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Neighbourhood and physical activity in German adolescents: GINIplus and LISAplus

Iana Markevych [a,b,*], Maia P. Smith [a], Susanne Jochner [c], Marie Standl [a], Irene Brüske [a], Andrea von Berg [d], Carl-Peter Bauer [e], Kateryna Fuks [f], Sibylle Koletzko [g], Dietrich Berdel [d], Joachim Heinrich [a,h], Holger Schulz [a,i]

[a] Institute of Epidemiology I, Helmholtz Zentrum München – German Research Center for Environmental Health, Neuherberg, Germany
[b] Division of Metabolic and Nutritional Medicine, Dr. von Hauner Children's Hospital, Ludwig-Maximilians-University of Munich, Munich, Germany
[c] Physical Geography/Landscape Ecology and Sustainable Ecosystem Development, Catholic University of Eichstätt-Ingolstadt, Eichstätt, Germany
[d] Research Institute, Department of Pediatrics, Marien-Hospital Wesel, Wesel, Germany
[e] Department of Pediatrics, Technical University of Munich, Munich, Germany
[f] IUF – Leibniz Research Institute for Environmental Medicine, Düsseldorf, Germany
[g] Division of Pediatric Gastroenterology and Hepatology, Dr. von Hauner Children's Hospital Munich, Ludwig-Maximilians-University of Munich, Germany
[h] Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, Inner City Clinic, University Hospital of Munich (LMU), Munich, Germany
[i] Comprehensive Pneumology Center Munich (CPC-M), Member of the German Center for Lung Research, Germany

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ABSTRACT

Introduction: Impact of neighbourhood on physical activity (PA) is under-investigated in European adolescents, and few studies have used objective data on both exposures and outcomes. Therefore we investigated the association between objectively measured neighbourhood characteristics and PA in 15-year-old German adolescents.
Methods: Study populations comprised of 688 adolescents residing in the urban Munich area and 504 from the rural Wesel area from the GINIplus and LISAplus birth cohorts. Neighbourhood was defined as a circular 500-m buffer around the residence. Greenness was calculated 1) as the mean Normalized Difference Vegetation Index (NDVI), and 2) as percent tree cover. Neighbourhood green spaces and sport and leisure facilities were defined as present or absent in a neighbourhood (data only available for Munich). Data on PA were collected from one-week triaxial accelerometry (hip-worn ActiGraph GT3X). Minutes of PA were classified into moderate-to-vigorous (MVPA), light and sedentary using Romanzini's et al. triaxial cutoffs, and averaged over the recording period. Activity diaries were used for differentiation between school and leisure (total minus school) PA. Area-specific associations were assessed by adjusted negative binomial regressions.
Results: In the Wesel area, residing in a neighbourhood with higher NDVI was associated with 9% more leisure MVPA among females and with 8% more leisure MVPA in rural dwellers. In the Munich area, residing in a neighbourhood with sport facilities was associated with 9% more leisure MVPA. The latter association was only significant in urban dwellers while neighbourhood leisure facilities increased MVPA in rural dwellers. Estimates were very similar when total MVPA was considered rather than solely leisure.
Conclusion: There is indication that neighbourhood features could be associated with MVPA in German adolescents. However, different features seem to be important across sexes and in rural/urban settings, which need to be specifically addressed in future studies.

1. Introduction

Physical inactivity is rated to be among the ten leading risk factors for global disease burden, increasing risk of noncommunicable diseases such as cardiovascular disease, diabetes and cancer (Lim et al., 2012). According to the estimate of World Health Organization (WHO), 81% of adolescents worldwide are insufficiently physically active (WHO, 2015), indicating that this group is especially vulnerable.

A well-planned, functional and aesthetically pleasing neighbourhood with many trees and other vegetation that provides good access to green spaces and recreational facilities has potential to promote physical activity (PA) (Sallis et al., 2012). Numerous

* Corresponding author at: Institute of Epidemiology I, Helmholtz Zentrum München – German Research Center for Environmental Health, Ingolstädter Landstraße 1, 85764 Neuherberg, Germany.
E-mail address: iana.markevych@helmholtz-muenchen.de (I. Markevych).

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observational as well as interventional epidemiological studies have examined to which degree different neighbourhood characteristics could encourage participation in walking or sports, but results are somewhat inconsistent as has been summarized in many reviews. Some of the most recent are: Hunter et al. (2015), Mayne et al. (2015), Durand et al. (2011), Hansen et al. (2015), McGrath et al. (2015), James et al. (2015), Ding et al. (2011), and Lachowycz and Jones (2011).

One source of inconsistency may be related to the fact that some studies have utilized objective measures of neighbourhood and PA while others have relied on self-reported metrics. Different meaning of perceived and objectively-measured neighbourhood as well as PA and consequently, poor agreement between them is known (Dewulf et al., 2012; Lackey and Kaczynski, 2009; Slootmaker et al., 2009). At first glance, perceived measures of a neighbourhood, in particular, are advantageous as they could reflect the behaviour better than objective measures (Bancroft et al., 2015). However, perceived measures might be more prone to bias (Blacksher and Lovasi, 2012). Taking into account how costly reshaping of built environment often is, decision-making should be based on robust evidence, in particular on studies with objective assessment of both neighbourhood and PA.

However, there are not many such studies in adolescents. A comprehensive review (Ding et al., 2011) concluded that recreational facility access was associated with PA in children and adolescents. However, 95 of the 103 reviewed papers did not include adolescents, or relied on questionnaire-derived PA and/or neighbourhood characteristics. A more recent systematic review and meta-analysis (McGrath et al., 2015) that included studies with only objectively assessed PA and neighbourhood, concluded that neighbourhood recreational facilities, gyms, parks and sport venues increased moderate-to-vigorous PA (MVPA) in adolescents. Still, the review by McGrath et al. (2015) focused on MVPA due to the lack of studies investigating other PA intensity levels. Moreover, among 23 reviewed studies, only five were from Europe.

Because of the public health importance of the topic and the lack of epidemiological studies with objective PA data in European adolescents, we investigated whether neighbourhood characteristics such as vegetation level (greenness), green spaces and sport and leisure facilities were associated with different PA levels in 15-year-olds in Germany. The choice of neighbourhood and PA variables was based on their presumed importance as well as on the data availability. Based on Sallis et al. (2012) and James et al. (2014), we hypothesized that higher greenness and tree cover as well as better access to sport and leisure facilities and to green spaces could be associated with higher levels of light PA and MVPA and lower levels of sedentary behaviour in adolescents. Furthermore, we anticipated that different neighbourhood features could be of different importance for males and females and across urban and rural settings. Exposure and outcome variables were objectively assessed: neighbourhood characteristics in Geographic Information System (GIS) by using satellite images and land use datasets, and total and leisure PA by accelerometry.

2. Methods

2.1. Study population

The GINIplus study (German Infant Study on the Influence of Nutrition Intervention plus Environmental and Genetic Influences on Allergy Development) and the LISAplus study (Influence of Life-Style Factors on the Development of the Immune System and Allergies in East and West Germany plus the Influence of Traffic Emissions and Genetics) are ongoing birth cohorts that recruited healthy full-term neonates with a normal birth weight at selected maternity hospitals shortly before or after birth. Briefly, GINIplus participants were recruited in the cities of Munich (n=2949) and Wesel (n=3042) between 1995 and 1998. This cohort consists of two study groups: one is an observation group and the second includes a nutritional intervention conducted during the first four months of life, in which a randomized, double-blind controlled trial compared the effect of three hydrolyzed formulas versus cow's milk formula on allergy development. Newborns with a family history of allergy were invited for the intervention group. Participants with a negative family history or a positive family history but who declined to participate in the intervention trial were included in the observation group (von Berg et al., 2010; Heinrich et al., 2012). LISAplus is a population-based cohort recruited in the cities of Munich (n=1,467), Leipzig (n=976), Wesel (n=348) and Bad Honnef (n=306) between 1997 and 1999 (Zutavern et al., 2006; Heinrich et al., 2012). In both birth cohorts, self-completed questionnaires were filled in by parents at birth and when children were 1, 2, 3, 4, 6, 10 and 15 years of age in the GINIplus and at 6, 12, 18, and 24 months and 4, 6, 10 and 15 years of age in the LISAplus. At later follow-ups, children were additionally invited for anthropometric measurements (at 10 and 15 years), and for a subset of children the consent was received for blood collection (GINIplus: at 3, 6, 10 and 15 years; LISAplus: at 2, 6, 10 and 15 years). As the GINIplus and LISAplus birth cohorts have nearly identical study designs at later follow-ups, data were pooled. The GINIplus and LISAplus studies have been approved by their local ethics committees (Bavarian General Medical Council, University of Leipzig, Medical Council of North-Rhine-Westphalia) and informed consent was obtained from all parents of participants.

As PA data were not collected in Leipzig and Bad Honnef, these study areas are not included. The current cross-sectional analyses are thus restricted to participants who resided in the city of Munich and the adjacent regions of Upper Bavaria and Swabia (predominantly urban part of the region; hereafter referred to as Munich area; see Fig. 1) and in the city of Wesel and the adjacent regions of Münster and Düsseldorf (predominantly rural part of the region; hereafter referred to as Wesel area; see Fig. 1) both at birth and at the 15-year follow-up. Furthermore, participants had to agree and to provide valid accelerometry data (Smith et al., 2015). Finally, all covariate data had to be available. The final study population comprised of 688 participants from the Munich area and 504 participants from the Wesel study area. Detailed flow chart of the participants enrolled into the current analyses is provided in Supplemental Fig. 1.

2.2. Exposure assessment

In line with many other studies (e.g., Almanza et al., 2012; Dadvand et al., 2012, 2014; Fuertes et al., 2014; Markevych et al., 2014; Mitchell and Popham, 2007; McMorris et al., 2015), a neighbourhood was defined as a circular 500-m buffer around the residence which refers to the distance reachable within 10 min of walking, and all exposure variables were derived for this area. Alternatively, as associations between behaviour and neighbourhood could be sensitive to buffer size, being more pronounced for larger buffers (James et al., 2014), a 1000-m buffer was used as sensitivity analysis.

2.2.1. Greenness

Greenness was defined 1) as the mean Normalized Difference Vegetation Index (NDVI) and 2) as percent tree cover. NDVI refers to all vegetation, and it is calculated based on the knowledge that plants strongly absorb visible red light (RED) for use in photosynthesis while strongly reflecting near-infrared light (NIR) to prevent overheating; the equation for NDVI is based on spectral