry Rutter[g], Helga Bardos[h], Ilse De Bourdeaudhuij[a,*], Delfien Van Dyck[a]

[a] Department of Movement and Sport Sciences, Faculty of Medicine and Health Sciences, Ghent University, Watersportlaan 2, B-9000 Ghent, Belgium
[b] Department of Public Health, Faculty of Medicine and Health Sciences, Ghent University, De Pintelaan 185, 4k3, B-9000 Ghent, Belgium
[c] Department of Human Biometry and Biomechanics, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium
[d] Department of Epidemiology and Biostatistics, the EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, the Netherlands
[e] Équipe de Recherche en Épidémiologie Nutritionnelle (EREN), Université Paris 13, Centre de Recherche en Épidémiologie et Statistiques, Inserm (U1153), Inra (U1125), Cnam, COMUE Sorbonne Paris Cité, F-93017 Bobigny, France
[f] Université Pierre et Marie Curie-Paris 6, Department of Nutrition Pitié-Salpêtrière Hospital (AP-HP), Centre for Research on Human Nutrition Ile-de-France (CRNH IdF), Institute of Cardiometabolism and Nutrition (ICAN), Paris, France
[g] ECOHOST – The Centre for Health and Social Change, London School of Hygiene and Tropical Medicine, London, UK
[h] Department of Preventive Medicine, Faculty of Public Health, University of Debrecen, Hungary

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ABSTRACT

This cross-sectional study aimed to determine which objective built environmental factors, identified using a virtual neighbourhood audit, were associated with cycling for transport in adults living in five urban regions across Europe. The moderating role of age, gender, socio-economic status and country on these associations was also investigated. Overall, results showed that people living in neighbourhoods with a preponderance of speed limits below 30 km/h, many bicycle lanes, with less traffic calming devices, more trees, more litter and many parked cars forming an obstacle on the road were more likely to cycle for transport than people living in areas with lower prevalence of these factors. Evidence was only found for seven out of 56 possible moderators of these associations. These results suggest that reducing speed limits for motorized vehicles and the provision of more bicycle lanes may be effective interventions to promote cycling in Europe.

1. Background

Regular physical activity (PA) can reduce the risk of chronic diseases, such as cardiovascular diseases, type 2 diabetes, and certain types of cancer (World Health Organization, 2010), and is an important part of treatment and rehabilitation of chronic conditions (World Health Organization, 2015). However, more than one third of the global adult population does not meet the PA public health recommendations of 150 min/week moderate to vigorous PA (World Health Organization, 2015, 2010). Cycling for transport has the potential to contribute to increased PA levels among adults, since it is an accessible and inexpensive form of activity that can be incorporated in everyday life throughout adult life (Menai et al., 2015; Oja et al., 2011; Pucher et al., 2010a; Rabl and de Nazelle, 2012; World Health Organization, 2010). Additionally, cycling may also lead to economic benefits, reduced CO_2-emissions, noise and air pollution, and reduced traffic congestion (Rabl and de Nazelle, 2012). Nevertheless, cycling remains an under-used form of transport compared to motorized modes in most countries (Eurobarometer, 2011). There are plentiful opportunities to increase cycling levels in European cities, given that around 40% of all trips are less than 2.5 kilometres, and 50% of all car trips are shorter than 5 kilometres (Dekoster and Schollaert, 1999; Janssens et al., 2014; Pucher and Buehler, 2007). These distances could be covered by bicycle by most adults or by most people, and cycling may often be even quicker than driving in some urban areas (Ministry of Transport/ Public Works and Water Management, 2009; Rudinger et al., 2006). Communities and cities can contribute to increasing cycling levels in adults by providing cycling-friendly environments (Buehler and Pucher, 2012; Commission of the European Communities, 2007). Next to individual-level factors (such as socio-demographics, abilities and motivations), socio-ecological models emphasise the importance of the physical or built environment in explaining behavior change (Sallis

* Correspondence to: Department of Movement and Sport Sciences, Ghent University, Watersportlaan 2, 9000 Gent, Belgium.
E-mail address: Ilse.Debourdeaudhuij@Ugent.be (I. De Bourdeaudhuij).

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et al., 2006), or more specifically cycling for transport. Therefore, it is necessary to identify the most relevant physical environmental correlates of cycling for transport.

Both objective and perceived attributes of the built environment have been found to be important for cycling for transport and have previously shown distinct associations with cycling for transport (Heesch et al., 2012; Ma and Dill, 2015). Since, these two methods assess two distinct dimensions of the physical environment (Ding and Gebel, 2012; Kirtland et al., 2003; Kweon, 2006; Mackenbach et al., 2014), it is important to distinguish the objective and perceived environmental correlates of cycling for transport. Self-reported outcomes (i.e. perceived attributes of the built environment) may be biased through recall bias (i.e. participants may have difficulty to recall information) or social desirability bias (i.e. participants want to fit with social expectations) (Adams et al., 2005). Since objective measurement methods rely on information obtained by an external person or from solid data coming from a device, they often meet the disadvantages (e.g. recall bias, social desirability) of self-report methods (Sallis et al., 2009). The objective built environment is directly and indirectly (i.e. by influencing individual's perceptions of the built environment) associated with the cycling behavior (Ewing and Handy, 2009; Gebel et al., 2009; Heesch et al., 2015; Ma, 2014; Prins et al., 2009; Sallis et al., 2008, 2006; Winters et al., 2010). Most previous studies have used existing spatial data (e.g. based on Geographic Information Systems, GIS) to examine the objective built environment in relation to cycling for transport (Brownson et al., 2009; Ma and Dill, 2015). However, these studies were only able to draw conclusions about the macro-environment (i.e. raw urban planning features, such as street connectivity or residential density) because GIS-data about the micro-environment are often lacking. Nevertheless, the micro-environment is more feasible to adjust in environmental interventions since these factors are relatively small-scaled (e.g. speed limits, or vegetation) and only influenced by local actors or individuals, while adjustments to the macro-environment requires extensive collaboration between authorities (Cain et al., 2014; Swinburn et al., 1999). Consequently, evidence about the association between the objectively determined micro-environment and cycling for transport is still scarce and less consistent in comparison to the association with the macro-environment (Van Holle et al., 2014). For example, a study by Parkin et al. found that objectively measured traffic volumes were negatively related with cycling for transport (Parkin et al., 2008), while other studies have not found an association between objectively determined traffic volume and cycling for transport (Foster et al., 2011; Moudon et al., 2005). Another study has shown that the impact of traffic volume on cycling differed substantially between regions within the same country (Vandenbulcke et al., 2011). Furthermore, the role of aesthetics (e.g. presence of vegetation, trees, litter) to explain cycling for transport is inconclusive. Several studies have found positive associations between greenery and cycling for transport (Lee and Moudon, 2008; Wendel-vos et al., 2004), while other studies have not found an association between aesthetics and cycling for transport (Van Holle et al., 2012). Therefore, there is a need for empirical evidence about the association between objectively determined detailed environmental characteristics and cycling for transport.

The use of desk-based rating of the built environment using remote imaging sources such as Google Street View (GSV) or Bing Maps is now increasing (Bethlehem et al., 2014; Charreire et al., 2014; Curtis et al., 2013; Vanwolleghem et al., 2014). These remote sensing techniques can capture large-scale environments in detail efficiently, and in a way that is both standardized and quality controlled (Bethlehem et al., 2014; Charreire et al., 2014; Mooney et al., 2014; Odgers et al., 2013). Another important advantage of using a virtual audit tool is the possibility of obtaining harmonized data across different countries. Since this is a relatively new methodology, empirical evidence on the relation between objectively determined built environmental factors using virtual audits and cycling for transport is still scarce (Bauman et al., 2012; Fraser and Lock, 2010; Heinen et al., 2010; Pucher et al., 2010b; Yang and Sahlqvist, 2010).

Furthermore, previous research has already demonstrated that cycling for transport varies depending on gender, age, education level or country (Eurobarometer, 2011; Heesch et al., 2012; Rietveld and Daniel, 2004; SafetyNet, 2009; Sallis et al., 2013). Therefore, it might be necessary to include these socio-demographics as moderators in studies investigating the physical environment (Ewing and Handy, 2009; Wen et al., 2006), as these factors might help to clarify certain inconsistent associations between objective built environmental factors and cycling for transport.

This cross-sectional study aimed to identify which objective physical environmental neighbourhood factors, assessed via a virtual audit, are associated with cycling for transport in adults living in five urban regions across Europe. We also investigated whether these associations were moderated by socio-demographic variables such as age, gender, socio-economic status (SES) and urban region.

2. Methods

2.1. Study design and sampling

This study was part of the SPOTLIGHT project, a cross-European research project that aimed to enhance knowledge about the wide range of determinants of obesity, and provide an evidence-based model for effective integrated intervention approaches (Lakerveld et al., 2015, 2012). Research was conducted in five large cities (urban regions) of five European countries which were defined as study areas: Ghent region (Belgium), Paris region (France), greater Budapest (Hungary), Randstad region (The Netherlands) and Greater London (the United Kingdom). Neighbourhoods were considered according to local administrative boundaries in each country except for Hungary because their districts are much larger than the equivalent administrative areas of the other countries. Therefore, the study areas were defined as 1 km^2 areas in greater Budapest to guarantee comparability between study areas. The average study area of a neighbourhood (across all five countries) was 1.5 km^2 with a mean population density of 2700 inhabitants per neighbourhood (Lakerveld et al., 2015). The neighbourhood sampling was based on a combination of residential density and socioeconomic status (SES) data at the neighbourhood level. This resulted in four types of neighbourhoods: low SES/low residential density, low SES/high residential density, high SES/low residential density and high SES/high residential density. In each country, three neighbourhoods of each neighbourhood type were randomly sampled (i.e. 12 neighbourhoods per country, 60 neighbourhoods in total). Subsequently, a random sample of adult inhabitants (age ≥18 years) was invited to participate in an online survey. The survey contained questions on demographics, neighbourhood perceptions, social environmental factors, health, motivations and barriers for healthy behavior, obesity-related behaviors and weight and height. A total of 6037 (10.8%, out of 55893 invited persons) individuals participated in the study between February and September 2014. The study was approved by the corresponding local ethics committees of participating countries and all survey participants provided informed consent.

2.2. Measures

2.2.1. Demographic variables

The following demographic variables were reported: age, gender, educational level and country of residence (Belgium, France, Hungary, the Netherlands, or United Kingdom). Educational level of participants was divided into two categories to enable comparison between the country-specific education systems: lower education (no education, primary, lower secondary or higher secondary) and higher education (bachelor or master degree). Furthermore, age was split into two groups using the median of the study population: younger adults (18–