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Mediating role of energy-balance related behaviors in the association of neighborhood socio-economic status and residential area density with BMI: The SPOTLIGHT study

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A R T I C L E I N F O

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A B S T R A C T

Objectives. This study aimed to examine the mediating effects of energy-balance related behaviors on the association of neighborhood socio-economic status (SES) and neighborhood residential area density (RAD) with body mass index (BMI).

Methods. In total, 6037 adults from four neighborhood types (high SES/high RAD, high SES/low RAD, low SES/high RAD, and low SES/low RAD) in five Mid-European urban regions completed an online survey asking about their energy-balance related behaviors (physical activity [PA], sedentary behavior, and dietary behavior), determinants of these behaviors and their body weight and height. MacKinnon's product-of-coefficients test was used to assess mediating effects.

Results. Transport-related PA, leisure-time PA and vegetable intake seemed to mediate the association between neighborhood type and BMI. Residents from low SES/low RAD neighborhoods reported less transport-related PA, less leisure-time PA and less vegetable intake than high SES/high RAD residents, and these behaviors (i.e. transport-related PA, leisure-time PA and vegetable intake) were related to having a higher BMI.

Conclusion. The association between neighborhood type and BMI can be explained, at least in part, by energy-balance related behaviors.

Background

The prevalence of overweight has increased rapidly during the last decades (World Health Organization, 2010). Estimates indicate that over 50% of European adults are currently overweight (World Health Organization, 2010; Branca et al., 2007). These high prevalence rates are alarming, given the relation with chronic diseases (Kopelman, 2007).

Ecological models suggest that determinants of overweight operate at different levels (Sallis et al., 2008). Although past research has mainly focused on factors at the intrapersonal level, these factors alone cannot explain the sharp increase in the prevalence of obesity (Pearce and Witten, 2012). Therefore, other levels have gained increasing recognition during recent years, such as the community level. Community or neighborhood studies have revealed that one of the main social environmental determinants of overweight is neighborhood socioeconomic status (SES) (Van Lenthe and Mackenbach, 2002; Wang et al., 2007; Berry et al., 2010; Drewnowski et al., 2014). Low SES residents are more likely to have increased BMI, compared to high SES residents, independent of their individual SES (Van Lenthe and Mackenbach, 2002; Wang et al., 2007; Berry et al., 2010).

In contrast to the relation between neighborhood SES and BMI, current evidence on physical environmental determinants remains unclear (Mackenbach et al., 2014). Based on recent reviews, only two physical environmental characteristics seem to be consistently associated with BMI, namely urban sprawl and land use mix (Mackenbach et al., 2014; Ding and Gebel, 2012; Grasser et al., 2013). Urban sprawl is a

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concept that has been used to refer to a metropolitan area in which large percentages of the population live in low density residential areas (Lopez, 2004). Land use mix is defined as the degree to which different uses are intermixed within a given area (Frank and Engelke, 2001). Residential area density (RAD) is a central component of both urban sprawl and land use mix. Previous studies examining the relation between RAD and BMI have reported higher odds of being overweight in low RAD neighborhoods than high RAD neighborhoods (Bodea et al., 2009; Burgoine et al., 2011; Frank et al., 2004; Huang et al., 2014). However, the majority of these studies were conducted in the United States, and cannot be generalized to Europe, given the large differences in built environments between both regions (Sundquist et al., 2011).

Although BMI has been linked to both neighborhood SES and RAD, little is known on the joint effect of neighborhood SES and RAD. As low SES residents are generally spending more time in their local neighborhood (Ivory et al., 2015; De Meester et al., 2012; Macintyre et al., 1993), their behaviors may depend more strongly on neighborhood residential density than high SES. Moreover, the pathways through which these neighborhood characteristics affect BMI remain unclear. It is highly likely that the associations are mediated by energy-balance related behaviors (i.e. sedentary behavior, physical activity [PA], and dietary habits), as some studies have shown significant associations between neighborhood SES or RAD, and energy-balance related behaviors (Ardern and de Sa, 2014; Dubowitz et al., 2008; Frank et al., 2008; McNeill et al., 2006; Ross and Mirowsky, 2008; Van Dyck et al., 2010, 2012; Witten et al., 2012; de Sa and Ardern, 2014; Ball et al., 2015), while other studies have focused on the association between energy-balance related behaviors and BMI (Ba and WPT, 2004; Egger and Swinburn, 1997). However, some energy-balance related behaviors seem to support the association, whereas others seem to suppress the association. Neighborhood SES and RAD have been positively associated with PA (Frank et al., 2008; Van Dyck et al., 2010; Witten et al., 2012; de Sa and Ardern, 2014), and healthy dietary habits (Dubowitz et al., 2008; Ball et al., 2015), which in turn negatively correlates with BMI. On the other hand, neighborhood RAD has also been positively associated, although less clearly, with sedentary behavior (Van Dyck et al., 2012), which positively correlates with BMI. No studies were found showing an association with unhealthy dietary habits.

Given the expected negative association of neighborhood SES and RAD with BMI, we hypothesize that the mediating role of PA and healthy dietary habits is stronger than the suppressing role of sedentary behavior and unhealthy dietary habits. Nevertheless, more insight is needed into the underlying mechanisms of the association between both neighborhood factors and BMI to confirm this hypothesis. Therefore, the aim of this study was to assess the mediating effect of energy-balance related behaviors on the association of neighborhood SES and RAD, with BMI in Mid-European adults.

Methods

Data were used from a cross-sectional survey conducted as part of the SPOTLIGHT project. This project was established to increase and combine knowledge on overweight and obesity-related determinants to support effective health promotion approaches (Lakerveld et al., 2012).

Neighborhood selection

From the five Mid-European countries, which were selected during the process of building partnerships in the SPOTLIGHT project, a total of 60 neighborhoods were selected in five urban regions: Ghent and suburbs (Belgium); Paris and inner suburbs (France); Budapest and suburbs (Hungary); the Randstad (a conurbation including Amsterdam, Rotterdam, The Hague and Utrecht in the Netherlands); and Greater London (United Kingdom). The neighborhood sampling process has been described in detail elsewhere (Lakerveld et al., in press). Briefly, the neighborhoods were selected based on their scores for two environmental variables: neighborhood RAD and neighborhood SES. Neighborhood RAD was derived from the Urban Atlas dataset (Meirich, 2008), which is based on a compilation of satellite photographs covering Europe and providing high resolution land use data. Within the Urban Atlas, RAD is described per minimum mapping unit (MMU) by one of the following six categories: continuous urban fabric, discontinuous dense urban fabric, discontinuous low density urban fabric, discontinuous medium density urban fabric, discontinuous very low density urban fabric and isolated structures (Mapping Guide for a European Urban Atlas). Based on these categories, three levels of RAD were created per MMU: high RAD (>80% is covered with residential buildings), medium RAD (between 50% and 80% is covered with residential buildings), and low RAD (<50% is covered with residential buildings). Using GIS, RAD values per MMU were aggregated to obtain neighborhood RAD in each urban region. Neighborhood SES was determined by analyzing median income data at the neighborhood level. Income data were derived from the national census databases of all the five countries, and were divided into low (tertile 1), medium (tertile 2), and high neighborhood SES (tertile 3). Four neighborhoods types were defined: low SES/low RAD, low SES/high RAD, high SES/low RAD and high SES/high RAD. Three neighborhoods per neighborhood type were randomly selected in each urban region, leading to a total of twelve neighborhoods per urban region and sixty for the entire study.

Participant recruitment

A random sample of 1200 residential addresses or adult inhabitants was drawn in each low SES neighborhood, and 800 in each high SES neighborhood, due to the lower expected response rate in low SES neighborhoods (Demarest et al., 2012). Between February and September 2014, potential participants (≥18 years) were invited by letter using the Dillman method (i.e. if no response was received after the initial invitation, reminders were sent) (Dillman et al., 2014) to participate in an online survey assessing participants' energy-balance related behaviors, determinants of these behaviors and body weight and height. Upon request, the participants received a paper-based version of the survey instead of the online version. This recruitment process resulted in 6037 participants (overall response rate of 10.1%, ranging from 7.4% in Hungary to 15.6% in Belgium, and from 8.9% in low SES/low RAD neighborhoods to 12.7% in high SES/low RAD neighborhoods (Lakerveld et al., in press)) completing the survey. The participants spend on average of 25.1 ± 12.4 min to complete the questionnaire, which contained 50 key questions on 30 pages. All the participants provided informed consent, and the study was approved by centers' institutional review boards.

Measures

Socio-demographic variables

Socio-demographic variables included age, sex, educational level (lower, higher), employment status (employed/in education, not employed/in education), and household composition (number of people in the household).

Sedentary behavior

Sedentary behavior was assessed using the Marshall questionnaire (Marshall et al., 2010). In this validated questionnaire, domain-specific sedentary time was estimated by asking the average time spent sedentary while traveling, working, watching television, using a computer and during other leisure-time activities on both weekdays and weekend days during the last 7 days (Marshall et al., 2010). Total sedentary time was calculated by summing the weekday minutes per domain (multiplied by 5) and the weekend day minutes per domain (multiplied by 2). The sum was divided by 420 to transform minutes/week into hours/day.

Physical activity

Transport-related and leisure-time PAs were estimated by multiplying the frequency (number of days in the last 7 days) and duration (average time/day) of PA per domain using questions from the long version of the, last 7 days, International Physical Activity Questionnaire (IPAQ). The questionnaire showed good reliability (intra-class correlations range from 0.46 to 0.96) and acceptable criterion validity (median