Preventive Medicine 111 (2018) 35–40

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Neighbourhoods and obesity: A prospective study of characteristics of the built environment and their association with adiposity outcomes in children in Montreal, Canada

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A R T I C L E I N F O

Keywords:
Childhood obesity
Adiposity
Built environment
Neighbourhoods
Prospective

A B S T R A C T

This paper examined prospective associations between built environment features assessed at baseline using direct audits and adiposity outcomes two years later in Montreal, Canada. Data stem from the Quebec Adipose and Lifestyle Investigation in Youth study of 630 children aged 8–10 years with a parental history of obesity. Baseline measurements took place between 2005 and 2008. Follow-up took place between 2008 and 2011. Built environment features were assessed at baseline in up to 10 contiguous street segments around participants' residential addresses using on-site audits. Analyses were restricted to participants who reported the same address both at baseline and follow-up. Prospective associations between adiposity outcomes at follow-up (BMI z-score and waist-height ratio) and built environment features at baseline (traffic-calming features, pedestrian aids, disorder, physical activity facilities, convenience stores, and fast-food restaurants) were examined using multivariable regression models. 391 children were included in the analyses. In fully-adjusted models, children living in residential areas with presence of pedestrian aids had lower BMI z-score, and lower waist-height ratio. Also, children residing in residential areas with at least one convenience store had lower BMI z-score, and lower waist-height ratio at follow-up. Findings provide evidence of the potential role of street-level urban design features in shaping childhood adiposity. To better inform policy and intervention, future research should explore the possibility of reducing obesogenic neighbourhoods by enhancing street-level design features.

1. Introduction

The prevalence of childhood overweight and obesity has increased dramatically over the past four decades (Roberts et al., 2012). Although overweight trends have improved and obesity appears to have plateaued in recent years, over 1 in 4 Canadian children aged 6 to 19 years remain overweight or obese (Rodd & Sharma, 2016). Obesity has a range of associated health complications, chiefly cardiovascular disease (Reilly et al., 2003; Singh et al., 2008) which we know now to have its origins in childhood (Rao et al., 2016). Moreover, obese children may be up to five times more likely to become obese adults, compared to their leaner counterparts (Simmonds et al., 2016).

The etiology of obesity is complex, influenced by numerous behavioural, psychosocial, genetic and environmental determinants (Spruijt-Metz, 2011). Among the latter, several reviews have implicated features of the built environment. These features are thought to influence weight-related outcomes via physical activity, outdoor play, active transportation, dietary habits, sedentary behaviour, and other energy-related putative mediators or precursors to obesity (Ding et al., 2011; Dunton et al., 2009; de Vet et al., 2011; Feng et al., 2010; Galvez et al., 2010; Safron et al., 2011). Built environment features previously investigated for their potential to influence weight-related outcomes in

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https://doi.org/10.1016/j.ypmed.2018.02.018
Received 20 September 2017; Received in revised form 23 January 2018; Accepted 12 February 2018
Available online 17 February 2018
0091-7435/

children and adolescents include proximity to recreational and physical activity (PA) facilities (Ding et al., 2011; de Vet et al., 2011; Galvez et al., 2010; Safron et al., 2011; Carroll-Scott et al., 2013; Wasserman et al., 2014), proximity and/or density of fast food restaurants (Galvez et al., 2010; Carroll-Scott et al., 2013; Wasserman et al., 2014), traffic density (Carver et al., 2008; de Vries et al., 2010; Timperio et al., 2005), road safety (Carver et al., 2008; de Vries et al., 2010; Timperio et al., 2005), land-use mix (Frank et al., 2007; Larsen et al., 2009; Spence et al., 2008), street connectivity (Frank et al., 2007; Larsen et al., 2009), walkability (Spence et al., 2008), residential density (Frank et al., 2007; Larsen et al., 2009), crime-related and other neighborhood safety measures (Carroll-Scott et al., 2013; Côté-Lussier et al., 2015; Sandy et al., 2013; Davison, 2009), and disorder/incivilities (Kimbro et al., 2011; Van Hulst et al., 2013; de Vries et al., 2007).

Still, the potential role of most of these features in shaping weight-related outcomes in children is not consistently supported in the literature (Ding et al., 2011; Dunton et al., 2009; de Vet et al., 2011). This is due in part to substantial heterogeneity in conceptual and methodological approaches across studies (Ding et al., 2011; Dunton et al., 2009; Feng et al., 2010). A variety of factors are at the base of these differences, including how built environment features are measured, defined and operationalized (Ding et al., 2011; Dunton et al., 2009; Feng et al., 2010), and a tendency to rely on cross-sectional designs (Ding et al., 2011; Dunton et al., 2009; de Vet et al., 2011; Safron et al., 2011). These issues limit our ability to make causal inferences, and to better understand the mechanisms needed to inform policy (Sallis & Glanz, 2006). Moreover, only a few studies have used direct assessments or audits to measure some features of residential built environments and none, at least to our knowledge, have included a comprehensive set of indicators potentially associated with adiposity outcomes in children. Direct assessments can have several advantages over administrative databases or other secondary data. Notably, while resource-intensive, direct assessments allow for a standardized approach to assess built environment features, they can provide up-to-date data collection, capture nuances in a finer level of detail than administrative databases, and they can be tailored to measure specific geographic scales (e.g.: different buffer zone types vs. fixed administrative spatial units) at which health-related processes are thought to operate.

The objective of this study is to examine prospective associations between distinct built environment street-level features assessed at baseline using direct observation and adiposity outcomes two years later in Montreal, Canada. Our hypotheses are that 1) children residing in neighbourhoods with features that facilitate physical activity and active transportation (e.g.: traffic calming features, pedestrian aids, physical activity facilities) will have lower BMI z-scores and waist-height ratios at follow-up, whereas 2) those residing in neighbourhoods with potentially obesogenic features (e.g.: presence of disorder, fast food restaurants and convenience stores) will have higher BMI z-scores and waist-height ratios at follow-up.

2. Methods

2.1. Study Sample

This study was conducted within the context of the ongoing QUALITY cohort (Quebec Adipose and Lifestyle Investigation in Youth), a longitudinal investigation of the natural history of obesity and cardiovascular risk in Quebec in high-risk youth. A school-based recruitment strategy was used to identify potential participants. To this end, flyers were distributed to parents of children in grades 2–5 attending 1040 elementary Quebec schools located within 75 km of Montreal, Quebec City and Sherbrooke. Of the 3350 families expressing interest in participating, 1320 met the inclusion criteria: 1) having a Caucasian child of Western European ancestry aged 8 to 10 years; 2) having at least one obese biological parent, since parental obesity is recognized in the literature as an important risk factor for childhood obesity (Anzman et al., 2010; Parsons et al., 1999; Strauss & Knight, 1999); and 3) both biological parents being available and agreeing to participate. A total of 630 participants (48% of eligible families) completed a baseline visit between 2005 and 2008. Biological and physiological measurements were taken by trained nurses at the Unité de recherche clinique du Centre Hospitalier Universitaire Sainte-Justine in Montreal and Hôpital Laval in Quebec City. During this visit, an interviewer-administered questionnaire for children and self-administered questionnaires for parents were also completed. Questionnaires included items related to lifestyle behaviours and health outcomes for children and parents. Self-administered questionnaires also included socio-demographic, and children/other family members' medical history. Follow-up questionnaires, and biological and physiological measurements were completed two years later, when children were aged 10–12 years. Written informed consent was obtained from the parents, and assent was provided by the children. Detailed information regarding the QUALITY study design and methods is available elsewhere (Lambert et al., 2012).

The analyses described in this paper are restricted to participants residing in the Montreal Metropolitan Area (built environment features were not measured elsewhere), for which 1) complete baseline data were available (n = 506), 2) complete follow-up measurements were available (n = 458), and 3) who resided at the same address both at baseline and follow-up (n = 391), to reduce risk of misclassification. Approximately one third of responders resided on the Island of Montreal, in more densely populated neighbourhoods, while two thirds lived in the surrounding predominantly suburban areas.

2.2. Measurement of built environment features

Participants' residential neighbourhoods were assessed at baseline using the QUALITY Neighborhood on-site audit tool, an observation grid adapted from an existing neighborhood assessment instrument (Paquet et al., 2010). This grid includes a checklist scoring 60 street-level built environment features surrounding each participant's residential address. Audits were conducted by independent pairs of trained observers. Inter-rater reliability was substantial (kappa > 0.60) (Landis & Koch, 1977) for most of the indicators used in our analyses for which this information was available (Van Hulst et al., 2013). For details see Supplementary Table 1. Up to ten street segments around each participant's residential address, including the street segment on which the family was located, and up to nine first and second-degree connecting streets were audited. This area represents a road network buffer ranging from 200 to 400 m approximately from the family residence. In cases of discordance between assessments, consensus was sought through additional audits and discussion (Rundle et al., 2011).

Six street-segment level categories of features comprising 19 items were retained for this analysis; (exclusions were largely due to redundant items and those with little or no variaton): 1) presence of traffic calming features (i.e.: speed bumps, mid-street section stop signs, 30 km/h speed limit signs, traffic obstacles, and traffic lights), 2) presence of pedestrian aids (i.e.: zebra crossings, mid-street section crossings, other marked pedestrian crossings, pedestrian lights, 4-way stop signs, and wider sidewalks), 3) presence of physical disorder (i.e.: presence of graffiti, signs of vandalism, presence of litter, and presence of abandoned buildings), 4) presence of PA facilities (i.e.: sports centres, and playgrounds/outdoor PA facilities), 5) presence of fast-food restaurants, and 6) presence of convenience stores.

Given that the prevalence of any given item was generally low, the four indices grouping multiple features were operationalized as dichotomous indicators for the presence of at least one feature in any of the street segments surrounding participants' residences (0 = no presence, 1 = presence). Details are available in Supplementary Table 1.

2.3. Outcome measures

Child weight and height were measured at baseline, and again at