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Associations between green area in school neighbourhoods and overweight and obesity among Norwegian adolescents

Christine Koteng Wilhelmsen [a], Katrine Skalleberg [a], Ruth Kjærsti Raanaas [a], Håvard Tveite [b], Geir Aamodt [a,*]

[a] Department of Public Health Science, Faculty of Landscape and Society, Norwegian University of Life Sciences, Ås, Norway
[b] Faculty of Sciences and Technology, Norwegian University of Life Sciences, Ås, Norway

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ABSTRACT

The aim of the present study was to investigate the relationship between green areas and adolescents' body mass index (BMI). This is based on the notion that nature environment is known to have beneficial effects on human health, and that some of the explanation for this is that green areas are especially motivating or suitable as arenas for physical activity. We included 10,527 participants from the Norwegian Youth Study, which was conducted between 2001 and 2004. The participants reported body weight, height, and important potential confounding variables about lifestyle, family situation, and neighbourhood characteristics. Green area was assessed from land cover maps and we calculated the percentage of green areas within 1 km and 5 km buffers around the adolescents' schools. We found that the percentage of overweight and obese adolescents increased significantly when the percentage of green areas in the participants' surrounding increased ($p < 0.001$ for both outcomes and buffer sizes). The same results were found in logistic regression models where we adjusted for a large set of variables. As an example, the odds for being overweight was 1.38 times higher (95% CI: 1.02–1.85) for participants living in the most green surroundings compared to participants living in the least green surroundings (1 km buffer). Norwegian green areas are typically farmland, woods, and mountains, and we speculate if these areas are less accessible and attractive for adolescents, who might need more facilitated green areas for sport and physical activity.

1. Introduction

Overweight and obesity among children and adolescents are global problems. According to the World Health Organization (WHO), 42 million children under 5 years were overweight or obese in 2015 (WHO, 2016). Overweight and obesity among children and adolescents can lead to troubles in breathing, increased risk of fractures, hypertension, insulin resistance, psychological effects, and increased risk of overweight and obesity in adulthood (WHO, 2003). Among adults, overweight and obesity can lead to cardiovascular diseases, musculoskeletal disorders, cancer, and diabetes type 2 (WHO, 2008). Prevention of overweight and obesity should start as early as possible, and if we start in childhood or adolescence, serious physical, social, and psychological consequences can be prevented (WHO, 2014).

The mechanisms leading to overweight and obesity are complex, and they are linked to both lifestyle, the environment, and genetics. Overweight and obesity are caused by energy intake exceeding the energy expenditure, i.e. an imbalance between food intake and how much energy they use (Han et al., 2010). Some genes increase the risk of overweight and obesity (Mutch and Clement, 2006), but the large increase in overweight and obesity during the past 30 years cannot be explained by genetics alone. The causes are more likely connected to the environment and lifestyle factors (Ebbeling et al., 2002).

The environment affects human health, and studies have found significant associations between green surroundings and physical and mental health (Hartig et al., 2014; James et al., 2015). Lachowycz and Jones suggested three groups of explanations, which in different ways include the physical environment's ability to create changes in individuals' health behaviour (Lachowycz and Jones, 2013); nature's capabilities for restitution and aesthetic satisfaction, social interactions within greenspace, and possibilities for health promoting physical activities.

Several studies have investigated the relationships between green areas and overweight and obesity. Most studies have examined adults (Astell-Burt et al., 2014; Bjork et al., 2008; Coombes et al., 2010; Cummins and Fagg, 2012; Michimi and Wimberly, 2012; Mowafi et al., 2012; Nielsen and Hansen, 2007; Pereira et al., 2013; Prince et al., 2012; Prince et al., 2011; Richardson et al., 2013; Rundle et al., 2013), but some have examined children and adolescents (Bell et al., 2008; Burgoine et al., 2015; Dadvand et al., 2014; Liu et al., 2007; Lovasi et al., 2013; Potestio et al., 2009; Potwarka et al., 2008; Wall et al., 2012;

* Corresponding author at: Department of Public Health Science, Faculty of Landscape and Society, Norwegian University of Life Sciences, Norway.
E-mail address: geir.aamodt@nmbu.no (G. Aamodt).

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Wolch et al., 2011; Groholt et al., 2008). Different definitions of green areas have been used in these studies, but the majority have used distance to parks (Dadvand et al., 2014; Liu et al., 2007; Potestio et al., 2009; Potwarka et al., 2008; Wall et al., 2012; Wolch et al., 2011). Several studies focus on the interaction between green area, physical activity, and bodyweight such as Potestio and co-workers (Potestio et al., 2009). Most of the studies were conducted in urban areas, but some were also conducted in rural areas (Bell et al., 2008; Groholt et al., 2008; Sjoberg et al., 2011).

The aim of this study was to investigate the association between green areas surrounding adolescents' schools and overweight and obesity among Norwegian adolescents. We also wanted to investigate how specific variables, which could initiate a difference in health behaviour, modify or mediate the relationship between greenspace and health. These variables were adolescents' use of nature, physical activity level, and mode of transportation to school.

2. Methods and material

This cross-sectional study was based on data from the *Norwegian Youth Studies* conducted by University of Tromsø, University of Oslo, and The Norwegian Institute of Public Health between 2001 and 2004. The school-based survey collected information on health related issues among Norwegian adolescents, in addition to diet, smoking habits, life events, physical activity and sport, family relations, and welfare and living conditions in six of 19 counties in Norway (Fig. 1). All 10th graders (predominantly 15 or 16 years old) were invited to participate. A total of 15,966 adolescents from 356 schools answered the questionnaires:

7342 in Oslo, 1939 in Hedmark, 1877 in Oppland, 2657 in Nordland, 1514 in Troms, and 637 in Finnmark. The response rate was 86.4% (Groholt et al., 2008). The size of the complete-case dataset with relevant variables was 10,527. All data from The Norwegian Youth Studies are self-reported.

2.1. Geographical variables

We used a Geographical Information System (GIS) to determine the percentage of green areas around schools. First, all the schools were geocoded. Next, we produced buffers with radii of 1000 m and 5000 m around each school, and then we computed the amount of green areas within each buffer (Fig. 2). Green area was retrieved from land cover maps downloaded from the Norwegian Mapping Authority's website. We selected the following attributes to represent green areas: park, forest, open area, sports arena, alpine hill, cropland, river and stream, fresh water dry fall, golf course, graveyard, ocean surface, lake, and marsh. We also produced green area variables without the “open area” attribute. The green area variable was included in the analyses as both continuous and categorical variables. For the latter, we divided the variables into five categories (quintiles), representing five degrees

Fig. 1. Adolescents in six counties participated in the Norwegian Youth Study 2001–2004.