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Original article

The built environment correlates of objectively measured physical activity in Norwegian adults: A cross-sectional study

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Abstract

Background: Built environments that are designed to provide accessible, attractive, and convenient locales promote regular physical activity (PA). Norway has great variability in its geographic, natural, and built environment features. Urban areas have well-developed built environment features, whereas the rural areas are less walkable and this may influence the mode of transport. In general, active transport is more common in urban centers. Further, public transportation is more developed in urban areas, whereas motorized transport may be more widespread in the rural areas. Despite this, in Sogn & Fjordane, a rural county in western Norway, high PA levels are frequently observed. Thus, the aims of this study were to (1) explore perceived built environment features and characterize their associations with objectively measured PA levels in Norwegian adults and (2) explore the differences in these correlates between Sogn & Fjordane and the rest of Norway.

Methods: In this cross-sectional study, participants used questionnaires to rate perceptions of their built environments, and their PA was objectively measured for 7 consecutive days using the ActiGraph GT1M accelerometer. There were 972 Norwegian adults who were included in the study. The average age was 46.9 ± 6.5 years and 43.8% of participants were men. Data were analyzed using multiple linear regression.

Results: Total PA and moderate-to-vigorous physical activity (MVPA) were both associated with perceived walkability, the community perception score, and active transport for commuting (all $p \leq 0.004$). We also observed geographic-area-specific associations: the community perception score was negatively associated with total PA and MVPA in the rest of Norway ($p \leq 0.012$) but not in Sogn & Fjordane. Public transport for commuting was positively associated with MVPA in Sogn & Fjordane ($p = 0.03$) but not in the rest of Norway.

Conclusion: Total PA level and MVPA were associated with built environment factors, such as perceptions of community, perceived walkability, and engaging in active transport for commuting. Geographic differences in the PA correlates were observed, and thus, locally customized environmental population approaches aimed at increasing PA levels may be essential complements to individual behavior and lifestyle strategies. Further, objective measures of Norwegian built environments, such as geographic information system data, and validated walk- and bike-scores would advance the field.

Keywords: Accelerometry; Active transport; Built environment; Correlates; Physical activity; Walkability

1. Introduction

Built environments that are designed to provide accessible, attractive, and convenient locales promote regular physical activity (PA).[1-7] Factors such as access to key destinations (e.g., shops, services, work, *etc*.), safety from traffic, degree of urbanization (population density or size of municipality), and quality of the environment (general activity-friendliness) are related to adults' total PA.[2,3,5-7] However, built environments vary across countries and regions and may be cultural and locally determined.[3,7] In particular, Norway has great variability in its geographic, natural, and built environment features. However, there are few studies that examine the association between objectively measured PA and built environment features in

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Norway. Thus, characterizing the association between Norwegian adults' activity patterns with perceptions of their built environments could provide insights into person–environment fit and unravel possible person-level characteristics that can inform future public health initiatives to promote PA.

A substantial body of literature highlights the benefits of regular PA in preventing non-communicable diseases.[8-10] Worldwide, physical inactivity (i.e., not meeting recommended guidelines for PA[11]) is estimated to cause 6%–10% of the major non-communicable diseases and 9% of premature deaths. This makes inactivity similar to the established risk factors of smoking and obesity. Despite this knowledge, a large proportion of the world's population remains physically inactive.[12-15] In Norway, only 32% of the population meets the recommended guidelines for PA.[16]

There are, however, considerable variations in PA levels and health within Norway.[17-20] In particular, for decades, the county of Sogn & Fjordane, located in the west part of Norway, has experienced one of the lowest levels of risk for myocardial infarction.[17,21] In addition, the county's residents have higher levels of PA[18,19] and longer life expectancy[20] compared with other regions in Norway, despite the fact that the built environment—where the majority of the population lives—has been particularly designed to enhance PA only to a limited degree. As of 2017, Sogn & Fjordane has a population of approximately 110,000 inhabitants, and people mainly live in small urban areas or are scattered over a wide rural area. The population density for the region is 5.9 inhabitants/km^2, compared with 13.2 inhabitants/km^2 throughout Norway. Sogn & Fjordane is situated in the middle of Fjord Norway, and contains some of the wildest and most beautiful scenery in Norway. The area has dramatic scenery including glaciers, mountain ranges, lakes, waterfalls, and fjords.[22]

Based on the knowledge of the influence of built environments on PA, the limitation of the built environment to enhance PA, and the beneficial health status and PA levels identified in Sogn & Fjordane, the primary aim of this study was to explore perceived built environment features and characterize their associations with objectively measured PA levels in Norwegian adults. The secondary aim was to explore the differences in these correlates between Sogn & Fjordane and the rest of Norway.

2. Materials and methods

2.1. Participants

In 2008–2009 we mailed a representative sample of 2462 men and women from 13 out of 19 counties in Norway, who were born between 1954–1956 and 1967–1969, to invite them to participate in the Physical Activity among Adults and Older People Study. This included a major sub-sample of $n = 1096$ adults from the county of Sogn & Fjordane and $n = 1366$ adults from the rest of Norway. In the event of nonresponse, we contacted participants by phone and mail. Fifty-one invitations were returned because of an unknown address or death; therefore, the eligible sample consisted of 2411 men and women from across Norway. In total, 1032 adults participated in the study, and 972 adults (40%) provided data with at least 1 built environment variable, which included 590 adults from Sogn & Fjordane and 382 adults from the rest of Norway. Average age of participants was 46.9 ± 6.5 years (mean ± SD) and 43.8% of participants were men. We described the study population in greater detail elsewhere.[12,18]

Data collection occurred between May 2008 and December 2009. When we received the signed informed consent form, we mailed participants the study questionnaires, an accelerometer (to objectively measure PA), and a prepaid envelope (to return the data and accelerometer). The study was approved by the Regional Committee for Medical Research Ethics, the Norwegian Social Science Data Services AS, and the Norwegian Tax Department.

2.2. Measures

2.2.1. PA

We used the ActiGraph GT1M accelerometer (ActiGraph LLC, Pensacola, FL, USA) to capture participants' patterns of PA over 7 days. We initialized the accelerometer and analyzed data using ActiLife (ActiGraph). We instructed participants to wear the monitor above their right hip during all waking hours for 7 consecutive days, except during water activities and showering. We set the epoch length to 10 and reintegrated data into 60 s epochs. We excluded all night activity (between 00:00 and 06:00) and all periods of at least 60 min of consecutive zero counts, with an allowance for interruptions of 1–2 min of counts above 0.[12] Participants with at least 10 h of PA data for at least 4 days were included in the analyses.[23] We present PA as total PA (mean counts per minute per day, cpm) and moderate-to-vigorous physical activity (MVPA) (≥2020 cpm, MVPA, min/day).[24] We used SAS-based software program (SAS-Institute Inc., Cary, NC, USA) and CSA Analyzer (csa.svenssonspork.dk) for accelerometry data reduction.

2.2.2. Built environment

We used the empirical literature on built environment factors as a guide for including outcomes that are associated with PA in various settings and populations.[6,25] We asked participants to self-report the size of home municipality (number of residents) and provide their home address. We used a perceived community attribute using a 7-item scale, where participants indicated on a 4-point Likert scale the extent to which they agreed or disagreed with statements describing their community such as (1) safety of recreation areas and park; (2) access to PA facilities or locations; (3) organized opportunities for PA; (4) access to shops; (5) walking and biking facilities; (6) pedestrian street safety; and (7) crosswalks and signal lights.[26,27] The measures showed good internal consistency ($\alpha = 0.79$). We calculated a community perception score using the mean of at least 6 out of 7 items. We measured perceived walkability using a 4-item scale on which participants indicated their walking time from home to a (1) grocery store; (2) recreational area, park, or trail; (3) gym, swimming pool, sport center, or outdoor sport facility; and (4) forest or open field or mountain. We calculated a perceived walkability score by the mean of at least 3 out of 4 items. Participants self-reported commuting to work was assessed using the categories (1) car or motorbike (called motorized

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