How the environment affords physical activity in adolescents

Evaluation of spatial analysis methods for adolescents' outdoor environment in physical activity research

Philosophiae doctor (Ph.D.) thesis

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Acknowledgement

"This mountain shouldn't be there…"

One autumn weekend we went for a hiking trip with a couple of friends. The weather was nice and sunny at the foot of the mountain when we started our tour. Some places were already snowy and icy, but still full with autumn colours. We conquered a few small ridges and after a few hours hiking one part of the group decided to turn back. Five of us kept on climbing up to a higher peak. The mountain top was wrapped in dense fog. At one point we left the track and continued freely between the rocks, hardly saw anything, but not for a moment doubting our tour guide. Suddenly he stopped, stared uncertainly at the map, checked his compass and pointing to the right he said that *"this mountain shouldn't be there.."*. Knowing him, being always fascinated by getting lost, the situation was more funny than scary. Having not many other options, we continued towards the *"mountain that shouldn't be there"*. Few minutes later the sun broke through the fog and illuminated the "mountain": it was just a small hill, a part of a mountain range. Climbing this hill we got to a plateau and back on the track we descended to the valley again.

Working on the PhD was like this hiking. I started the trip full with energy, followed a trail and tried to absorb all the unfolding wisdom. With the expanding knowledge the fog descended and the safe path disappeared. It was a demanding work to find my trail, but at last the wind rose and I saw my Mount Everest shrinking and blending in a spectacular landscape.

I was never alone in this tour. Many people accompanied me for shorter-longer term, colleagues and friends helped on the way for who I would like to express my gratitude here.

I would like to thank to my main supervisor, Kine Halvorsen Thorén. You were my guide and also the one who prepared me for this tour. You assisted my first rather uncertain steps when I left the known path and tried to find my own way. Beside the professional guidance your warm hospitality helped me to feel at home in Norway soon after I arrived. Thank you for all the interesting and inspiring discussions, for introducing me the Norwegian landscape and culture, including cross-country skiing!

As a part of a research group I had the opportunity to get know and work together with some other fantastic people from whom I've learnt a lot too. Ingunn, Håvard and Owe, I'm grateful for these years! You followed my way from more distance, but were ready to help when I asked for. I will always remember our writing seminars where I learnt that working on the field of physical activity means that some outdoor activity has to be integrated part of the intensive teamwork.

Sometimes hiking turns out to be more demanding than expected. On one of my first via ferratas I had to cross horizontally a smooth vertical wall. I didn't know the technique yet. I stopped before the wall in full panic, couldn't move just gazed at the thin wire. Others followed me, there was no way back. An experienced friend going in front of me turned back and calmly told me to trust the equipment and explained how to go over the chasm. Shelley Egoz, I'm greatly indebted to you for showing me how to pass the last precipice at the end of my trip.

I was lucky to have an encouraging supportive work environment and colleagues. With some of you we shared parts of our trips, with others we just passed each other. Even if we were not in close work contact, smiling and asking some interested questions were enough to remind me the sunshine over the fog. I'm happy to say that with some of you the similar difficulties of our different ways forged friendship from being colleagues.

Thanks for my family! You were not here with me, but your steady belief, that I am able to conquer whatever mountain I choose, pushed me forward on the way. You trusted me more than I did myself. You made me persistent and never giving up.

Dear friends! Your contribution was essential. You distracted my thoughts from the problems when the terrain got more difficult. I'm grateful for all the hiking, skiing and windsurfing, for the trainings and music, and for the dinners and discussions. Special thanks to you, who offered your home when I needed a quiet place to work. You were my family here.

Finally I would like to express my gratitude to my former colleague and friend Zsuzsa Földi. You gave the idea of this trip although you haven't participated in it. Without you I haven't be here.

Thanks to all of you for this tour! I'm looking forward the next!

Ås, November 2013. Renáta Aradi

Abstract

The importance of physical activity in health promotion is an extensively researched topic. Several aspects of the environment contribute to the development of physical activity behaviour, one of which is the physical environment. Studies investigating associations between the outdoor environment and physical activity focus mainly on details of the environment, such as residential density, land use mix, road network characteristics or accessible facilities. The landscape approach can give a more complex understanding of outdoor environmental factors that might influence physical activity behaviour.

The methodology for incorporating the landscape approach in physical activity research was developed in a comprehensive research project within which I accomplished my PhD study. This main project aimed to explore how the physical environment might influence physical activity behaviour in 14-year-old children. Two schools and their neighbourhoods in different landscapes were the case areas, in the same municipality. The sample consisted of 121 14-year-old adolescents. We collected objectively measured and self-reported physical activity data. Landscape characteristics were developed from those themes of the physical environment that might have an influence on physical activity behaviour. I analysed the physical activity patterns and activity levels in relation to the landscape and found landscape-specific physical activity patterns.

The application of multiple methods in the main research project triggered my curiosity and I wanted to find out how the methods functioned together. The main objective of my study was to evaluate a spatial analysis method for adolescents' physical activity. A further, additional aim was to explore how the landscape approach contributed to physical activity research. The two main questions to explore were:

How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?

How does the landscape approach contribute to physical activity research?

In order to answer these questions I derived assessment methodology from general research evaluation and physical activity research assessment practice. I analysed the practical applicability, trustworthiness and relevance of the methods.

The combination of objective (global positioning system [GPS] heart rate monitoring) and self-reported (mapping survey) methods for collecting physical activity data and landscape characterisation seems to be promising for interpreting physical activity patterns on the landscape scale. Landscape characterisation was a suitable method to incorporate the

selected detailed characteristics of the physical environment and to demonstrate variation of the landscape in the whole neighbourhood. The findings from the main research project (i.e. landscape-specific physical activity patterns) demonstrated that with landscape-level interpretation of physical activity behaviour, it was possible to bring a new approach to physical activity research. Nevertheless, to increase credibility and reliability, further development of the method and testing it in other cases and in larger samples would be necessary.

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1. Introduction

My PhD study was a contribution to an ongoing comprehensive research project, "How the environment affords physical activity in adolescents", hereafter referred to as "Adolescents' Landscape" (explained below). This project aimed to explore how the physical environment might influence physical activity behaviour in 14-year-old children. There are several studies exploring the impact of our surroundings on physical activity, with different foci. Nevertheless, due to methodological issues, to a large extent, generalising the findings is difficult (Ding et al., 2011). This points out the necessity of a detailed and transparent method description and evaluation. The application of multiple methods in the Adolescents' Landscape project triggered my curiosity and I wanted to find out how different methods functioned together, which method was appropriate for specific research questions and how would it be possible to integrate the various methods into a comprehensive and consistent system that could explain complex contextual relations between adolescents and landscape?
Furthermore, as a landscape architect with a background in regional planning, unlike the common practice in physical activity research, I interpreted the results on a landscape scale. Within the Adolescents' Landscape project I investigated the possibilities of landscape-scale understanding of physical activity patterns. A further aim was to explore how this landscape approach supports research on physical activity and its contexts.

My PhD research thus focuses on the application and assessment of methodologies. The two main questions to explore were:

1. How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?
2. How does the landscape approach contribute to physical activity research?

1.1. The frame of the PhD project

The Adolescents' Landscape project was administered and organised by the Norwegian University of Life Sciences (UMB) and funded by the Norwegian Research Council. It started in the second quarter of 2007. The PhD project began in February 2008.
There were four researchers in the project group:

Kine Halvorsen Thorén	project leader, landscape architect Professor at the Norwegian University of Life Sciences (UMB ILP) main supervisor of the PhD thesis
Ingunn Fjørtoft	outdoor education expert Professor at the Telemark University College (HiT) co-supervisor of the PhD thesis
Owe Löfman	medical doctor, spatial epidemiology expert professor at the Norwegian University of Life Sciences (UMB IMT)
Håvard Tveite	GIS, data modeling and database expert associate professor at the Norwegian University of Life Sciences (UMB IMT)

1.1.1. Objectives of the Adolescents' Landscape project

The project aimed at a deeper understanding of how the complex urban environment influences physical activity (hereafter PA) behaviour. It focused on the importance of everyday PA and the neighbourhood environment.

The main research objectives were to identify:

- the environmental correlates of PA in 14-year-old children, as expressed through objective mapping of activity patterns and their intensity
- whether these correlates of PA significantly differ between boys and girls
- the roles of spatial patterns of the landscape, in relation to levels of PA

1.1.2. The PhD study within the Adolescents' Landscape project

The project frame was already set out when the PhD project started (for a detailed description see Appendix 4). The case areas, the sample and the main data collection methods had been selected. The theoretical framework was determined by the behaviour settings and affordances concepts. The first data collection phase (Figure 1: I) had been completed.

I was deeply involved in the further stages of the Adolescents' Landscape project. I participated in further data collection (Figure 1: II–III), processed these data and conducted the spatial analysis. From the first data collection phase I included the processed GPS/heart rate data in the analysis.

The GPS/heart rate data from the first data collection phase were processed by Håvard Tveite and analysed by Ingunn Fjørtoft and Owe Löfman (Fjørtoft et al., 2010). The descriptive data (i.e. the essays and photos) from the second data collection phase were analysed by Kine Halvorsen Thorén (Thorén et al., in prep.).

Some of the results from these analyses are presented in this thesis with reference to the source.

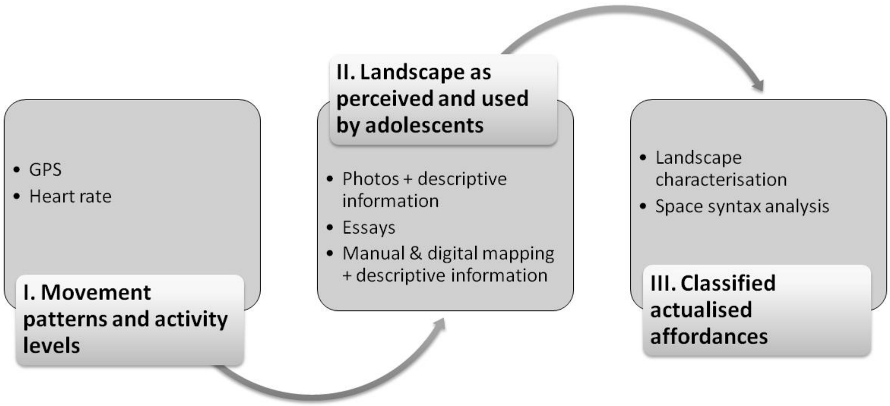


Figure 1 The assessed methods

Combining landscape and activity data, i.e. the application and combination of the predefined methods; completing these; and interpreting the results were my contribution to the Adolescents' Landscape project. Based on this work I assessed the applied methods considering general method evaluation, practical applicability and contribution to the research field.

1.2. The structure of the thesis

Figure 2 presents the structure of the thesis. First, in the chapter *Theoretical and methodological approaches in PA research related to physical environment* I give an overview of the research field, focusing on the role of physical environment in PA research and presenting the commonly used theories, methods and method assessment. I conclude by highlighting and addressing the knowledge gap.

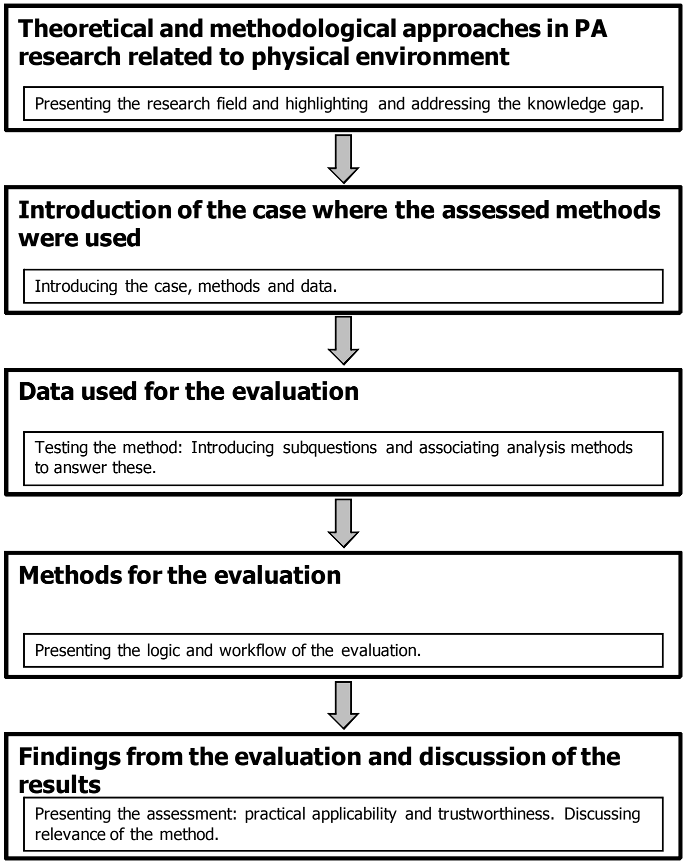


Figure 2 The structure of the thesis

The basis for the theoretical frame and most of the data collection methods had been defined before the PhD project started; my contribution to the Adolescents' Landscape project did not involve choosing these. However, I present theoretical alternatives in this chapter, and I also introduce the extended theoretical frame that guided the interpretation of results from the Adolescents' Landscape project. As part of the evaluation I also discuss the methodologies in the chapter *Findings from the evaluation and discussion of the results*.

In the chapter *Introduction of the case where the assessed methods were used* I specify the frame of my PhD study that was part of the Adolescents' Landscape project. Here I introduce the case areas and the basis data that provide the context for my study. I describe the methods that were used to produce the basis data and introduce the results I used in my further analysis.

In the chapter *Data used for the evaluation* I describe the analyses I applied to test whether the methods of the Adolescents' Landscape project give meaningful results. I also summarise the results I got by interpreting PA patterns in landscape scale.
In the chapter *Methods for the evaluation* I present the logic and workflow I followed in the method assessment. I set up specific questions which I aim to answer so as to explore the main research questions. I also introduce the associated analyses I applied in order to answer these specific questions.
In the chapter *Findings from the evaluation and discussion of the results* I assess the applied methods with a focus on practical applicability and trustworthiness. To address the main research questions, I discuss the relevance of the methods in a broader context.

1.3. Delimitations and definitions

The scope of my study is methodological issues related to the landscape and the everyday PA of 14-year-old adolescents. PA means "any bodily movement produced by skeletal muscles that requires energy expenditure" (WHO, 2013). My thesis explores how the analysis methodology for PA functioned. In this context, PA refers to every outdoor activity. Indoor activities, including training, were not taken into consideration.
The adolescents are considered a particular group. Their activities are investigated at group level with neighbourhood and gender subgroup analysis.
Landscape includes both physical and cultural factors. In my thesis, landscape characterisation is restricted to the physical landscape. I used case areas selected in the Adolescents' Landscape study. Cultural differences were not addressed in this study.
Since 14-year-old pupils move independently in their free time, but do not have driving licences, they rely more on their close neighbourhood than do older adolescents (Clifton, 2003). *Neighbourhood* in this study covers the outdoor area that was used by the pupils and could be reached on foot or by bike. This neighbourhood gives the context for everyday activities: this was the scale of the local landscape (Selman, 2006). *Landscape scale* in my study refers to this scope; the arena of everyday activities.
In my study, *landscape characterisation* means a general approach to describe variation on landscape scale. It is a thematic categorisation that includes relevant themes (specified later). *Landscape character area types* are the result of this characterisation. These area types have distinctive characteristics derived from the combination of the included themes.

Numerous influential factors determine PA behaviour, yet the Adolescents' Landscape project only addressed those connected to the physical landscape. This means that intrapersonal and socio-economic factors are not included in the study, and neither is the indoor environment. The policy environment of the study areas, being in the same municipality, is the same; thus from the policies regarding outdoor use, just the spatial aspects of the municipal plans are taken into consideration.

2. Theoretical and methodological approaches in PA research related to physical environment

This chapter provides the background for the research questions. My aim with this literature overview is to highlight the knowledge gap. For this purpose I give an outline of how the physical environment is present in the PA research field and present the existing practice of method evaluation.

First, I focus on how the physical environment appears in PA behaviour research. I explore what is actually meant by "physical environment" in terms of analysed parameters. Next I summarise methods for measuring physical activity and analysing the relation between the environment and activities. Then I give an overview of the common theoretical approaches describing human–environment interactions and present the extended theoretical frame I used to interpret the results from the Adolescents' Landscape project. After this I investigate method evaluation both in PA research and at a general level. The summary of this overview results in the knowledge gap. I conclude this chapter by presenting how I addressed this knowledge gap in my thesis.

This literature overview is not a systematic review. My aim here is to present a summary of the main focus areas concerning (1) the environmental characteristics (with respect to the physical environment) on neighbourhood level and (2) physical activity behaviour. The ISI Web of Knowledge (Thomson Reuters, 2013) and the Active Living Research literature database (Active Living Research, 2013) were the starting point for my literature search. In the ISI Web I began with broad keywords: physical activity and environment. The ALR database has detailed predefined search options. As a starting point I selected studies that investigated the physical environment on a neighbourhood or city scale.

It is widely known that environmental preferences vary with age. Measurement methods are also age-specific (Dollman et al., 2009). Therefore I focused here primarily on studies that included adolescents of 14 ±2 years old.

2.1. The outdoor environment in PA research

Physical activity behaviour is a complex phenomenon with several influential factors (Cavill et al., 2006, Sallis et al., 2008). Although there is no direct link to physical environment, research results suggest that there are correlations between certain characteristics and physical activity (Davison and Lawson, 2006, Ding et al., 2011,

Ferreira et al., 2007, Limstrand, 2008, Panter et al., 2008, Sallis et al., 2000) and there is a need to explore the influence of the built environment on physical activity behaviour: "built environment factors may help to explain the variability of active lifestyles across different populations and urban contexts" (Moore and Cosco, 2010:39).
In the Adolescents' Landscape study, this physical environment meant the local neighbourhood. The sample of the Adolescents' Landscape project consisted of 14-year-old youths. Adolescents in this age group are not able to hold a driving licence. Although public transport is available and their parents are willing to drive them by car, walking and cycling are still important transport options. The main arenas for their everyday activities are those areas that are available by foot or by cycle. Therefore in this overview I focus on those environmental properties and measurements that are able to capture neighbourhood-level characteristics.

Many research projects have explored how the physical environment relates to PA behaviour. Ewing's (2005) classification for the built environment on a neighbourhood level provides a good starting point for the overview. He used the term "3Ds" (density, diversity and design) to indicate umbrella categories. "Density is usually measured in terms of persons, jobs, or housing units per unit area. Diversity refers to land-use mix. It is often related to the number of different land uses in an area, and the degree to which they are 'balanced' in land area, floor area, or employment. Design includes street network characteristics within a neighborhood" (Ewing, 2005:71).
In the Adolescents' Landscape the environmental characteristics embraced both built and non-built environments; thus the "3Ds" here include more than was included in Ewing's categories. So how are these "3Ds" present in the research on adolescents' PA?

Density

Density can cover different factors, some of which are more function-oriented than others (e.g. employees pr. km^2; Cradock et al., 2009). The Adolescents' Landscape project addressed the physical environment, thus I focused on characteristics describing only that. The majority of the studies that have investigated density used housing/residential density (Cradock et al., 2009, Kligerman et al., 2007, Ding et al., 2011, Frank et al., 2007, Kerr et al., 2007, Kyttä et al., 2012, Larsen et al., 2009, Norman et al., 2006). In one study (Cradock et al., 2009), open space density was also included along the lines of this characteristic.

Diversity

Diversity was present in the studies on both a general and a detailed level. The studies using general categories made distinctions between rural vs. urban areas (Babey et al., 2008). Sometimes this was refined with level of urbanisation (Boone-Heinonen et al., 2010; Ferreira et al., 2007). Another, rather general approach was a distinction between built-up and non-built-up areas (Cradock et al., 2009).

Land-use mix describes diversity on a more detailed level and has also been widely used in research into adolescents' PA (Ding et al., 2011, Frank et al., 2007, Grow et al., 2008, Kerr et al., 2007, Larsen et al., 2009, Norman et al., 2006, Tucker et al., 2009, Voorhees et al., 2010). Beside land use mix other special themes are also used for describing variety. One often used index is functional diversity (Boer et al., 2007, Frank et al., 2005, Kerr et al., 2007, Kligerman et al., 2007, Norman et al., 2006, Roemmich et al., 2007). Some studies focused on more detailed housing typology (Babey et al., 2008, Panter et al., 2008) or block size (Voorhees et al., 2010). Regarding the green areas, diversity is characterised by the proportion/percentage of green areas (Kyttä et al., 2012, Roemmich et al., 2007, Tucker et al., 2009).

Design

There has been intensive research into how characteristics of the way and path network are associated with PA behaviour. The investigated properties include intersection density (Boer et al., 2007, Davison and Lawson, 2006, Frank et al., 2005, Frank et al., 2007, Kerr et al., 2007, Larsen et al., 2009, Norman et al., 2006, Rodríguez et al., 2012), street connectivity (Boone-Heinonen et al., 2010, Bungum et al., 2009, Cohen et al., 2006, Ding et al., 2011, Grow et al., 2008, Kerr et al., 2007, Limstrand, 2008, Mota et al., 2005, Voorhees et al., 2010), and presence of sidewalks/walking facilities/biking facilities (Davison and Lawson, 2006, Ding et al., 2011, Evenson et al., 2007, Grow et al., 2008, Limstrand, 2008, Mota et al., 2005, Norman et al., 2006, Panter et al., 2008) or length (Larsen et al., 2009).

Beside the street network, I included in the design functions and destinations of interest. Functions might appear on a general level as home/neighbourhood/school/town centre (Clark and Uzzell, 2002). There are also studies examining presence/number/accessibility of destinations of interest (Kyttä et al., 2012, Mota et al., 2005). Many others focus on more specific targets: areas designed for leisure time, recreational or sport activities

(Boone-Heinonen et al., 2010, Cohen et al., 2006, Davison and Lawson, 2006, Ding et al., 2011, Evenson et al., 2007, de Farias et al., 2011, Ferreira et al., 2007, Grow et al., 2008, Limstrand, 2008, Mota et al., 2005, Norman et al., 2006, Panter et al., 2008, Sallis et al., 2000, Tucker et al., 2009, Voorhees et al., 2010) or schoolyards (Davison and Lawson, 2006, Larsen et al., 2009, Rodríguez et al., 2012).

When the role of nature is in focus, it mostly relates to the presence/number/accessibility of parks (Babey et al., 2008, Cohen et al., 2006, Davison and Lawson, 2006, Ding et al., 2011, Frank et al., 2007, Kerr et al., 2007, Norman et al., 2006, Rodríguez et al., 2012). Occasionally other indices appear, such as presence of street trees (Larsen et al., 2009) or green space characteristics (Mäkinen and Tyrväinen, 2008).

Safety

In addition to the "3Ds", both the literature study and the Adolescents' Landscape project indicated that if safety is an issue, it might have an overriding influence on PA behaviour relative to other factors. In the studies, general neighbourhood safety (Babey et al., 2008, Davison and Lawson, 2006, Ding et al., 2011, Evenson et al., 2007, de Farias et al., 2011, Ferreira et al., 2007, Grow et al., 2008, Limstrand, 2008, Mota et al., 2005, Voorhees et al., 2010) and traffic safety/heavy traffic (Cradock et al., 2009, Davison and Lawson, 2006, Ding et al., 2011, Grow et al., 2008, Limstrand, 2008, Panter et al., 2008) were the priority issues.

Summary

The findings from the studies were not consistent. Ding et al. (2011) found an association between residential density, mixed land-use and adolescent PA, but Tucker et al. (2009) found no significant correlation between land-use mix and PA. An association between moderate to vigorous PA and access to parks and sport facilities was supported by most of the studies, but literature reviews (Davison and Lawson, 2006, Ferreira et al., 2007, Limstrand, 2008) were contradictory and a recent review (Ding et al., 2011) concluded that these results were inconsistent. Findings mostly confirmed a negative association between traffic safety and PA. The contradiction in the findings suggests methodological issues.

In the reviewed studies the environment was described with one or a combination of the above summarised attributes. The characteristic was usually generated from existing maps or databases, seldom based on self-reported information. Fieldwork was the most common method for describing detailed characteristics. With these attributes or combinations of them it is possible to describe some aspects of the neighbourhood environment, but a more holistic image of the physical landscape is missing.

2.2. Methods for analysing PA in the outdoor environment

Here I intend to explore three questions with regard to measuring PA: (1) what is being measured, (2) what kind of methods are used and (3) what are the common analytical methods for combining PA and environmental parameters?

Measured PA

The studies measure the general existence or characteristics of PA. PA is often characterised by type, intensity, frequency or duration of the activities. The PA parameters most often investigated in the reviewed studies were use of facilities, walking/cycling and activity levels.

Use of certain destinations is the most general approach taken to describe PA behaviour. These studies either focus more on detailed environmental characteristics (Clark and Uzzell, 2002, Mäkinen and Tyrväinen, 2008) or include other parameters (Grow et al., 2008).

Many of the studies investigate active transport behaviour (Bungum et al., 2009, Frank et al., 2007, Grow et al., 2008, Kerr et al., 2007, Kyttä et al., 2012, Larsen et al., 2009, Voorhees et al., 2010). In this age group, walking/cycling behaviour mostly means active transport between school and home.

Activity levels are generally categorised into vigorous, moderate and inactive/sedentary levels, with the upper two categories (moderate to vigorous) grouped together. The meanings of the categories are not consistent and are dependent on the applied measurement methods. Activity level can refer to actually measured body movement (Cohen et al., 2006, Cradock et al., 2009, Evenson et al., 2007, Rodríguez et al., 2012) or (seldom) to physiological parameters (i.e. heart rate). It more often describes self-reported frequency of visits to destinations or self-reported time used/frequency for different intensity PA (Babey et al., 2008, Boone-Heinonen et al., 2010, de Farias et al., 2011, Tucker et al., 2009). The division can be more general, grouping the study sample into actives and non-actives (Mota et al., 2005). Another approach to activity levels is analysing daily activity relative to the group pattern (Norman et al., 2006).

Measuring methods

Several well-tested objective and self-reported methods exist for collecting data on PA behaviour, each having certain advantages and disadvantages (Dale et al., 2002, Warren et al., 2010). For objective measurements, the most commonly used equipment types are pedometers, accelerometers and heart rate monitoring. For the purpose of getting spatially located information, these instruments are used in combination with GPS. These methods are considered to have low technical error and to be suitable for collecting data from small to medium/large samples. To measure general PA behaviour it is recommended to monitor activities for one week, including the weekend. Disadvantages of this method are that the equipment is expensive, is not able to assess some activities, and does not make it possible to get information about activity type and context. Furthermore, in some circumstances, the equipment is not practical to wear (Dollman et al., 2009).

Self-reported or parent/teacher-reported information is often collected by questionnaires, mail/telephone surveys, interviews or diaries. Another method is field study with direct observation, where the data is collected by the researcher(s). The majority of these methods are suitable for collecting data from small/large groups, and have large/moderate technical error. The data collection is relatively cheap. Interviewing is appropriate for small samples and considered to have low technical error, but is an expensive method. With these methods it is possible to get information on contextual data, but they are dependent on the individual's memory and judgement (Dollman et al., 2009).

The data collection method is determined by its purpose and practical considerations. The great majority of the reviewed studies used large samples and used different kinds of surveys or a travel diary for data collection. This means also that in these studies, mostly self-reported physical activity data were collected. From the described parameters, use of facilities and walking/cycling behaviour was generally self-reported. For measuring activity levels, only a few studies used an objective measurement, applying an accelerometer (Cohen et al., 2006, Norman et al., 2006, Rodríguez et al., 2012).

Sometimes different combinations of data collection methods were applied, e.g. survey and accelerometer (Cradock et al., 2009, Evenson et al., 2007) or survey and document analysis (Mäkinen and Tyrväinen, 2008).

Analysis methods

The reviewed studies used statistical analysis to explore correlations between the physical environment and physical activity. In some cases they were completed with focus group interviews (Clark and Uzzell, 2002) or document analysis (Mäkinen and Tyrväinen, 2008). The quantitative approach dominated the research fields. The fact that most of the reviews summarising environmental correlates to PA in adolescents focused only on quantitative studies (Davison and Lawson, 2006, Ding et al., 2011, Ferreira et al., 2007, Panter et al., 2008) also points in this direction.

Summary

A great variety of measured PA parameters and methods for measuring PA exist. The meaning of indices is not consistent; the same index (e.g. intensity, level) can refer to a broad variety of measured factors. In terms of methods, questionnaires and statistical analysis seem to dominate over the objective methods. However, the inconsistent results have raised interest in objective/subjective combined measures (Ding et al., 2011).

2.3. Theoretical approaches related to the outdoor environment and PA

There are a number of different approaches to describe human–environment relations. Here I give a short review of the commonly used ones that emphasise mutual interdependent relations among the individual, behaviour and environment. These are context-oriented theories that embrace behavioural and spatial-related elements from an environmental psychology approach, characterising "environment-behavior relationships as a unit" (Bell, 2001:6) and considering this relationship an interrelationship.

Affordance concept

Gibson's affordance concept has already proved to be useful in research on children's/adolescents' use of the urban outdoor environment (Clark and Uzzell, 2002, Fjørtoft, 2000, Heft, 2003, Kyttä, 2002, Kyttä, 2003, Kyttä, 2004, Ward Thompson, 2010). Affordance is a "combination of physical properties of the environment that is uniquely suited to a given animal – to his nutritive system or his action system or his locomotor system" (Gibson, 1977:79). The concept has ecological origins and presents the environment–animal interaction from a relational approach (Heft, 1989, Heft, 2010):

"Affordances are relational properties of the environment taken with reference to a specific individual" (Heft, 2010:17) and "[b]ecause affordances are action-related properties of environments, they are particularly well suited for considering the implications of environmental design for health promotion and 'active living'" (ibid:28). Affordances are the qualities and possibilities which the physical environment provides an individual. These qualities and possibilities are responded by the person thorough perception and interpretation and then expressed through behaviour (Fjørtoft, 2004). Fjørtoft and Gundersen (2007) interpreted landscape affordances related to physical activity as being expressed through the movement behaviour of the person in context with the physical environment.

Place-space theory

Place and space can be equally relevant in analysing spatial structures. Place theories are also used in research on environmental influences on adolescents' PA behaviour (Mäkinen and Tyrväinen, 2008). Places are "transactions between physical settings and people acting in them" (Bell, 2001:52). "Place experiences often include some feeling of ownership" (Bell, 2001:51) and place attachment "refers to the sense of rootedness people feel toward certain places, a phenomenon sometimes called *a sense of place*" (Bell, 2001:50). Exploring place attachment gives a better understanding of the motivations for using certain locations. In the Adolescents' Landscape project the aim was to get a neighbourhood-level picture about variation in the landscape and interpret the PA patterns in relation to this. Place theories and place attachment might become relevant in a further stage of the research project focusing on deeper analysis of single locations.

In Castell's interpretation, the difference between place and space is that "while space is used as a relational category and refers to the general social powers that structure the development of society and its spatial expressions, the concept of place is used as an existential category constituting the background of human identity development and actions" (Simonsen, 1993:73, Nylund, 2001). Space can describe different thematic categories in the landscape, e.g. open space or recreational space. The relations between these categories present the variation, e.g. land-use mix. In the Adolescents' Landscape project, describing variation in the landscape was important, but the focus was not on presenting "general social powers" but on interpreting the actual use.

Connecting the activities to the landscape brings up the place–landscape relation. Discussing the relation between place and landscape, Muir concluded that "Landscape and place are intimately connected but not identical. … it is generally accepted that places have no meanings other than those that humans give them… Landscape makes a forceful contribution to the spirit of place… it does… determine so many qualities of that spirit" (Muir, 1999: 294). In practice this means that these meaningful places are embedded in the landscape.

In this interpretation, places are human constructions with physical locations. The meaning that constructs a place, from the point of view of PA research, can be interpreted as the adolescents' activities. This reasoning leads to Barker's behaviour-setting concept.

Behaviour setting

Barker's behaviour setting "provides an evidence-based method of subdividing an environment or area behaviourally" (Moore and Cosco, 2010:41). The concept brings together "physical and behavioral attributes" (Barker, 1968:19). Behaviour settings have physical locations. They are composed of both environmental and behavioural components and also have temporal limitations. This concept also provides a background to interpret activities on a group level.

The theoretical framework of the Adolescents' Landscape project was defined by the behaviour-setting and affordance concepts (Appendix 4). These concepts were united by Heft (2008) and this combination was applied in research linking activities to the environment (Moore and Cosco, 2010): "Together territorial range development, behaviour setting and affordance…provide a theoretical base for measurement of behavioural links between the built environment and physical activity" (Moore and Cosco, 2007:88).

Summary

Reviewing the most relevant theoretical approaches in human–environment relations and taking into account Moore and Cosco's statement (2007), the theoretical approach of the Adolescents' Landscape project seemed a sufficient starting point.

2.4. Modified refined theoretical frame

The theoretical frame gave a guideline for the interpretation of the results. The affordance concept and behaviour setting was the frame used by the Adolescents' Landscape project. While applying the analytical methods I found that in order to ensure consistent results, the refinement and further development of this given frame was necessary to clarify how the given concepts function together on a landscape scale. In order to include the landscape approach, I extended the given theoretical approach (Figure 3).

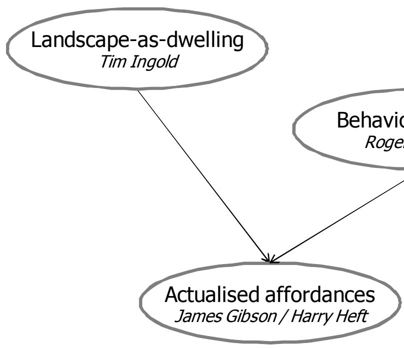


Figure 3 The theoretical frame of the project

These three concepts (Figure 3) all explain the environment–behaviour relation, from different angles. Ingold's concept of landscape incorporates the use of it. Barker's behaviour setting describes the adjacent milieu of an activity. Gibson's affordance concept characterises the environment according to what it offers to the person under consideration. The combination of these approaches is specified in more detail in this chapter.

2.4.1. Approaches to landscape

Landscape-as-dwelling

As defined by the European Landscape Convention, landscape "means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000:Ch1, A1a). This commonly used definition still leaves space for many different interpretations of landscape.
The landscape for everyday PA is the inhabitants' lived landscape, in which they express their perception of landscape through their activities. Perception in this sense is

represented by the choices people make when they decide which areas of the landscape to use for their activities. This understanding is close to landscape phenomenology, which unifies actors and landscape. According to Wylie (2007:14), landscape phenomenology defines landscape "primarily in terms of embodied practice of dwelling – practices of being-in-the-world in which self and landscape are entwined and emergent". This "everyday embodied dwelling" (ibid:160) is hallmarked with the anthropologist Tim Ingold's name. His "perspective which situates the practitioner, right from the start, in the context of an active engagement with the constituents of his or her surroundings… [is] the 'dwelling perspective'" (Ingold, 2003:5). This understanding of landscape is well suited to the intention to characterise landscape according to everyday activities.

There is much evidence that subgroups of population use landscape differently; age, gender, cultural-ethnic and socio-demographic factors influence their activities (Baranowski et al., 1993, Kerr et al., 2007, McMillan et al., 2006, Mota and Esculcas, 2002, Whitehead et al., 2006, Witlox and Tindemans, 2006) and preferences change with time. As Muir (1999:193) wrote, "Landscape taste varies through time and between places… It may also vary between genders". This temporality of landscapes, which also justifies the importance of adolescents' perception, is a core element in Ingold's landscape interpretation.

Describing the perceived landscape leads to the question of its objective-subjective properties. Both Muir (1999) and Wylie (2007) reflect on this issue in their synthesising work on the interpretation of landscape. According to Muir (1999:115), we experience "two closely related but different landscapes" simultaneously: the "real", i.e. physical, landscape and the "perceived" landscape. Similarly, Wylie notes: "Landscape is both the phenomenon itself and our perception of it. In other words, while being linked in one way to what are usually called objective facts, to the real word 'out there', landscape is also found in the eye of the beholder" (Wylie, 2007:7). Using Wylie's interpretation of the objective-subjective properties of landscape, this duality has some practical implications in my study. In the course of the analysis, landscape is interpreted from two angles: the physical landscape and the perceived landscape. The former comprises objective properties, such as landforms, water or vegetation. In this work, landscape characterisation is used to describe this physical landscape. The latter is a filtered image based on personal preferences and experiences. The movement patterns and activity levels represent the landscape understood by adolescents. To describe PA behaviour on the landscape scale, neither the physical landscape nor the perceived landscape is enough in itself. Therefore these two approaches are synthesised.

2.4.2. Connecting PA and landscape

Behaviour settings and actualised affordances

Ingold's landscape phenomenology and Gibson's affordance concept emphasise the unity of the environment and its inhabitants. Inspired by Gibson's work, Ingold's (2003) *landscape-as-dwelling* approach has much in common with the affordance concept. Affordances are "most essentially about function… affordances identify possibilities for action, as well as constraints on action" (Heft, 2010:23). In the Adolescents' Landscape project, affordances were considered as what the landscape offers for outdoor use. There are an infinite number of affordances in the landscape. These, following Heft's terminology, are called *potential affordances*. In the course of the analysis these potential affordances had to be narrowed down to the affordances that are utilised by young people, i.e. to the *actualised affordances*.

Until the affordance concept refers to individuals, behaviour-setting characterises environments of group activities. In Barker's interpretation, the physical environment is part of the behaviour setting's *milieu*, which is an essential part of a behaviour setting. Barker associates places "with particular behavioural and organizational programs that are directly (objectively) observable and recur at regular, specified intervals" (Clitheroe et al., 1998:104). Strictly interpreted through this concept, non-organised, i.e. non-regular, activities are not behaviour settings. However, the behaviour-setting approach makes it possible to characterise the landscape according to activity types and narrow down the potential affordances to the actualised ones.

The affordance and behaviour-setting concepts are similar. Bell's conclusion on the two main approaches in landscape and health research helps to highlight the difference: he notes "division among researchers to date – those who focus on the people and those who look at the landscape" (Bell, 2010:269). In my interpretation, while Barker's behaviour setting starts from behaviour, Gibson's affordance concept approaches behaviour from the environment.

My aim in the Adolescents' Landscape project was to characterise the whole territory of everyday activities. This neighbourhood/landscape scale identifies "distinctive 'units' within which environmental and socio-economic interactions can helpfully be framed" (Selman, 2006:24). However, there are some challenges to applying the affordance and behaviour-setting concepts on the landscape scale. Both concepts were developed for and applied mostly in smaller-scale analysis. For example, Moore and Cosco (2007:87–88) discuss park design: "[The b]ehaviour setting concept provides an invaluable vehicle for specifying the function of sub-areas and laying them out in appropriate relationships to each other… the concept of affordance can be used to identify and analyse similarities and differences among behaviour settings… It is also valuable for explaining… variations in activity across behaviour settings of the same type".

My attempt to use affordance theory on the neighbourhood scale is not a novelty: Clark and Uzzell (2002) used Gibson's affordance concept to describe social affordances on a neighbourhood level and Kyttä's (2003) child-friendly environment characteristic also takes a similar approach, but uses a bottom-up method.

In the Adolescents' Landscape study, landscape characterisation explored the combination of different layouts or "shapes of surfaces" (Gibson, 1977:77) on the local landscape scale. The results of the landscape characterisation were the potential environmental affordances. "Environment" in this context refers to the physical landscape. These potential environmental affordances were the landscape character area types.

Some of the potential affordances are utilised by the inhabitants' everyday activities. These are the actualised affordances. In the Adolescents' Landscape project, the collected PA data showed the utilisation of the landscape character area types. *Behaviour settings* helped to define these actualised affordances in the landscape: "Systematically observing activities in everyday environments will begin to illuminate some of the affordance properties of the environment" (Ward Thompson, 2010:20).

2.5. Method evaluation

2.5.1. In PA research

My purpose here is to review evaluation methods, with a focus on what they assessed and along what criteria so to get inspiration for my assessment method. The evaluation of a method focuses on the potential of the assessed tool. Method assessments in PA research focus on measurement validity and reliability of the results. (These concepts are specified later.) The majority of the evaluations I investigated assessed relatively simple methods for collecting PA data or characterising the environment. Complex assessment of a compound method is rare. For practical reasons, I divided the studies into three groups: (1) validation of a single method; (2) comparison of several methods; (3) evaluation of a given combination of multiple methods.

Validation of a single method

The majority of the method assessment consists of evaluation of specific questionnaires/surveys (Arvidsson et al., 2005, Ekelund et al., 2006, Florindo et al., 2006, Kirtland et al., 2003, Kowalski et al., 1997a, Kowalski et al., 1997b, Ridgers et al., 2012, Spittaels et al., 2010, Stanley et al., 2007, Treuth et al., 2005) or comparison of questionnaires (Rifas-Shiman et al., 1999). This is not surprising; questionnaires are the most commonly used data collection method. Since in the Adolescents' Landscape project other methods were used for collecting PA data, I found these evaluations irrelevant for my purpose.

A review of application possibilities of GPS in PA measurement (Maddison and Mhurchu, 2009) is another example for single method evaluation. Maddison and Mhurchu reviewed the common application of the method for measuring PA based on literature review. They provide a descriptive evaluation with broadly defined criteria. Their presentation of the tool includes details of its origin, how it functions, the common areas and the technical conditions of use. They argue for certain advantages of using GPS in PA research, concerning practical applicability (portable, non-obtrusive, continuous measurement, free access), cost implications (reasonable cost), data management and benefits of using it in combination with other methods. Examples of use in PA measurement, validation of accuracy of the tool and barriers for use (e.g. no standard approach for analysing the data) are also presented.

Comparison of methods

Method comparisons are useful inputs for research design or practical planning. Ben-Joseph et al. (2013) evaluated the relative accuracy of on-site and web-based mapping tools for environmental characteristics. They defined detailed characteristics to be measured simultaneously by on-site and by web-based mapping and coded these characteristics according to whether or not they are visible by these tools. Statistical methods were used to test agreement between the methods.

Dollman et al. (2009) and Warren et al. (2010) published an overview of the methodologies commonly used for PA assessment. Dollman et al. (2009) focused on young people's PA, Warren et al. (2010) on epidemiological research. The compared properties (summarised from both studies) of the methods included measured variable, population age, sample size, respondent burden, method/delivery mode, assessment time frame, physical activity information required, validity for specific purpose (Warren et al., 2010), data management, measurement error, cost (instrument and administration) and other limitations. They also presented protocols for method choice.

Evaluation of multiple methods

A simpler compound method evaluation was a feasibility study of heart rate monitoring in combination with GPS published by Duncan et al. (2009). The assessment presents an experiment in which this combination of measurements was attempted. The study introduced the sample and the tools. The data collection was described in terms of data type (location, distance, speed, HR), frequency of registration (1-s recording interval) and duration. The data processing (analysis using a statistical program) was not presented in detail. This method was highly relevant for the Adolescents' Landscape project. Experiences with the combination of GPS and heart rate monitoring and functionality of this measurement were published earlier (Fjørtoft et al., 2010) with similar descriptive assessment. In my study I present only a short summary of the most important aspects of this method of assessment.

The method which Moudon and Lee (2003) applied for comparing and evaluating complex methods was somewhat different. This study focused on methods that measure walkability/bikeability. These methods aim to capture a specific type of PA and combine this with environmental characteristics; therefore the assessment was more complex. The evaluation concentrated on (1) scope of the instrument and (2) variables used to define environmental factors. For evaluation of the scope of the instrument, the following criteria were set: measured activity (walking, bicycling or both); field of the instrument (transportation, planning, health); purpose (inventories, route quality or area quality assessment, latent demand estimation for walking/biking); level of service; data model;

unit of analysis (segment, network, area); testing/calibration; application; and instrument user (professional, researcher, lay people/neighbours). For the environmental factors, categories of variables were set up: general class (e.g. roadway, network, area); data collection time; measured component (route, area, all); type of measure (objective/subjective); and data source (e.g. institute, GIS, field, survey).

Summary

These examples show how different evaluation strategies exist depending on the aim. For testing a new method feasibility by application seems to be a good approach. However the here reviewed studies were not systematic assessment. In the Adolescents' Landscape project a compound method was applied. The application was the test of the method which I assess in my PhD study. The assessment methods reviewed here offered guidelines for me to develop evaluation criteria for investigating the practical applicability of the method(s) applied in the Adolescents' Landscape project. However, to involve more comprehensive aspects in the assessment it was necessary to find some general criteria that help to position the assessed method in the research field.

2.5.2. Research evaluation

In this chapter my aim was to gain comprehensive criteria for assessing the methods used in the Adolescents' Landscape project. My aims here were (1) to define a possible set of criteria for general assessment and (2) to explore methods for applying these in evaluation.

"Quality is one of the most important issues in research" (Trochim, 2008:14). Validity and reliability are considered the two basic requirements that ensure research quality. However, neither these concepts nor the assessment methods are straightforward. The interpretation of these concepts depends on the general properties of the research. There are several different approaches for ensuring the quality of qualitative research. The Adolescents' Landscape project is a naturalistic inquiry. It is a descriptive case study that "reports characteristics of reactions that occur in a particular situation" (Bell, 2001:13). It consists of separate studies that together aimed to give a better understanding of a phenomenon. The methods applied in that part of the Adolescents' Landscape project that I present here are in the qualitative domain. Therefore, for general assessment I relied primarily on two main sources: required properties and quality criteria for naturalistic inquiry (Lincoln and Guba, 1985) and quality criteria for case study research (Yin, 2009).

Guba (1981) proposed relevance, rigour and feasibility as overall quality criteria. Relevance refers to assessing the potential contribution to the research field. Rigour means the adequacy of the selected method and solidity of the study design. This is ensured by assessing the trustworthiness (Krefting, 1991) of the method. Feasibility explores whether the research project can be completed. This later criterion deals with project management and was not relevant for my evaluation.

For assessing trustworthiness, Guba defined detailed evaluation criteria. The criteria for qualitative research evaluation are usually derived from the quantitative assessment tradition and then adjusted and further developed. The conventional quality criteria in quantitative studies are: internal and external validity; reliability; and objectivity. These are found to be "inconsistent with the axioms and procedures of naturalistic inquiry" (Lincoln and Guba, 1985:43).

Lincoln and Guba instead propose credibility, transferability, dependability and confirmability, "together with corresponding empirical procedures that adequately… affirm the trustworthiness of naturalistic approaches" (Lincoln and Guba, 1985:43). Credibility stands instead of internal validity. Internal validity focuses on whether the method is capable of measuring what it intends to measure. Credibility in naturalistic inquiry is similar. The research is credible if the research results are believable from the participants' perspective.

Transferability is connected to external validity, i.e. generalisability of the results. Lincoln and Guba reject the concept of generalisation on the grounds of indeterminism: "The axiom of limited generalisability (transferability) is served in that determinism is abandoned and neither prediction nor control is claimed to result from explanations, except at a very similar times and in similar contexts" (ibid:156). In this sense, "[g]eneralizability becomes, at best, probabilistic" (ibid:113). Transferability means providing enough information for other researchers to judge whether the results would be meaningful in a similar context.

Dependability is used instead of reliability. A method is reliable if the repeated measure gives the same result. Since naturalistic inquiries are conducted in an ever-changing context, dependability raises the need to describe the changing research context.

Confirmability is connected to objectivity. As with generalisability, the concept of objectivity also contradicts the basic principles of naturalistic inquiry: "… the inquirer's values not only implicitly affect selected aspects of the inquiry process but may in fact be the central driving force in the work" (ibid:175). Confirmability of the study relates to whether other researchers are able to confirm the results.

Flyvbjerg (2006) and Yin (2009) suggested examining validity (construct, internal and external), reliability and theory for case studies. By construct validity Yin means "identifying correct operational measures for the concepts being studied" (Yin, 2009:40-41). This refers to the adequacy of methods that is included in Guba's rigour criterion. Internal validity means "seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships" (ibid:40-41). This criterion is covered by Guba and Lincoln's credibility aspect.

External validity in Yin's terminology is "defining the domain to which a study's findings can be generalized" (ibid:40-41); Guba and Lincoln used transferability as a substitute for this.

Reliability refers to the traditional understanding of "demonstrating that the operations of a study – such as the data collection procedures – can be repeated, with the same results" (ibid:40-41). This concept was reformulated as dependability in Guba and Lincoln's terminology.

Yin's aspects of case study assessment are included in the framework developed by Lincoln and Guba. This latter is a more comprehensive approach to research assessment; therefore I used this as a starting point.

Summary

Guba's relevance and trustworthiness overall assessment criteria were the main guide of my quality check of the method applied in the Adolescents' Landscape project. Within "trustworthiness" I evaluated the credibility, transferability, dependability and confirmability of the method.

2.6. The knowledge gap

Through this overview of theories and methodologies, I intended to point out the knowledge gap which my PhD project aimed to fill. Furthermore I wanted to get tools to assess whether and how the Adolescents' Landscape project reached its aim. In this chapter I give a short summary of the knowledge gap and how it leads to the research questions (Figure 4).

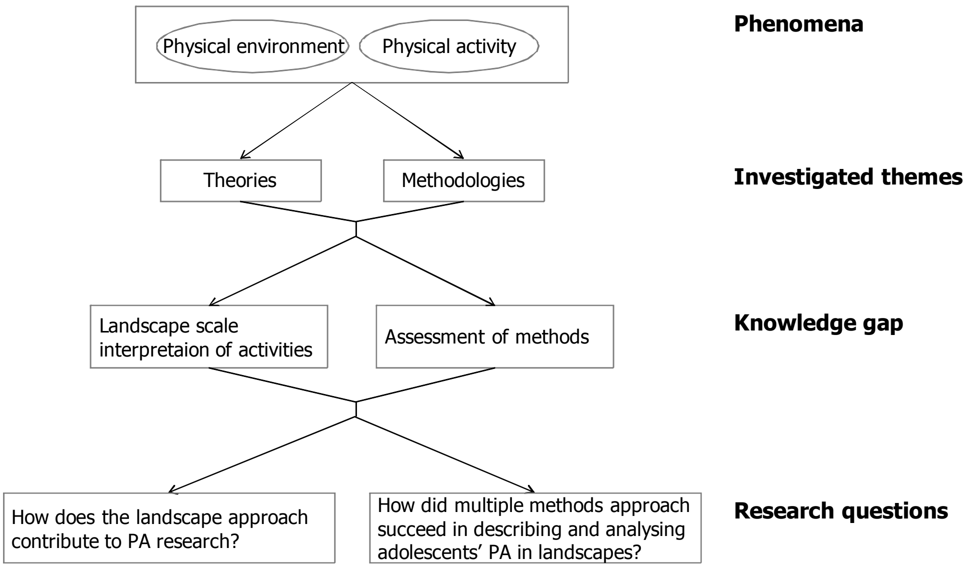


Figure 4 Deriving the research questions

Why the landscape approach?

Different environmental characteristics are used in PA research to explore environmental correlations of PA behaviour. Many studies use several different environmental characteristics in the same study, but often independently. In the analyses, correlations between the measured PA and the single indices are investigated. If a combination of indices is used in the analysis, the applied (mostly statistical) analytical method is not suitable to describe how the findings would look in the landscape. These analyses can capture only parts of the environment that affect PA behaviour.

Nevertheless, these attributes seem to be important in promoting physical activity. The results provide some general knowledge about the environmental factors that have an influence on PA activity behaviour. It is also possible to develop some rather normative guidelines for planning (i.e. certain sized parks should be accessible at certain distances from residential areas of a given population). These suggestions are undoubtedly useful for quality-checking of designs, but it would be difficult to rely on these indices during planning neighbourhoods for PA. Bringing the landscape approach into PA research, i.e.

combining the relevant environmental themes, analysing them in terms of PA behaviour and interpreting the variation on the landscape level might give an easier-to-interpret result from a landscape planning point of view.

The whole is different and more than a simple sum of its parts. The landscape approach is not the ultimate solution for capturing *the whole*, but it might be capable of bringing the complexity of the environment into PA behaviour research as an explanatory model for the contextual relations between landscape and performed physical activity.

Need for evaluation

The findings of the examined studies were inconsistent for most environmental variables. Ding et al. (2011:451) concluded that this contradiction in findings might appear due to methodological issues and suggested that "[f]uture papers should provide methodologic details regarding the operationalization of environmental constructs to facilitate the synthesis of fındings".

By assessing the methods applied in the Adolescents' Landscape project I aimed to explore the applicability of the method and ensure comparability of the results. However, the method assessment practice in the PA field presented here focused mainly on practical applicability of measurement methods. For a more comprehensive evaluation, I had to include general research evaluation methods in the assessment.

2.6.1. Addressing the knowledge gap

The purpose of the Adolescents' Landscape study was to capture PA behaviour on the landscape level. My intention with the method assessment was to evaluate the analysis method of the Adolescents' Landscape project for research purposes. My aim, in this assessment, is to answer the following questions:

1. How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?
2. How does the landscape approach contribute to PA research?

I answered these questions through assessing the Adolescents' Landscape project (Figure 5). Through the internal method evaluation I aimed to explore the first research question and some aspects of the second one. This internal assessment focuses on (1) testing the method, (2) practical applicability of the method(s) and (3) trustworthiness of the method.

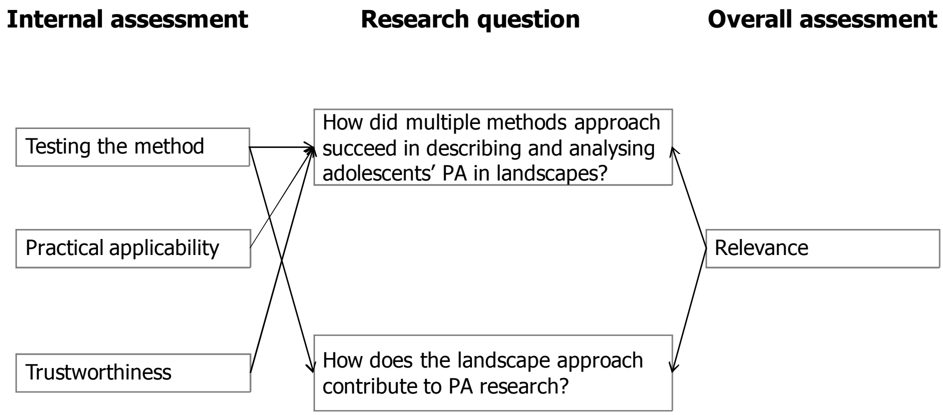


Figure 5 Answering the research questions by assessment

The first step was testing the method. Within the Adolescents' Landscape project, I applied the analytical methods used to develop a landscape-level understanding of activities. I introduce the addressed subquestions and associated methods in the chapter *Data used for the evaluation*. Based on the results from this phase, I assessed the practical applicability of the method(s).[1] To do this I selected criteria from PA research method assessment practice. I assessed trustworthiness by applying Guba's credibility, transferability, dependability and confirmability criteria.

Of Guba's overall criteria, relevance (potential contribution to the research field) explores the answer to the second research question and provides some input for the first one. In practice, I assessed relevance by discussing the method(s) in broader context (*Discussion* chapter).

The logic of the assessment and methods for evaluating practical applicability, trustworthiness and relevance are presented in the chapter *Methods for the evaluation*.

[1] "Methods" refers to the single methods that constitute the complex analysis method. "Method(s)" means both the complex analysis method and the single methods.

3. Introduction of the case in which the assessed methods were used

My study focuses on methodological issues; this chapter introduces the case to which the methods of the Adolescents' Landscape project were applied. For evaluation of the methodology, it is important to get a sufficiently detailed picture about the context.

To explore how adolescents use the neighbourhood landscape for their everyday activities, information about PA behaviour and landscape was collected and analysed (Figure 6).

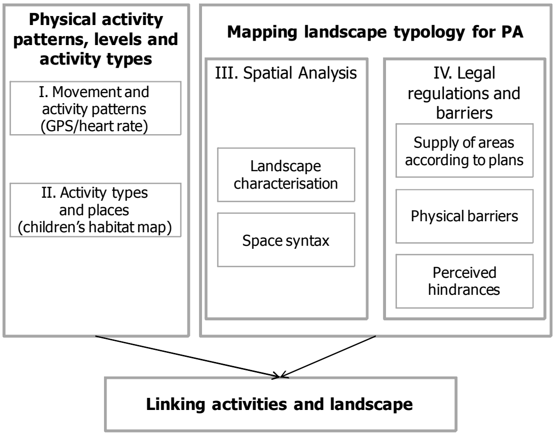


Figure 6 Data collection (I-IV) and analysis methods in the Adolescents' Landscape project

3.1. The environmental context

In the Adolescents' Landscape project, two schools and their neighbourhoods in Fredrikstad were selected as case areas. The case selection strategy was contrasting (Yin, 2009); the criteria were to find cases in different landscapes to explore whether and how differences in the landscape influence PA behaviour.

Fredrikstad municipality has approximately 72,000 inhabitants. It is divided into western and eastern parts by the Glomma River and consists of several small settlements. The city centre is on the southern part of the west side; the two case areas, Gudeberg and Begby, are located on the eastern side (Figure 7). The names refer to local communities, the borders of which follow the school districts and contain more basic statistical circuits.

Gudeberg is on the riverside plain. The open plain determines the main character of the area, bordered by the river on the west side. On the east side, hills running from northeast to southwest dominate the landscape.

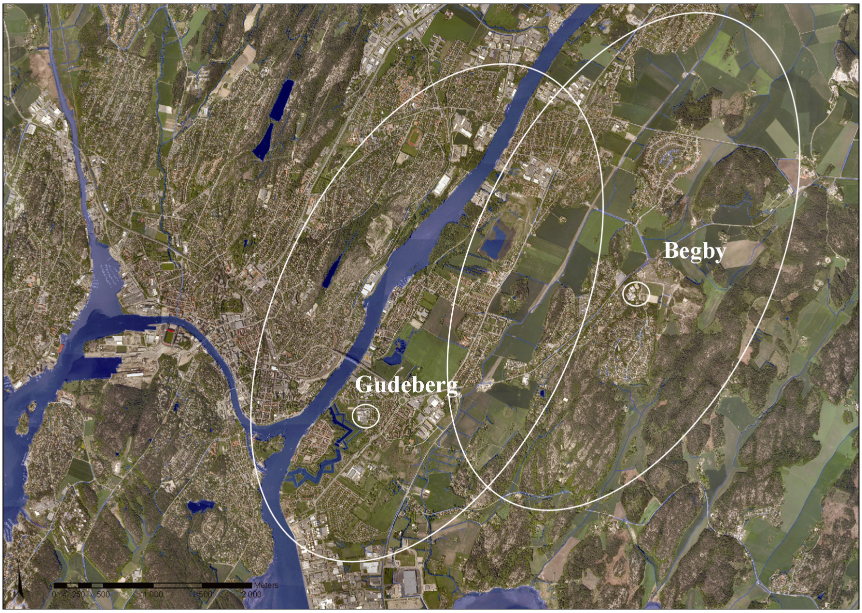


Figure 7 Overview map (Source: Norge digitalt (2010))

Gudeberg has direct connections to the city centre through a bridge and by ferry. In 2007 it had 3099 inhabitants (SSB, 2011). The settlement grew and was organised around the historical centre: the Vaterland and Gamlebyen (Figure 8a), established in 1567 as part of the Kongsten fortress. With the cities having been rebuilt after many conflagrations, today's image dates back to the seventeenth–nineteenth centuries (Leivestad, 2003). Careful protection has conserved the historical atmosphere in both Vaterland and Gamlebyen. While Vaterland is a small residential area containing mostly one-storey houses (Photo 1), Gamlebyen is a small living centre with one- or two-storey houses, a square (Photo 2), charming cafes, restaurants and small shops embraced by drainage system and green ridges of ramparts. Despite the city's development and the road which crosses it from south to north, the ramparts and ditches still connect Gamlebyen to the old fortress.

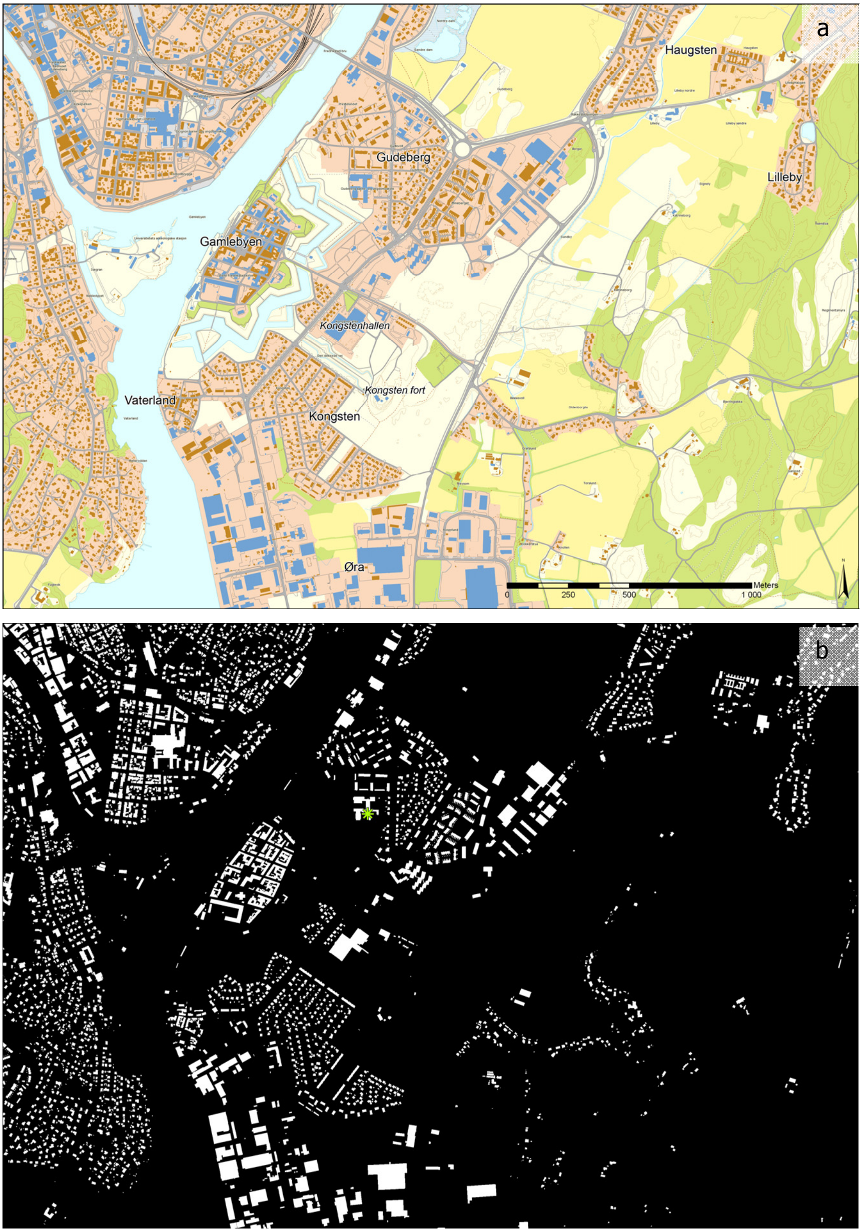


Figure 8 The Gudeberg neighbourhood (a) (Statens kartverk, 2012) and variation in the built-up areas (b) (Statens kartverk)

Photo 1 Vaterland
(*photo: Renata Aradi, 27.10.2009*)

Photo 2 Gamlebyen
(*photo: Kine H. Torhén 12.11,2009*)

In the eastern part of Gudeberg, cultivated fields provided supplies for the inhabitants. The first houses appeared here in the nineteenth century. As they grew, the small communities were organised in clusters with their own services.

Industry related to construction was present in Gudeberg from the very beginning, with timber and stone industries and brickworks, but the twentieth-century industrialisation brought major changes in the city structure. That was the beginning of the development of the huge southern industrial areas.

Responding to the needs of the increasing labour force, new residential areas grew up in accordance, with careful planning.[2] The housing area near Vaterland was built at this time (Photo 3).

Photo 3 Housing area next to Vaterland
(*photo: Renata Aradi, 27.10.2009*)

Photo 4 Garden city
(*photo: Renata Aradi, 27.10.2009*)

[2] According to Sverre Pedersen's plans. He was an architect and the first professor of urban planning in Norway. He planned several Norwegian cities in the twentieth century.

Photo 5 Modern housing
(*photo: Renata Aradi, 23.10.2009*)

After the Second World War garden cities were built around the fortress according to the original plans (Photo 4). In the middle of the twentieth century modern housing blocks (Photo 5) were built to the north of Gamlebyen, close to Fredrikstad centre and the ferry. In the north part of Gudeberg there are row houses from the 1970s–80s.

This gradual development in response to changing needs resulted in great variation in residential areas in Gudeberg (Figure 8b).

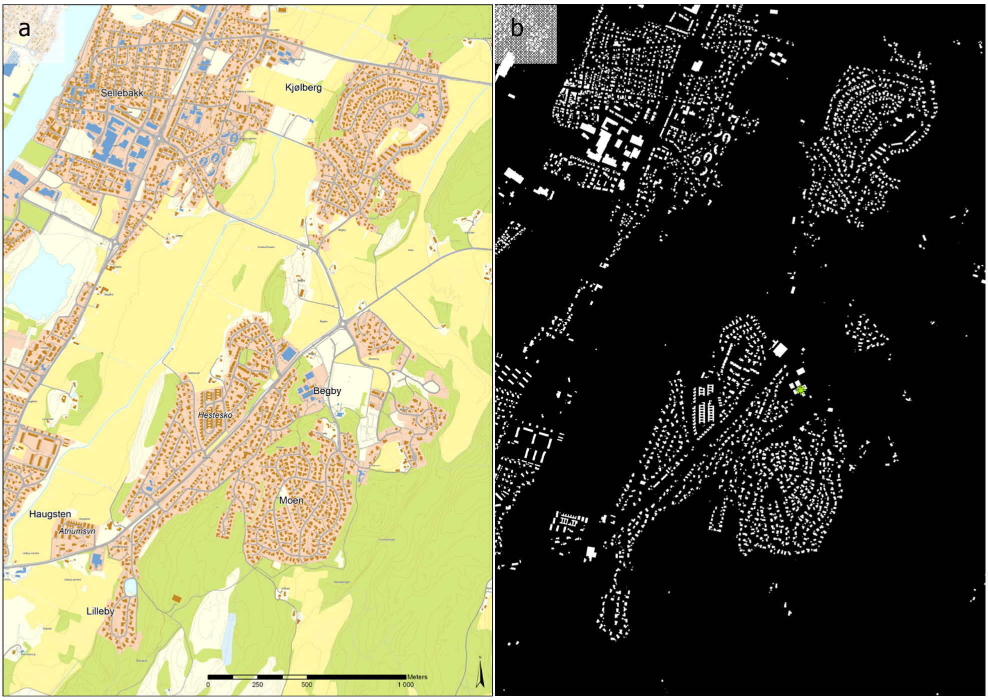


Figure 9 The Begby neighbourhood (a) (Statens kartverk, 2012) and variation in the built-up areas (b) (Statens kartverk)

Begby (Figure 9a) is located north of Gudeberg. The landscape is framed by hilly ridges stretching from northeast to southwest. Water surfaces are rare here; there is only one small lake in the southern part. From Begby, Fredrikstad centre is accessible through Gudeberg. Transport connections with the northeast settlement part (Selbak) are also important in order to access local services. Although the history of the Begby area dates back to the Bronze Age and it was inhabited continuously, the settlement, as it is known today, is relatively young. It was a rural area until the 1950s. The majority of the houses were built after 1960 and, apart from a few four-apartment houses and welfare houses, most are detached houses (Fredrikstad kommune, 1997). It is mostly a housing area (Photo 6) without a real centre, although Begbyhall, the local shopping mall, fulfils similar functions. However, the residential area is not homogenous (Figure 9b). The Hestesko (Photo 7) and Atriumsveien are denser, with row and atrium houses and intimate and pleasant common areas.

Photo 6 Begby
(*photo: Marianne Solberg, 7.10.2009*)

Photo 7 Hestesko
(*photo: Marianne Solberg, 9.10.2009*)

In 2007, the number of inhabitants was 3654 (SSB, 2011).
The residential area is divided into two parts by a main road which crosses it. Due to the heavy traffic, the road forms a real barrier for non-motorised transport.

Gudeberg and Begby are generally green. The residential areas are nested in and interwoven with forests and agricultural fields. The forests have an extensive footpath system with lit tracks, and the agricultural fields – outside growth periods – are also accessible for outdoor recreation.

Gudeberg is a diverse urban area with historical routes and mostly cultivated green areas. Here the ramparts and ditches around Gamlebyen (Photos 8–9) form the popular city park. In the east, the housing areas are wedged within cultivated fields and forests.

Photo 8 Ramparts and ditches
(*photo: Renata Aradi, 12.05.2008*)

Photo 9 The Kongsten fort
(*photo: Renata Aradi, 25.05.2008*)

Begby is more homogeneous with regard to the housing areas and is surrounded by mostly natural green spaces. There are no typical parks in Begby, but the provision of recreational areas and playgrounds is good. The residential area is embedded in forests with good connections to the path system (Photo 10) and is surrounded by agricultural land to the west and south

Photo 10 Path system south from Begby
(*photo: Ine Woldstad, 07.10.2009*)

3.2. Participants

The participants in the Adolescents' Landscape project for studying PA were selected by nonprobability, purposive (Trochim, 2008) or focused sampling (Hughes, 1976). The 9th–10th graders in the two schools were invited to participate in the project, making 121 pupils altogether (Table 1).

Table 1 Number of 13- and 14-year-olds in Begby and Gudeberg in the years of data collection (Source: KOMPASS/SSB, Fredrikstad kommune)

	2007	2008
Begby 13-year-old	61	
Begby 14-year-old		61
Gudeberg 13-year-old	37	
Gudeberg 14-year-old		40
Altogether[3]	**98**	**101**

The selection determined, to some extent, the time schedule of the project, since they finished their primary school studies in the 2008/2009 school year. For the data collection planning, the school time schedule had to be taken into consideration; some had to be finished in 2008 and at the beginning of 2009.
Participation in the project was voluntary in each data collection stage (described in chapter 3.4), therefore the number of participants varied (Table 2).

Table 2 Participants in different data collection phases

Data collection phase	**All participants N = 121**	**Gudeberg boys N=34**	**Gudeberg girls N= 32**	**Begby boys N= 26**	**Begby girls N= 29**
GPS & heart rate	73 (60,3 %)	21 (61,8 %)	9 (28,1 %)	21 (80,8 %)	22 (75,9 %)
		30 (45,5 %)		43 (78,2 %)	
Barnetråkk paper mapping	57 (47,1 %)	8 (23,5 %)	8 (25 %)	17 (65,4 %)	24 (82,8 %)
		16 (24, 2 %)		41 (74,5 %)	
Barnetråkk digital mapping	88 (72,7 %)	21 (61,8 %)	22 (68,8 %)	22 (84,6 %)	21 (72,4 %)
		43 (65,2 %)		55 (78,2 %)	
Photo taking (groups) + description (individual)	49	10	12	6	21
		22 (groups)		17 (groups)	
Essays	44	34		10 (groups)	

[3] The pupils studying in these two schools were not only from these two school districts; therefore the number of invited participants was higher than the number of pupils in the corresponding cohort of the two school districts.

3.3. Ethical aspects

The data collection and storage methods, and later the publication of the results, are the most sensitive issues from the ethical aspect. The National Committee for Research Ethics in the Social Sciences and the Humanities provided support in this regard during the elaboration of the research project.

In the data collection phase written consent for participation in the project was requested from the pupils and their parents, and parents and pupils were informed about the research project in meetings arranged by the schools. During the data collection and processing, anonymity and privacy were key. The teachers were involved in communication to make sure that pupils understood the aims and important details of the project.

All monitoring, data collection and analysis was treated anonymously, in accordance with ethical guidelines. The project was approved by the Norwegian Data Inspectorate.

3.4. PA patterns, levels and activity types

Detailed analysis of the PA patterns, levels and types (Figure 6: I–II) is not part of the PhD study. Both methods of this phase (i.e. GPS/heart rate monitoring and child tracking) were predefined by the Adolescents' Landscape project, therefore the reasons for these choices are not presented here. Nevertheless, the relevance of the methods in relation to other possibilities is addressed in the *Discussion* chapter.

Here I present those parts of the data collection, processing and analysis that are necessary to know so as to understand the possibilities and limitations of these data sources in the further analysis. From the results of the preliminary analyses I introduce here those as background that I used when connecting the PA patterns, levels, activity types and the landscape.

3.4.1. Movement and activity patterns (GPS/heart rate)

The first data-collecting phase (Figure 6: I) in this study was a combination of global positioning system (GPS Garmin Forerunner 305) and heart rate monitoring (heart rate belts) with an average of 7 seconds' sampling frequency. The data collection was conducted on regular school days in October 2007 in good weather conditions with a temperature of above 10°C and heavy rain on one afternoon. Altogether, 81 pupils' (Table 2) movement patterns and activity levels were monitored, each for one day. Due to the limited amount of equipment, the data collection took seven days, stretching over three consecutive days in Gudeberg and four in Begby.

The data were downloaded and processed (for details see Data collection and processing in Appendix 5) using data management software. Because of problems with the equipment, only 73 pupils' movement patterns were used in the analysis process. The time interval for afternoon activities was defined as running from the time the pupils left school (1pm) until late in the evening, when activity was very low (11pm)[4].

The PA levels were categorised according to Reilly et al. (2004) and Ridgers et al. (2007):

- low activity: HR[5]<120 bpm
- low–moderate PA: HR=120–140 bpm
- moderate to vigorous and vigorous PA: HR>140 bpm.

When analysing the activity levels, observations with HR=0 were excluded.

For the analysis, the observations were aggregated to locations and along the road/track system for further analysis. Through this method it was possible to get an overview of the whole pattern and carry out analysis at group level. Individual analysis would have been another option, but to compare with the child track data (explained below), group-level analysis was a logical choice.

To define activity, areas were defined in 10x10m and 100x100m regular grids. With these two scales it was possible to identify areas of activities demanding less or more space. For each cell, the following values were calculated:

- total spent time;
- number of subjects;
- average heart rate;
- percentages of the above defined activity levels.

Cells where the aggregated total time spent was equal to or more than 30 minutes were defined as hotspots (Figure 10).

[4] The results of the analysis of the school-time activities have been published previously in Fjørtoft, I., Löfman, O. & Thorén, A.-K. H., 2010. Schoolyard physical activity in 14-year-old adolescents was assessed by mobile GPS and heart rate monitoring was analysed by GIS. *Scandinavian Journal of Public Health,* 38**,** 28-37.

[5] HR: heart rate.

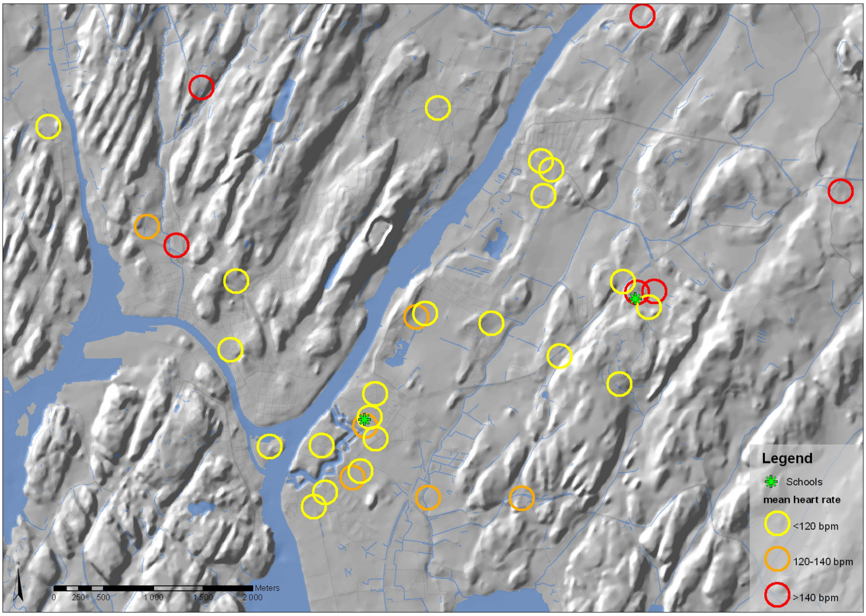


Figure 10 Activity levels in hotspots

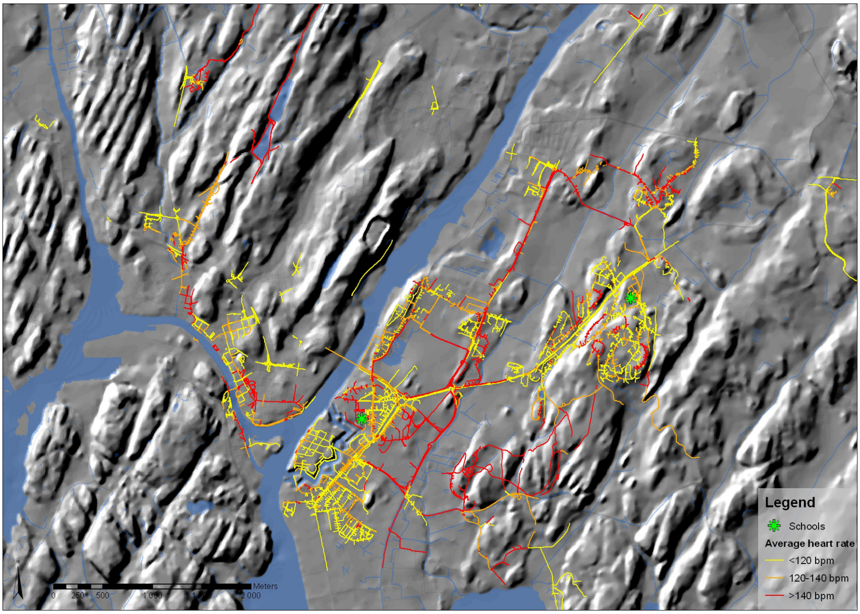


Figure 11 Aggregated activity levels along the routes

To define average activity levels along the road/path system, the observations were aggregated to the existing road/path network (Statens kartverk): every observation closer than 10m to a road segment was connected to that segment. From these observations, the segments were given an average heart rate value (Figure 11).

To gain deeper insight into how the most active pupils use the neighbourhood, *individual activity routes* were defined from the observations by sorting the points after the registration time or registration number and connecting them with straight lines. For the purpose of capturing directed locomotion, a maximum rest time of 1 minute was defined. Sections considered as rest were excluded from the routes (Figure 12).

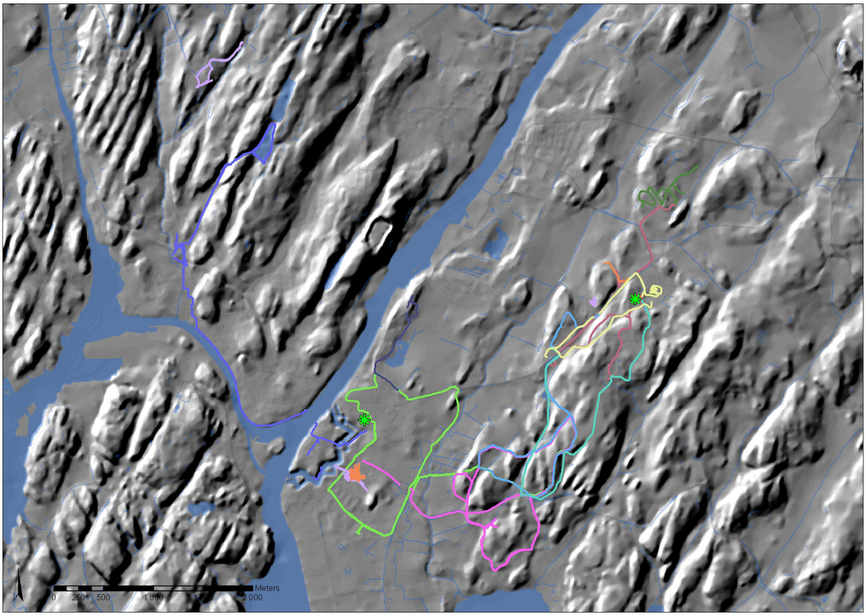


Figure 12 Routes involved in the activity level study: those individuals who fulfilled the required amount of 60 min/day physical activity

The movement pattern/activity level analyses during school time were published previously (Fjørtoft et al., 2010). The results of the afternoon data analysis have not yet been published.

3.4.2. Activity types and places (children's habitat map)

In the second phase (Figure 6: II) of the Adolescents' Landscape project an extended version of a participative planning tool, called child track[6] (Almhjell and Ridderstrøm, 2003), was used to gather self-reported data about the adolescents' activities. This method was developed originally for use in practical planning; in this project we adapted the further developed digital version (Norsk Form & Statens kartverk) to the research purposes. This extended version was called *children's habitat maps* (Aradi, 2010). Collecting and processing the data was part of my work. I used the mapped activities from the collected evidence in my analysis. The photos, with accompanying descriptions and essays, were used for interpreting the adolescents' perceptions of the landscape. This study is not part of my PhD. Those parts from which I used the results for further analysis are specified below.

The data collection took place in three stages. The first preparation phase was a self-guided walking tour with paper maps (Appendix 5, Figures I–IV) and disposable cameras, in October 2008. The pupils used the cameras in groups but prepared paper maps individually, described their photos and filled out a short questionnaire about comfortable walking/biking distances (Appendix 5, Figures V–VI) and their free-time use (Appendix 5, Figure VII). The number of participants in the different data sources varied (Table 2). In Gudeberg the students used the PA lesson for the outdoor mapping tours; in Begby they did it for homework. The weather conditions were generally good, with the temperature around 10°C.

After the walking tours the pupils digitalised their registrations and completed descriptive information in an online mapping program (KartISkolen, 2010). To access the program, passwords were provided by the software administrator Statens kartverk. This part was carried out in the schools individually (Begby) or in small groups of two to three pupils (Gudeberg) with the guidance of researchers from the research group. It took place in November 2008 (Begby) and in January 2009 (Gudeberg). The registered data (Figure 13) types were as follows:

- Point features: *Places* the pupils want to improve or consider dangerous. Descriptive information about the proposed change or perceived danger.
- Polygon features: *Areas* they use. They registered the estimated number of users, the activity types and seasonal differences.

[6] *Barnetråkk* in Norwegian.

- Line features: The *roads* and tracks they use, with a distinction between school and free-time use and descriptive information about perceived dangers if there were any.

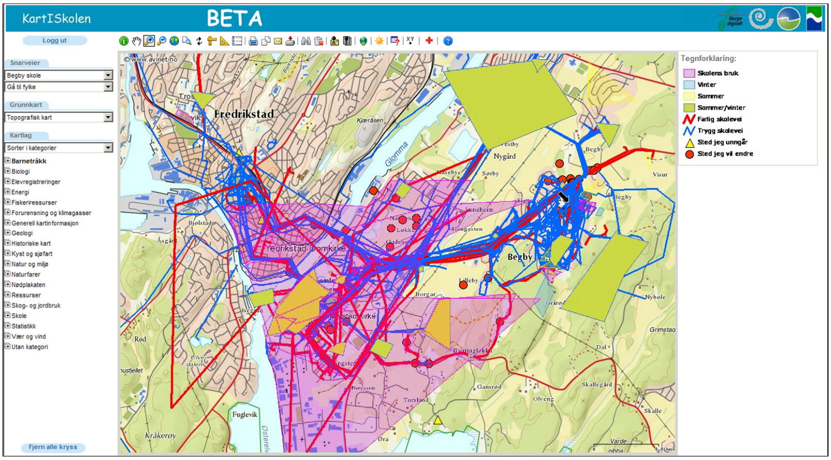


Figure 13 Digital maps (Aradi, 2010)

The last part of this data collection phase involved writing essays/articles about the neighbourhood. This was included in Norwegian education in the 2008/2009 school year.

The digital data were downloaded from the KartISkolen website (KartISkolen, 2010) and I processed them in ArcGIS© software. I digitalised the paper maps and used them also in spatial analysis. Information that cannot be interpreted and/or which was ethically sensitive was removed from the database.

Activity types and places

This analysis highlighted how the pupils use specific areas and what kind of outdoor activities they perform on average weekdays. The main data source for the activity types and places was the digital maps from the *children's habitat maps*. The GPS/heart rate data was also taken into consideration to illustrate the intensity levels of activities. The GPS/heart rate data was divided into movement routes and activity areas according to the child track method. The data types from the *children's habitat maps* corresponded to the ones from the GPS registration: the registered school ways/free-time ways from the children's habitat maps to the routes from the GPS study; the drawn areas from the children's habitat maps to the hotspots from the GPS study.

The use of *roads* (children's habitat maps) was aggregated on the existing road/path system of the road/path network (Statens kartverk). I updated this database with the shortcuts used. The road segments were given values according to the number of registrations. From the paper maps it was possible to distinguish between the schools, and also between boys and girls. The digital database just showed differences between the schools. Due to the drawing method, the digitalised routes did not follow the road network. Therefore I rasterised the routes to 20x20m cells and values to the road segments were given by overlaying and summarising the raster layers (Appendix 5, Figures VIII–IX, Data processing of the line features).

The findings presented below, which I used in later analysis, are from a study conducted by Kine Halvorsen Thorén (not yet published).

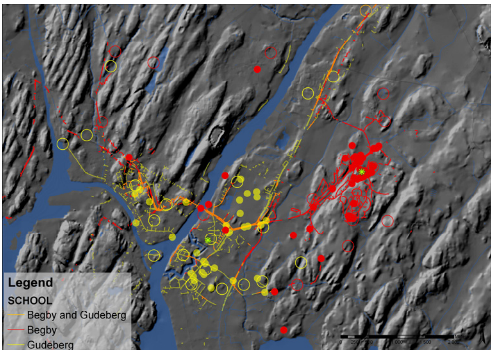


Figure 14 Registrations by schools

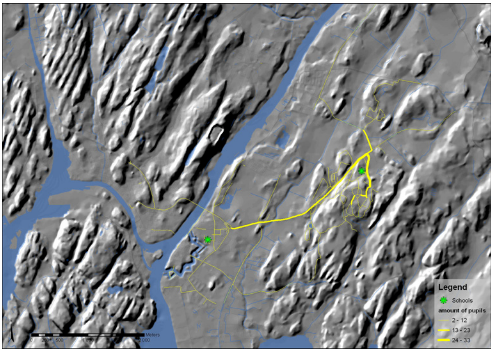


Figure 15 Most used routes

The pupils' registered free-time activities showed neighbourhood-oriented use. This meant an area of about 2.5km around the schools. The spatial overlapping of the activities from Begby and Gudeberg was limited (Figure 14).

The school ways and free-time ways were studied separately through both the GPS and *children's habitat maps* sources. The locomotion patterns showed – not surprisingly – shorter, more destination-oriented school ways. As school ways, the pupils used less than half of the path/road system used for the afternoon activities. The smaller and residential roads were important in the pupils' activities as both school and free-time ways.

Regarding the routes, the number of registrations from the *children's habitat maps* and the activity levels from the GPS data were studied. The main roads had the most users both as school and free-time routes (Figure 15).

The aggregated activity levels along the routes are relatively low for both school and free-time use. However, there were more active routes in free-time activities. The highest activity levels were registered in the natural area, connected to the path system, in some of the residential areas and on parts of the main roads (Figure 11). Pupils from Begby and Gudeberg used similar road lengths: approximately 19km.

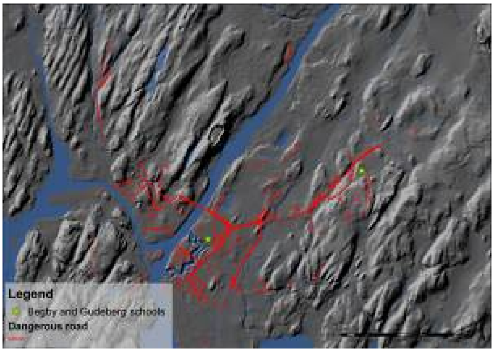


Figure 16 Roads perceived as dangerous

Traffic-related issues were among the most important hindrances that have influence on the pupils' free-time activities. Heavy traffic, dangerous crossings and lack of visibility through underpasses and bends were priority issues (Thorén et al., in prep.). Road segments perceived as dangerous were present across the entire study area (Figure 16).

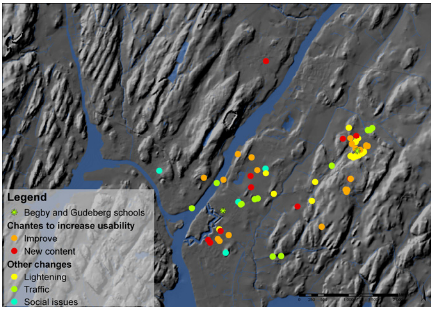
The *places* from the *children's habitat maps* (Figure 17) were categorised into two main groups according to the given types and subcategories were defined from the descriptive information:

Perceived as dangerous

- Doesn't want to be associated with the environment or the people
- Scary people
- Too much traffic
- Lack of lighting

Want to change

- Improve
- Lighting
- New content
- Social issues
- Traffic



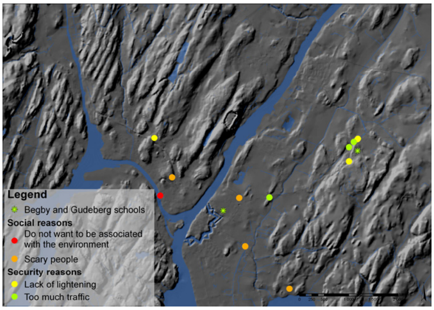


Figure 17 Places they want to change Places perceived as dangerous

The barriers are places that hinder activities. In the Adolescents' Landscape project, these were divided into three groups: routes and places they try to avoid because of

- heavy traffic and dark paths/areas;
- social reasons;
- the setting/equipment hindering the activity.

Most of the registered danger spots (60%) and more than half of the suggestions were related to safety. The proposed improvements aimed to increase usability or security.

From the registered *areas*, based on the descriptive information, the researchers defined the following 12 activity-type areas (Figure 18) and classified them into organised and non-organised activities:

Summer activities

Organised

- paintball
- football
- riding
- rowing

Organised / non-organised

- other ballgames

Non-organised

- skateboarding
- biking
- using play equipment
- meeting friends, hanging around (built -up / nature)
- shopping

Winter activities

Non-organised

- skiing
- ice skating

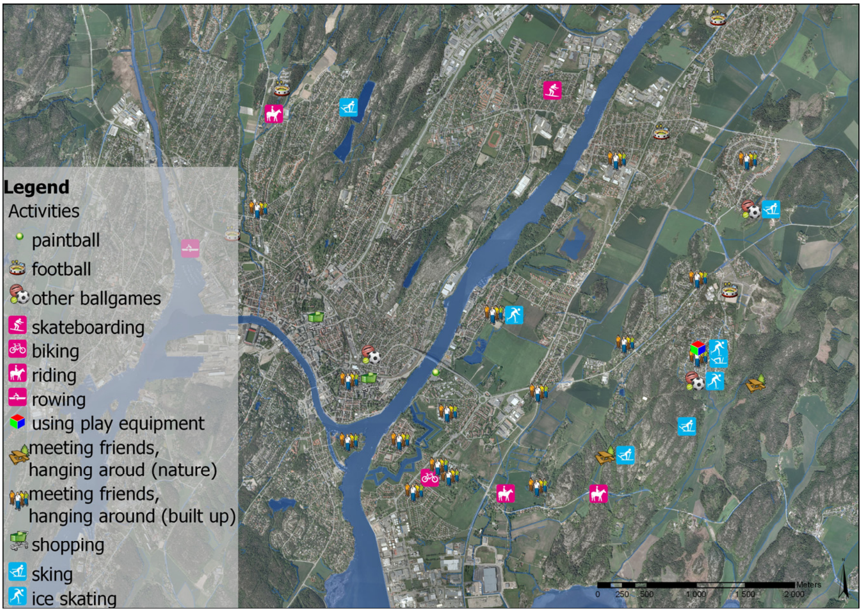


Figure 18 Activity type map

The pupils from Gudeberg used more activity areas than those from Begby.
The activity levels of the hotspots in both these areas were generally low: in about two-thirds the monitored average heart rate was lower than 120 bpm, which indicates a low intensity level of PA. Football seemed to be one activity type that stimulated higher activity levels.
In summary, the activity levels were higher along the road system than in the hotspots.

3.5. Mapping landscape for PA

Mapping the landscape was accomplished as part of the Adolescents' Landscape project. Adapting the predefined frame from the Adolescents' Landscape project, I refined the method and carried out practical analysis.

3.5.1. Spatial analysis

Two approaches were used for describing the landscape: landscape characterisation and space syntax methods (Figure 6: III). The starting point for landscape characterisation was determined by the Adolescents' Landscape project. The idea of testing the space syntax method emerged from my previous work experience and seemed to be supported by some previous studies (specified later).

3.5.1.1. Landscape characterisation

The aim of landscape characterisation was to describe the physical environment in a way that shows variation of the physical landscape in the whole neighbourhood. This method originates from the Sauerian traditions that "describe… the *morphology* – that is, the shape, form and structure – of a given landscape, and in so doing… reveal the characteristics… of the human cultures that had inhabited and moulded it" (Wylie, 2007:23).

The analysis was based on those characteristics that – according to the literature – might have an influence on PA behaviour. "Beginning with the infinite diversity, salient and related features are selected in order to establish the character of the landscape and to place them in a system" (Sauer, 1969:322). The characterisation method in the Adolescents' Landscape project focused on the physical structure. The selected themes were as follows:

- Terrain and water: water, steepness, landforms;
- Vegetation typology (for non-built-up areas);
- Urban morphology: roads, built typology, vegetation typology.

The ground is the basis for physical activity and, as Gibson (1977) describes, different layouts afford different activities. Steepness, landforms and water surfaces were analysed within the theme of *terrain and water*. Steepness determines how easy or difficult it is to pass an area, and thus how the terrain and landforms afford different physical activities like walking, hiking and climbing, or prevent activities. It is included in the landforms that describe the physical structure and accommodate the activities. The ground also gives the frame for visual perception, thus it visually guides locomotion. Water surfaces are highlighted as destinations for recreation and, beside landform and land cover, are key elements in the visual characterisation of landscapes (Brabyn, 2009). As a medium or as a surface, water affords different physical activities both in summer and winter, but it also stops pedestrian locomotion.

Variations of *vegetation* cover result in variations in activities (Fjørtoft, 2000, Grahn and Berggren-Bärring, 1995). Research shows that green areas play an important role in children's motor development (Fjørtoft, 2001) and might be important for teenagers' outdoor activities (Gearin and Kahle, 2006, Jago et al., 2005, Mäkinen and Tyrväinen, 2008, Owens, 1988, Travlou, 2006, Ward Thompson et al., 2006).

Built typology is usually developed from building structure, plot pattern and street pattern. In an urban settlement environment the construction, accessibility and design of the outdoor space have been found to influence physical activity behaviour in adolescents (Babey et al., 2008, Boone-Heinonen et al., 2010, Jago et al., 2005, Kerr et al., 2006, Kligerman et al., 2007, Limstrand, 2008, Mota et al., 2005). These vary within a city; thus, the affordances offered are significantly influenced by the built morphology. "Urban morphology is a study of the form and shape of settlements" (Carmona, 2003:61). It usually embraces land-use, building structure, plot pattern and street pattern. In the Adolescents' Landscape study, for the built-up areas, *urban morphology* was derived from built morphology and vegetation typology.

To describe the *terrain and water*, basic maps from the Norwegian digital map database were used: the Felles KartdataBase[7] (Statens kartverk) for water surfaces and a digital terrain model with 10x10m grid (Statens kartverk) to categorise steepness and defining landforms. The maps were generated by ArcMap© software.
A steepness map was generated from slope categories using the digital terrain model. Five slope classes were defined (Figure 19), according to how difficult it is to pass (Elvestad, 1981).
Landform is a more complex category that encompasses steepness. It takes into consideration the elevation, surface shape, topographic position and context, spatial scale and landform object (Deng, 2007). When the analysis was done, no detailed landform characterisation was available for Norway[8] and the existing description (Klemsdal, 2002) seemed to

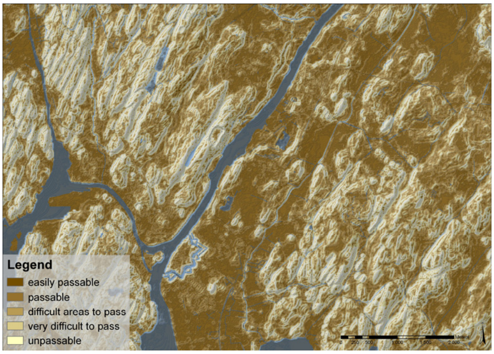


Figure 19 Slope classes according to Elvestad

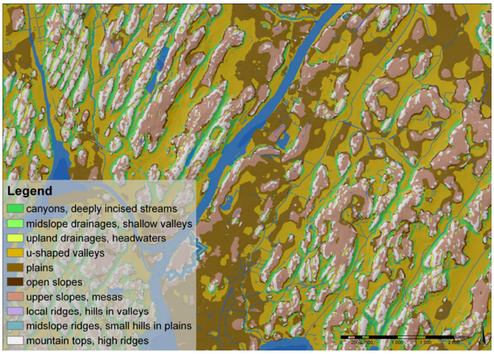


Figure 20 Detailed landform categories

[7] Suitable for scales 1:500 to 1:30,000.
[8] Since then a new method has been developed that may be applied in similar analysis in future research: see Halvorsen, R. and Erikstad, L. (2011) Unpublished: http://www.regjeringen.no/nb/dep/md/tema/planlegging_plan-_og_bygningsloven/landskapskonvensjonen/referansegruppe-for-landskap.html?id=667661

be too general for this analysis. Landforms were generated by an ArcView extension (Jenness, 2006) in ArcMap© from the elevation model (Figure 20). This program makes it possible to define smaller and larger neighbourhoods. The applied settings were two-level spatial scales of 50m and 250m with circular sampling. The program defined 10 landform categories.

Overlaying these detailed landforms with the activity data brought no meaningful results; therefore the terrain was simplified for further analysis into three categories: plains (1), hilly terrain (2) and artificial terrain (ditch and palisade system around the old town and fortress) (3).

The starting point for the *vegetation typology* was a digital map (scale 1:5000) of green structure classification (Thorén, 2000) provided by Fredrikstad municipality. It defines two main classes for the vegetation cover: natural/cultivated and subcategories based on the structure and layers (Figure 21). These categories give a three-dimensional understanding of the vegetation, i.e. its role in spatial structure. I updated this map manually in ArcMap© by using orthophotos (TerraTec AS, 2007).

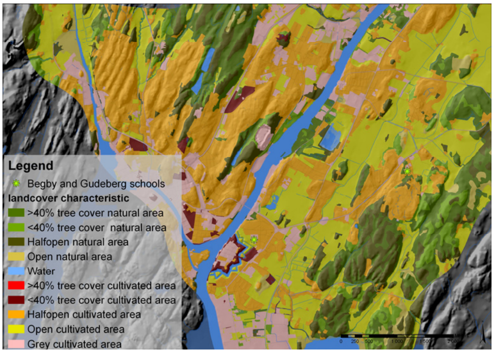


Figure 21 Vegetation typology

Urban morphology is a combination of three themes: roads, built typology and vegetation typology. The road/path network (Statens kartverk) was classified into two categories based on visual assessment. For the classification of built-up areas, the database of the building map[9] from the Felles KartdataBase (Statens kartverk) was used. Eight categories were defined based on the building type (Table 3).

Table 3 Built typology (Aradi, submitted)

Built typology	
Small detached houses in organic structure	Row and terraced houses
Orderly small & bigger detached houses	Big multi-family houses
Urban block structure	Scattered housing
Blocks of houses	Detached big buildings

[9] 32_0106bygg_flate

I tested whether these single themes, overlaid with the PA data, showed specific patterns. This separate analysis did not seem to be meaningful. Therefore I developed combined characteristics from these themes (Figure 22). The result of the characterisation was a landscape character area-type map that covered the whole neighbourhood area. For this map, the different layers (vegetation typology+terrain, urban morphology+vegetation typology+terrain) were combined in ArcMap© with the Union tool. After simplification the final map (Figure 23) consisted of 37 unique area types (Table 4). In the analysis, the PA levels and patterns were connected to these landscape character area types.

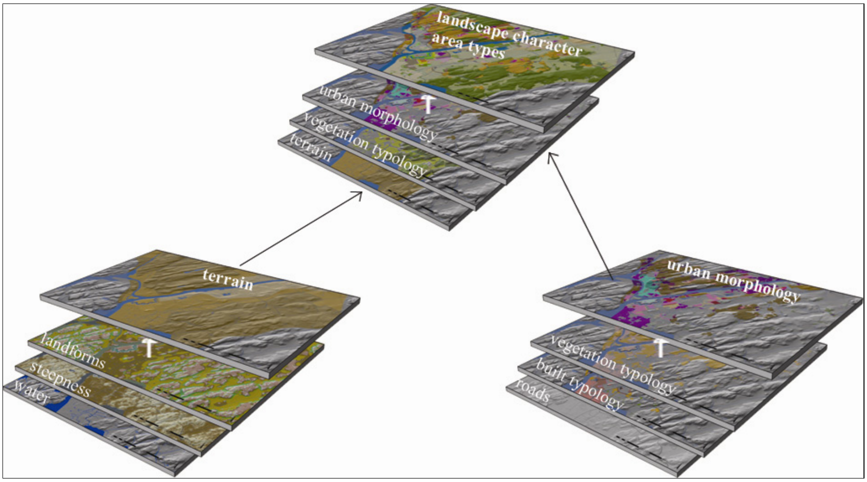


Figure 22 Landscape characterisation process (Aradi, submitted)

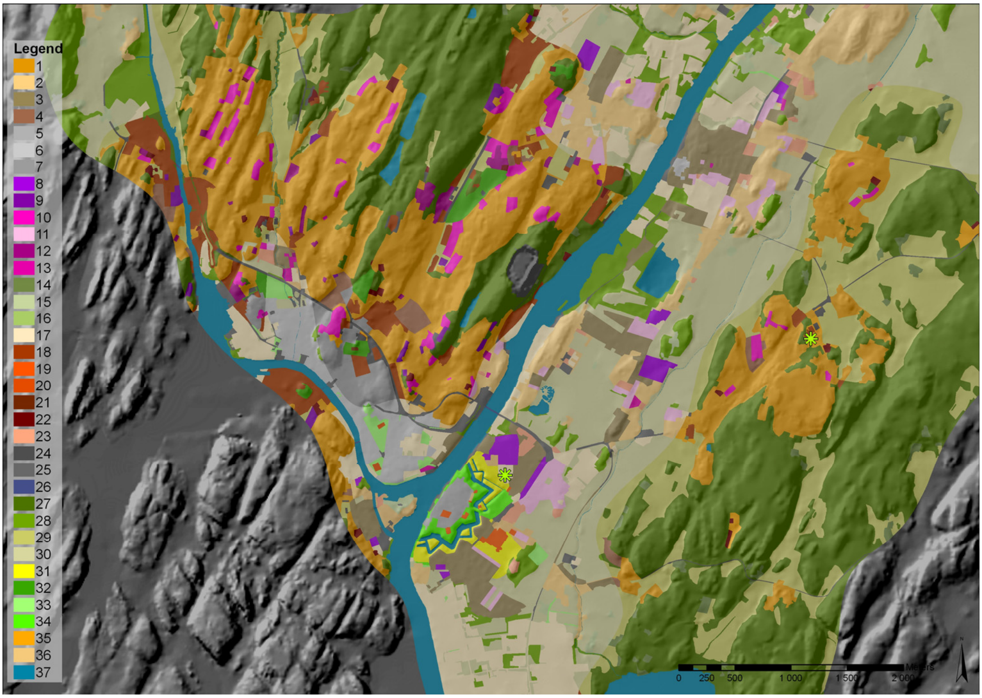


Figure 23 Landscape character area types

Table 4 Landscape character area types

ID	Landscape character area type	ID	Landscape character area type	ID	Landscape character area type
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	14	Scattered housing in half-open cultivated areas in hilly terrain	26	Grey cultivated areas on water surfaces
2	Small detached houses in organic structure in half-open cultivated areas in plains	15	Scattered housing in half-open cultivated areas in plains	27	Various nature areas in hilly terrain
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	16	Scattered housing in grey cultivated areas in plains	28	Various nature areas in plains
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	17	Detached big buildings in grey cultivated areas in plains	29	Open cultivated areas in hilly terrain
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	18	Detached big buildings in grey cultivated areas in hilly terrain	30	Open cultivated areas in plains
6	Urban block structure in half-open/grey cultivated areas in plains	19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	31	Open cultivated areas in artificial terrain
7	Urban block structure in half-open/grey cultivated areas in hilly terrain	20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	32	<40% tree cover cultivated areas in hilly terrain & riverside valley
8	Blocks of houses in half-open/grey cultivated areas in plains	21	Detached big buildings in <40% tree cover cultivated areas in hilly terrain	33	<40% tree covered areas in plains
9	Blocks of houses in half-open/grey cultivated areas in hilly terrain	22	Detached big buildings in half-open cultivated areas in hilly terrain	34	<40% tree covered areas in artificial terrain
10	Row and terraced houses in half-open cultivated areas in hilly terrain	23	Detached big buildings in half-open cultivated areas in plains	35	Half-open cultivated areas in hilly terrain
11	Row and terraced houses in half-open cultivated areas in plains	24	Grey cultivated areas in hilly terrain	36	Half-open cultivated areas in plains & artificial terrain
12	Big multi-family houses in half-open cultivated areas in hilly terrain	25	Grey cultivated areas in plains	37	Water surfaces
13	Big multi-family houses in half-open cultivated areas in plains				

Main differences in landscape characteristics in the study areas

Selecting study areas in dissimilar landscapes was one main aspect of consideration during the design of the Adolescents' Landscape project. With the applied characterisation method the main differences are presented as follows.

The terrain in the Gudeberg neighbourhood is flat; it has various housing areas and bigger industrial/commercial areas. The non-built-up areas are predominantly *open cultivated areas*, i.e. sport grounds, lawns or agricultural fields in various terrains (ID30, 31), but there are also bigger park areas (ID33, 34).

The Begby neighbourhood lies in more varied terrain. The residential areas are mostly single family houses with organic road structure and half-open vegetation (ID1). Various nature areas in hilly terrain (ID27) dominate the non-built-up areas, although open cultivated areas (ID29) are also found.

The more diverse built morphology resulted in more varied characteristics in the Gudeberg neighbourhood than in Begby. Hence, the landscape character area-type structure is more mosaic-like in Gudeberg and more homogeneous in Begby.

3.5.1.2. Space syntax

The idea of testing the space syntax method came from my previous work experience. Space syntax derives the characteristics of possible locomotion patterns, which made me curious about whether it would be meaningful to apply this method in my PhD project. The road system, which affords locomotion, is one of the most studied factors of the outdoor environment that has an influence on physical activity behaviour (Bungum et al., 2009, Frank et al., 2007, Grow et al., 2008, Kerr et al., 2007, Kyttä et al., 2012, Larsen et al., 2009, Voorhees et al., 2010). The road system was included in the building typology of the landscape character analysis, but space syntax provides information about the social characteristics. What was of interest was testing how the actual use of an area corresponded to this pattern. Cutumisu and Spence (2009) proposed the use of this method to obtain more objective information on children's movement patterns in urban settings. My interest was also strengthened by other studies that have already used or suggested using space syntax in PA research (Foltete and Piombini, 2007, Wineman et al., 2009, Harder et al., 2012, Conroy Dalton and Hanson, 2010).

This method was pioneered in the 1970s and 1980s by Bill Hillier and Julienne Hanson (Hillier and Hanson, 1984). The "syntax theory of space" makes a strong connection between space and society: "spatial organization is a function of the form of social solidarity" (Hillier and Hanson, 1984:142). It claims that "[i]n urban systems configuration is the primary generator of pedestrian movement patterns" (Hillier et al., 1993:31) and aims to point out how the road system influences social behaviour through these patterns. The method originates in urban morphology theory and measures geometric accessibility (Jiang et al., 1999).

The space syntax method does not take into account any other information from the environment, such as destinations or individual motivation. Although possible destinations are indirectly involved in the method, i.e. selecting locations for public or commercial functions, good accessibility is an important factor.

The method uses different measures to describe how parts are connected in the system. Based on these values, social characteristics are generated, such as sense of community, safety, inhabitant–visitor interaction or local relations (Cutumisu and Spence, 2009, Space Syntax, 2009, Vaughan, 2005, Vaughan et al., 2005). The method has already been tested in general PA research (Foltete and Piombini, 2007, Wineman et al., 2009) and suggested (Cutumisu and Spence, 2009) or used (Harder et al., 2012) to explore young people's PA. The method is also present in recent landscape and health research (Conroy Dalton and Hanson, 2010).

The space syntax analysis uses axial maps as a basis. I generated this map with software called DepthMap© (2006) using the existing road/path network (Statens kartverk) as a starting point and completing it with pedestrian shortcuts. Due to technical problems with the software this analysis was conducted on a reduced neighbourhood area: from the western part, only the city centre was involved (Figure 24). Since most of the registered activities in the western part of the city were in this central part, even within this limited neighbourhood, the most frequented area was still included in the analysis.

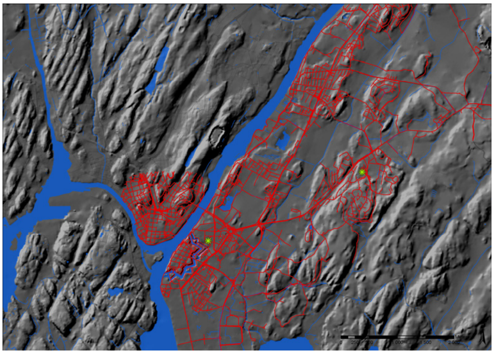


Figure 24 The reduced neighbourhood in the space syntax analysis

The space syntax analysis calculates different values for each axial line according to their position in the system or in relation to a defined group of axial lines. The outputs of the analysis are colour-coded maps, with a colour range from blue to red. There are nine categories defined with equal interval method. On the maps, blue shows segments with low values and red those with high values. In the analysis, I interpreted these values as

- low: in the lowest three categories;
- middle: in the middle three categories;
- high: in the highest three categories.

Several different measures are available; I selected *integration*, *control* and *choice* to test. *Integration* is a normalised value given to an axial line based on the shortest distance from all other lines in the network. The more integrated an axial line, the more it is frequented by pedestrians (Baran et al., 2008, Hillier et al., 1993). Integration is used to predict economic and social activities at street level. The global *integration* characteristic of the study area (Figure 25) shows that the roads of the Begby area mainly had mid- or low-level integration with the whole neighbourhood. The Gudeberg-area road system was more integrated. The integration values were mid-level or better in the area located north of Gudeberg and south-west of Begby. The integration was lower in the north, where the road system was organic, like in the Begby neighbourhood. The highest level of integration was seen along the main roads, in the common part of the two neighbourhoods and in a northern residential area with grid structure. The city centre in the west was relatively less integrated with the neighbourhood.

There is a *local* measure of *integration* that calculates integration three lines away from each line, and in an urban system this is the best predictor of small-scale (pedestrian) movements (Hillier, 2007). The *local integration* is supposed to highlight those areas that are more frequented for local use. This value was high in the city centre (Figure 25), in the Gudeberg area and in one of the residential areas in the north. These were areas with structured grid road systems.

Pedestrian densities showed the strongest correlation with spatial structure using the combination of integration and *control* values (Hillier and Hanson, 1984). Control is a local measurement. It gives a value to a segment depending on the degree of choice that it gives to the immediate neighbours to move to. In my study area the *control* values were generally low (Figure 25).

Connectivity is a local measure that shows how many other lines connect directly to the segment. The degree to which movement patterns are predictable depends on the *intelligibility* of the layout – that is, the correlation between integration and connectivity – and shows how well the whole system can be read from the parts (Hillier, 2007). The intelligibility of my study area (0.31) was low (El-Khouly and Penn, 2012), which suggests low predictability of pedestrian movement.

The main characteristics of the whole system in my study area were:

Number of segments: 3267
Mean integration: 0,46
Mean local (R3) integration: 1,52
Mean connectivity: 3,5
Intelligibility: 0,31

However, intelligibility is more related to orientation and wayfinding (Haq and Girotto, 2003), thus predicting movements of those who are not familiar with the system. To predict movement patterns of inhabitants who have better knowledge of the urban layout, Hillier suggested using *choice,* which shows "how likely [a place] is to be passed through on the shortest routes from all spaces to all other spaces in the system" (Hillier et al., 1987:237). In my study area the choice values were generally low, except in the case of the main roads (Figure 25).

In the Adolescents' Landscape project I tried to find associations between those indicators that are used for predicting small-scale (local integration, control) or inhabitants' (choice) pedestrian movements and the actual PA patterns.

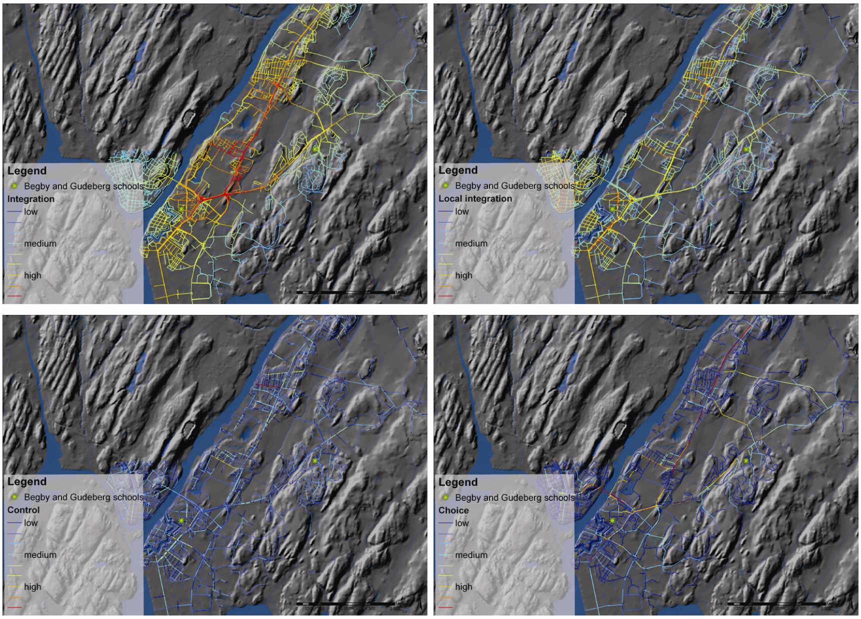


Figure 25 The selected space syntax measures in the study area

3.5.2. Legal regulations and barriers

Legal regulations and barriers (Figure 6: IV) might determine the physical arena for activities. The provision of areas for physical activity according to municipal plans means the zoned publicly accessible areas for recreational use. These are important possible target areas for free-time activities. Barriers are negative affordances (specified below).

Legal regulations

In destination-oriented transport, the shortest/fastest connections have higher priority than other qualities of the environment. Community buildings and areas have, in many cases, certain functions that could explain some of the outcomes of the analysis. From the plans (Fredrikstad kommune, 2010a; Fredrikstad kommune, 2010b), those functions that could stimulate everyday movements were selected as possible destinations. Some of these were targets in everyday life; some were destinations for recreation, play and sports (details specified under Figure 26).

Generally, the neighbourhoods had a good provision of publicly accessible green areas (Figure 26). The eastern part is better covered with agricultural nature and recreation areas. The accessibility of agricultural fields is limited to winter.

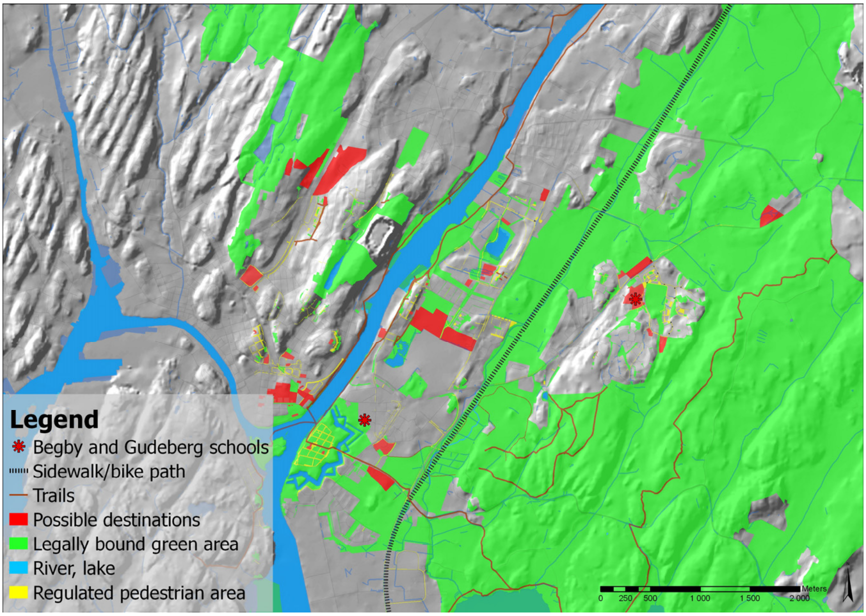


Figure 26 Legally bound green areas[a] for physical activity in the neighbourhoods and possible destinations

[a]parks, playgrounds, sport facilities, recreational areas for outdoor life, agricultural areas, nature and recreation areas, protected nature and cultural heritage areas, church yards, green isolation belts of industrial areas, small boat harbours, recreational buildings, educational institutes, community, administrative and public buildings, churches, gasoline stations

According to the plans, the number of possible destinations does not vary much between the two neighbourhoods. The common part of the two neighbourhoods, to the north from Gudeberg and to the west from Begby, had the best provision of possible target areas.

Traffic characteristic

Traffic was one of the main barriers to freely moving around, according to the students' own statements in *children's habitat maps* (see above). Official traffic information was available only for a limited number of roads in the case area. It showed heavy traffic on the main roads (Figure 27).

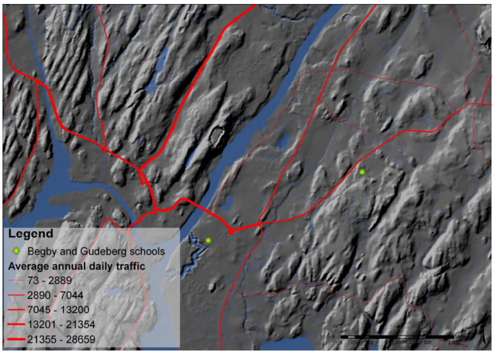


Figure 27 Traffic information (Norge digitalt, 2010)

4. Data used for the evaluation

This is the first part of the assessment – testing the analysis methods of the Adolescents' Landscape project (Figure 5). My focus here is to explore with which analysis methods it is possible to get meaningful results. The results offer input to help answer both of the research questions:

1. How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?
2. How does the landscape approach contribute to PA research?

I tested the analysis method by applying it. This application was an integrated part of the Adolescents' Landscape project. I presented the necessary basis information about the context, sample, tools and basis data in the chapter *Introduction of the case where the assessed methods were used*. Here, by presenting the practical analysis and its results, I introduce the way in which the landscape approach was put into practice.

To explore whether and how the landscape influences PA I combined the activity and landscape data using the ArcMap 10.0© software. My aim with these spatial analyses was to find patterns in the landscape that correspond with the PA behaviour.

My specific questions to answer	**The analysis I conducted to find the answer**
Is it possible to find landscape characteristics that are typical for certain activity types?	*Landscape pattern in relation to PA types*
Is it possible to find specific activity patterns in the landscape character area types?	*PA patterns in landscape character areas*
Are there specific characteristics of the locomotion patterns in relation to the landscape?	*Moving through the landscape*
What can explain the lack of use in case of non-used landscape character area types?	*Non-favoured landscape character area types*
Do the planned recreation facilities and possible destinations play a role regarding the activity patterns?	*Legal regulations and barriers*
Do perceived barriers in the neighbourhood influence the activity patterns?	*Legal regulations and barriers*
Do the space syntax characteristics of the neighbourhood have meaningful correlation with the activity patterns?	*Space syntax method*

Treating the number of users

I wanted to get insight into the popularity of areas/routes. The GPS/heart rate monitoring lasted one day; therefore the number of users were analysed only from the child track (Table 2). Treating the number of users was not straightforward. In the digital mapping the participants estimated the number of users in the areas they registered, thus these numbers are not exact. So as to get a picture about the popularity of the areas/routes, I categorised the number of users into four groups: one, few, some and many users. The routes/areas with more than one user were divided into few, some and many user categories by equal intervals. From these intervals the upper category was *many*, the middle *some*, and the lowest *few*.

4.1. Results from the Adolescents' Landscape project

4.1.1. Landscape pattern in relation to PA types

The specific question to answer: Is it possible to find landscape characteristics that are typical for certain activity types?

To explore whether there exist characteristic landscape patterns according to the registered activities, the activity patterns were overlaid with the landscape character areas. The start points for this analysis were the landscape character map and the activity types from the *children's habitat maps.* The amount of users in this analysis is based on the registered user numbers for each registered activity area.

The overall picture showed 12 different activity types in 27 different landscape character area types (Figure 28). The most popular activity type was meeting friends/hanging around and this was registered in all the landscape character area types used, with the exception of grey areas in hilly terrain (Figure 28, Table 5). The rest of the activity types, according to the number of different landscape character area types where they occurred, are as follows, in decreasing order:

- horseback riding (in seven);
- shopping (in five);
- biking and skiing (in four);
- ball games and rowing (in three);
- football (in two);
- playing with play equipment, paintball, ice skating and skateboarding only (in one).

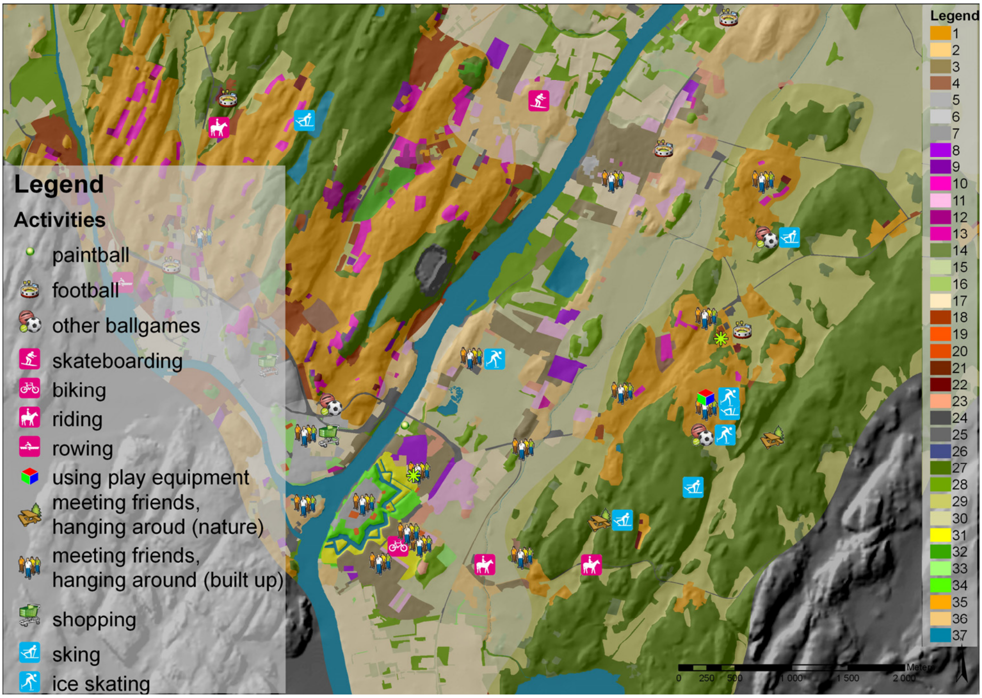


Figure 28 Activity types in the landscape character areas (Aradi et al., in review)

Most activity types were registered in such few locations that *activity-specific landscape characteristics* were not possible to find. Only meeting places were registered in sufficient numbers for deeper analysis.

Landscape character area types with many (four or more) registered *meeting places* were the following:

- mainly lawns, sports/agricultural fields or park areas (ID30,36);
- one residential area type (ID1);
- one area type with detached big buildings (ID17) with possible recreational/commercial/industrial functions.

Regarding the number of users, five meeting places were registered with many (ID36) or some users. Of those with some users, only one was in a residential area (ID5); the others were located in various non-residential areas (ID25, 34, 37).

Table 5 Activities, activity levels, amount of users, and gender and neighbourhood differences in the landscape character area types

user number categories in the activity type areas (child track): few: 2-41; some: 42-82; many: 83-122
aggregated user number categories in landscape character area types (child track): few: 2-52; some: 53-105; many: 106-155
B=Begby, G=Gudeberg
g=girl, b=boy
nda: no data available

ID	**Landscape character area type**	**aggregated amount of users** (child track)	**Activity types**: amount of users / neighbourhood / gender (child track)												**Hotspots** number of hotspots / amount of users / activity levels / neighbourhood / gender (GPS study)
			meeting friends	**horse-back riding**	**shopp-ing**	**biking**	**skiing**	**ballgames**	**rowing**	**foot-ball**	**play-ing**	**paint ball**	**ice skating**	**skate boarding**	
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	few	few/B; G/g,b	1/G/g	few/G /g,b		few/B/ g	few/B/ g,b			few/B/ g,b		few/B/ g,b		4/low/B/g,b
2	Small detached houses in organic structure in half-open cultivated areas in plains	few	few/G/ g,b		few/G /g,b										1/moderate/B;G/b
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	1	1/G/ g,b												1/low/G/g,b
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	1	1/G/b												
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	few	some/ G/g,b												3/low/G/g
6	Urban block structure in half-open/grey cultivated areas in plains	few	few/G/ g,b		few/G /g,b										
7	Urban block structure in half-open/grey cultivated areas in hilly terrain														1/low/G/g
8	Blocks of houses in half-open/grey cultivated areas in plains														6/low/B;G/g,b
10	Row and terraced houses in half-open cultivated areas in hilly terrain	1	1/B/b												
11	Row and terraced houses in half-open cultivated areas in plains	1	1/G/g, b												
13	Big multi-family houses in half-open cultivated areas in plains														1/vigorous/G/g
14	Scattered housing in half-open cultivated areas in hilly terrain	few	few/G/ g,b	few/B/ g			few/B; G/g,b								1/moderate/B/g

ID	Landscape character area type	aggregated amount of users (child track)	**Activity types**: amount of users / neighbourhood / gender (child track)												**Hotspots** number of hotspots / amount of users / activity levels / neighbourhood / gender (GPS study)
			meeting friends	**horse-back riding**	**shopp-ing**	**biking**	**skiing**	**ballgames**	**rowing**	**foot-ball**	**play-ing**	**paint ball**	**ice skating**	**skate boarding**	
15	Scattered housing in half-open cultivated areas in plains	few	few/G/g,b												2/low/G/b
17	Detached big buildings in grey cultivated areas in plains	few	few/G/g,b	1/G/g	few/G/g,b				1/G/g			few/B/b			22/vigorous, moderate, low/B;G/g,b
18	Detached big buildings in grey cultivated areas in hilly terrain	few	few/B/g,b		few/G/g,b										9/vigorous, low/B/g,b
19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	few	few/G/g,b												2/moderate, low/B;G/g,b
22	Detached big buildings in half-open cultivated areas in hilly terrain	few	few/B;G/g,b												1/low/B/b
23	Detached big buildings in half-open cultivated areas in plains	few	few/G/g,b												5/moderate, low/B;G/g,b
24	Grey cultivated areas in hilly terrain	few						few/G/g,b							
25	Grey cultivated areas in plains	some	some/G/g,b	1/G/g					1/G/g				few/G/nda		7/moderate, low/B;G/g,b
27	Various nature areas in hilly terrain	few	few/B;G/g,b,	few/B;G/g			few/B;G/g,b	few/B/g,b							
28	Various nature areas in plains	few	few/G/g,b			few/G/g,b									
29	Open cultivated areas in hilly terrain	some	few/B;G/g,b	few/B;G/g			few/B;G/g,b			few/B/g,b					2/vigorous/B/g,b
30	Open cultivated areas in plains	some	few/G/g,b	1/G/g		few/G/g,b				few/B;G/g,b				1/B/b	1/vigorous/G/b
31	Open cultivated areas in artificial terrain	some	few/G/g,b			few/G/g,b									
33	<40% tree covered areas in plains	few	few/G/g,b												
34	<40% tree covered areas in artificial terrain	few	some/G/g,b												
35	Half-open cultivated areas in hilly terrain	few	few/G/g,b												2/low/B/g,b
36	Half-open cultivated areas in plains & artificial terrain	many	many/G/g,b			few/G/g,b									
37	Water surfaces	few	some/G/g,b						1/G/g						

4.1.2. PA patterns in landscape character areas

The specific question to answer: Is it possible to find specific activity patterns in the landscape character area types?

My aim with this analysis was to find out if there were typical activity patterns in different landscape character areas, in order to determine those characteristics that afford: 1) the most varied activity types, 2) high/various activity levels.
The starting points for the analysis were the landscape character map and the registered activities from the children's habitat maps. To explore whether certain landscape characteristics trigger different activity levels I overlaid the landscape character map with the hotspots from the GPS heart rate registration.
To look at whether there were differences in the intensity of use of the landscape character areas, I aggregated the registered numbers of users (activity areas from the children's habitat maps) for these area types. The categories of the *amount of users* were generated from these aggregated numbers.

Variety of activities
Different activities were registered in 27 of the total 37 different landscape character areas. The landscape character area type that accommodated the most different activity types (Table 5) was a residential area (ID1). Area types with more than three different activity types were mainly connected to areas with special community and/or free-time activity functions (ID17, 25, 27, 29, 30).
The GPS/heart rate study showed some similarities. Hotspots were registered in 18 different landscape character area types (Table 5). The landscape character area type with the *most hotspots* (ID17) was a non-residential grey area, often with community and/or free-time activity functions. There were five more areas with more than three hotspots. Three of these were non-residential grey areas with/without buildings (ID18, 23, 25) and two were residential areas (ID1,8).
The *most preferred* areas, with many (ID36) or some (ID25, 29, 30, 31, 37) registered users, were in non-residential areas dominated by open cultivated areas (e.g. lawns, sport fields). In terms of walking/biking activities, of all the registered routes in the neighbourhoods, the most frequently used were, not surprisingly, the main collector roads.

Activity levels

Only in one landscape character area type (ID17) with the most hotspots (Table 5) were activity levels across the whole scale, from low to vigorous, registered. In most hotspots the average *activity level* was low. There were only five landscape character area types where vigorous activity was registered. These were around recreational areas (ID17, 18), on sport fields (ID29, 30) and in one residential area type with big multi-family houses (ID13).

4.1.3. Moving through the landscape

The specific question to answer: Are there specific characteristics of locomotion patterns in relation to the landscape?

Locomotion embraces movement between destinations and also as a leisure time activity in itself. The goal of this analysis was to explore what kinds of landscapes afford walking, biking and running activities and whether and how different settings influence activity levels. The analysis is based on: 1) the marked routes from the children's habitat maps; and 2) the GPS heart rate dataset, aggregated on the road system.

It was also interesting to explore whether the most active pupils' movement patterns reveal specific landscape preferences. For this purpose we selected those 11 individuals from the GPS/heart rate study who fulfilled the requirement for amount of physical activity. I investigated their aggregated length of routes and average activity levels in the landscape character area types, to see whether there were any specific patterns.

Overall picture

The overview picture from the *children's habitat maps* (Figure 15) showed that of all the registered routes in the neighbourhoods, the most frequently used were, unsurprisingly, the main collector roads.

Middle–high-average heart rate levels were registered along some of the main roads in parts of residential areas both in Gudeberg and Begby, and in the nature area (ID27) with floodlit tracks south of Begby (Figure 11).

Individual routes

Of the 37 landscape character area types, 28 were used by the selected pupils. There were three landscape character area types with aggregated route length of more than 10 km (Table 6); one residential area (ID1); and the other two were non-built-up areas (ID27, 29).

Table 6 Individual routes and activity levels in landscape character area types

aggregated length	**>10km**	**2-10km**	**1-2km**	**0,1-1km**	**<0,1km**
landscape character area types	Small detached houses in organic structure in half-open cultivated areas in hilly terrain (ID1)	Orderly small & bigger detached houses in half-open cultivated areas in plains (ID3)	Small detached houses in organic structure in half-open cultivated areas in plains (ID2)	Urban block structure in grey/half-open cultivated areas in artificial terrain (ID5)	Various natural areas in plains (ID28)
	Various natural areas in hilly terrain (ID27)	Detached big buildings in grey cultivated areas in hilly terrain (ID18)	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain (ID4)	Blocks of houses in half-open/grey cultivated areas in plains (ID8)	
activity levels: *<120bpm* *120-140bpm*	Open cultivated areas in hilly terrain (ID29)	Detached big buildings in grey/half-open cultivated areas in artificial terrain (ID19)	Urban block structure in half-open/grey cultivated areas in plains (ID6)	Row and terraced houses in half-open cultivated areas in hilly terrain (ID10)	
>140bpm		Open cultivated areas in plains (ID30)	Detached big buildings in grey cultivated areas in plains (ID17)	Row and terraced houses in half-open cultivated areas in plains (ID11)	
			Grey cultivated areas in hilly terrain (ID24)	Big multi-family houses in half-open cultivated areas in plains (ID13)	
			Grey cultivated areas in plains (ID25)	Scattered housing in half-open cultivated areas in hilly terrain (ID14)	
			Half-open cultivated areas in hilly terrain (ID35)	Detached big buildings in half-open cultivated areas in hilly terrain (ID22)	
			Water (ID37)	Detached big buildings in half-open cultivated areas in plains (ID23)	
				Open cultivated areas in artificial terrain (ID31)	
				<40% tree cover cultivated areas in plains (ID33)	
				<40% tree cover cultivated areas in artificial terrain (ID34)	
				Half-open cultivated areasin plains & artificial terrain (ID36)	

The activity level was middle–high (HR = 120–140 bpm) in almost all the landscape character area types used. There was only one residential area (ID7) with a low activity level.

There was no distinct landscape character-specific pattern found in the most active pupils' activities or activity levels.

4.1.4. Non-favoured landscape character area types

The specific question to answer: What can explain the lack of use in the case of non-used landscape character area types?

My purpose was to investigate those landscape character area types where no activities were registered and explore whether there is an explanation for their not being used. For this I examined the location, amount and size of these areas.

There were seven landscape character area types where no activities were registered (Table 7).

Table 7 Non-favoured landscape character area types

ID	Landscape character area type	Description	Location	Number	Size (m2)
9	Blocks of houses in half-open/grey cultivated areas in hilly terrain	Smaller residential areas.	West	21	895 - 37 744
12	Big multi-family houses in half-open cultivated areas in hilly terrain	Smaller residential areas.	West	20	892 - 29 342
16	Scattered housing in grey cultivated areas in plains	Very small areas with local industry, agriculture or service building.	East	3	383 - 1 515
20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	Buildings in parks or churches in churchyards.	West	3	473 - 3 957
21	Detached big buildings in <40% tree cover cultivated areas in hilly terrain	Church in churchyard.	West	1	1 803
26	Grey cultivated areas on water surfaces	Bridges. One between the western and eastern parts, the rest on the western part.	West	6	141 - 2 080
32	<40% tree cover cultivated areas in hilly terrain & riverside valley	Park areas close to the city centre.	West	9	401 - 94 377

These, with one exception, were only in the western part of the study area. There were no activities registered in some distant residential (ID9, 12) and more central park (ID20, 21, 32) areas and on the bridge (ID26). Most of them were rare and small, and distance can explain the lack of use: the western part of the city was not extensively used. The only area type not used in the eastern part of the city was one that is typically an industrial, agricultural or service area (ID16).

4.1.5. Interpreting PA in relation to landscape

From the landscape point of view, we defined actualised affordances for adolescents as the landscape character area types where their activities take place. Differentiating the landscape on the basis of the activities, we identified three main classes (the findings are discussed in Aradi et al., in review):

- (actualised) affordances for getting together;
- (actualised) affordances for various activities;

- (actualised) affordances for high activity.

These classified actualised affordances were the main result of the analysis. Each of these three categories included more of the landscape character area types that favoured the specified physical activity behaviours.

Affordances for getting together

Most of the areas used by many or some pupils were registered in non-residential areas: nature areas (ID37), non-built-up half-open areas connected to residential areas (ID36), open grey areas (ID25), sports fields and lawns (ID29, 30, 31). Looking specifically at those places registered for meeting activity (Table 5), it appears that Gudeberg is an area for getting together. Along with the area types listed here (ID25, 36, 37) the park area around the fortress (ID34) and one urban area (ID5), located in the historical old town with a mixed commercial/residential function, also attracted many users.

Affordances for various activities

According to the variety of activity types registered, the Begby neighbourhood can be considered as an area for various activities. The conducted analyses all demonstrate that the single family housing area with organic road structure and scattered vegetation (ID1) favours outdoor activities; seven out of the 12 activity types were found in this area type (Table 5). In terms of registered activity types in Begby, both built-up and non-built-up recreational areas (ID14, 27, 29) seem to be important for accommodating different activity types, e.g. meeting friends, football, ballgames, horse-riding, skiing and shopping. Beyond the Begby neighbourhood, open grey or cultivated areas (ID25, 30) and areas typically connected to recreational/commercial functions (ID17) are also important for various activities, such as meeting friends, football, biking, horse-riding, ice skating and shopping.

Affordances for high activity

In the Adolescents' Landscape study, built-up and non-built-up recreational areas (ID17, 18, 19, 23, 25) appear to stimulate various activity levels from low to vigorous (Table 5); these are typically areas planned for recreation, such as sport halls and grey sport fields. The highest activity levels (hotspots with moderate to vigorous activity) were mostly found in similar areas connected to recreational/commercial functions (ID17, 18, 19, 23) or grey/cultivated sport fields (ID25, 29, 30). Some more active places were in housing

areas with half-open vegetation (ID2, 13, 14). Of these, the first two were single- and multi-family residential areas; the third is a scattered housing area.
Nevertheless there was more high–vigorous activity registered along the routes than in the activity areas. Apart from the various nature areas (ID27), the high activity level along the routes did not appear to be associated with special landscape characteristics; nor did the presence of bike paths predict high activity.

4.1.6. Legal regulations and barriers

The specific questions to answer: Do the planned recreation facilities and possible destinations play a role regarding the activity patterns? Do perceived barriers in the neighbourhood influence the activity patterns?

The hypothesis for analysing the provision of public accessible green areas and possible target areas for physical activity in municipal plans was that lack of provision hinders physical activity. Overlaying the possible target areas with the landscape character area types also gives an overview of how important a role they play in adolescents' everyday physical activity. On the assumption that areas with better provision are more attractive for use for free-time activities, using the municipal plans, I calculated the accumulated area size of the possible target areas and zoned areas for recreation for each landscape character area type.

The landscape character area types with the most users in the view of the zoned green and recreational area provision and possible destinations showed that non-residential landscape character area types with bigger green and/or target areas (ID17, 27, 29, 30, 37) had an important role in outdoor activities. From the residential area types with the best provision (ID1, 2, 3, 6), only one (ID1) was between the most used ones regarding amount of users. Furthermore, there were also favoured landscape character area types where the size of the legally regulated public green areas and possible destinations were not associated with preferences: built-up and non-built-up grey areas (ID23, 25), parks connected to water (ID37) and non-built-up areas with half-opened vegetation (ID36). Common to these was that in all of them, gathering places were marked.

Barriers

The combination of the traffic information and the adolescents' own observations from the *children's habitat maps* showed where barriers were present and where these were realised as barriers. I took into account other safety-related issues, such as lighting and social fears. From the *children's habitat maps* I overlaid safety-related issues – those concerning lack of lighting and social fears – with the space syntax control values (that are supposed to reflect upon feelings of safety).

Of those roads where traffic data were available (Figure 27), all roads/parts of them in the Gudeberg area were marked as "dangerous" by the pupils (Figure 29). Places registered due to traffic danger were also located along these roads (Figure 29). One main road leading toward the south was marked as presenting traffic danger by several pupils, but no traffic data was available. The main road from the Gudeberg area toward Begby also had heavy traffic and was considered to be dangerous.

No relations were found between the fears and the analysed space syntax measures.

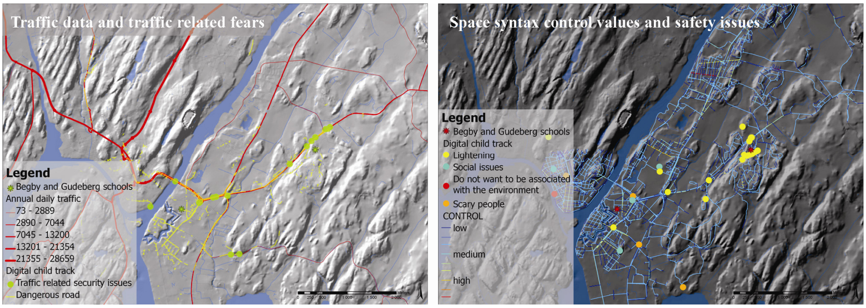


Figure 29 Traffic and road characteristics, and children's habitat map

The pupils reported *lack of lighting* as an important factor that hinders outdoor activities. They marked places either along main roads, along shortcuts or through underpasses (Figure 17). A greater number of locations were registered in the Begby neighbourhood, where more shortcuts were in the residential areas.

Perceived fear is an important barrier to outdoor activities. In the Adolescents' Landscape study *social issues*, mainly in terms of scary groups of people, were also considered an environmental fear by the pupils. The places they avoided for social reasons were in different locations but were mostly built-up areas (Figure 17). Social fears did not connect to areas with special landscape characteristics but were reported mostly from Gudeberg.

The activity patterns showed that despite their concerns, the pupils did use places they marked with heavy traffic or lack of lighting, or even those areas with social fears.

4.1.7. Testing the space syntax method

The specific question to answer: Do the space syntax characteristics of the neighbourhood have meaningful correlation with the activity patterns?

The activity areas, most used routes, aggregated activity levels along the routes and gender differences were collated with local integration, control and choice values. Correlations of heart rate ranges and number of users (both in neighbourhoods and with gender distinction) with local integration, control and choice values, respectively, were analysed with the Spearman correlation test, which is suitable for small or non-normally distributed data sets.
Regarding the activity types, I also tested a more general level grouping (organised–non-organised activities) with the local integration measure.

The results (Appendix 6) showed no correlation between the selected space syntax characteristics and the PA data. None of these characteristics were associated with the number of users or activity levels at the whole group or subgroup (neighbourhood and gender) level.
No correlation was found between the PA data aggregated on the road/track system and the selected space syntax measures. The registered activity areas were in environments with medium–low local integration and choice levels and a low control value. The space syntax characteristics of the 13 different activity types were similar. Grouping the activities into organised and non-organised groups, the organised activities were located in more frequented spots (middle integration value) than the non-organised activities (low integration value). This meant that the locations of organised activities were in somewhat easier and more accessible locations, which is not a surprising result.

4.2. Summary

By applying the analysis methods used in the Adolescents' Landscape project I explored whether the results of the analyses help to develop a landscape-scale interpretation of PA behaviour. My main aim was to test which analysis method gave meaningful results. In summary, the following input was received to answer my research questions.

1. How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?

Some of the part-analyses gave no significant results. It was not possible to find an activity-specific landscape character due to the low number of registered activity areas. Nor did we find landscape-specific activity patterns with the individual route analysis. The space syntax measures did not show any correlation with the activity patterns. However, analysing the physical activity types in landscape character area types gave meaningful results.

2. How does the landscape approach contribute to PA research?

It was possible to associate specific landscape characteristics with certain kinds of use and PA level: affordances for getting together, affordances for various activities and affordances for high activity.

5. Methods for the evaluation

This chapter gives an overview of the practical workflow I completed during the further steps of the internal assessment (Figure 5). The method testing revealed which combination of methods contributed to the landscape scale interpretation of activity patterns. In this chapter I focus on the assessment of (1) practical applicability and (2) trustworthiness of the methods.

Practical applicability of the methods

Practical applicability explores how the successful single methods and the compound method functioned during the testing. This assessment contributes to the answer of the first research question: How did multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?

I derived the assessment criteria from the method assessment practice in PA research. The detailed descriptive evaluation of a method that explores the origin and common areas of use was not relevant for the method developed in the Adolescents' Landscape study. It is not yet a widely used method. The commonly used criteria for method evaluation are: purpose, measured variable (activity, component), population age, sample size, respondent burden, data delivery mode, time frame for data collection, information required/data source, data model, data management, measurement error, cost implications and other limitations. From these I used in my evaluation criteria for assessing

- the function of the methods (purpose and measured variable),
- population age and sample size, and
- practical data management (data output/input, data processing, analysis, and time).

In the limitations I included respondent burden, reflections on measurement error and cost implications.

The advantages of a method are important assessment criteria; however, they are more meaningful in comparison with other methods. I addressed this in the *Discussion* chapter, exploring the relevance of the methods.

To assess practical applicability, I defined specific questions and assigned assessment criteria to answer these questions.

Specific questions to answer	**Assessment criteria**
What kind of information was possible to get?	Function of the method: purpose, measured variable
How did the methods function? What were their limitations?	Population age and sample size
	Data output/input
	Data processing (preparing the data for analysis)
	Analysis
	Time
	Limitations

I dealt with the practical applicability of the methods on two levels. First I assessed each of the single data collection methods (GPS/heart rate, *children's habitat maps* and spatial analysis) separately. In practice, I fulfilled some details of this practical applicability assessment as a part of the iterative process while applying the methods. After this single methods assessment I summarised the results as an evaluation of the complex method.
I presented the basis information about the methods (conditions of measurement, sample size, analyses) in the chapter *Introduction of the case where the assessed methods were used*. From this, I now summarise some relevant issues as a part of the assessment.

Trustworthiness

By assessing trustworthiness I also aim to contribute to the answer to the first research question: How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?

Guba suggested four criteria – credibility, transferability, dependability and confirmability – for assessing trustworthiness. He also suggested techniques to establish these qualities (Guba, 1981). The credibility of research can be judged only by the participants. The data, but especially the results, have to be discussed with the participants and differences in opinion have to be negotiated. Techniques to establish credibility include prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis and member checking (Lincoln and Guba, 1985).
It is not possible to ensure transferability by assessing one's own findings: "an investigator can make *no* statements about transferability for his or her findings based solely on data from the studied context alone" (Lincoln and Guba, 1985:217). However, it is possible to provide the basis for judgement of transferability by describing the context.

"It is the function of the case study, with its "thick description," to provide that essential judgemental information about the studied context" (ibid).
Lincoln and Guba suggested that if a study is credible, "it ought not to be necessary to demonstrate dependability separately" (1985:317). Nevertheless, three techniques are suggested to establish dependability: "overlap methods", "stepwise replication" and "inquiry audit" (ibid). The first is equal to triangulation. The second is parallel analysis of the same datasets by a separate group of researchers. Auditing involves a systematic examination of the process and is the main technique used to establish confirmability (Lincoln and Guba, 1985). Auditing requires an external evaluator, therefore in my study I focused on how to provide the conditions for a possible audit. For this I relied on what Yin (2009) proposed for ensuring confirmability (reliability) in case study research: it can be secured by using case study protocol or developing case study database.

A subquestion to answer was: How were credibility, transferability, dependability, and confirmability assured in the Adolescents' Landscape project?

6. Findings from the evaluation and discussion of the results

6.1. Findings

6.1.1. Practical applicability

The Adolescents' Landscape project aimed at a deeper understanding of how the complex urban environment influences PA behaviour. For this, it was necessary to have information on PA and on landscape. PA data was collected by GPS/heart rate monitoring and by a method called *children's habitat maps*. Landscape characterisation, space syntax and analysis of legal regulations and barriers provided information about the landscape.

GPS/heart rate monitoring

Discussion of the feasibility of combining GPS with heart rate belts in the Adolescents' Landscape project has been published previously (Fjørtoft et al., 2010). This assessment concluded that this combination of methods proved to be useful for exploring PA levels and patterns.

Function: GPS/heart rate monitoring provided objective data on activity levels with exact spatial location. The measurement was able to give an objective picture of the use of the neighbourhood area and, at the same time, of activity levels.

Population age and sample size: Both heart rate belts and GPS were found to be suitable for all populations and a small to medium sample size (Dollman et al., 2009, Duncan et al., 2009, Warren et al., 2010); however, were the equipment to decrease in price, this might make it possible to use it for large samples.

Data output: Points with coordinates, heart rate (beat pr. minute), registration time, user code and gender information.

Data processing: The data was downloaded and processed with database management software. There were no existing protocols for data processing; the data treatment method (summarised in brief in Appendix 5) had to be developed as a part of the Adolescents' Landscape project.

Analysis: The data was aggregated on the street network and hotspots were defined. The hotspots were defined at two levels: important small (10m × 10m) places and bigger (100m × 100m) areas that were more suitable for space-demanding activities. This method gave the same type of information as the *children's habitat maps*; thus it was possible to compare the different data sources.

Time: The recommended data collection time for "capturing habitual PA" with heart rate monitoring is one week (Dollman et al., 2009). In the Adolescents' Landscape project the data collection was done over one day for each participant. The limited amount of equipment extended the data collection period.

Limitations: The adolescents' activity level analysis was based on objective data but with short-term data collection and only from one season (autumn). Therefore, the general pattern might be different from that recorded here. The short-term data collection determined, to some extent, the possibilities for the analysis and interpretation of the outputs.

This method is not obtrusive. It has low measurement error, but the GPS is suitable only for outdoor use and there were errors in registration close to buildings. The cost is relatively high compared with self-reported data collection methods.

Children's habitat maps

Experiences with the *children's habitat maps* in the Adolescents' Landscape project were published in a previous study (Aradi, 2010). In that study I found this method to be suitable for collecting information on the children's interpretation and use of landscape.

Function: Information about the general use of the neighbourhood. Complex method: an extended version of a mapping-based survey with predefined questions. Self-reported information about activity types and locations.

Population age and sample size: The method was developed primarily for the 10–12-year age group. However it worked well in the Adolescents' Landscape project with older (14-year-old) adolescents. Generally, the method is suitable for small to large sample sizes.

Data output: Paper maps (routes, areas with gender information), digital maps (routes, places, areas, no gender information) with descriptive information, photos with descriptive information, essays.

Data processing: Summarising the information of the paper maps and digitalising the results was time-demanding. The self-recorded digital information was downloaded from a web-mapping program. The data was processed in ArcGIS© software. The digital data was relatively easy to treat, but for the routes it was necessary to develop a method to correct the inaccuracy of the self-recorded data (Appendix 5). The descriptive information from the photos and essays were transcribed.

Analysis: In the analysis, thematic categories of routes, places and areas (specified in the chapter *Introduction of the case where the assessed methods were used*) were developed based on the descriptive information. Analysing the processed digital data was simple. The descriptive data and photos were analysed using the Atlas.ti software (not completed yet).

Time: This method was a time-efficient way of collecting self-reported activity data. One specific weakness of the method was that, due to the strict time schedule of the final exams, it was not possible to go back and discuss the registered data with the pupils. Digitalisation of the maps and essays and analysing the essays was time-demanding.

Limitations: In the digital phase, the pupils saw the previous registrations. This might have influenced the results. It was possible to register gender information only during the paper mapping. Due to the limited number of participants, the possibilities for gender analysis in the Adolescents' Landscape project were restricted.

Completing the whole data collection was time-demanding for the participants and some of them experienced it as too much extra work. The measurement error with this self-reported method is assumed to be high. Undertaking the digital mapping individually, supported by personal guidance and discussion, would have increased the accuracy of the information gathered. Compared with the GPS/heart rate data collection, it is a low-cost method.

Landscape characterisation

Function: The map developed with this method provided contextual landscape information for the further analysis. It is a comprehensive method with which it was possible to incorporate the relevant themes and to get a neighbourhood-level picture. It was possible to obtain complex information about the neighbourhood without extensive fieldwork. The output map gave an overview of the variations in the landscape of the neighbourhood areas.

Population age and sample size: Not relevant.

Data input: Terrain, water, vegetation, building and road typology.

Data processing: Developing principles for classifying the basic themes (see chapter *Introduction of the case where the assessed methods were used*), updating the information content and testing these maps was time-demanding.

Analysis: Combining the themes was simple, but it was necessary to develop a method to reduce the categories. With the developed protocol, reapplying the analysis would be simple. The result of the analysis was the landscape character area type map.
Time: Depending on the quality of basis data, this method is relatively time-efficient.
Limitations: The method gave a sufficiently detailed picture at neighbourhood scale; however, the large number of categories makes it difficult to interpret the results.
The building typology was developed from an existing database. The basic categories were function-, not form-oriented. This might result in some errors in the categorisation. For further detailed analysis of the PA patterns, the three simplified terrain categories might be too general.

Space syntax
Function: It was a methodological experiment within the Adolescents' Landscape project. Using this method it is also possible to get information about the neighbourhood without extensive fieldwork. The developed indices gave specific characteristics of the neighbourhood. The developed characteristics were derived from possible movement patterns.
Population age and sample size: The method was used for all populations, but it is questionable whether it is suitable for subgroups. The method seems more suited to a large sample. (These issues are addressed in the *Discussion* chapter.)
Data input: Axial map from the revised road network.
Data processing: I updated the maps with pedestrian shortcuts. This required fieldwork.
Analysis: With the DepthMap© software, the analysis is simple and straightforward. Many different measures are calculated based on the road system. These include those road variables that are commonly used for urban form characteristics in PA research, namely connectivity and intersection density.
Time: Time-efficient.
Limitations: The analysed area might have been too big for the software, causing problems. The method is cost-efficient.

Legal regulations and barriers
Function: The aim was to provide explanatory spatial information for the activity patterns. For this, the zoned green areas, together with possible destinations and possible and reported danger, were mapped.

Population age and sample size: Not relevant.

Data input: Municipal plans, traffic data, dangerous routes and places from the *children's habitat maps*.

Data processing: Not relevant.

Analysis: Selecting the possible destinations (specified in the chapter *Introduction of the case where the assessed methods were used*) from the municipal plans and combining the dangerous routes and places with the traffic data was simple and resulted in maps of possible destinations and dangers.

Time: Time-efficient.

Limitations: Official traffic information was available only for the main roads, thus the perceived traffic danger was important in obtaining a more realistic picture. Other factors, such as social conditions or design, might have added further details about the perceived hindrances, but we did not have sufficiently detailed information to include these in the analysis.

Complex method

Function: The aim was to give a landscape-level interpretation of activities.

Population age and sample size: The age limit for the complex method is set by the children's habitat maps: younger adolescents. The other methods did not have stricter age limitation. The complex method is suitable for a small to large sample size.

Data input: GPS/heart rate data, *children's habitat maps*, landscape character area types, legal regulations and barriers, space syntax characteristics.

Data processing: Not relevant.

Analysis: The analysis methods are described in detail in the chapter *Data used for the evaluation*. Developing the analysis method was time-consuming, but applying the methods was easy.

The method can be simplified by excluding those analyses that did not contribute to development of the results. Furthermore, in the Adolescents' Landscape project, the space syntax method did not provide a better understanding of the activity patterns. However, examining activities in the landscape character area types led to some meaningful results, presented in the chapter *Data used for the evaluation*.

Time: Applying the method was time-demanding.

Limitations: To apply the method in research, further simplification of the analysis and specification of the results is necessary.

Due to the method of analysis, the actualised affordances here contain "places for interaction" as defined by Lieberg (2006). Places for retreat (ibid) would require individual analysis of the physical activity patterns.
The initial attempt to interpret the movement dynamics from the perspective of the landscape was unsuccessful, though this opportunity is provided by further analysis of the individual records.

6.1.2. Trustworthiness

Credibility
In the Adolescents' Landscape project we kept contact with pupils through the schools. Prolonged engagement and persistent observations were not possible. The results of the analyses were presented and discussed in several forums (conferences and seminars) that gave the opportunity for peer debriefing. In the Adolescents' Landscape project the aim was to explore a phenomena. Negative case analysis, i.e. treating unexpected results, was part of the iterative process of method development. Here, in the credibility assessment, I focus on triangulation and member checking.

In the Adolescents' Landscape project, methodological triangulation of multiple sources of evidence (GPS/heart rate and children's habitat maps) secured the credibility of the results. One important factor in the design of the PA data collection phase was that the different data collection methods should complement each other. This meant that information which could not be obtained with one method could be provided by another; it was also essential that the methods counterbalanced each other's natural weaknesses. The choice of GPS/heart rate monitoring and children's habitat maps proved to be a good combination (Table 8).

Table 8 Advantages and disadvantages of the GPS/heart rate monitoring and children's habitat map data collection methods (Aradi, submitted)

GPS and heart rate monitoring	Child track
Advantages • objective data about the places used • place located activity levels • gender information	**Advantages** • spatially located descriptive information: reason for choices • diverse and information rich descriptive data • place located activity types • general use • digital output • time-efficient data collection
Disadvantages • psychological barriers limit the willingness to participate • short-term data collection –> not general use • little information about the activity types • no information on the reason of choices • knowledge demanding data processing	**Disadvantages** • little/missing gender information • no information on activity levels

Combining the GPS/heart rate data with the *children's habitat maps* had certain advantages. It was not possible to obtain activity-type information from the GPS/heart rate study; instead, this was provided by the *children's habitat maps*. The strength of combining these methods was that similar information was collected in different ways; thus, it was possible to test the credibility of the information. For this purpose, the GPS and child track registrations were overlaid.

Guba emphasised above all the discussion of results with the participants to ensure credibility: "demonstrate the credibility of the findings by having them approved by the constructors of multiple realities being studied" (Lincoln and Guba, 1985:296). One main shortcoming of the Adolescents' Landscape project was that due to the participants' strict time schedule, it was not possible to discuss the results. Despite the methodological triangulation, this greatly weakens the credibility of the results.

Transferability

It is not possible to assess transferability, but it is possible to provide a basis for judgement of transferability. This basis is given by "thick description", i.e. sufficient information about the study.

In my study I defined the purpose of the Adolescents' Landscape project. I gave a thorough description of the context of the study, presented the data collection methods, introduced the data and the analytical methods and discussed the outcomes. This is the "thick description" of the study that is the basis for transferability.

Dependability and confirmability

Triangulation (overlap methods) is a technique that ensures both credibility and dependability. I presented the methodological triangulation in the Adolescents' Landscape project as a part of the credibility assessment. Parallel analysis of the same datasets by separate groups of researchers (stepwise replication) is another technique to establish dependability. This was not possible in the Adolescents' Landscape project.

Guba proposes auditing to ensure both dependability and confirmability. In my study, I tried to secure the conditions for a possible audit, following Yin's suggestion of developing a case study database.

The data collection and processing are documented in detail both for the GPS/heart rate and the children's habitat map studies. The basic layers for the spatial analysis were the official maps provided by the Norwegian mapping authority and the latest municipal plans provided by Fredrikstad municipality. Where required, these were revised and updated based on field observations or newer data sources (orthophoto). All the preparations and analyses were conducted in ArcMap© and the process has been well documented.

6.1.3. Summary: How did the multiple methods approach succeed in describing and analysing adolescents' physical activity in landscapes?

The method evaluation up to this point revealed that:

- Apart from case-specific problems, both the GPS/heart rate and the children's habitat maps methods functioned well in the Adolescents' Landscape project.
- The GPS/heart rate study and the children's habitat maps complemented each other well.
- The landscape characterisation method was suitable for describing variation in the neighbourhoods.
- The space syntax method did not show associations with the PA patterns.
- The combination of GPS/heart rate monitoring, children's habitat maps and landscape characterisation is a suitable method to interpret PA patterns on landscape scale.
- The legal regulations and barriers gave explanatory information for understanding PA behaviour.
- From the analysis methods, investigating the characteristics of activities in each landscape character area types (chapter 4.1.2 PA patterns in landscape character areas) proved to be successful.
- With the developed data processing protocols, the analysis method is time-efficient.
- The method needs further refinement and specification.
- Credibility and dependability of the method was secured by methodological triangulation.
- Thick description provides the basis for judging transferability.

- A case study database was developed to secure dependability and confirmability.

These results focus mainly on the functionality of the methods: whether it was possible to get meaningful results, how the methods functioned in practice and whether the results were trustworthy. This is essentially the answer to the first research question.

However, an important issue has not yet been addressed in this assessment: how adequate was the choice of method(s)? This adequacy or relevance of the single methods relates to assessment of the advantages of the methods in view of other possibilities and discussion of possible reasons for failure (space syntax). The relevance of the complex method answers the question of why it was interesting to introduce a new approach in PA research.

6.2. Discussion

Addressing the relevance of the single methods completes the answer to the first research question (Figure 5). I discuss whether and why the chosen methods were suitable for the purposes of the Adolescents' Landscape project.
For the second research question – how does the landscape approach contribute to PA research? – the results of the Adolescents' Landscape project provided the initial input; it proved possible to interpret the activities on the landscape scale by applying these methods. Discussing the relevance of the landscape approach gives the answer to this second research question.

6.2.1. Relevance of the methods for measuring PA patterns, levels and activity types

In the Adolescents' Landscape project is was important to collect both objective and subjective PA data to define patterns and levels of PA.

GPS/heart rate monitoring

For objective measurements, the most commonly used types of equipment are pedometers, accelerometers and heart rate monitors (Dollman et al., 2009, Warren et al., 2010). All of these instruments are considered to have low technical error (Dollman et al., 2009). Pedometers count steps (km), therefore they are not sensitive to non-locomotive movements. Accelerometers count body movement in real time. This tool is not sensitive to some activities, including biking. Heart rate monitoring measures heart rate in real time. Although heart rate might be affected by other factors (temperature, fitness, emotions), it is suitable for most non-water activities. Therefore it was the best option for the Adolescents' Landscape project.

The combination of heart rate monitoring and GPS provided spatially located PA patterns with recorded intensity level. At the time of the study, this was a promising new approach to PA research (Duncan et al., 2009, Fjørtoft et al., 2010, Maddison and Mhurchu, 2009).

Children's habitat maps

In PA research, self-reported information is often collected by questionnaires, mail/telephone surveys, interviews, diaries or direct observation. Methods are often age group-specific (Dollman et al., 2009). Several different data collection methods exist for expressing children's experience of place, including interviews, drawings, walking interviews and photography, all of which have certain advantages and disadvantages (Cele, 2006).

As Mäkinen and Tyrväinen concluded (2008), and Høibraaten (2008) also found in her related master study, mapping together with explanatory data gives a much better understanding of outdoor area use than these methods separately. For the Adolescents' Landscape study it was important to get spatially located information, but due to language difficulties[10] the verbal methods were restricted. Although the children's habitat maps method provided descriptive information, walking interviews would have been useful additional data sources. Personal conversations and information on socio-economic status aggregated on a group level would have given more detailed background explanations of motivation and activity patterns.

Despite the case-specific difficulties related to this mapping tool (Aradi, 2010) it was an efficient way to gather data on landscape perception. Similar mapping tools have previously been successfully used to identify affordances on the neighbourhood level for children/adolescents (Kytta, 2012, Kyttä et al., 2012, Mäkinen and Tyrväinen, 2008). It has been proven already that this kind of digital mapping tool has great potential for use in practical participative planning, as well as for research purposes in different age groups (Berglund and Nordin, 2007, Kahila and Kyttä, 2009).

[10] I am not a native speaker and my Norwegian is not good enough for deep discussions.

Similar methods were developed in Sweden (Berglund and Nordin, 2007) and Finland (SoftGIS 2010), for similar purposes: to include children's (people's) knowledge in urban planning (Berglund, 2008, Berglund and Nordin, 2007, Berglund et al., 2006) and, in the case of the Finnish method, also in research (Rantanen and Kahila, 2009). The Swedish tool *Barnkartor i GIS* is a digital tool that was designed exclusively for children above the age of 10 years. The Finnish method, *SoftGISChildren*, is an online digital tool that was designed for children between 9–15 years. The Norwegian child track was developed originally for younger children, but despite complaints about the name of the program, this caused no difficulties in the data collection.

With the aim of stimulating the children to think about the outdoor environment, the Swedish method uses mental mapping as a preparatory exercise for the GIS mapping (Berglund and Nordin, 2010). Unlike the *children's habitat maps*, these mental maps are not used later as part of the method of analysis. Depending on the aim of the registration, both methods can be useful. Although the outcomes are different, it might be important if the end user wants to use these maps. Working with cartographic maps and outdoor walking tours, the maps give an overview of general use. The cognitive maps are self-drawn and prepared indoors. Thus, these show the most significant elements of the neighbourhood environment that help orientation, but provide no systematic information about the routes and areas used. With mental mapping, it would have been possible to gather more qualitative information on how the children orient themselves and experience the landscape, but in the Adolescents' Landscape project the aim of the adaptation of digital child tracking was to get information about general use, and working with cartographic maps in preparation was more suitable for this purpose.

Concerning the basis of digital mapping, in *SoftGISChildren* 1:4000 aerial photographs are used with street names and highlighted orientation points. In *Barnkartor i GIS* the children use digital maps of various scales (1:4000–1:10000 is recommended). Finnish experiences show that the address maps are easier to use for the participants than the aerial photographs are (Kahila and Kyttä, 2009), but in our case the participants' preference varied between the aerial photographs and cartographic maps. It seems to be a good solution to leave this choice to them.

Another important difference in the registration is gender information. Research results show a significant gender difference in physical activity from very early childhood (Anderssen et al., 2008), and Finnish experiences from research projects also confirm that girls' needs in relation to the outdoor environment differ from boys' (Horelli, 1997, Kytta et al., 2004); therefore it is very important to explore gender differences in outdoor area use in order to provide equal opportunities for boys and girls. Both the Swedish and Finnish digital mapping tools ask for gender information, and in the old guidelines of the Norwegian child track it was also suggested to register gender differences in area use (Almhjell and Ridderstrøm, 2003), but it was not included in the online mapping program. All in all, the Norwegian child track proved to be a successful data-collection choice.[11] By extending the basis method in the Adolescents' Landscape project, it was possible to mitigate the shortcomings (lack of gender information, limited descriptive data).

6.2.2. Relevance of the methods for spatial analysis

The methods used for analysing the landscape (both landscape characterisation and space syntax) are also used in municipal planning.

Landscape characterisation was a good basis for interpreting the PA data. The choice of themes to include depends on the expert: "in the selection of the generic characteristics of landscape the geographer is guided by his own judgement that they are characteristic, that is, repeating; that they are arranged into a pattern, or have structural quality…" (Sauer, 1969:323). The most emphasised environmental factors that encourage PA are residential density (the first of the "3Ds") and land-use mix (diversity: the second "D"), assuming that increased density and easily available destinations reduce car dependency and facilitate active transport: "Healthy community design emphasizes two key factors at a higher level in the built environment ecosystem: density and mixed-use development" (Moore and Cosco, 2010:36). However, Cavill et al. (2006) argue against this on a general (not cohort-specific) level.

Landscape character area type in the Adolescents' Landscape study aggregated the plot structure and housing typology; thus it facilitates reflection on housing density. It also included road/traffic characteristics and vegetation typology. Diversity is presented by the variation of landscape character area types. Connecting functions (i.e. possible destinations, recreational/PA facilities) to the area types through legal regulations brought the third "D" (design) to the characteristic. However, in order to compare the results from the Adolescents' Landscape study easily with others' findings, a detailed description of the landscape character area types would be necessary. This description should involve how the commonly used physical environment characteristics (e.g. density, land-use mix,

[11] Further details about the child track method have been presented and discussed previously: see Aradi, R. 2010. Kartlegging av barns bruk av plass. Erfaringer fra Fredrikstad, Norge. Kart og Plan, 70, 295-310.

street connectivity, intersection density and accessibility of destinations) are present in the landscape character area types.
The single themes included in the Adolescents' Landscape study did not show any specific pattern in relation to group-level activities, but the compound characteristics, i.e. the landscape character types, proved to be meaningful. Nevertheless, individual analysis of the movement patterns might have given a better understanding of whether and how single themes influence the movement patterns.
There is a potential to extend the method. The possibilities of landscape characterisation are not limited to physical environmental themes. It would be possible to incorporate neighbourhood-level social characteristics in the analysis to get a more detailed picture.

Space syntax seemed to be a promising method for testing. The basic hypothesis of space syntax is that human spatial orientation in an urban environment is determined by the visual properties of the environment. Gibson's ecological approach to visual perception (1986) connects this method to affordance theory (Turner and Penn, 2002). Being related to the affordance concept, the method seemed to fit theoretically to the Adolescents' Landscape project.
Furthermore, Cutumisu and Spence (2009) suggested using it in children's PA research, and Harder et al. (2012) found some correlation between the space syntax integration measure and adolescents' actual movement patterns (measured with GPS) in Aalborg. The overemphasis of active transport behaviour in PA research increased my interest in testing this method. However, I found no connections between the activity patterns and the chosen neighbourhood space syntax characteristics.

The lack of association between the tested space syntax measures and the actual use in the Adolescents' Landscape project might have both theoretical and practical explanations. Theoretically, two main questions are raised: (1) the adolescents' motivation to use the neighbourhood; (2) how this might relate to the space syntax method. Deep analysis would require separate research; here I outline only the major doubts derived from experience with the method in the Adolescents' Landscape project.
(1) Adolescents' main motivation for outdoor activities is socialising (Clark and Uzzell, 2002, Travlou, 2007, Ward Thompson, 2007), and this also seemed to be true in the Adolescents' Landscape project (Høibraaten, 2008). Lieberg (1995) defined two purposes of social interaction: (first) to withdraw from and (second) to encounter the adult world

(in city centres). These purposes demand different environmental characteristics, which in the first case most likely do not follow adults' choices. Another influential factor for selecting locations could be if the adolescents are not welcome in public spaces (Lieberg, 2006; Malone and Hasluck, 1998), which might also result in unexpected patterns.

(2) Preferences change with age. There is well-founded evidence that different age groups use the neighbourhood in different ways. Therefore general, population-level movement patterns might not be valid for specific subgroups. If only the two categories of *to-movement* and *through-movement* (Hillier and Iida, 2005) are used for classifying human movement patterns, this means a focus on destination-oriented movements. Some of the places for socialising might be captured with this analysis, but when looking for places without adult supervision, some of the adolescents' destinations might differ from adults' and not follow the "social logic of space" in every case (Hillier and Hanson, 1984). In addition, being neither *to-* nor *through-movement*, walking/biking for purely recreational purposes cannot be explored with this method.

One practical reason for the lack of association could be that space syntax is used mostly in denser urban areas. Although the neighbourhoods in the Adolescents' Landscape project were urban areas, they are urban in a Norwegian context. A possible explanation might be a lack of core areas in Begby. As Hillier et al. (1987) wrote: "suburban areas, which lack … core structures, have their movement patterns dominated more by the attraction of key spaces within the system" (ibid:243). The Gudeberg area, on the contrary, has a "core structure" and the road configuration is mostly a grid. Based on space syntax studies these road type has higher local integration values, that assumes more activities. I did not find specific space syntax characteristics for the activities in the neighbourhoods.

Suggestions have been raised regarding how to adapt the space syntax method to suburban areas, which would describe better our case areas, and also predict inhabitants' use (Hillier et al., 1987), but even taking into account these proposals I got no significant results. It might be that the place syntax method, which was developed by Stahle (2008) based on the space syntax, would have given a better understanding of the activity patterns. Stahle found "that neither conventional axial line analysis nor walkability attraction-accessibility based on Euclidean straight-line or network distance captures the distribution of pedestrian movements in post-war modernist suburbs" (Stahle, 2008:83-84). In the place syntax method axial lines were integrated in the attraction–accessibility analysis, and this method was found to be a more precise predictor of pedestrian movements in uneven urban areas than space syntax was.

Another explanation for the lack of association could be the limited number of participants in the Adolescents' Landscape research project. The measures might work on a population level but not for smaller groups.

More studies would be required if seeking to explore whether and how space syntax analysis can be used to predict the PA patterns of adolescents. Further investigations might provide a better understanding of the activities and space syntax characteristics – namely, a combined analysis of the space syntax measures including other factors (e.g. population density).

6.2.3. Relevance of the landscape approach

Neighbourhood is the territory for everyday activities. "Landscapes and places are the contexts of daily life…" (Relph, 1989:149). Planning also happens on the landscape scale. Using the landscape approach, it was possible to give an overall, detailed picture of this arena.

The literature overview showed many different combinations of environmental variables in the research practice. This points to the need to find a more complex approach to characterise the physical environment. However, landscape assessment does not provide automatic answers. The attribute-oriented approach also exists in landscape analysis and has – in some cases – been sharply criticised: "like judging wines by measuring their alcohol content… the information obtained may be accurate but it seriously misinterprets the subject matter" (ibid:149). Beside the practical need for a better way of describing the environment, the attribute approach is also questioned from a theoretical point of view. Gibson argued that the "invariant combination of properties is 'meaningful' whereas any single property is not" (Gibson, 1977:68) when opposing the perception of isolated properties with the perception of affordances. Barker, discussing the relevance of behaviour settings, wrote that the "structure cannot be discovered by observing a single part…" (Barker, 1968:9). In the Adolescents' Landscape project, the landscape character area type is this *combination of properties* or *structure*.

With the selected measurable attributes in the Adolescents' Landscape project, the variation in landscape can be described. This is an expert's interpretation, but "the line between 'expert' landscape evaluation and public appraisal is usually clear and distinct" (Lowenthal, 1978:389). What makes it the inhabitants' landscape is their perception.

The combined objective-subjective characterisation of the environment is a focus of PA research. Arguing in favour of objective characteristics (by using GIS), Davison and Lawson (2006) also point out that perception might have a stronger influence on behaviour than objectively measured environmental variables. Ding et al. (2011) in their review suggest that "[f]uture studies should include both objective and perceived measures in one study" (Ding et al., 2011:451). In the Adolescents' Landscape project, through combining PA and landscape, both the objective and perceived landscapes were involved and synthesised.

This comprehensive landscape approach has made it possible to study complex phenomena of urban landscapes in relation to patterns of activity. The findings from the application of the method were presented (chapter 4.1.5) and discussed in the context of relevant literature (Aradi et al., in review).

The landscape approach went beyond the attributed–oriented level. It united the single properties and presented this combination in the form of landscape character area types. Both the GPS/heart rate monitoring and the children's habitat maps provided spatially located activity information and made it possible to explore activity routes and places. These methods identified the actual use, and landscape characterisation revealed the spatial context of these activities.

With the analysis methods used in the Adolescents' Landscape project it was possible to bring the landscape perspective into PA research that embraced many related research areas of active living. However, we have to keep in mind that "there are always multiple perspectives; that no one perspective can "tell the full story"; and that all perspectives aggregated do not necessarily sum to the whole of the phenomenon" (Lincoln and Guba, 1985:119)

6.1. Limitations

My study is an assessment of analysis methods. The main limitation to this process is that – except for practical applicability issues – it was post-evaluation. As Lincoln and Guba suggested, the quality, i.e. trustworthiness, of a study "is tested by four naturalistic analogues to the conventional criteria of internal and external validity, reliability, and objectivity, which are termed 'credibility,' 'transferability,' 'dependability,' and 'confirmability,' respectively. This testing begins early in the study and continues throughout, culminating in a final critical review by a panel of local respondents" (Lincoln and Guba, 1985:189). This limitation resulted in the main shortcoming of the method: questionable credibility.

Another limitation of the evaluation process is that dependability and confirmability is not evaluated, only the possibility is provided for the assessment: the "thick description". An independent audit would be required to assess these criteria.

6.2. Conclusion and suggestions for further research and improvement

The landscape approach seems to be relevant in PA research. The method developed in the Adolescents' Landscape project, i.e. the combination of GPS/heart rate monitoring, self-reported activities by mapping/survey and landscape characterisation, is suitable to interpret adolescents' PA behaviour in landscape scale. These single methods functioned well in the Adolescents' Landscape project and were relevant choices for the purpose. However, the method needs further development and refinement to improve its practical applicability, dependability and confirmability. In future applications, credibility issues must be given greater emphasis from the beginning of the project.

Suggestions for further research and improvement

1. Detailed description of the landscape character areas, focusing on the most used urban factors in PA research. This would make it easier to compare results with other findings from the PA research field.
2. Further simplification of the character area types, based on their meanings for PA behaviour.
3. Further testing of the method is necessary to establish credibility of the results.
4. Detailed environmental information is available for deeper analysis of the preferred areas.
5. One aim at the beginning of the Adolescents' Landscape project was to explore the dynamic movement in the landscape. This was not possible with this method; it remains an open subject for further research.

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8. Appendix

8.1. Paper 1

Kartlegging av barns bruk av plass. Erfaringer fra Fredrikstad, Norge

Mapping of children's use of space. Experiences from Fredrikstad, Norway

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Abstract

«Barnetråkk» (children's tracks) is a participative planning tool with a long, successful history that aims at involving children in spatial planning processes. This method was adapted in a research project that studies the influence of the landscape context on the physical activity of adolescents. The experiences with «digital barnetråkk» aroused curiosity about the method.

«Barnetråkk» is introduced through the historical background. Afterwards, the adaptation to the research project and experiences are described; the working process and main results.

«Digital barnetråkk» raised other questions than the manual version. The discussion concentrates on the feasibility and possible improvements of the method both for practice and research.

«Digital barnetråkk» is a promising method that can be used for different purposes. However, with some improvements, it would be more efficient and easier to apply.

Keywords: barnetråkk, children's tracks, research method, adolescents

Introduction

This article was inspired by experiences gained in a research project which had the overall aim to study the influence of the landscape context on the physical activity of adolescents. Within the project, «barnetråkk»[12] was primarily used for data collection. «Barnetråkk» was developed as a participative planning tool to involve children in physical planning. The difficulties that emerged while working, aroused curiosity to learn more about the operation and history behind the development of «barnetråkk».

The main aim of the research project in which the digital version of «barnetråkk» was used is to increase our understanding of the environmental influences on the adolescents' use of the outdoor environment and the gender differences in it. The research design is based on case study methodology at landscape/ neighbourhood level. Since the research project focuses on how the landscape influences physical activity, the case areas were selected in different landscapes. Two schools and their neighbourhoods were chosen from the city of Fredrikstad. The city is located in southern Norway, divided into western and eastern parts by the Glomma river. Altogether, it has approximately 72 000 inhabitants. The settlement structure is dispersed, as it consists of several neighbourhoods. The selected schools are located in two different neighbourhood areas in the eastern part. One of them is in a hilly landscape; the other in a more open, flat area. From the schools, the 9th–10th grade classes (14 years old pupils) were invited to participate in the project, 121 children altogether. The participants' homes were not registered in the project, but most of them live in neighbourhoods close to the schools, only some of them live in other parts of the city.

In our case, the digital version of «barnetråkk»[13] was adapted and used as a data collection method, and hence we gained experiences about the operation of the tool, but not about the use in planning. Therefore, this article focuses on performing «digital barnetråkk » in a research project instead of analysing it for planning purposes. The aim of this paper is:

- to communicate the experiences with «digital barnetråkk» as a tool for increasing the understanding of adolescents' use of public space
- to outline how «digital barnetråkk» could be improved based on the experiences from our research project and similar projects in Sweden and Finland

«Barnetråkk» was the paper based predecessor of «digital barnetråkk». It was a pioneering project, initiated by Eva Almhjell and developed with her guidance from the

[12] In English: Children's tracks. In this article I use the Norwegian name.
[13] Afterwards «barnetråkk» refers to the manual method and «digital barnetråkk» to the digital version.-

late 1970's (Almhjell & Ridderstrøm 2003). The method is based on cooperation, and use children's own knowledge as a source to map the areas that have value from their point of view. Now it has more than three decades of tradition in the spatial planning system of several municipalities in Norway (Kommunenes Sentraforbund Vestfold, Statens Utdanningskontor Vestfold & Vestfold fulkeskommune 2000). The first digital version came out in 2006, when the technical development had become sufficient to allow for its introduction.

«Digital barnetråkk» is a powerful tool for involving children in spatial planning, but its existence in itself is not enough; the implementation process determines the expediency. Besides the early technical difficulties, some of the most sensitive elements of the digital method are very similar to the paper (Haukelien & Holsen 2004); i.e. the organization of the workflow and cooperation between the participants are crucial in the procedure. Through the historical review in this article, we give insights into the background, development and expansion of «barnetråkk». The case description positions the tool within the research project, introduces how «digital barnetråkk» was customized to the research project and how it contributed to the development of «children's habitat maps», and presents the process and outcomes. In the last part, the results and experiences from the use of the tool will be discussed from a research point of view in the light of international examples.

Mapping children's use of space. The Norwegian context.

The sociologist Eva Almhjell was the first to initiate the concept of «barnetråkk», and under her leadership a group of skilled professionals developed a method for mapping the children's neighbourhood area use. «Barnetråkk » was elaborated during the 1980s and 1990s in Vestfold county, Norway (Almhjell & Ridderstrøm 2003). The method addressed primarily the age group form 10–12 years (Vestfold County Council 2002). It was developed through action research and approved by the Norwegian Data Inspectorate[14]. The basic idea of «barnetråkk» was drawn from work on animal tracks (Haukelien & Holsen 2004). At that time tracking animals' movements had already been a well known concept for the assessment of natural values and biodiversity. When «barnetråkk» was introduced, nature protection had a strong influence on planning, while children's interest did not appear (Almhjell 2010a).

[14] Datatilsynet

The four main principles of «barnetråkk» were: democracy, culture, health and contribution to sustainability (Almhjell 2009). The forerunner of the development was the extensive research on the children's urban environment that in Norway started in the early 1970's (Hammarqvist & Stenbråten 2009). In parallel with the urbanisation process, the number of cars also increased; traffic took over public spaces. There were little space left for playgrounds and the quality of these in general was quite poor. In the urban renewal processes, several researchers took part from different fields, aimed at improving the urban environment. Both the building and traffic safety policy concentrated on children's residential and neighbourhood environment. In the late 70s it became clear that the accumulated knowledge was not enough to change the policy and planning practice, therefore the focus of researchers moved to the children's role in physical planning processes.

«Barnetråkk» was also inspired by the UN International Year of the Child in 1979. This event intended to draw attention to the problems children face all around the world. Most of the results of the work performed during that year were included in the UNICEF Convention on the Rights of the Child (United Nations 1989).

The Norwegian legal system was ahead of the international process, with children's right taken into account already in the early 80's (Hammarqvist & Stenbråten 2009). The innovative technique of «barnetråkk» contributed in the Norwegian «National Policy Guidelines for the Interests of Children and Young People in Planning»[15] that was put into force in 1989.

In the legal system, the Planning and Building Act (Plan- og bygningslov 1985) provides the legal basis for children's participation in spatial planning; in which the children's right is significantly present in accordance with the UN Convention. In the previous version of the Planning and Building Act, a children's representative function was established at municipality level. Amongst other tasks, his/her responsibility was to communicate children's interest in planning and make sure that consequence analyses of children in connection with development plans was made by the responsible planners. In the new law, the children's representative is not named, but the municipalities have to find a solution in order to represent children's interest in planning.

So as to help planners in the implementation, the Children and Planning guideline was elaborated (Miljøverndepartement 2008). This guideline has no formal status; therefore

[15] Rikspolitiske retningslinjer for å ivareta barn og unges interesser i planleggingen

the solution of children's participation in planning process at local level is the responsibility of the planning authorities.

By 2010, planning with children's active participation become a daily planning routine in the land use planning of several municipalities in Vestfold county and Norway (Almhjell 1998; Almhjell 2010a); it was used by Statens vegvesen[16] (Statens vegvesen Vestfold 1999; Statens vegvesen Vestfold 2000), become a part of the impact assessment process (Statens Vegvesen 2006) and has been adapted as a planning tool in the entire Nordic region (Almhjell 2010a).

It has become a working tool also in the European policy to make children's voice heard and in the EU «the Vestfold method» is used as a good example of involving children in the democratic decision making process (Almhjell 2010a). Also the WHO informs about the Children's track on its website (World Health Organization 2004) and the method is known in Canada (Almhjell 2009).

Mapping children's use of space. The method.

The main motivation behind «barnetråkk» was to transform the object oriented perspective on children in planning into an active participation, where children's knowledge are valued and their interests are drawn into the planning process (Almhjell 2010a). This approach is parallel with the changes of view on the children's representation in society, that started in the 70s (Christensen & Prout 2005). However, in the publications there was no explicit theory associated with «barnetråkk».

The method was elaborated through action research with children's active participation, where the awareness of their own value, knowledge and role in the community was raised. The development was a strategic work on the implementation of children's knowledge in the local, regional and national planning processes. The work included training of the children's representatives, planners, relevant teachers in the primary schools, adults in kindergartens localised within the planning areas and municipality management organizations. The training also contained teaching the special planning jargon to the children and participating teachers in the primary schools and kindergartens, as well as giving the planners an overview and understanding of how to work with children. During the development of «barnetråkk» there was a systematic cooperation with the municipalities and through them with schools and kindergartens (Almhjell 2010a).

[16] Norwegian Public Roads Administration

The main outputs of «barnetråkk» registration are paper maps with associated descriptive information. The children register the area that they use in their free time on 1:5000 scale maps (this can be customized to meet the demand) or ortophotos. The participants use transparent markers and predefined legend to draw the areas. A distinction between summer, winter and all year around use of the areas is made. Additionally, the children also sketch the routes they use, differentiating them into secure and unsecure parts, and on a form describe the characteristics of the registered places: who uses them (gender, age groups, many/some/few), when (daytime/ evening), how often (often/rarely), how they go there and the activities they take part in. The guideline (Almhjell & Ridderstrøm 2003) contains questions intended to remind the children about possible activities.
The registration can be included in the regular education, i.e. cartography, history, social or nature sciences. The main steps of the registration are described in a guideline (Almhjell & Ridderstrøm 2003). The process starts with preparation; the working groups are established at the municipality and in the school(s) and the workflow is planned.
The data collection has three main phases: 1) information about the task for all participants, 2) teachers/pre-school teachers register the areas used during school/kindergarten time, 3) children register the same areas (in schools). The teachers' and children's registration are similar. They mark the areas and routes they use on the maps with transparent markers, and fill out forms for each registered area. The children work in groups of max. 8. The groups are set up according to the residential areas. Every group has 2 adult assistants, 1 local teacher and 1 external expert. First, the pupils draw a circle around their homes, afterwards they mark the play areas and routes. Each child should be given the opportunity to mark at least 1 play area. The play areas are consecutively numbered. The group leader (one of the adult assistant) makes sure that a form is filled in for each numbered area in collaboration with the children. (These forms are less detailed than the ones the teachers fill in individually.) The registrations are done at the same time by all the children. The whole mapping exercise takes about two school hours including a short break.
In the next phase, the paper maps are digitalized. This is done by the end-user (e.g. municipalities, Statens vegvesen). To help the municipalities, there is a standard for digitalization (Ridderstrøm 2010). To provide quality assurance of the registration, the digital data have to be controlled by the schools and can be checked by the (student) representative of the student council. For privacy and anonymity reasons, the children's homes that are marked on the paper maps are not put in the digital database. The aim of

marking their homes at the beginning of the paper registration is to help them to orientate on the map.

After putting the data in digital form, the gathered information is presented and a printed map is given for the participants. The digital information can be used in several areas of spatial planning (Norsk Form 2010a). As a last step, a report has to be written about the work with «barnetråkk». This is important feedback on the method and input for its development.

This paper based version was first used in spatial planning in 1993 (Almhjell & Ridderstrøm 2003; Norsk Form 2010a) and tested in several schools and also kindergartens in Vestfold between 1998 and 2003 (Haukelien & Holsen 2004).

In 2006, the conditions were matured for further development and «digital barnetråkk » was evolved by the collaborative work of Norsk Form and Statens kartverk (Norge digitalt ; Norsk Form 2010a; Norsk Form 2010b). At the time, digital tools were widely used also in the planning practise, thus most of the municipalities already had the necessary technical background and experts. Another prerequisite of the digital version was the well organized and accessible digital map database, the Norge digitalt (Norge digitalt 2010). Now «digital barnetråkk» is freely accessible online (KartISkolen 2010) after a username and password from Statens kartverk has been provided in order to complete the registration. The workflow in the digital version (Norsk Form 2010a) is very similar to the manual registration, but there are some differences that influence the output. The preparation phase is organised in a more flexible way, so it is easier to customize to the school schedule. It could be made by walking tours with paper mapping in the neighbourhood area, photo taking and making collages, the pupils can prepare exhibitions, it is also suggested to discuss the theme before the registration in the school or in the groups.

One important difference is that the children themselves register the areas and routes on a computer that has internet access. They also write their comments in a database at the same time. In the digital version, it is suggested to avoid that the children mark their homes, in order to maintain anonymity. Another difference is that the participants work individually or in pairs. In case of need, the adult supervisors help to navigate on the map, choose the proper tools and symbols. The pupils themselves decide whether to use a topographical map or an ortophoto. It is also possible to overlay other thematic layers from the map database. The scale of the map can be dynamically changed. The registration takes about 15–30 minutes for each child. Many children can register at the same time, thus, depending on the available computers and internet bandwidth, in a class with 30 pupils, the registration can be completed within a few hours.

Now, the digital and paper versions of the «barnetråkk» are both used in Norway. The two versions are basically the same, but the slight differences in the process may have influence on the output. An interesting point is that in Vestfold, only the paper version is used (Brekke 2010). One reason is that the digital version is criticized as a democratic tool[17], because the individualisation of the process (Almhjell 2010b). This is an important question considering «digital barnetråkk » as a participative planning tool, but this is outside the scope of this article and will not be discussed further.

The «digital barnetråkk» in the «How the environment affords physical activity in adolescents?» research project.

Children's habitat maps: adaptation of «digital barnetråkk»

The workflow we followed in the research project with «digital barnetråkk» was quite similar to the official version, but our intention with this method in the research project was different from the objectives of the original one, and these differences influenced the implementation and the outputs (Figure 1).

The GPS & heart rate registration together with «digital barnetråkk» and essays provide information on the use of the neighbourhood area, and the data collection method and information sources construct the «children's habitat maps».

As a first step, the adolescent´s movements were tracked by GPS, and simultaneously, the heart rate was monitored for measuring the level of physical activity. Through this method it was possible to get objective information about the physical activity level and the used areas. In this article under «children's habitat maps» only the adapted «digital barnetråkk» and essays will be discussed. Our experiences with the GPS & heart rate monitoring and the data analysis are published in a separate article (Fjørtoft, Löfman & Halvorsen-Thorén 2010).

The time schedule of «children's habitat maps» (Figure 2) and the cooperation with the teachers were strongly influenced by the fact that the pupils were in their 10th school year, they had a lot of compulsory exercises and had to prepare for their final exams.

In those phases that connected directly to «digital barnetråkk» (paper mapping, photo taking, digital mapping) the participation was voluntary and required parental permission. Hence the number of the participants varied.

[17] democracy was one of the main principles for «barnetråkk»

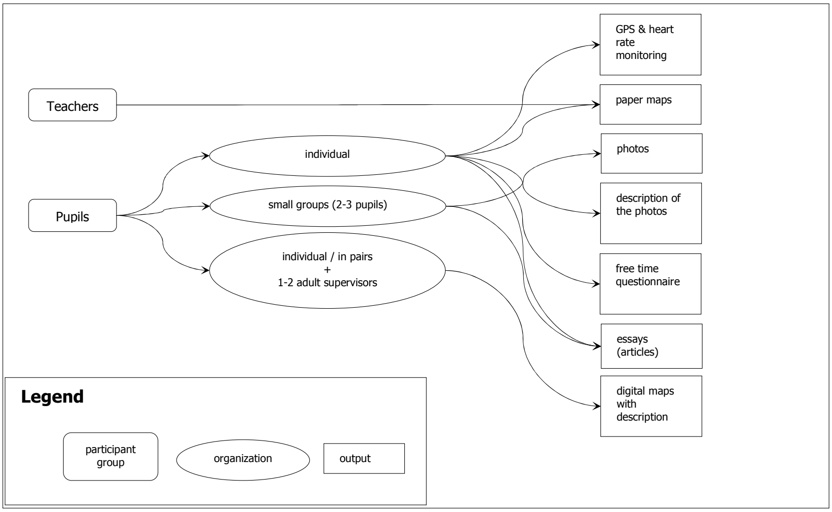


Figure 1: Data collection with «children's habitat maps»

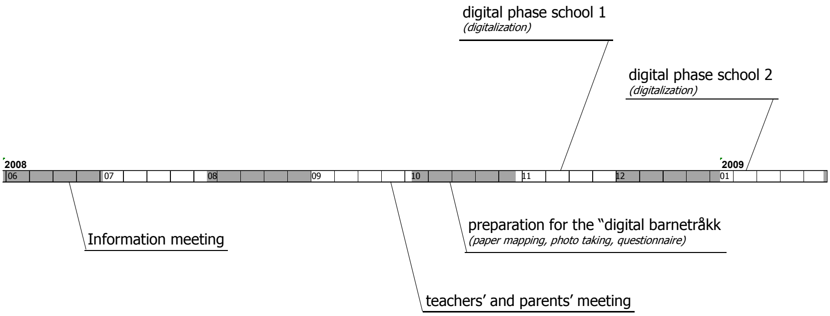


Figure 2: «Children's habitat maps». Data collection time schedule

In the same way as for both «barnetråkk» and «digital barnetråkk», the first step in «children's habitat maps» was the preparation for the registration. The teachers, parents and pupils were informed about the «children's habitat maps» method and the goals of the data collection. They already knew about the research project, because the GPS tracking phase had been finished earlier.

The information was given in a process of multiple stages. Our aim was to integrate the whole process in the curriculum as much as possible, as it is suggested in the guidelines

(Almhjell & Ridderstrøm 2003; Statens kartverk 2010), therefore the discussion with the teachers started before the summer holiday, in June 2008.

For both «barnetråkk» and «digital barnetråkk » the teachers' registration preceded the children's one. During the information procedure, at one of the teachers' meetings, the teachers were asked to register how they use the schoolyard and neighbourhood areas during school days. They used an A3 format ortophoto based map to register the use of the schoolyard and close neighbourhood.

At the beginning of the semester, before we began the data collection from the pupils, the parents were also informed about the project in written form, and they were asked to give permission for their child to participate. In one of the schools, we managed to present the project on a PTA meeting (September 2008) too, but it was not possible to organize this for the other school. In the second school, the detailed information meeting was done only for the teachers.

The data collection from the pupils with «children's habitat maps» started in October 2008. The children did paper mapping as preparation for the digital mapping. In «barnetråkk » this phase contains the registration on paper maps and the work is done in the schools, during school time. In «digital barnetråkk » it is an optional part in the preparation phase. In «children's habitat maps» the paper maps were used as a preparation for the digitalization. The pupils went out in small groups (2–3 children) and walked around the neighbourhood area. In one of the schools, this phase was successfully included in the physical education class, in the other school they did it as part of the homework.

The children took paper maps in a plastic A4 folder with them. They marked the routes, areas and places with predefined legend. They got 2-sided A3 format maps with an overview of the area, a more detailed map of the closer school neighbourhood and in the school located in the north, they received another map of the city centre. An important aspect of the paper mapping phase was that we asked them to mark their gender on the maps.

This mapping tour was combined with photo taking + description and a small questionnaire about the free time use and convenient walking/biking distance.

The photo taking is not part of «barnetråkk », but it was used as a data collection tool in a related research project (Almhjell 2002), and it is an optional preparation for «digital barnetråkk». In «children's habitat maps» it was a complementary data source which gave the opportunity to see and understand the children's point of view and in addition got their own, more detailed description on the neighbourhood area.

For the photo taking, the instruction was to take photos on those outdoor places that were important to them and describe on a sheet why they took the photo and what was on it. Afterwards, the cameras were collected and digital photos were developed. Each group used one camera, but each pupil prepared the maps and descriptive sheets individually. The pupils got back the photos in digital and paper formats so they could use them for the essays in the next stage.

To get a more complete view on the pupils' outdoor time use, it was important to get information on how much free time they had, and how much scheduled indoor activities they had in their free time. Therefore we included a small questionnaire at the end of the photo sheet.

The questionnaire covered the use of free time, including indoor and outdoor activities, the means of transportation and social factors. We also asked them about their favourite places and the furthest and longest walking and biking distance.

So as to get in-depth descriptive information on the neighbourhood area use, the pupils were asked to write articles. This exercise was also an extra task compared to «barnetråkk » and «digital barnetråkk».

It was executed as a part of the Norwegian education. The teachers customized this task to their teaching goals[18] (Utdanningsdirektoratet 2009); therefore the articles varied in form and topic.

In one school, the pupils wrote articles in groups and the exercise was not evaluated. The topic in most cases was the neighbourhood, but some of the articles were about their experience with the research project. In the other school the pupils individually wrote essays about their neighbourhood.

The digital mapping was the last phase of the «children's habitat maps» data collection. During this exercise we used the official digital mapping tool of «digital barnetråkk». The digital database contains generalized information; it is not possible to distinguish the individual registrations.

In one of the schools, we managed to finish this phase in November 2008, but in the other school it was feasible only in January 2009. The digital phase is also possible to include in teaching, but in the research project we didn't succeeded with this. The schools

[18] *«Competence aims after Year 10. Written texts: The aims for the education are that the pupil shall be able to read and write texts in various genres … such as articles, discussion input, formal letters, short stories, narratives, poems, drama texts and informal talks…»*

provided the computers for the registration, but we had to «borrow» the pupils from the official classes until they digitalized their registration. The online registration was guided only by experts from the research project. The digitalization was done individually or in pairs. It took in total 2 days in each school.

Results from Fredrikstad

The focus of this article is the process of the «children's habitat maps». Thus, in this section, besides the paper maps, photos, essays and digital maps, the experiences with the completion are also considered as results.

The outcomes of the preparation phase were paper maps and photos with descriptions. The paper maps give similar information as the digital maps, i.e. used routes, areas, places, but without descriptive information. In our case it was important that the children marked their gender on the paper maps, because one objective of the research project is to disclose gender differences in the outdoor area use. (It was not possible to get gender information in the digital phase.) Altogether we got 56 paper maps.

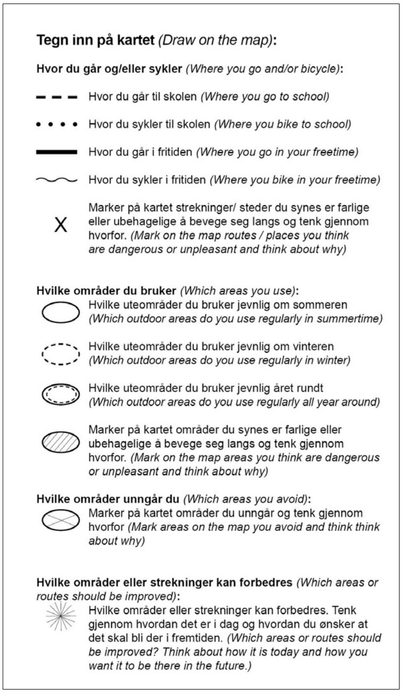


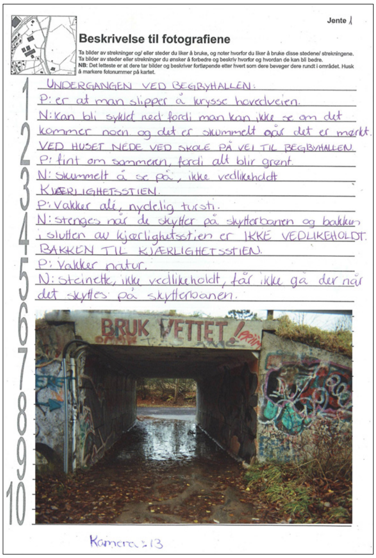
Figure 3: Preparation phase – paper maps, legend

Regarding the technical implementation, the A3 format for the maps we used was selected from practical reasons. The pupils had to go out and use the maps while walking, therefore too big or too many maps would have been unusable. The selected scale was the largest that was possible so as to include the neighbourhood area in this frame. We supposed that instead of colour schemes a monochrome legend (Figure 3) that was possible to draw with one pencil would be more convenient during a walking tour, but the pupils in some case customized the predefined legend and used colour pencils.

These maps proved to be very important when the data analysis started, partly because of the deficiencies of the other data collection parts. The children drew the routes more accurate and the gender information was also essential.

The photo taking and photo sheets with

description were successful in terms of getting an insight into how the pupils see their surroundings and also more detailed descriptive information. The children also marked their gender on the sheets. Technically, the disposable cameras caused problems for some pupils, and the photos were unusable. Fortunately, the related descriptions gave enough information on the locations in most cases. We collected 502 photos from 38 groups and 49 descriptive sheets from individual pupils (Figure 4).


Jente 1

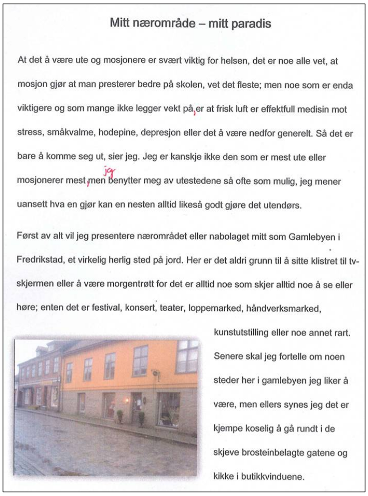
Beskrivelse til fotografiene

Ta bilder av strekninger og/ eller steder du liker å bruke, og noter hvorfor du liker å bruke disse stedene/ strekningene.
Ta bilder av steder eller strekninger du ønsker å forbedre og beskriv hvorfor og hvordan de kan bli bedre.
NB: Det letteste er at dere tar bilder og beskriver fortløpende etter hvert som dere beveger dere rundt i området. Husk å markere fotonummer på kartet.

UNDERGANGEN VED BEGBYHALLEN:
P: er at man slipper å krysse hovedveien.
N: Kan bli syklet ned fordi man kan ikke se om det kommer noen og det er skummelt når det er mørkt.
VED HUSET NEDE VED SKOLE PÅ VEI TIL BEGBYHALLEN.
P: fint om sommeren, fordi alt blir grønt.
N: Skummelt å se på, ikke vedlikeholdt
KJÆRLIGHETSSTIEN.
P: Vakker alé, nydelig tursti.
N: stenges når de skyter på skytterbanen og bakken i slutten av kjærlighetsstien er IKKE VEDLIKEHOLDT.
BAKKEN TIL KJÆRLIGHETSSTIEN.
P: Vakker natur.
N: steinete, ikke vedlikeholdt, får ikke gå der når det skytes på skytterbanen.

Kamera 13

Figure 4: Preparation phase – photos & photo sheets


Mitt nærområde – mitt paradis

At det å være ute og mosjonere er svært viktig for helsen, det er noe alle vet, at mosjon gjør at man presterer bedre på skolen, vet det fleste; men noe som er enda viktigere og som mange ikke legger vekt på, er at frisk luft er effektfull medisin mot stress, småkvalme, hodepine, depresjon eller det å være nedfor generelt. Så det er bare å komme seg ut, sier jeg. Jeg er kanskje ikke den som er mest ute eller mosjonerer mest, men jeg benytter meg av utestedene så ofte som mulig, jeg mener uansett hva en gjør kan en nesten alltid likeså godt gjøre det utendørs.

Først av alt vil jeg presentere nærområdet eller nabolaget mitt som Gamlebyen i Fredrikstad, et virkelig herlig sted på jord. Her er det aldri grunn til å sitte klistret til tv-skjermen eller å være morgentrøtt for det er alltid noe som skjer alltid noe å se eller høre; enten det er festival, konsert, teater, loppemarked, håndverksmarked, kunstutstilling eller noe annet rart. Senere skal jeg fortelle om noen steder her i gamlebyen jeg liker å være, men ellers synes jeg det er kjempe koselig å gå rundt i de skjeve brosteinbelagte gatene og kikke i butikkvinduene.

Figure 5: Articles

Concerning the process, including the preparation phase in the physical education lesson was a good idea on the one hand, because it was not an extra task, but on the other hand there was not enough time to go far away, and the photos were taken mainly of the school's neighbourhood. Besides, on the chosen day, the weather was rainy, which also influenced the scope of the explored area. Giving this task as homework without control resulted in the pupils considering it as extra work, and they didn't give an effort to fulfil it exhaustively.

The articles (Figure 5) which were written in the next step are great resources for qualitative analysis. It was the easiest to include this in the schools' curricular activities, but the task was defined in a very different way in the two schools, thus a comparison is difficult. The teachers adapted the exercise to their teaching objectives and schedule; therefore the essays we got from the two schools varied in topic. An influential factor was that the task was communicated in different ways in the schools. In one case the pupils' attention was directed more to environmental problems (i.e. pollution, graffiti, litter) that also might have lead to deviation. The result was affected also by the fact that in one of the schools, this exercise was evaluated, in the other one it was not. Generally, the articles give a good insight about the likes/dislikes, everyday use of and

attachment to the city. We also got some reflection on how they felt about participating in the research project. Altogether 44 articles (34 individual + 10 group work) were written. The digital mapping was challenging to organize. «Borrowing» the pupils from the official classes was stressful both for them and for us. The children's computer skills varied greatly, but on average they had few problems with the digitalization, however in some case it took more time than we estimated. In the schools, we used the new version of the «digital barnetråkk» online mapping tool for the first time, therefore we met some technical problems, but most of these were solved, some of them already during the registration thanks to the online support from Statens kartverk.
The drawn routes are stored in line feature layer, the areas as polygons, the places as points (Figure 6). The connected databases contain the descriptive information for every single digitalized object. Regarding the areas in our case, the children registered these very generously. To avoid many overlapping objects on the same area (because the previous registrations were seen), if an area had been already registered, we asked them to add their information to the existing one. This proved to be difficult when giving the users' number of an area. It was not clear whether they had to estimate the number of users or just increase the number.

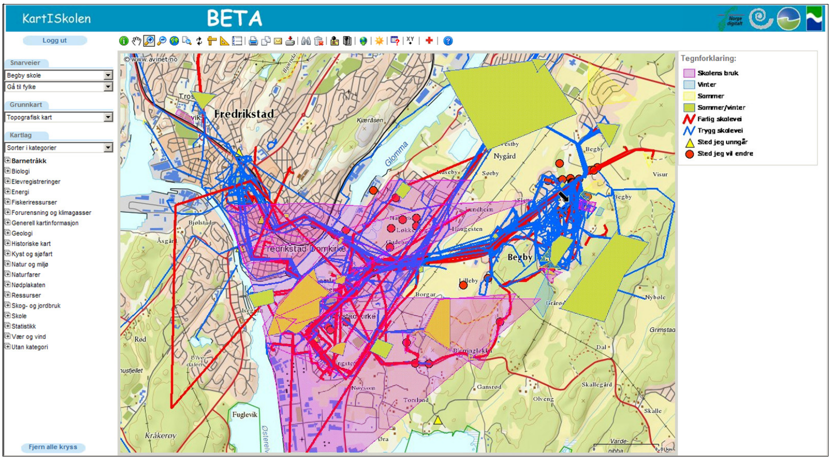


Figure 6: Digital maps

Altogether 88 pupils (48 girls and 40 boys) completed the digital mapping.
The digital registration is an individual work or, according to the guideline, it could be done in pairs. Using group work as a preparation, it was possible to include the

stimulating effect of the group discussion (Almhjell 2010a; Norsk Form 2010a) that was very important to get the most exhaustive result.

As the guidelines emphasize, our experience also proves that the local expert presence would have been very important, especially when the pupils had problems with finding the places they wanted to register.

Discussion

The Norwegian «barnetråkk» was pioneering in the involvement of children into planning processes. Nowadays, similar digital methods exist in Sweden and Finland (Table 1), developed for similar purposes: to involve children's (people's) knowledge in urban planning (Berglund 2008; Berglund & Nordin 2007b; Berglund, Nordin & Eriksson 2006) and in case of the Finnish method also in research (Rantanen & Kahila 2009).

Table 1: Similar methods in the Nordic region

	"digital barnetråkk" (Norway)	**"Barnkartor I GIS"** (Sweden)	**"SoftGISchildren"** (Finland)
online accessibility	online	local PC with internet connection	online
teachers' mapping of school time area use	x	x	not known
preparation	paper mapping / photo taking	mental mapping (optional: guided tours/group interviews, diaries)	not known
mapped themes	school way free time routes used areas places	school way free time routes used areas places	social characteristic[a] activities feelings free time
registered features	line area point	line area point	line point

[a] One main difference comparing with the Norwegian and Swedish method is that the Finnish one is built around 5 different themes: social characteristic, activities, feelings, free time, and perceived health (OPUS Project) and physical activity related questions (pehmoGIS Helsinki). With registering their feelings children develop an emotional map of the city.

The Swedish tool, «Barnkartor i GIS»[19] has its roots in «barnetråkk» (Berglund 2008; Berglund & Nordin 2010b). It is a digital tool that was designed exclusively for children

[19] In English: Children's Maps in GIS. It was developed within a research project, but was developed for spatial planning and has never been used for research purposes. The first tests with the «Barnkartor i GIS» started in 2003 (Berglund & Nordin 2010b) and it has been used by Täby and Västerås municipalities.

above the age of 10 years. The Finnish method[20], the «SoftGISchildren», is an online digital tool that was designed for children between 9–15 years.

There are some differences in these methods that are interesting to review in light of our experiences with the adaptation of «digital barnetråkk» in the research project. Even if the Swedish and Norwegian methods were not developed for research purposes, the comparison gives important input for the proposed improvements.

Here, the general remarks that are relevant both for «digital barnetråkk» and «children's habitat maps» are related to «digital barnetråkk» and the research specific ones to the «children's habitat maps».

The easiest way to reach as many children as possible is through schools. This method can be criticized, because the teachers' control influences the output, but it roots in the method: if the aim is involving the maximum number of children through the school system, this effect has to be taken into consideration. But without proper preparation «digital barnetråkk» can be considered as extra work on the teachers' as well as on the pupils' side. An important aspect is that if a task is a part of the curriculum and evaluated, the pupils put more effort into it.

So as to show that it is beneficial for the teaching, it is important to involve the teachers much more than we managed in this research project. The conduction of «(digital) barnetråkk» supposes a good cooperation between the schools and the planning unit of the municipality/ researchers. A successful implementation depends very much on personal conditions; engaged project leaders and mediators are crucial to encourage and involve the children.

Both the Norwegian and Swedish guidelines emphasize and contain detailed description about how to develop the cooperation with the schools (Berglund & Nordin 2010b; Statens kartverk 2010). This is very valuable for the persons who coordinate the work with this method. (No such published guideline has been founded for the «SoftGISchildren ».)

Presenting the outcomes for the children in the same semester as when the work was done, is an important part of «barnetråkk» and «digital barnetråkk». Unfortunately, we

[20] The overall method is called SoftGIS. It was elaborated through several joint research projects (Kahila & Kyttä 2009; Kyttä ; Kyttä, Kahila & Broberg 2009) and includes different theme and age specific online mapping tools. Such as the first version, the «SoftGISquality», with which it is possible to map the perceived environmental quality, used local services, perceived health and well-being. Or the «SoftGISsafety» that aims at evaluating the perceived safety, gathers information about the sense of community and everyday infrastructure. The first prototype of the SoftGIS method was tested in 2004 and by 2007 five different type were developed (Kahila & Kyttä 2009). The «SoftGISchildren» was tested in Turku (2008–2009) with 10–15 years old children (Kyttä) and in Helsinki (2009–2010) (Broberg 2009; SoftGIS 2010).

didn't have the opportunity to go back to the schools with the results, which was a major weakness of the project.

Our experience shows that it is not the best choice to do the registration in the 10th grade, because preparing for the exams is stressful for the pupils as well as for the teachers. Thus it is difficult to find the time for extra exercises. This problem resulted partly from the fact that we did not succeed very much in adapting the method as an educational tool. Therefore, some tasks took time from the normal classes others were given as homework.

It is important to point out that this method is not only beneficial from a researcher's/ planner's point of view. The children learn collaboration, democracy and social responsibility through the registration, and they deepen their knowledge of the environment, in addition to the practical knowledge they gain for example in cartography or in digital techniques.

Despite the described instructions for «digital barnetråkk», we found it difficult to figure out how to define the specific parts for different courses. With good examples it might be easier for the teachers to include the method in teaching and thus engage them in the process.

In the available publications, there was no preparation exercise described for «SoftGISchildren » but both the «children's habitat maps» and the «Barnkartor i GIS» had a preexercise before the digital mapping.

The paper mapping proved to be very important in our case. Even though it was conducted without adult supervision, the advantage of this outdoor method is that it helps to recall the memories. In order to understand the perception of the outdoor environment, the field experience seems to be important.

With the aim of stimulating the children to think about the outdoor environment, the Swedish method uses mental mapping as preparatory exercise for the GIS mapping (Berglund & Nordin 2010b). Unlike the «children's habitat maps», these mental maps are not used later as part of the method.

Depending on the aim of the registration, both methods can be useful. Although the outcomes are different, it might be important if the end user wants to use these maps. Working with cartographic maps and outdoor walking tours, the maps give an overview of the general use. The cognitive maps are self drawn, and they are prepared indoors. Thus, these show the most significant elements of the neighbourhood environment that help orientation, but there is no systematic information about the used routes and areas. With this method, it would have been possible to gather more qualitative information on how the children orient themselves and experience the landscape, but our aim with the adaptation of «digital barnetråkk» was to verify the data from the GPS registration. Since that lasted only one day, we needed more accurate data, and working with cartographic maps as preparation was more suitable for this purpose. Considering the digital maps, both methods prepare the children's thoughts for mapping, though it is a question whether, and if yes, how the two methods influence the registration.

Concerning the basis of digital mapping, in SoftGISChildren 1:4000 aerial photographs are used with street names and highlighted orientation points. In «Barnkartor i GIS» the children use digital maps of various scales (1:4000–1:10000 is recommended). Finnish experiences show that the address maps are easier to use for the participants than the aerial photographs (Kahila & Kyttä 2009), but in our case the participants' preference varied between the aerial photographs and cartographic maps, therefore it seems to be a good solution to leave this choice to them. One technical problem that can occur is that the aerial photo slows down the network connection.

Another important difference in the registration is the gender information. Research results show a significant gender difference in physical activity from very early childhood (Anderssen et al. 2008), and Finnish experiences from research projects also confirm that girls' needs towards outdoor environment differ from boys' (Horelli 1997; Kytta, Kaaja & Horelli 2004), therefore it is very important to explore the gender differences in the outdoor area use in order to provide equal opportunities for boys and girls. Both the Swedish and Finnish digital mapping tool ask for gender information, and in the old guideline of «barnetråkk» there was also suggested to register the gender differences in the area use (Almhjell & Ridderstrøm 2003), but it is missing from the new one (Norsk Form 2010a) and it was not included in the online mapping program.

In all the three described methods, it is possible to register routes (as line objects) and places (as points) and exclusively for the Finnish version areas (as polygons). While digitalizing the routes, the drawn lines don't follow the road network automatically (no snapping option), but this was purely a technical problem. For spatial analysis, especially for planning purposes, it is crucial to get the data in a form that doesn't require too much follow up work, otherwise the required extra work diminishes one of the most important advantages of the digital version, namely time saving. Besides, both with handmade and also with automatic justification, the reliability of the database decreases. However, cleaning up the database will be necessary in every case, because sometimes nonsense data are registered (i.e. lines across everything).

The area registration doesn't prove to be very accurate or informative in our case, therefore it is questionable whether it is important to include in the digital version or if it would be enough to register them as point objects and include in the description whether it is a single spot or an area. The problem we experienced, i.e. that it was difficult to use the tool, is not individual. It was also criticized in relation with «Barnkartor i GIS» (Östlund 2009). This strengthens the question whether to keep this tool and improve it or exclude it from the program.

In all versions, the participants give short descriptive information of the registered objects during the digitalization. The inbuilt questionnaire in the Swedish version is very similar to the Norwegian one, the Finnish is more detailed[21]. The comments in «digital barnetråkk» are very short and gave limited insight about the pupils' opinion. For spatial planning purposes – depending on the content – this would be enough, but for this research project it would have been far too little. Therefore, the adaptation of «digital barnetråkk » was necessary. With the article exercise and the photo descriptions, we counterbalanced this deficiency. From these data sources, we are able to derive information similar to the Finish emotional maps, but for planning purposes the direct mapping seems to be more useful (easier to work with) than a written document.

Unlike the Swedish and Finish version, in «digital barnetråkk», the children don't mark their homes because of ethical concerns. However, in some cases, when the focus is on the close neighborhood use, it would be important to see. This might be solved if they were be able mark not exactly their homes, but blocks or name the neighbourhood instead.

The registration has been done individually or in pairs in «children's habitat maps» and it is individual in «Barnkartor i GIS» as well as in «SoftGISchildren». In case of the Swedish version this also means that one facilitator supervise only one child at the time (Berglund & Nordin 2007a) that helps to avoid the digitalization of nonsense data. In «children's habitat maps», due to technical problems and less strict control, the digital maps are less accurate therefor the paper maps were important for confirmation.

An important question is raised by the fact that during the digital mapping, the pupils saw each other's registration. It is partly a technical problem, because the overlapping digitalized objects make it difficult to see the map underneath the previously digitalized

[21] It is important to refer back that it was developed also for research purposes.

objects after only a few registrations. Partly, it is ethically sensitive, since the pupils saw each others' registrations before the revision.
The descriptive data needs careful revision in all cases, because it could be ethically sensitive; i.e. in our case some of the pupils registered private houses and wrote personal information.
The Swedish and Finnish versions have different technical solutions to avoid this. The «Barnkartor i GIS» runs from a local PC, thus the data collection is independent of the type of internet connection (Berglund & Nordin 2010a). The «SoftGISchildren» seems to be easier to handle, since it doesn't require installation of software.

Conclusion

The objectives of the research project required to extend the «digital barnetråkk» in order to get more detailed qualitative data. The developed «children's habitat maps» proved to be suitable to collect information on the children's interpretation of the landscape, and it was also possible for them to express their wishes towards the neighbourhood area.
In the research project, the different data collection methods completed each other in terms of counterbalancing the weaknesses of single tools. In «children's habitat maps», both the paper and digital maps provide information about the general use of the neighbourhood. The paper maps also show gender differences, and proved to be useful to validate the digital maps. The digital maps contain spatially located short descriptive information. The photos with description give more detailed qualitative data, but only about specific spots in the close neighbourhood. The articles/essays are valuable sources for exploring the pupils' preferences and attachment to the urban landscape.
Using multiple data sources were essential in the research project, but in planning practice it would be time consuming to analyse all of these sources, especially the written ones.
Research projects claim different demands according to their objectives, and although the aims are different in spatial planning, some of our experiences could contribute in the development of «digital barnetråkk» as well as its adaptation in research projects. To sum up: the parts of «children's habitat maps» that are the same as in the «barnetråkk », i.e. the background work and the preparation phase, work quite well. Though concrete examples on how parts should be successfully included in the teaching would have been helpful.
According to our experiences, the main possible development proposals are:

- both for practice & research
  - best practice of using «digital barnetråkk » as an educational tool should be collected
  - gender information should be included in the registration
  - the participants should not see each others' results
  - during the digitalization, the routes should automatically follow the road/track network
- mainly for research
  - «emotional mapping» for gathering more qualitative information should be included
  - in some cases it would be useful to name the neighbourhood / mark the homes as larger blocks.

It is interesting that until «barnetråkk» was a pioneering project in the Nordic region, the digital version seems to lag behind. Even if «digital barnetråkk» was tested in Bergen, Oppegård and Stavanger, and was used during the E6 and railway development, there is no systematic evaluation of it. About 100 passwords were given out, but there are no exact data about the number of municipalities, how they used the «digital barnetråkk» and their experiences with it (Sønstegaard 2010).

However, it must be noted that the «digital barnetråkk» is a very promising method[22]. It can be extended and used in several different ways for unlike purposes, as it has been done in Finland and already tried in Norway (Norsk Form 2010a). The technical support of the «digital barnetråkk» is flexible; it is possible to customize the tool for the needs.

Acknowledgements

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[22] The «digital barnetråkk» is not an independent method anymore. Its life is continued within a recently started urban development project, called «Bylab» (Norsk Form 2009). The «Bylab» focuses on meeting places in small and medium size cities. It seems to be a good solution that this already existing tool is integrated in this new project, but with the «digital barnetråkk» out of the meeting places it is possible to get more sophisticated information on the outdoor area use that could be valuable in spatial development.

Brekke (Vestfold fylkeskommune), Hanne Marie Sønstegaard (Norsk Form), Gunnar Ridderstrøm (Statens vegvesen) and Lars Inge Arnevik (Statens kartverk).

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8.2. Paper 2

The urban landscape as affordance for adolescents' everyday activity

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Abstract

This study explores factors in the physical outdoor environment of the urban landscape that promote or hinder physical activity. The analysis is inspired by Gibson's affordance concept. It combines actual use with the potential affordances in the neighbourhoods to generate special classes of actualised affordances.

Two school neighbourhoods in different landscapes were used as case study areas. A total of 121 fourteen-year-old pupils from the schools were invited to participate. The adolescents' everyday activity patterns and levels were recorded using child track methodology, GPS and heart rate monitor. Landscape analysis connected the activity patterns to the physical structure.

The study revealed that urban landscapes influenced physical activity patterns and adolescents´ choice of activity types. Similar to previous studies, our results confirm the importance of neighbourhood design, physical activity facilities and also the role of the road system in promoting activity. No gender-specific activity pattern was found, however.

Keywords: physical activity, GPS, heart rate monitoring, child track, landscape analysis

Introduction

Generally, the level of physical activity of adolescents in Norway is too low (the Norwegian Directorate of Health, 2012); it lags behind the recommended 60 minutes of moderate to vigorous physical activity per day (WHO, 2007). In addition to the insufficient level, activity changes with age. There is also a clear gender difference; girls are less active than boys (Anderssen et al., 2008).

Physical activity is an important factor in health promotion. Urban planning can contribute to stimulating physical activity by providing accessible and high-quality areas for activities. The importance of freely and easily accessible areas is underlined by the fact that those groups with the lowest socioeconomic status and poorest education are the most inactive (the Ministry of Health and Care Services, 2005).

Providing an arena for physical activity has spatial demands. However, sustainability in European urban planning policies promotes compact cities. Densification policy claims to use limited urban areas more effectively, which nevertheless has social implications. To enhance the liveability of compact cities, it is crucial to understand the inhabitants' needs and use of the urban landscape. This study aims to explore whether and how neighbourhood-scale physical environmental factors influence adolescents' everyday activities.

The knowledge gap and research questions

Physical activity behaviour is a compound phenomenon with numerous influential factors, and previous research has explored it from many different approaches. The relationship between physical activity and the physical environment is complex and often indirect.

Urban form is one of the most studied topics, concentrating mainly on the accessibility of parks or leisure facilities, distances to destinations and neighbourhood characteristics. The analyses are usually quantitative and measure distances, size or spatial patterns.

One of the most investigated themes in physical activity research, which is closely related to urban form, is *transport*; more specifically, the walkability/bikeability and connectivity of the road network (Frank et al., 2005, Kerr et al., 2007, McMillan, 2007). The structure of pedestrian and cycle networks is considered to have a significant influence on their use (Saelens et al., 2003, Tucker et al., 2009).

The *content and facilities of the outdoor environment* for promoting physical activity is also a central research theme. In general, functional diversity is considered to improve walking activity (Boer et al., 2007). Many studies show that accessible free-time facilities facilitates physical activity (Gordon-Larsen et al., 2006, Hume et al., 2005, Motl et al., 2005, Norman et al., 2006, Tucker et al., 2009). In most cases, accessible leisure/sports facilities (Haikkola et al., 2007, Limstrand, 2008) or parks (Babey et al., 2008, Cohen et al., 2007) are associated with increased physical activity and walking/biking (Grow et al., 2008), or associated with moderate to vigorous physical activity in adolescents (Boone-Heinonen et al., 2010). On the other hand, Ferreira et al. (2007) found no association between the accessibility of physical activity equipment and physical activity.

Nature is an important part of this research field. The role of the natural environment appears to be significant in promoting activity in small children (Fjørtoft, 2001, Fjørtoft and Sageie, 2000). However, the preference for natural settings varies with a child's age in a complex manner (Korpela et al., 2002). Travlou also concluded in her review (2006) that wild adventure space has a positive influence on young people's physical development and emotional and mental health.

Another important influential factor is *safety*. In general, perceived safety appears to affect physical activity behaviour (Grow et al., 2008, Limstrand, 2008) to a greater extent than objectively measured safety. However, no association was found between perceived neighbourhood safety and adolescents' physical activity by Ferreira et al. (2007). Traffic safety is also associated with adolescents' physical activity behaviour (Grow et al., 2008), although the results are not consistent (Haikkola et al., 2007).

An overall assessment of the status of knowledge relating to the outdoor environment and physical activity reveals a research field with a fragmented view of the landscape. Studies are often attribute-oriented (distance to activity areas, local services, area size, etc.) and mainly quantitative. They often lack detailed landscape information, although the importance of this field has been recognised by the research community (Davison and Lawson, 2006, Wells et al., 2007). By studying physical activity behaviour based on a more holistic landscape scale approach, it may be possible to understand what motivates people to move in and through the landscape.

With this overall objective, the main questions to be answered in this study are:

1) Are there characteristics of the urban landscape that promote or hinder certain kinds of use and physical activity?

2) Do girls and boys use the urban landscape differently?

In our study, the term *physical activity* equates to everyday outdoor activities.

Theoretical approach

The affordances concept (Gibson, 1977) interprets the link between humans and environment as inherently relational. This concept has already proved to be useful in research on children and adolescents' use of the urban outdoor environment (Clark and Uzzell, 2002, Heft, 2003, Kyttä, 2003, Kyttä, 2004).

We believe that Gibson's approach fits well with our understanding of landscape as a comprehensive arena. He claims that 'the invariant combination of properties is "meaningful" whereas any single property is not' (Gibson, 1977 p.68), which shifts the focus from the attribute-oriented aspect to the complex landscape level.

Figure 1 gives an overview of the application of Gibson's affordance theory in the research project.

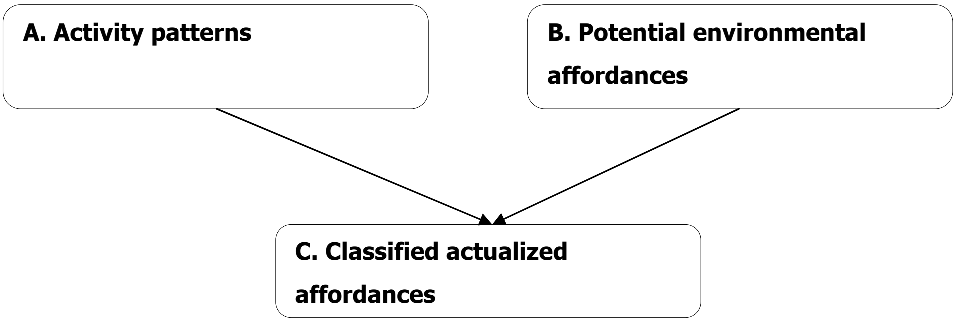

Figure 1 The application of Gibson's affordance theory (Gibson, 1977, Heft, 1989) in the research project

As the landscape contains an infinite number of potential affordances for physical activity, the problem has to be narrowed down to identifying the *affordances utilised* by young people. In Heft's terminology (1989), these are called *actualised* affordances (Figure 1C). Actualised affordances were studied on the basis of physical activity behaviour; movement patterns and levels (Figure 1A). Through their everyday activities, the participants expressed their perception of the neighbourhood outdoor environment. This is the landscape 'as perceived by people' (Council of Europe, 2000).

The second parameter is the potential affordances in the landscape (Figure 1B). These are *all that the landscape has to offer* in terms of opportunities for activity and general outdoor use. Landscape analysis is the expert's interpretation of landscape; it explores the role of combinations of different *layouts*, or more accurately, *shapes* of *surfaces* (Gibson, 1986 p.28-29), i.e. spatial patterns, and specifies the *potential environmental affordances*, including negative affordances, for physical activity

Case selection

The research project focuses on how different urban landscapes influence physical activity behaviour. For this purpose, a comparative case study design was used. Two schools and their neighbourhoods were selected in different landscapes in Fredrikstad, Southern Norway. The municipality has approximately 72,000 inhabitants. The settlement structure is scattered on both sides of the Glomma River. The selected schools are located in two different neighbourhood areas on the eastern side. Begby is in a hilly, natural landscape with an organic road structure; Gudeberg is in a more open, flat area with mainly cultivated vegetation and a structured grid road system.

All the 9th-10th grade classes in the schools, which totalled 121 pupils (14-year-olds), were invited to participate in the project. Participation was voluntary and the number of participants was thus different in the data collection stages (Table 1). The Norwegian Data Inspectorate approved the research project.

Table 1 Number of participants in different data collection phases

Data collection phase	**All participants N = 121**	**Gudeberg boys N=34**	**Gudeberg girls N= 32**	**Begby boys N= 26**	**Begby girls N= 29**
Gps & heart rate	73 (60,3 %)	21 (61,8 %) 30 (45,5 %)	9 (28,1 %)	21 (80,8 %) 43 (78,2 %)	22 (75,9 %)
Barnetråkk paper mapping	57 (47,1 %)	8 (23,5 %) 16 (24, 2 %)	8 (25 %)	17 (65,4 %) 41 (74,5 %)	24 (82,8 %)
Barnetråkk digital mapping	88 (72,7 %)	21 (61,8 %) 43 (65,2 %)	22 (68,8 %)	22 (84,6 %) 55 (78,2 %)	21 (72,4 %)

Methodology

Figure 2 gives an overview of the analysis method applied in the research project.

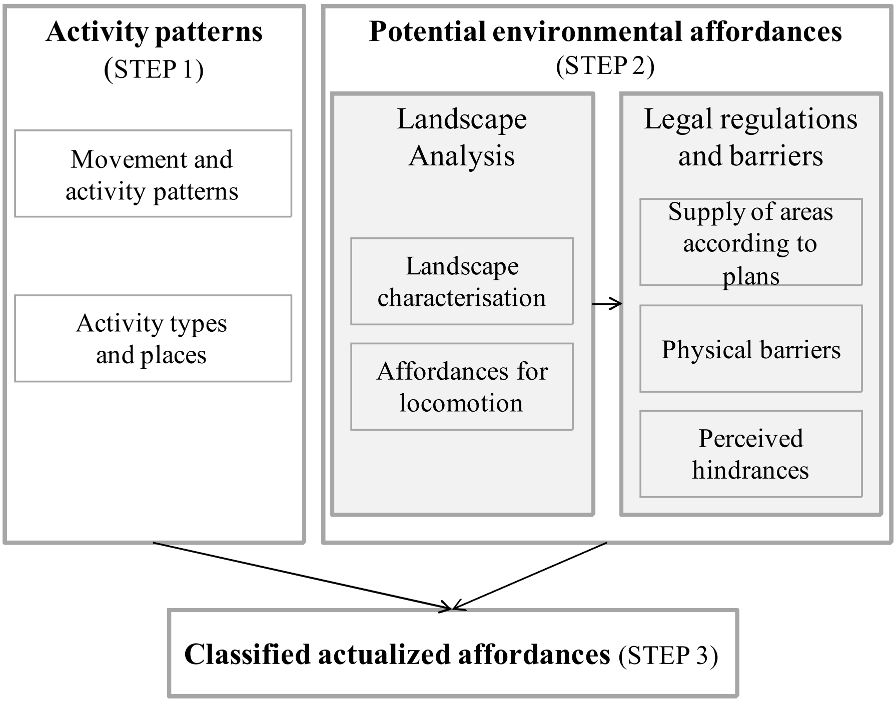

Figure 2 Methodology

STEP 1. Identifying activity patterns and levels

We collected both objective and self-reported data relating to the adolescents' use of the neighbourhood areas. First, their movements were monitored using GPS (GPS Garmin Forerunner 305) and their heart rates were simultaneously measured using heart rate monitoring belts. Data was collected during one day only for each participant, but it took seven days to complete due to equipment limitations (Gudeberg: Tuesday, 9 to Thursday, 11 October 2007, Begby: Monday, 15 to Thursday, 18 October 2007). The data were downloaded and processed using database management software. By combining the speed and heart rate of the movements, we excluded motorised transport. In this study, only the afternoon activities (13.00-23.00) were analysed: approximately 254,000 registrations totalling 636 hours of activity. On the basis of these observations, we defined movement patterns (Fjørtoft et al., 2010); activity areas and movement routes. The activity areas were defined as 10X10 m (not space demanding) and 100X100 m (space demanding) grid systems. From these, we selected hotspots, i.e. cells where all participants spent more than thirty minutes during the observation period.

In the subsequent data collection phase, we used a method called child track (Almhjell and Ridderstrøm, 2003). This took place in October to November 2008. The pupils mapped (both on paper and PC) and described their activities (Aradi, 2010). The preparation included self-guided tours and paper mapping organised by the schools. Altogether, a total of 57 paper maps were compiled. The digital phase took place in the schools and was guided by researchers from the project group. In total, 88 pupils registered 248 road segments, 69 areas and 93 places. Based on the described and mapped activities, we categorised the pupils' activities into twelve groups (Figure 3) and classified them as organised and non-organised activities:

- *organised activities*: football, (other) ballgames, horseback riding, paintball, rowing
- *non-organised activities*: meeting friends, (other) ballgames, biking, playing with play equipment, skiing, ice skating, shopping, skate boarding.

The child track data were also used to check the credibility of the GPS study.

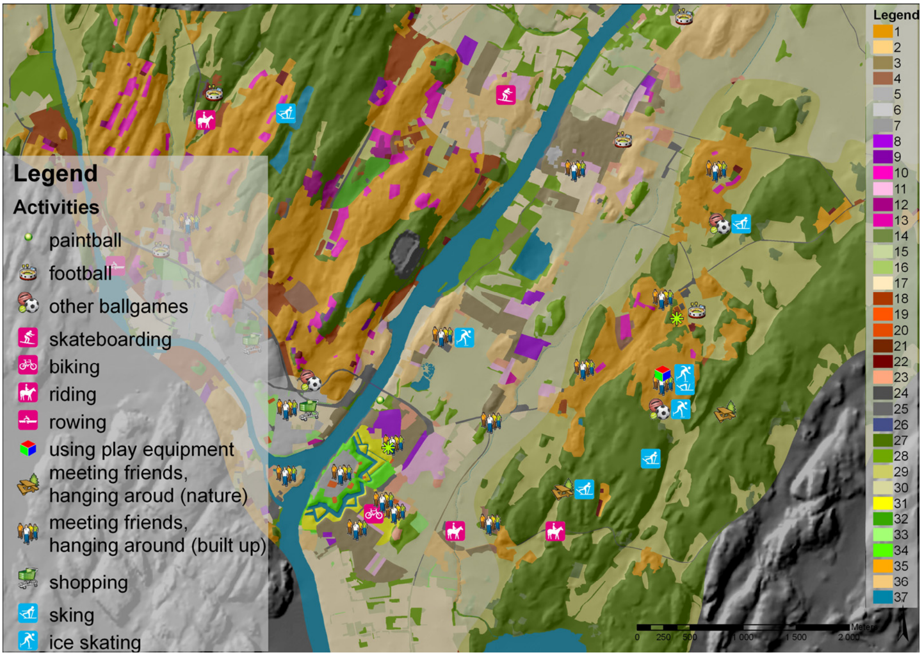

Figure 3 Activity types in the landscape character area types

The output from the movement pattern analysis together with the activity types provided one of the essential inputs for the actualised affordances (Figure 2).

STEP 2. Identifying potential environmental affordances in the urban landscape

Our starting hypothesis was that areas with different landscape characteristics offer different opportunities for activities. Our analysis concentrated on the physical structure, and the method we used originates from Sauer who describes the morphology of a given landscape: the shape, form and structure (Sauer, 1925).

To characterise the landscape, we included specific themes that might influence adolescents' physical activity behaviour: terrain, built morphology, vegetation typology. The combination of these themes resulted in a landscape character area type map that covers the study area. This provided an overview of the differences in the neighbourhood and provided the physical framework for the actualised affordances. The analyses were conducted in ArcGIS©.

We delineated the study area by including all registered movement patterns. As a first step, we categorised the landscape in single themes. We generated landforms from a digital elevation model (Norge digitalt, 2010) and generalised them into three main terrain categories:

1) plains,
2) hilly terrain and
3) artificial terrain around the fortress.

The vegetation mapping was based on an existing vegetation typology map, scale 1:5000 (Thorén, 2000) and was updated using orthophotos. This typology had two main vegetation categories: nature (N) and cultivated (K), and there were five subcategories in each category based on the openness of the vegetation cover: >40% tree cover areas, <40% tree cover areas, half-open areas, open areas and water surfaces (nature) or grey areas (cultivated).

In an urban environment, the terrain or vegetation cover alone does not provide adequate information about the landscape. In order to refine the categories in the built-up areas, we defined eight different building typologies : small detached houses, orderly small & bigger detached houses, urban block structure, blocks of houses, row and terraced houses, big multi-family houses, scattered housing and detached big buildings. We combined these categories with the terrain, vegetation information and two road structure types: organic and grid.

After simplification, this synthesis resulted in 37 distinct landscape character areas (Figure 3 and Table 2). These landscape character areas show the unique characteristics of the physical landscape, i.e. the *'combination of properties'* (Gibson, 1977 p.68).

Table 2 Landscape character area types

ID	Landscape character area type	ID	Landscape character area type	ID	Landscape character area type
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	14	Scattered housing in half-open cultivated areas in hilly terrain	26	Grey cultivated areas on water surfaces
2	Small detached houses in organic structure in half-open cultivated areas in plains	15	Scattered housing in half-open cultivated areas in plains	27	Various nature areas in hilly terrain
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	16	Scattered housing in grey cultivated areas in plains	28	Various nature areas in plains
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	17	Detached big buildings in grey cultivated areas in plains	29	Open cultivated areas in hilly terrain
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	18	Detached big buildings in grey cultivated areas in hilly terrain	30	Open cultivated areas in plains
6	Urban block structure in half-open/grey cultivated areas in plains	19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	31	Open cultivated areas in artificial terrain
7	Urban block structure in half-open/grey cultivated areas in hilly terrain	20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	32	<40% tree cover cultivated areas in hilly terrain & riverside valley
8	Block of houses in half-open/grey cultivated areas in plains	21	Detached big buildings in <40% tree cover cultivated areas in hilly terrain	33	<40% tree covered areas in plains
9	Block of houses in half-open/grey cultivated areas in hilly terrain	22	Detached big buildings in half-open cultivated areas in hilly terrain	34	<40% tree covered areas in artificial terrain
10	Row and terraced houses in half-open cultivated areas in hilly terrain	23	Detached big buildings in half-open cultivated areas in plains	35	Half-open cultivated areas in hilly terrain
11	Row and terraced houses in half-open cultivated areas in plains	24	Grey cultivated areas in hilly terrain	36	Half-open cultivated areas in plains & artificial terrain
12	Big multi-family houses in half-open cultivated areas in hilly terrain	25	Grey cultivated areas in plains	37	Water surfaces
13	Big multi-family houses in half-open cultivated areas in plains				

STEP 3. Identifying actualised affordances

We explored the places in the landscape that were used by the pupils. For this purpose, we overlaid the landscape character area types with activity patterns. We aimed to find patterns in the landscape that corresponded with the physical activity behaviour. The analysis resulted in the actualised affordances.

First, we analysed the activity patterns. We used the categorised activity areas from the pupils' digital maps and the hotspots (Figure 4) from the GPS/heart rate data. The paper maps from the child track were used for analysing walking/biking activity patterns.

Next, we explored the activity levels. In this analysis, we used the hotspots and the aggregated activities on the routes from the GPS study (Figure 5). The activity levels (heart rates) were divided into three categories:

low < 120 bpm,

middle 120-140 bpm,

high-vigorous >140 bpm.

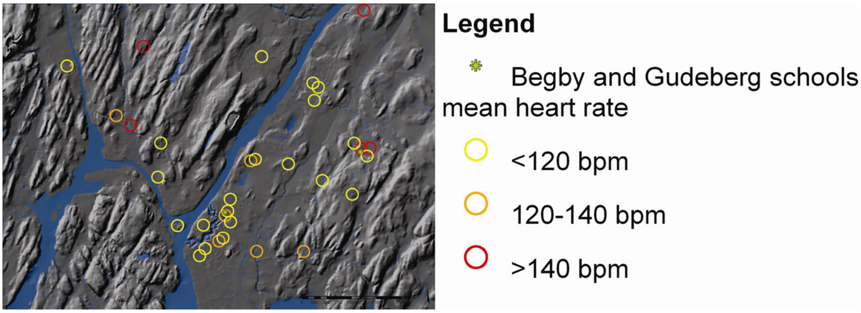

Figure 4 Activity levels in hotspots

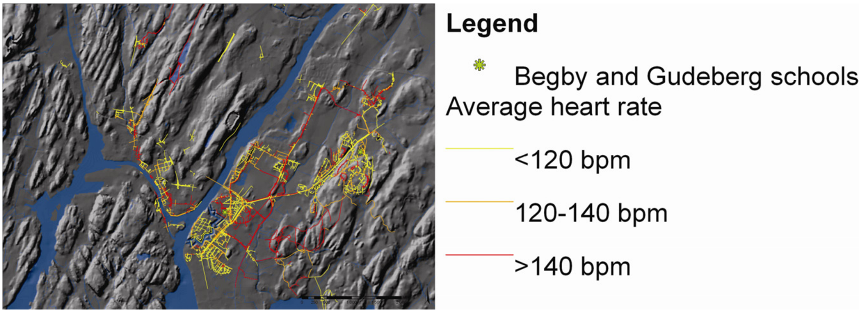

Figure 5 Aggregated activity levels along the routes

We also wanted to gain insight into how popular areas/routes were. The GPS/heart rate monitoring lasted for one day only, so the number of users were only analysed from the child track registration (Table 1). This analysis was not straightforward. In the digital mapping, the participants estimated the number of users in the areas they registered, which means these numbers are not exact. We therefore categorised the number of users into four groups: one, few, some and many users. The routes/areas with more than one user were divided into few/some and many user categories by equal intervals. From these intervals, the upper category was *many*, the middle *some* and the lowest *few*.

We analysed gender differences in the overall pattern, and area differences between Gudeberg and Begby. Gender information was available from the GPS study and from the paper maps from the child track.

In order to understand the context of the actualised affordances, we analysed possible limiting factors: the provision of areas for physical activity according to municipal plans and barriers (specified later). These *legal regulations and barriers* might determine the physical arenas in which activities can be realised. The analysis is based on:

- municipality plan (Fredrikstad Municipality, 2010a), detailed zoning plan (Fredrikstad Municipality, 2010b)
- traffic information
- self-reported fears from child track.

We restricted the legal regulations to publicly accessible areas for activities and to possible destinations (Figure 6). By overlaying zoned green, sports and special transportation areas with the landscape character area types and comparing the results with the activity patterns and levels, we gained an overview of the importance of these zoned green areas in the adolescents' everyday activities.

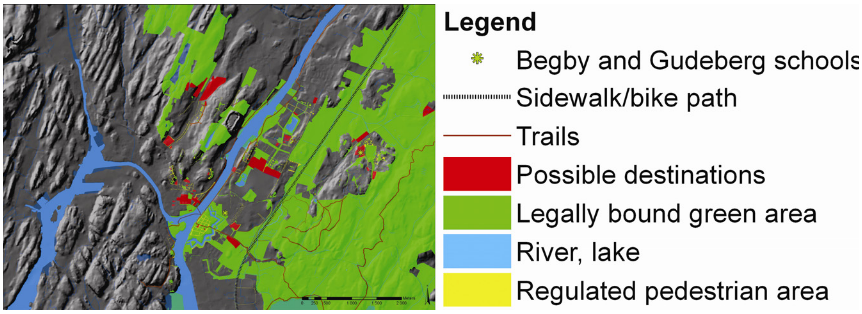

Figure 6 Zoned green areas (parks, playgrounds, sport facilities, recreational areas for outdoor life, agricultural- nature and recreation areas, protected nature and cultural heritage areas, church yards, green isolation belts of industrial areas, small boat harbours) and possible destinations (recreational buildings, educational institutes, community, administrative and public buildings, churches, gasoline stations) for physical activity in the neighbourhoods

Table 3ctivities, activity levels, amount of users, and gender and neighbourhood differences in the landscape character area types

user number categories in the activity type areas (child track): few: 2-41; some: 42-82; many: 83-122

aggregated user number categories in landscape character area types (child track): few: 2-52; some: 53-105; many: 106-155

B=Begby, G=Gudeberg

g=girl, b=boy

nda: no data available

ID	Landscape character area type	aggregated amount of users (child track)	Activity types: amount of users / neighbourhood / gender (child track)												Hotspots number of hotspots / amount of users / activity levels / neighbourhood / gender (GPS study)
			meeting friends	horse-back riding	shopp-ing	biking	skiing	ballgames	rowing	foot-ball	play-ing	paint ball	ice skating	skate boarding	
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	few	few/B; G/g,b	1/G/g	few/G /g,b		few/B /g	few/B /g,b			few/B /g,b		few/B /g,b		4/low/B/g,b
2	Small detached houses in organic structure in half-open cultivated areas in plains	few	few/G /g,b		few/G /g,b										1/moderate/B;G/b
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	1	1/G/ g,b												1/low/G/g,b
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	1	1/G/b												
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	few	some/ G/g,b												3/low/G/g
6	Urban block structure in half-open/grey cultivated areas in plains	few	few/G /g,b		few/G /g,b										
7	Urban block structure in half-open/grey cultivated areas in hilly terrain														1/low/G/g
8	Block of houses in half-open/grey cultivated areas in plains														6/low/B;G/g,b
10	Row and terraced houses in half-open cultivated areas in hilly terrain	1	1/B/b												
11	Row and terraced houses in half-open cultivated areas in plains	1	1/G/g, b												
13	Big multi-family houses in half-open cultivated areas in plains														1/vigorous/G/g

14	Scattered housing in half-open cultivated areas in hilly terrain	few	few/G/g,b	few/B/g			few/B;G/g,b								1/moderate/B/g
15	Scattered housing in half-open cultivated areas in plains	few	few/G/g,b												2/low/G/b
17	Detached big buildings in grey cultivated areas in plains	few	few/G/g,b	1/G/g	few/G/g,b				1/G/g			few/B/b			22/vigorous, moderate, low/B;G/g,b
18	Detached big buildings in grey cultivated areas in hilly terrain	few	few/B/g,b		few/G/g,b										9/vigorous, low/B/g,b
19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	few	few/G/g,b												2/moderate, low/B;G/g,b
22	Detached big buildings in half-open cultivated areas in hilly terrain	few	few/B;G/g,b												1/low/B/b
23	Detached big buildings in half-open cultivated areas in plains	few	few/G/g,b												5/moderate, low/B;G/g,b
24	Grey cultivated areas in hilly terrain	few						few/G/g,b							
25	Grey cultivated areas in plains	some	some/G/g,b	1/G/g					1/G/g				few/G/nda		7/moderate, low/B;G/g,b
27	Various nature areas in hilly terrain	few	few/B;G/g,b,	few/B;G/g			few/B;G/g,b	few/B/g,b							
28	Various nature areas in plains	few	few/G/g,b			few/G/g,b									
29	Open cultivated areas in hilly terrain	some	few/B;G/g,b	few/B;G/g			few/B;G/g,b			few/B/g,b					2/vigorous/B/g,b
30	Open cultivated areas in plains	some	few/G/g,b	1/G/g		few/G/g,b				few/B;G/g,b				1/B/b	1/vigorous/G/b
31	Open cultivated areas in artificial terrain	some	few/G/g,b			few/G/g,b									
33	<40% tree covered areas in plains	few	few/G/g,b												
34	<40% tree covered areas in artificial terrain	few	some/G/g,b												
35	Half-open cultivated areas in hilly terrain	few	few/G/g,b												2/low/B/g,b
36	Half-open cultivated areas in plains & artificial terrain	many	many/G/g,b			few/G/g,b									
37	Water surfaces	few	some/G/g,b						1/G/g						

Everyday movement patterns can either revolve around getting to school, organised activities etc. or they may be recreation-oriented without clear goals. In the first case, the function itself and the shortest/fastest connection has higher priority than other qualities of the location or possible routes. The community buildings/areas are, in many cases, the destinations of everyday movements. From the plans, we selected the possible destinations for everyday life or for recreation that could stimulate everyday movement (Figure 6).

Given that areas with a better provision of zoned green and sports areas and/or destinations are more attractive for use, we calculated the cumulative area size of these possible target areas in the landscape character area types (Table 4-5).

Table 4 Distribution of areas for sport, recreation and outdoor life according to the landscape character area types

ID	Landscape character area type	Area in the zoning plan (sqm)	Area in the municipal master plan (sqm)
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	164 391 374	25 907 782
2	Small detached houses in organic structure in half-open cultivated areas in plains	12 128 757	3 980 177
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	13 096 732	1 579 662
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	233 157	131 857
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	638 768	187 581
6	Urban block structure in half-open/grey cultivated areas in plains	936 169	820 976
7	Urban block structure in half-open/grey cultivated areas in hilly terrain	903 060	10 037
8	Block of houses in half-open/grey cultivated areas in plains	3 364 089	107 929
9	Block of houses in half-open/grey cultivated areas in hilly terrain	58 318	33 787
10	Row and terraced houses in half-open cultivated areas in hilly terrain	748 841	100 659
11	Row and terraced houses in half-open cultivated areas in plains	1 232 648	147 644
12	Big multi-family houses in half-open cultivated areas in hilly terrain	52 069	55 376
13	Big multi-family houses in half-open cultivated areas in plains	4 453	8 906
14	Scattered housing in half-open cultivated areas in hilly terrain	20 600	464 327
15	Scattered housing in half-open cultivated areas in plains	92 758	153 569
16	Scattered housing in grey cultivated areas in plains		1 685
17	Detached big buildings in grey cultivated areas in plains	10 712 945	4 833 750
18	Detached big buildings in grey cultivated areas in hilly terrain	1 025 801	855 396
19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	532 489	40 002
20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	2 196	
22	Detached big buildings in half-open cultivated areas in hilly terrain	21 221	51 106
23	Detached big buildings in half-open cultivated areas in plains	180 962	54 885
24	Grey cultivated areas in hilly terrain	336 313	265 628
25	Grey cultivated areas in plains	1 474 177	461 291
26	Grey cultivated areas on water surfaces	2 080	4 198
27	Various nature areas in hilly terrain	16 972 183	34 740 492
28	Various nature areas in plains	1 821 589	1 631 733
29	Open cultivated areas in hilly terrain	15 725 659	9 911 578
30	Open cultivated areas in plains	38 001 280	13 704 959

31	Open cultivated areas in artificial terrain	1 703 913	340 473
32	<40% tree cover cultivated areas in hilly terrain & riverside valley	283 132	31 250
33	<40% tree covered areas in plains	261 615	96 157
34	<40% tree covered areas in artificial terrain	1 176 840	891 430
35	Half-open cultivated areas in hilly terrain	263 512	190 072
36	Half-open cultivated areas in plains & artificial terrain	331 064	167 846
37	Water surfaces	21 035 666	49 405 254

Table 5 Distribution of the possible target areas according to the landscape character area types

ID	Landscape character area type	Area in the zoning plan (sqm)	Area in the municipal master plan (sqm)
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	5 657 212	2 864 108
2	Small detached houses in organic structure in half-open cultivated areas in plains	818 535	548 017
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	306 220	135 994
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	179 430	
6	Urban block structure in half-open/grey cultivated areas in plains	723 984	377 224
7	Urban block structure in half-open/grey cultivated areas in hilly terrain	66 249	
10	Row and terraced houses in half-open cultivated areas in hilly terrain	31 159	46 272
11	Row and terraced houses in half-open cultivated areas in plains	250 633	28 966
12	Big multi-family houses in half-open cultivated areas in hilly terrain		161 552
13	Big multi-family houses in half-open cultivated areas in plains	4 453	
15	Scattered housing in half-open cultivated areas in plains		2 156
17	Detached big buildings in grey cultivated areas in plains	466 500	340 487
18	Detached big buildings in grey cultivated areas in hilly terrain	163 042	31 074
19	Detached big buildings in grey/half-open cultivated areas in artificial terrain		2 430
22	Detached big buildings in half-open cultivated areas in hilly terrain	2 734	2 890
23	Detached big buildings in half-open cultivated areas in plains	65 949	15 212
24	Grey cultivated areas in hilly terrain	8 941	31 454
25	Grey cultivated areas in plains	1 190	17 078
27	Various nature areas in hilly terrain	1 733 493	4 740 329
28	Various nature areas in plains	245 936	48 666
29	Open cultivated areas in hilly terrain		454 780
30	Open cultivated areas in plains	4 157 875	1 249 448
31	Open cultivated areas in artificial terrain		64 104
32	<40% tree cover cultivated areas in hilly terrain & riverside valley		94 377
33	<40% tree covered areas in plains	7 517	51 631
35	Half-open cultivated areas in hilly terrain	124 989	39 854
36	Half-open cultivated areas in plains & artificial terrain		47 908
37	Water surfaces	102 488	

Barriers in our study were safety related issues (Figure 7). Traffic information (Norge digitalt, 2009) and the adolescents' own observations from the digital child track showed where barriers were present. We also took other safety-related issues, such as lighting and social fears into account.

Results

The free-time activities registered by pupils showed a neighbourhood-oriented use. This meant an area of about 2-3 km around the schools. There was limited spatial overlapping between the activities around Begby and Gudeberg.

Activity patterns

The overall picture showed activity types in 27 out of the 37 total different landscape character areas (Table 3). The landscape character area type with the *most different (seven) activity types* was a residential area in hilly terrain with small family houses in organic structure (ID1). Other area types with more than three different activities were mainly areas with special community and/or free-time activity functions (ID17,25,27,29,30).

The GPS/heart rate study showed some similarities. Hotspots were registered in 18 different landscape character area types (Table 3). The landscape character area type with (ID17) was a non-residential grey area in plains, often with community and/or free-time activity functions. There were five more areas with more than three hotspots. Three of these are non-residential grey areas in various terrains with/without buildings (ID18,23,25), two were residential areas (ID1,8).

The *most preferred* areas, with many (ID36) or some (ID25,29,30,31,37) registered users were in non-residential areas in various terrains, in which open cultivated areas (e.g. lawns, sports fields) dominate. The most frequently used walking/biking activities from all the registered routes in the neighbourhoods were, not surprisingly, from the main collector roads.

There were seven landscape character area types where no activities were registered (Table 6).

Table 6 Non-favoured landscape character area types

ID	Landscape character area type	Description	Location	Number	Size (m2)
9	Block of houses in half-open/grey cultivated areas in hilly terrain	Smaller residential areas.	West	21	895 - 37 744
12	Big multi-family houses in half-open cultivated areas in hilly terrain	Smaller residential areas.	West	20	892 - 29 342
16	Scattered housing in grey cultivated areas in plains	Very small areas with local industry, agriculture or service building.	East	3	383 - 1 515
20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	Buildings in parks or churches in churchyards.	West	3	473 - 3 957

21	Detached big buildings in <40% tree cover cultivated areas in hilly terrain	Church in churchyard.	West	1	1 803
26	Grey cultivated areas on water surfaces	Bridges. One between the western and eastern parts, the rest on the western part.	West	6	141 - 2 080
32	<40% tree cover cultivated areas in hilly terrain & riverside valley	Park areas close to the city centre.	West	9	401 - 94 377

Apart from one exception, these were all in the western part of the study area. Most of them were uncommon and small and the distance can explain the lack of use: the western part of the city was not extensively used. The only area type not used in the eastern part of the city was a typically industrial, agricultural or service area.

Activity levels

In most hotspots, the average activity level was low. There were only five landscape character area types where vigorous activity was registered. These were in various terrains around recreational areas (ID17,18) and on sports fields (ID29, 30) and also in one residential area type in plains with big multi-family houses (ID13).

There were more intensive activities along the routes than in specific locations. Middle-high average heart rate levels were registered along some of the main roads in parts of residential areas both in Gudeberg and Begby and in the hilly nature area (ID27) with floodlit tracks south of Begby (Figure 5).

Legal regulations and barriers

The hypothesis for analysing the provision of facilities for physical activity in municipal plans was that a lack of facilities hinders physical activity. Generally, the neighbourhoods had a good provision of green and recreational areas. The eastern part of the study area had more *agricultural-nature and recreation areas*. According to the plans, the number of possible destinations did not vary much between the two neighbourhoods. The part of the area shared by the two neighbourhoods, to the north of Gudeberg and to the west of Begby, had the best provision.

The landscape character area types with the most users with respect to the zoned area provision (Table 4) and possible destinations (Table 5) showed that non-residential landscape character area types in various terrains with bigger green and/or target areas (ID17,27,29,30,37) played an important role in outdoor activities. Only one (IDI) of the residential area types with the best provision (ID1,2,3,6) was among the most used. Furthermore, there were also favoured landscape character area types where the size of the zoned public green areas and possible destinations did not explain popularity: built up and non-built up grey areas (ID23,25), parks connected to water (ID37) and non-built up areas with half-open vegetation (ID36). The common denominator for these areas was that gathering places were marked in all of them.

For the roads where *traffic* data were available, the pupils marked all the roads/parts of them in the Gudeberg area as 'dangerous' (Figure 7). Places registered as a traffic hazard were also located along these roads. No traffic data were available for the main road leading to the south, but several pupils marked it as dangerous. The main road from the Gudeberg area to Begby also has heavy traffic, and it was also considered dangerous.

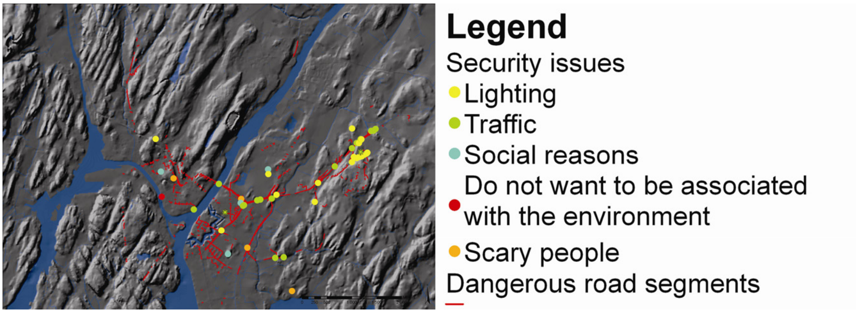

Figure 7 Perceived danger

The pupils reported *lack of lighting* as an important factor hindering outdoor activities, highlighting places either along main roads, shortcuts or underpasses. A greater number of locations were registered in the Begby neighbourhood, where there were more shortcuts in the residential areas.

Perceived fear, relating mainly to intimidating groups of people, was also considered a barrier for outdoor use of the neighbourhood by the adolescents. The places they avoided for social reasons were in different locations but were mostly built-up areas (Figure 7). Social fears did not correspond to areas with special landscape characteristics but were reported mostly from Gudeberg.

The activity patterns showed that, despite their concerns, the pupils did use places they marked as having *heavy traffic* or *lack of lighting* or even those areas with *social fears*.

Neighbourhood and gender differences

The landscape characteristics in the two neighbourhoods differ. These differences resulted in different activity patterns.

The terrain in the Gudeberg neighbourhood is flat; with various housing areas and bigger industrial/commercial areas. The non-built-up areas are predominantly open cultivated areas, e.g. lawns, sports or agricultural fields in various terrains (ID30,31) but there are also bigger park areas (ID33,34).

The Begby neighbourhood lies in more varied, hilly terrain. The residential areas consist mostly of single family houses with organic road structure and scattered half-open vegetation (ID1). Various nature areas (ID27) and open cultivated areas (ID29) dominate the non-built-up areas.

The built morphology is more diverse in the Gudeberg neighbourhood than in Begby. The overall landscape character area type structure is thus more mosaic-like in Gudeberg and more homogeneous in Begby.

In Begby, there were more recreational areas for non-organised activities. A greater variety of activity types was registered here, but they were fewer in number (Table 3). In contrast, Gudeberg seems to support more activities related to meeting friends/hanging around. A greater number of activity areas were marked and more different landscape character area types were used but with less activity variety. No neighbourhood differences were found in the levels of physical activity.

No convincing gender differences were found with respect to activity patterns or levels.

Main findings

From the landscape point of view, we defined the actualised affordances for adolescents as landscape character area types where they conduct their activities. By differentiating the landscape on the basis of the activities, we identified three main groups:

1) (actualised) affordances for getting together,
2) (actualised) affordances for various activities,
3) (actualised) affordances for high activity level.

Affordances for getting together

Most of the areas used by many or some pupils were registered in non-residential areas. Nature areas (ID37), non-built-up, half-open areas connected to residential areas (ID36), open grey areas (ID25), sports fields and lawns (ID29,30,31). If we look specifically at the places that are registered for meeting activities (Table 3), Gudeberg appears to be an area for getting together. In some of the listed area types (ID25,36,37) here, the park area around the fortress (ID34) and one urban area (ID5), located in the historical old town with mixed commercial/residential functions, also attracted many users.

Affordances for various activities

According to the variety of registered activity types, the Begby neighbourhood can be considered an area for various activities (Figure 3). All the analyses demonstrate that the single-family housing area with organic road structure and scattered vegetation in hilly terrain (ID1) favours outdoor activities; seven out of the twelve activity types could be found in this area type (Table 3). In the overview of registered activity types in Begby, both built-up and non-built-up recreational areas (ID14,27,29) seem to be important for accommodating different activity types, e.g. meeting friends, football, ballgames, horseback riding, skiing, shopping.

Outside the Begby neighbourhood, open grey or cultivated areas (ID25, 30) and areas typically connected with a recreational/commercial function (ID17) are also important for various activities: e.g. meeting friends, football, biking, horseback riding, ice skating, shopping.

Affordances for high activity

In our study, built-up and non-built-up recreational areas (ID17,18,19,23,25) appear to stimulate various activity levels from low to vigorous (Table 3); these are typically areas designed for recreation, i.e. sports halls and grey sports fields. The highest activity levels (hotspots with moderate-to-vigorous activity) were mostly in similar areas with a recreational/commercial function (ID17,18,19,23) or grey/cultivated sports fields (ID25,29,30). Some other active places were in housing areas with half-open vegetation (ID2,13,14). The first two were single and multi-family residential areas; the third a scattered housing area.

Nevertheless, more high-vigorous activity was registered along the routes than in the activity areas. Apart from the various nature areas (ID27), the high activity level along the routes did not appear to be associated with special landscape characteristics and neither did the presence of bike paths predict high activity.

Discussion

The main objective of our study was to explore how different urban neighbourhood landscapes influence everyday activities. Connecting the activity patterns to the landscape character area types illustrated the behaviour-environment relationship of the affordance concept. The results suggest that the affordance concept combined with the landscape approach may be useful for interpreting differences in activity patterns on the neighbourhood scale.

Landscapes for various activities

The Begby area, which appears to support various activities, has many qualities that are recommended for good urban planning in Norway (Bjørneboe et al., 2000). It is aligned with the terrain, provides diverse areas both for organised and unorganised activities, favours outdoor play with careful green structure designs and a road structure designed for traffic calming. A similar built-up environment ('Different kinds of dwellings, not too tall or ugly buildings / Low and small dwellings close to each other') was reported as a child-friendly characteristic (Haikkola et al., 2007 p.339) in a Finnish study. This type of environment appears to provide a broader range of outdoor facilities. This was considered an important factor in outdoor area use (Limstrand, 2008, Kyttä, 2004).

Landscapes for getting together

The reason for the domination of the activity type hanging around meeting friends in Gudeberg is perhaps that the area lacks the landscape variability of Begby. It may also be the case that the area offers other opportunities for outdoor recreation. One of the main reasons for adolescents participating in outdoor activities is socialising (Duzenli et al., 2010). Places for social interaction are not necessarily designed for activity; the important elements are outdoor settings 'allowing peer interactions in unstructured activities away from adult supervision' (Schiavo, 1988 p.9). Studies have also indicated that public spaces often do not fit adolescents' needs (Matthews, 1995). To some extent, this can result from the fact that adolescents are often considered undesirable in public spaces (Lieberg, 2006, Malone and Hasluck, 1998). In our study, the pupils, to a great extent, used areas that were not planned for physical activity; however, the activity levels were generally low in these places.

Our data, in accordance with other results (Boone-Heinonen et al., 2010), show that the zoned outdoor spaces are quite important as gathering places. The popularity of sports areas is consistent with previous research results (Babey et al., 2008, Limstrand, 2008). The different park area types in our study reported as an affordance for spending time with close friends, agrees with the findings of other researchers (Cohen et al., 2006, Duzenli et al., 2010, Simmons, 1994). Haikkola et al. (2007) found recreational facilities and the characteristics of the built environment and green areas to be the most important parameters in the physical environment for 11 to 12-year-old Finnish and Italian children. In this study, the importance of the local city centre with the wide variety of services provided appears to support the findings of Clark and Uzzell (2002) and Duzenli et al. (2010), who found the city centre to be the most preferred urban area for adolescents.

High activity landscapes

Walkable/bikeable connections play an important role in everyday activity. Safe connections might increase the possibility of independent mobility. This was indicated by Kyttä (2002), as one of the most important factors for the exploration and utilisation of affordances. There is very limited literature available that connects objectively measured levels of physical activity to landscape characteristics. Some studies associate levels of activity with residential density, land-use mix and road characteristics (Frank et al., 2005, Rodríguez et al., 2012) or perceived characteristics (Evenson et al., 2010, Hume et al., 2005).

Our study showed that no special landscape character types contributed to high activity levels. High activity levels generally seem to be related to the accessibility of sport and recreational facilities, which are consistent with previous research findings (Tucker et al., 2009). Our study also indicated the importance of accessible nature areas for high-intensity physical activity. Activity levels were, nonetheless, higher along the roads than in specific places. This suggests that the pedestrian/bike network is important for higher activity levels.

Neighbourhood design that supports physical activity is considered to have great potential to contribute to increasing levels of physical activity (Sallis et al., 2009). The results of our project suggest a possible strategy for increasing activity levels through neighbourhood design, i.e. to scatter different target areas and facilities for physical activity in the neighbourhood and provide safe walkable/bikeable connections between them and also to facilitate physical activity in nature areas.

Gender differences

Several previous studies showed gender differences in the use of outdoor areas. Duzenli et al. (2010) found that boys are more willing to participate in sports than girls. Norwegian studies (Limstrand and Rehrer, 2007, Schmidt, 2004) indicated that activities on football fields, even in Norway, where football is popular with girls, are dominated by boys. In the same study, they also concluded that while girls seem to prefer 'non-specific facilities with fewer determined rules', boys favour 'facilities designed for specific use and specific sports'. This might suggest that Begby would be favoured by girls and Gudeberg by boys but no such gender difference was found in this analysis. Even the qualitative analysis of the activity types shows very little gender difference in preferences.

Limitations

There are some limitations to this study. The adolescents' activity level analysis is based on objective data but with short-term data collection, and the general pattern may, therefore, differ from that recorded here.

The lack of gender differences in the activity patterns may be a result of the limited data contribution to the gender analysis. Another methodological limitation concerns activity levels. The hotspot analysis, by accumulating a minimum of 30 minutes activity, favours less-active spots. However, in this study the low activity levels only partly resulted from the aggregation; the row heart rate data showed generally low activity levels.

Due to the analysis method, the actualised affordances here contain 'places for interaction' as defined by Lieberg (2006). Places for 'retreat' (Lieberg, 2006) would require individual analysis of the physical activity patterns.

Socioeconomic status (SES) is reported to have an influence on physical activity behaviour. However, Gordon-Larsen found that sociodemographic factors were more associated with inactivity than activity (Gordon-Larsen et al., 2000). Limstrand (2008) showed that in most cases, low social economic status was reported to have negative associations with physical activity. Similarly, an association was found between high family income and increased moderate to vigorous physical activity (Gordon-Larsen et al., 2000). It was not possible to collect individual SES data in this project. Through the study design, i.e. selecting two neighbourhood areas in the same municipality, the inequalities in the macro environment can be reduced. Yet, the perceived status of the neighbourhoods were dissimilar, which may result in significant differences.

Conclusion

The comprehensive landscape approach has made it possible to study the complex phenomena of urban landscapes. The approach has also contributed to a better understanding of the patterns of activity. In our study, we found specific landscape characteristics that were associated with certain kinds of use and physical activity level. We found neighbourhood differences in activity patterns but no significant gender differences. Our results appear to indicate that variety is one important quality of the outdoor environment. Variety in affordances appears to be an important factor that influences physical activity behaviour. Variety in functions and variety in landscape seem to have different effects on activity patterns.

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8.3. Paper 3

Landscape Approach in Physical Activity Research

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Abstract

The main objective of this article is to introduce the landscape approach in physical activity research that has been developed within a research project. The aim of this project was to explore how the urban landscape influences physical activity behaviour of adolescents. The combination of different data collection and analysis methods gave meaningful results. However the method needs further development and refinement. Nevertheless the landscape approach seems to be relevant in PA research. It can give a complex understanding of outdoor environmental factors that might have influence on physical activity behaviour.

Keywords: landscape analysis; GPS/heart rate monitoring; child track; analysis method; outdoor environment

Introduction

The importance of physical activity (hereinafter PA) in health promotion is an extensively researched topic. Generally, the level of physical activity of adolescents in Norway is too low (the Norwegian Directorate of Health 2012). In addition to the insufficient level, activity decreases with age and there is a great decline from childhood to adolescent age (Anderssen et al. 2008).

There are several aspects of the environment that contribute to the development of PA behaviour, of which one is the physical environment. Although there is no direct link to physical environment, research results suggest that there are correlations between certain characteristics and physical activity (Davison and Lawson 2006, Ding et al. 2011, Ferreira et al. 2007, Limstrand 2008, Panter, Jones, and van Sluijs 2008, Sallis, Prochaska, and Taylor 2000). The landscape approach can give a complex understanding of outdoor environmental factors that might have influence on physical activity behaviour.

In this article first I give an overview of the common approaches to characterise physical environment in PA research, then I introduce a method that was developed in the 'How the environment affords PA in adolescents' research project with the aim of integrating landscape analysis and PA behaviour. Finally I discuss the relevance of the landscape approach in PA research.

The outdoor environment in PA research

Ewing (2005) used density, diversity and design ('3Ds') as umbrella categories for characterising the factors of the physical environment that has influence on PA behaviour. Majority of the studies that investigate density, use housing/residential density (Cradock et al. 2009, Kligerman et al. 2007, Ding et al. 2011, Frank et al. 2007, Kerr et al. 2007, Kyttä, Broberg, and Kahila 2012, Larsen et al. 2009, Norman et al. 2006) or open space density (Cradock et al. 2009).

Diversity can be present both a general or a detailed level. General categories made distinctions between rural vs. urban (Babey et al. 2008) areas. Sometimes this is refined with level of urbanisation (Boone-Heinonen et al. 2010, Ferreira et al. 2007). Another, rather general approach is a distinction between built-up and non built-up areas (Cradock et al. 2009). Land-use mix describes diversity on a more detailed level and has also been widely used in research into adolescents' PA (Ding et al. 2011, Frank et al. 2007, Grow et al. 2008, Kerr et al. 2007, Larsen et al. 2009, Norman et al. 2006, Tucker et al. 2009, Voorhees et al. 2010). Beside land use mix other special themes are also used for describing variety. One often used index is functional diversity (Boer et al. 2007, Frank et al. 2005, Kerr et al. 2007, Kligerman et al. 2007, Roemmich et al. 2007, Norman et al. 2006). Some studies focused on more detailed housing typology (Babey et al. 2008, Panter, Jones, and van Sluijs 2008) or block size (Voorhees et al. 2010). Regarding the green areas, diversity is characterised by the proportion/percentage of green areas (Roemmich et al. 2007, Kyttä, Broberg, and Kahila 2012, Tucker et al. 2009).

In Ewing's terminology design refers to characteristics of the way and path system. The investigated properties in PA research include intersection density (Boer et al. 2007, Frank et al. 2005, Kerr et al. 2007, Davison and Lawson 2006, Frank et al. 2007, Larsen et al. 2009, Norman et al. 2006, Rodríguez et al. 2012), street connectivity (Boone-Heinonen et al. 2010, Bungum et al. 2009, Cohen et al. 2006, Ding et al. 2011, Grow et al. 2008, Kerr et al. 2007, Limstrand 2008, Mota et al. 2005, Voorhees et al. 2010), and presence of sidewalks/walking facilities /biking facilities (Davison and Lawson 2006, Ding et al. 2011, Evenson et al. 2007, Grow et al. 2008, Limstrand 2008, Mota et al. 2005, Norman et al. 2006, Panter, Jones, and van Sluijs 2008) or length (Larsen et al. 2009).

Beyond the street network characteristics design can also embrace the functions and destinations of interest. Functions might appear on general level as home-neighbourhood-school-town centre (Clark and Uzzell 2002). There are also studies examining presence/number/accessibility of destinations of interest (Kyttä, Broberg, and Kahila 2012, Mota et al. 2005). Many other studies focused on more specific targets: areas designed for leisure time, recreational or sport activities (Boone-Heinonen et al. 2010, Cohen et al. 2006, Ding et al. 2011, Davison and Lawson 2006, de Farias et al. 2011, Evenson et al. 2007, Ferreira et al. 2007, Grow et al. 2008, Limstrand 2008, Mota et al. 2005, Norman et al. 2006, Panter, Jones, and van Sluijs 2008, Sallis, Prochaska, and Taylor 2000, Tucker et al. 2009, Voorhees et al. 2010) or schoolyards (Davison and Lawson 2006, Larsen et al. 2009, Rodríguez et al. 2012).

When the role of nature is in focus, it mostly relates to the presence/number/accessibility of parks (Babey et al. 2008, Cohen et al. 2006, Norman et al. 2006, Davison and Lawson 2006, Ding et al. 2011, Frank et al. 2007, Kerr et al. 2007, Rodríguez et al. 2012). Occasionally other indices appear, such as presence of street trees (Larsen et al. 2009) or green space characteristics (Mäkinen and Tyrväinen 2008).

In addition to the '3Ds' if safety is an issue, it might have overruling influence on PA behaviour relative to the other factors. General neighbourhood safety (Davison and Lawson 2006, Babey et al. 2008, de Farias et al. 2011, Ding et al. 2011, Evenson et al.

2007, Ferreira et al. 2007, Grow et al. 2008, Limstrand 2008, Mota et al. 2005, Voorhees et al. 2010) and traffic safety / heavy traffic (Cradock et al. 2009, Davison and Lawson 2006, Ding et al. 2011, Grow et al. 2008, Limstrand 2008, Panter, Jones, and van Sluijs 2008) are the priority issues.

The above presented characteristics of the physical environment show an attribute oriented approach with the focus on (variation of) functions, facilities for PA, accessibility or distance. With these attributes or combinations of them it is possible to describe some aspects of the neighbourhood environment, but a more holistic image of the physical landscape is missing. Bringing the landscape approach in PA research, i.e. combining the relevant environmental themes, analysing them with the PA behaviour and interpreting the variation on landscape level might give an easier-to-interpret result from landscape planning point of view.

A method to integrate PA behaviour and landscape

The here introduced method was developed within the 'How the environment affords PA in adolescents' research project that aimed to explore how the landscape influences PA in fourteen-year-old adolescents. In this project both objective measures (GPS and heart rate monitoring) and self-reported (children's habitat maps) methods were used for gathering PA data. Landscape analysis provided information about the landscape. The interpretation of the results were guided by Gibson's affordance concept, which has already been proved useful in research on children's and adolescents' use of the urban outdoor environment (Clark and Uzzell 2002, Heft 2003, Kyttä 2002, 2003, 2004, Ward Thompson 2010). Affordances are the 'combination of physical properties of the environment that is uniquely suited to a given animal – to his nutritive system or his action system or his locomotor system' (Gibson, 1977:79).

In this research project we interpreted that all that the landscape has to offer for outdoor use are the potential environmental affordances. Since the number of affordances in the landscape is infinite, it had to be narrowed down to the affordances that are actualised by young people. In Heft's terminology these are called actualised affordances. These actualised landscape-level affordances were investigated with the here presented method.

The case

To explore how different urban landscapes influence PA behaviour, a comparative case study methodology was used. Two schools and their neighbourhoods in Fredrikstad, southern Norway, were selected. Fredrikstad has approximately 72,000 inhabitants. The selected schools are located in two different neighbourhoods in the eastern side of the River Glomma: Begby is in a hilly landscape with organic road structure; Gudeberg is in a more open, flat area with a grid road system. All the ninth and tenth grade classes (fourteen-year-olds) at the schools were invited to participate in the project: 121 pupils altogether. Participation was voluntary, thus the number of participants differed between each of the data collection stages. The Norwegian Data Inspectorate approved the research project.

In our project the physical environment meant the local neighbourhood. The fourteen-years-old youths do not have driving license. Although public transport is available and the parents are willing to drive them by car, walking and cycling are still important transport options. The main arenas for their everyday activities are those areas that are available on foot or by cycle.

GPS/heart rate monitoring

The pupils' movements were monitored by global positioning system (GPS Garmin Forerunner 305) while the heart rate was measured simultaneously (heart rate belts) with an average of 7 seconds' sampling frequency. The data collection was conducted on regular school days in October 2007 in good weather conditions with a temperature of above 10 °C and heavy rain on one afternoon. Altogether, 81 pupils' movement patterns and activity levels were monitored, each for one day. Due to the limited amount of equipment the data collection took seven days, stretching over three consecutive days in Gudeberg and four in Begby. The data was downloaded and processed in database management software (Fjørtoft et al., 2010). Because of problems with the equipment, only 73 pupils' movement patterns were used in the analysis process. The time interval for afternoon activities was defined as running from the time the pupils left school (1pm) until late in the evening, when activity was very low (11pm). The movement patterns were analysed using the ESRI ArcMap© software.

The PA levels were categorized according to Reilly et al. (2004) and Ridgers et al. (2007):

- low activity: HR[1]<120 bpm
- low-moderate PA: HR=120-140 bpm
- moderate-to-vigorous and vigorous PA: HR>140 bpm.

1 HR: heart rate

When analysing the activity levels, observations with HR=0 were excluded.

For the analysis, the observations were aggregated to locations and along the road/track system for further analysis. Through this method it was possible to get an overview of the whole pattern and carry out analysis at group level. This was a logical choice so as to compare with the child track data (explained below).

To define activity areas the registrations were aggregated in 10x10 m and 100x100 m regular grids. With these two scales it was possible to identify areas for less and more space demanding activities. For each cell the following values were calculated:

- total spent time
- number of subjects
- average heart rate
- percentages of the above defined activity levels.

Cells where the aggregated total time spent was equal to or more than 30 minutes were defined as hotspots (Figure 1a).

To define average activity levels along the road/path system the observations were aggregated to the existing road/path network (Statens kartverk): every observation closer than 10 m to a road segment was connected to that segment. From these observations the segments were given an average heart rate value (Figure 1b).

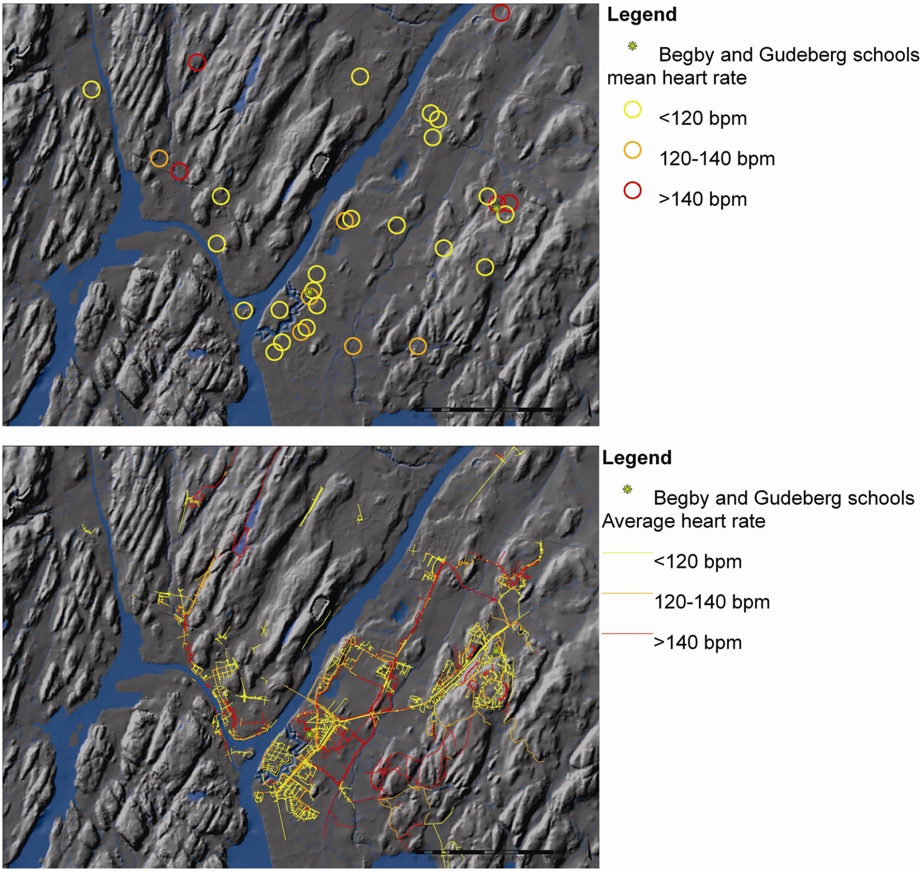

Figure 1 Hotspots (a) and activity levels (b) along the routes

Children's habitat maps

In the next data collection phase an extended version of a participative planning tool, called child track[2] (Almhjell and Ridderstrøm 2003), was used to gather self-reported data about the adolescents' activities. This method was developed originally for use in practical planning; in this project we adapted the further developed digital version (Norsk Form & Statens kartverk) to the research purposes. This extended version was called *children's habitat maps* (Aradi 2010).

The data collection took place in three stages. The first preparation phase was a self-guided walking tour with paper maps and disposable cameras in October 2008. The pupils used the cameras in groups but prepared paper maps individually and described their photos. In Gudeberg the students used the PA lesson for the outdoor mapping tours; in

[2] Barnetråkk in Norwegian

Begby they did it for homework. The weather conditions were generally good with the temperature around 10 °C.

After this the pupils digitalized their registrations and completed with descriptive information in an online mapping program (KartISkolen 2010). This part was carried out in the schools individually (Begby) or in small groups of two to three pupils (Gudeberg) with the guidance of researchers from the research group. It took place in November 2008 (Begby) and in January 2009 (Gudeberg). The registered data types were as follows:

- Point features: *Places* the pupils wanted to improve or considered as dangerous. Descriptive information about the proposed change or perceived danger.
- Polygon features: *Areas* they used. They registered the estimated number of users, the activity types and seasonal differences. We categorised the activity types into twelve classes (Table 1).
- Line features: The *roads* and tracks they used with a distinction between school and free time use and descriptive information about the perceived dangers if there were any.

The digital data were downloaded from the KartISkolen website and was processed in ArcGIS© software. The paper maps were also digitalized and used in spatial analysis. Information that cannot be interpreted and/or is ethically sensitive (e.g. private homes) was removed from the database.

Table 1 Activity types from the children's habitat maps

Summer activities

- paintball
- football
- riding
- rowing
- other ballgames
- skateboarding
- biking
- using play equipment
- meeting friends, hanging around (built up / nature)
- shopping

Winter activities

- skiing
- ice skating

Landscape scale analysis

The landscape character analysis is the expert's interpretation of landscape. In this project it was the description of the physical landscape that specifies potential affordances for PA.

Interpreting affordances as a combination of properties, Gibson claims that 'the invariant combination of properties is "meaningful" whereas any single property not' (Gibson, 1977:68), which moves the focus from the attributes to the complex landscape level. In this research project the combination of properties meant the specific combination of the physical environment factors that suited the adolescents' PA behaviour.

There are both positive and negative affordances in the environment. These were explored through landscape analysis in this research project. The factors that might limit the use of this arena for PA were approached through the legal regulations and barriers (specified later).

Landscape characterisation: potential environmental affordances

The landscape characterisation explored the combination of different layouts or 'shapes of surfaces' (Gibson, 1977:77) in local landscape scale. It provided an overview of the variation of landscape in the whole neighbourhood area. This method originates from the Sauerian traditions that "describe...the *morphology* – that is, the shape, form and structure – of a given landscape, and in so doing ... reveal the characteristics…of the human cultures that had inhabited and moulded it" (Wylie 2007:23)

Landscape characterisation included specific themes that, according to the literature, might play important roles in PA behaviour. Landscape character areas were developed from the combination of these (Figure 2). The characterization method in this project focused on the physical structure. The selected themes were as follows:

- Terrain and water: water, steepness, landforms
- Vegetation typology (for non-built-up areas)
- Urban morphology: roads, built typology, vegetation typology

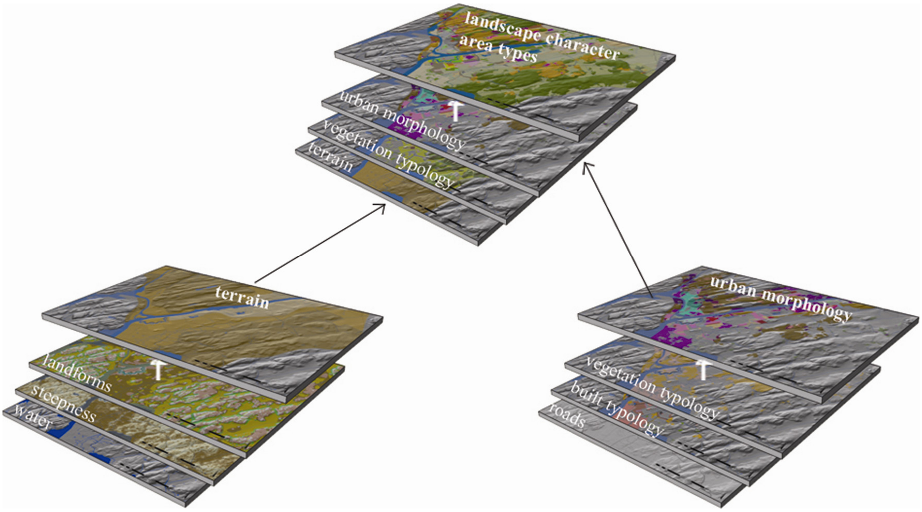

Figure 2 Landscape characterisation process.

Terrain

The ground is the basis for PA and, as Gibson (1977) describes, different layouts afford different activities. Steepness, landforms and water surfaces were analysed within the themes of terrain and water. Steepness determines how easy or difficult it is to pass an area, and thus how the terrain and landforms afford different physical activities like walking, hiking and climbing, or prevent activities. It is included in the landforms that describe the physical structure and accommodate the activities. The ground also gives the frame for visual perception, thus it visually guides locomotion. Water surfaces are highlighted as destinations for recreation and, beside landform and land cover, are key elements in the visual characterisation of landscapes (Brabyn 2009). As a medium or as a surface, water affords different physical activities both in summer and winter, but it also stops pedestrian locomotion.

The terrain in this research was categorised into three classes: plains (1), hilly terrain (2) and artificial terrain (ditch and palisade system around the old town and fortress) (3).

Vegetation typology

Variations of vegetation cover result in variations in activities (Fjørtoft 2000, Grahn and Berggren-Bärring 1995). Research shows that green areas play an important role in children's motor development (Fjørtoft 2001) and might be important for teenagers' outdoor activities (Gearin and Kahle 2006, Jago et al. 2005, Mäkinen and Tyrväinen 2008, Owens 1988, Travlou 2006, Ward Thompson, Travlou, and Roe 2006). The starting point for the vegetation typology was a digital map (scale 1:5000) of green structure classification (Thorén 2000), provided by Fredrikstad municipality. It defines two main classes for the vegetation cover: natural/cultivated and subcategories based on the structure and layers (Table 2). These categories give a three-dimensional understanding of the vegetation, i.e. its role in spatial structure. This map was updated manually in ESRI ArcMap© by using orthophotos (TerraTec AS 2007).

Table 2 Vegetation typology

Natural areas (n)	**Cultivated areas** (k)
>40% tree cover natural area	>40% tree cover cultivated area
<40% tree cover natural area	<40% tree cover cultivated area
half open natural area	half open cultivated area
open natural area	open cultivated area
water	grey cultivated area

Urban morphology

'Urban morphology is a study of the form and shape of settlements' (Carmona 2003:61). It usually embraces land use, building structure, plot pattern and street pattern. In this study, for the built-up areas urban morphology was derived from built morphology and vegetation typology based on the method developed by Thorén et al. (in Haug 1997). Urban morphology in this study was a combination of three themes: roads, built typology and vegetation typology.

Built typology is usually developed from building structure, plot pattern and street pattern. In an urban settlement environment the construction, accessibility and design of the outdoor space were found to influence PA behaviour in adolescents (Babey et al. 2008, Boone-Heinonen et al. 2010, Jago et al. 2005, Kerr et al. 2006, Kligerman et al. 2007, Limstrand 2008, Mota et al. 2005). These are varied within a city; thus, the affordances offered are significantly influenced by the built morphology. For the classification of built-up areas a building database from the Felles KartdataBase (Statens kartverk) was used (Table 3).

The road/path network (Statens kartverk) was classified into grid and organic categories based on visual assessment.

Table 3 Built typology

Built typology	
Small detached houses in organic structure	Row and terraced houses
Orderly small & bigger detached houses	Big multi-family houses
Urban block structure	Scattered housing
Blocks of houses	Detached big buildings

Landscape character are types

The developed landscape character area map (Figure 3, Table 4) was prepared from the vegetation typology, urban morphology and terrain. It consists of smaller unique area types (37) with individual characteristics that distinguish them from the surrounding areas. This recognisable characteristic is the combination of properties.

Figure 3 Landscape character area types and activity types

Table 4 Landscape character area types

ID	Landscape character area type	ID	Landscape character area type	ID	Landscape character area type
1	Small detached houses in organic structure in half-open cultivated areas in hilly terrain	14	Scattered housing in half-open cultivated areas in hilly terrain	26	Grey cultivated areas on water surfaces
2	Small detached houses in organic structure in half-open cultivated areas in plains	15	Scattered housing in half-open cultivated areas in plains	27	Various nature areas in hilly terrain
3	Orderly small & bigger detached houses in half-open cultivated areas in plains	16	Scattered housing in grey cultivated areas in plains	28	Various nature areas in plains
4	Orderly small & bigger detached houses in half-open cultivated areas in hilly terrain	17	Detached big buildings in grey cultivated areas in plains	29	Open cultivated areas in hilly terrain
5	Urban block structure in grey/half-open cultivated areas in artificial terrain	18	Detached big buildings in grey cultivated areas in hilly terrain	30	Open cultivated areas in plains
6	Urban block structure in half-open/grey cultivated areas in plains	19	Detached big buildings in grey/half-open cultivated areas in artificial terrain	31	Open cultivated areas in artificial terrain
7	Urban block structure in half-open/grey cultivated areas in hilly terrain	20	Detached big buildings or scattered housing in <40% tree cover cultivated areas in plains	32	<40% tree cover cultivated areas in hilly terrain & riverside valley
8	Blocks of houses in half-open/grey cultivated areas in plains	21	Detached big buildings in <40% tree cover cultivated areas in hilly terrain	33	<40% tree covered areas in plains
9	Blocks of houses in half-open/grey cultivated areas in hilly terrain	22	Detached big buildings in half-open cultivated areas in hilly terrain	34	<40% tree covered areas in artificial terrain
10	Row and terraced houses in half-open cultivated areas in hilly terrain	23	Detached big buildings in half-open cultivated areas in plains	35	Half-open cultivated areas in hilly terrain
11	Row and terraced houses in half-open cultivated areas in plains	24	Grey cultivated areas in hilly terrain	36	Half-open cultivated areas in plains & artificial terrain
12	Big multi-family houses in half-open cultivated areas in hilly terrain	25	Grey cultivated areas in plains	37	Water surfaces
13	Big multi-family houses in half-open cultivated areas in plains				

Legal regulations and barriers

Legal regulations and barriers might determine the physical arena for the activities. The provision of areas for PA according to municipal plans means the zoned publicly accessible areas for recreational use. These are important possible target areas for free-time activities. Barriers are negative affordances (specified below).

Legal regulations

In destination-oriented transport the shortest/fastest connections have higher priority than other qualities of the environment. The community buildings and areas have, in many cases, certain functions that could explain some of the outcomes of the analysis. From the plans (Fredrikstad Municipality 2010a, b), those functions that could stimulate everyday movements were selected as possible destinations. Some of these were targets in everyday life; some were destinations for recreation, play and sports (details specified under Figure 4).

The hypothesis for analysing the provision of zoned green areas and possible target areas for PA in municipal plans was that lack of provision hinders PA. Overlaying the possible target areas with the landscape character area types also gave an overview of how important a role they play in adolescents' everyday PA. On the assumption that areas with better provision are more attractive for use for free-time activities, from the municipal plans the accumulated area size of the possible target areas and zoned recreational areas were calculated for each landscape character area types.

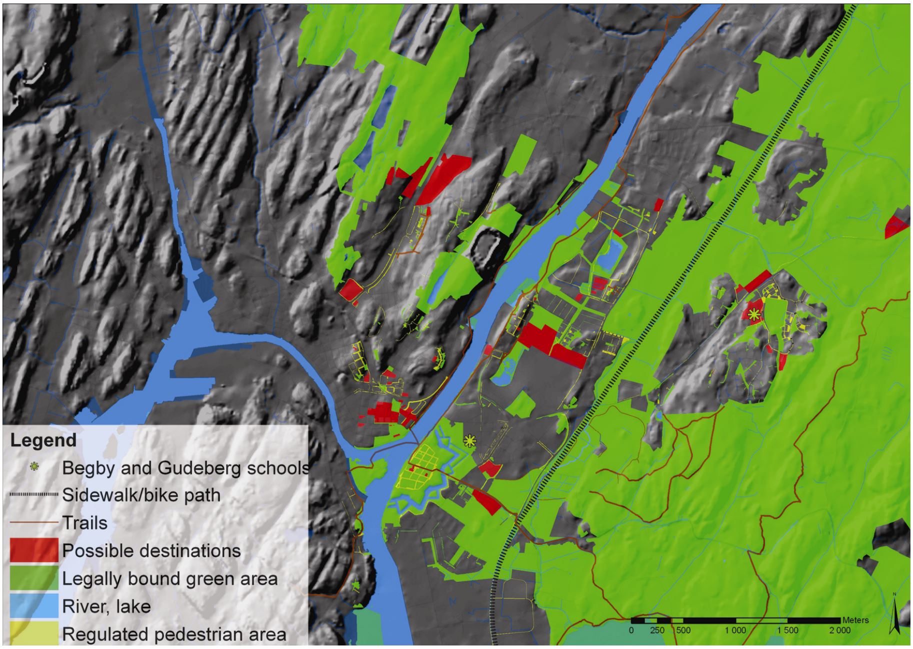

Figure 4 Zoned green areasa for physical activity in the neighbourhoods) and possible destinations

[a]parks, playgrounds, sport facilities, recreational areas for outdoor life, agricultural areas, nature and recreation areas, protected nature and cultural heritage areas, church yards, green isolation belts of industrial areas, small boat harbours (recreational buildings, educational institutes, community, administrative and public buildings, churches, gasoline stations

Barriers

Traffic was one of the main barrier to freely moving around, according to the students' own statements in the *children's habitat maps*. Official traffic information was available only for limited number of roads in the case area (Norge digitalt 2009). It showed heavy traffic on the main roads (Figure 5a). Of those roads where traffic data were available, all the roads/parts of them in the Gudeberg area were marked as "dangerous" by the pupils (Figure 5b). Places registered due to traffic danger located also along these roads (Figure 5b).

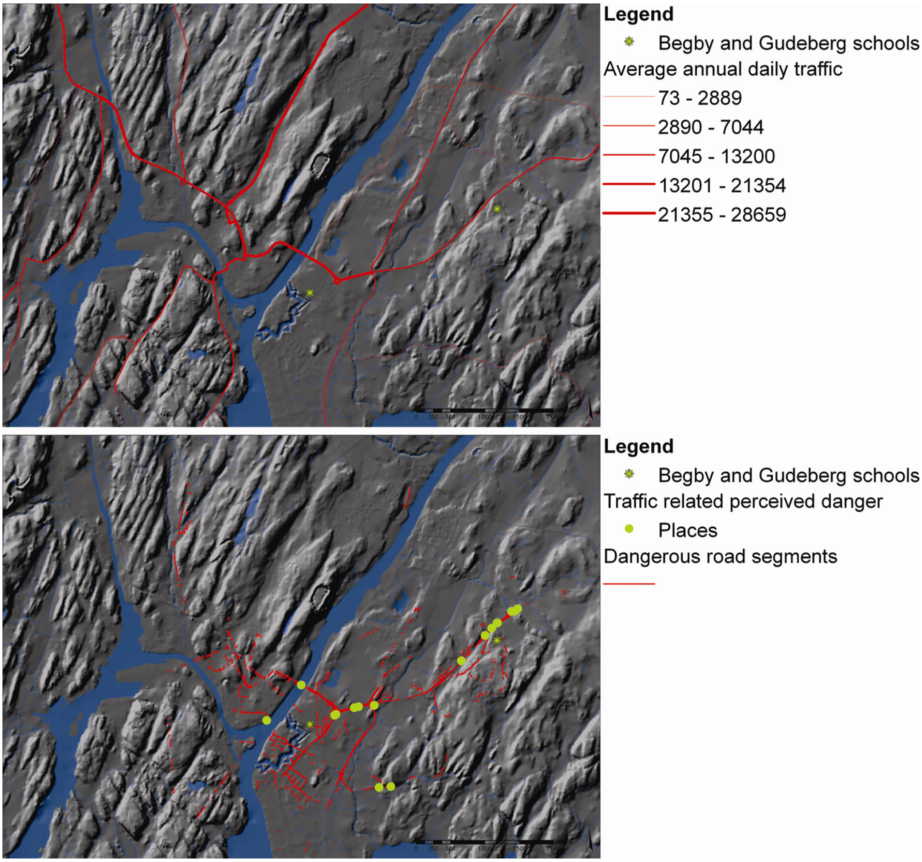

Figure 5 Traffic related barriers

The pupils reported *lack of lighting* as an important factor that hinders outdoor activities. They marked places either along main roads, along shortcuts or underpasses (Figure 6a). A greater number of locations were registered in the Begby neighbourhood, where more shortcuts were in the residential areas.

Perceived fear is an important barrier for outdoor activities. In this study *social issues*, mainly in terms of scary groups of people, were also considered as an environmental fear by the pupils. The places they avoided because of social reasons were in different locations but were mostly built-up areas (Figure 6b). Social fears did not connect to areas with special landscape characteristics but were reported mostly from Gudeberg.

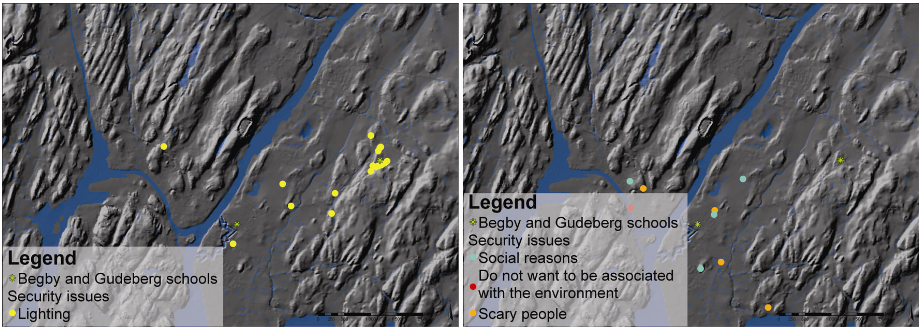

Figure 6 Other barriers

Summary of the results

In the analysis the hotspots, activity type areas and movement routes were overlaid by the landscape character area types, the zoned green/recreation areas and possible destinations. The spatial analysis were conducted in the ESRI ArcMap© program. The detailed results were presented and discussed earlier (Aradi, Thorén, and Fjørtoft in review).

The pupils' registered free-time activities showed a neighbourhood-oriented use. This meant an area of about 2.5 km around the schools. The spatial overlapping of the activities from Begby and Gudeberg was limited. The most popular activity was meeting friends/hanging around. The pattern of activity types was different in each of the two neighbourhoods: at Begby there were more activity types in fewer places, whereas Gudeberg had fewer activity types but in more registered places (Figure 3).

The activity patterns showed that despite their concerns the pupils did use places they marked with heavy traffic or lack of lighting or even those areas with social fears. In accordance with previous studies, our results also pointed to the importance of the neighbourhood design and road structure in stimulating PA.

Landscape level interpretation of the activities: classified actualised affordances

From the landscape point of view, we defined the actualised affordances for adolescents' as landscape character area types where their activities happen. Differentiating the landscape on the basis of the activities, we identified three main classes: (1) actualised affordances for getting together, (2) actualised affordances for various activities and (3) actualised affordances for high activity levels. These classified actualized affordances were the main result of the analysis. Each of these three categories included more of the landscape character area types that favoured the specified PA behaviours.

Affordances for getting together

Most of the areas used by many pupils were registered in non-residential areas. These were typically nature areas in various terrains, non-built-up half-open areas connected to residential areas, open grey areas, sports fields, lawns and park areas. There was also one urban area in the historical old town with mixed commercial/residential function.

Affordances for various activities

All the conducted analyses demonstrated that the single family housing area with organic road structure and scattered vegetation in hilly terrain favours outdoor activities; seven out of the twelve activity types were possible to found in this area type (Figure 3). Both built-up and non-built-up recreational areas seemed to be important for accommodating different activity types, e.g. meeting friends, football, ballgames, horseback riding, skiing, and shopping.

Affordances for high activity

The highest activity levels (hotspots with moderate-to-vigorous activity) were mostly in areas connected to recreational/commercial function or grey/cultivated sport fields. Some more active places were found in housing areas with half-open vegetation.
Nevertheless there was more high-vigorous activity registered along the routes than in the activity areas. Apart from the various nature areas in hilly terrain, the high activity level along the routes did not appear to be associated with special landscape characteristics and neither did the presence of bike paths predict high activity.

How did the methods function?

The combination of GPS with heart rate belts proved to be useful for exploring PA levels and patterns (Fjørtoft, Löfman, and Thorén 2010). The disadvantage of this method is that it is resource demanding and the data processing requires specialist knowledge. In this project the short-term data collection determined, to some extent, the possibilities for the analysis and the interpretation of the outputs. The analysis method (the hotspots and routes), was a practical choice: it gave the same type of information as the children's habitat maps.

The children's habitat maps method was a time-efficient way of collecting self-reported activity data (Aradi 2010). Processing the data was relatively simple, though the document analysis was more time consuming.

The choice of GPS/heart rate monitoring and children's habitat maps proved to be a good combination for collecting objective, measured and self-reported data on PA (Table 5). It was not possible to obtain activity type information from the GPS/heart rate study; instead, this was provided by the children's habitat maps. The data processing method made it possible to compare the results from these two data sources. The strength of combining these methods was that similar information was collected in different ways; thus, it was possible to test the credibility of the information. The GPS and child track registrations were overlaid in order to check the trustworthiness of the GPS data.

Table 5 Advantages and disadvantages of the GPS/heart rate monitoring and children's habitat map data collection methods

GPS and heart rate monitoring	**Child track**
Advantages • objective data about the used places • place located activity levels • gender information	**Advantages** • spatially located descriptive information: reason of choices • diverse and information rich descriptive data • place located activity types • general use • digital output • time efficient data collection, simple data processing
Disadvantages • psychological barriers limit the willingness to participate • short term data collection –> not general use • little information about the activity types • no information on the reason of choices • knowledge demanding data processing	**Disadvantages** • few/missing gender information • no information on activity levels

Landscape characterisation was suitable for obtaining complex information from big areas in a time-efficient way. It provided a good basis for interpreting the PA data: gave an overview of the variations in the landscape of the neighbourhood areas. This method made it possible to analyse several relevant themes together. The method gave a sufficiently detailed picture at the neighbourhood scale; however, further simplification of the categories might be possible based on their significance for activities.

The legal regulations and barriers gave important explanatory information for understanding PA behaviour.

Summary

The combination of GPS/heart rate monitoring, children's habitat maps and landscape characterisation seemed to be a suitable method to interpret PA patterns on landscape-scale. Both the GPS/heart rate monitoring and the children's habitat maps provided spatially located activity information and made it possible to explore activity routes and places. These methods were essential for identifying the actual usage, but the landscape characterisation revealed the spatial context of these activities. Nevertheless the method needs further refinement and specification. The high number of landscape character area types (37) made it difficult to interpret the results. Furthermore it would be necessary to develop a detailed description for the landscape character area types to make the results comparable with the commonly used environmental characteristics.

Discussion: Relevance of the landscape approach

Neighbourhood is the territory for everyday activities. 'Landscapes and places are the contexts of daily life…' (Relph 1989:149). Planning also happens on the landscape scale. Using the landscape approach, it was possible to give an overall detailed picture of this arena.

In the PA research practice many different combinations of environmental variables are used. This points to the need to find a more complex approach to characterise the physical environment. However, landscape assessment does not provide automatic answers. The attribute-oriented approach also exists in landscape analysis and has – in some cases – been sharply criticised: 'like judging wines by measuring their alcohol content – the information obtained may be accurate but it seriously misinterprets the subject matter' (ibid :149). Beside the practical need for a better way of describing the environment, the attribute approach is also questioned from a theoretical point of view. Gibson argued that the 'invariant combination of properties is 'meaningful' whereas any single property is not' (Gibson 1977:68) when opposing the perception of isolated properties with the perception of affordances. In the 'How the environment affords PA in adolescents' research project the landscape character area type is this combination of properties. The landscape approach went beyond the attributed-oriented level. It united the single properties and presented this combination as landscape character area types.

With the selected measurable attributes in this project the variation in landscape can be described. This is an expert's interpretation, but 'the line between "expert" landscape evaluation and public appraisal is usually clear and distinct' (Lowenthal 1978:389). What makes it the inhabitants' landscape is their perception. The landscape for everyday PA is the inhabitants' lived landscape where they express their perception of landscape through their activities.

The combined objective-subjective characterisation of the environment is a focus of PA research. Arguing in favour of objective characteristics (by using GIS), Davison and Lawson (2006) also point out that perception might have a stronger influence on behaviour than the objectively measured environmental variables. Ding et al. (2011) in their review suggest that '[f]uture studies should include both objective and perceived measures in one study' (ibid: 451). In this research project, through combining PA and landscape, both the objective and perceived landscapes were involved and synthesised. In this interpretation landscape for everyday PA is the inhabitants' lived landscape where they express their perception of landscape through their activities. Perception in this sense is represented by the choices people make when they decide which areas of the landscape to use for their activities.

This comprehensive landscape approach has made it possible to study complex phenomena of urban landscapes in relation to patterns of activity. With the analysis method of the 'How the environment affords PA in adolescents' project it was possible to bring the landscape perspective into the PA research that embraced many related research areas of active living. However we have to keep in mind that 'there are always multiple perspectives; that no one perspective can "tell the full story"; and that all perspectives aggregated do not necessarily sum to the whole of the phenomenon.' (Lincoln and Guba 1985:119)

Limitations to the method

Personal conversations and information on socio-economic status would have given more detailed background explanation for motivations and activity patterns. As Mäkinen and Tyrväinen (2008) concluded and Høybraaten (2008) also found, in her related master's study, mapping combined with explanatory data gives a much better understanding of outdoor area use. Although the children's habitat maps method provided descriptive information, walking interviews would have been useful additional data sources.

Based on the experience of this project, undertaking the digital mapping individually supported by personal guidance and discussion would have increased the accuracy of the information gathered. One case of a specific weakness of the method was that, due to the strict time schedule of the final exams, it was not possible to go back and discuss the registered data with the pupils; this would have strengthened the credibility of the results. When selecting the analysis method of movement patterns our aim was to compare the results from the GPS/heart rate monitoring and the children's habitat maps. The consequence of this choice was that the initial attempt to interpret the movement dynamics from the perspective of the landscape was not possible, though this opportunity is given by further analysis of the individual records.

Conclusion

The landscape approach seems to be relevant in PA research. The developed method in the 'How the environment affords PA in adolescents' project, i.e. the combination of GPS/heart rate monitoring, self reported activities by mapping/survey and landscape characterisation seem to be suitable to interpret adolescents' PA behaviour in landscape scale. However the method needs further development and refinement for improve practical applicability.

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8.4. Project description

How the environment affords physical activity: A transdisciplinary study of the environmental correlates of physical activity in adolescents

Revised project description to include PhD student.

(Abstract. Details in Esoknad: Project summary)

1. Introduction
The last few decades have been increasingly focused on environmental, socio-economic and modern life-style factors as major determinants of health and disease. Risk factors associated with modern life-style include obesity, high cholesterol, high glucose and high blood pressure levels, some of which are related to a sedentary life-style and to the metabolic syndrome (Deen 2004, Andersen et al. 2006). Health outcomes include major diseases such as diabetes, cardiovascular problems and possibly certain malignancies with decreased quality of life, high morbidity and premature death. Life-style risk factors are, to a great extent, preventable. Even minor reductions of risk factors with a high prevalence in the population, have a great potential for health improvement by lowering the population attributable risk (Barker, Rose et al. 1995).
Norway is reported to have the highest incidence of hip fractures in the world (Kanis, Johnell et al. 2002), a consequence of osteoporosis. To promote strong bones in adulthood, it is important to achieve an optimal bone mass in the twenties. The level of physical activity and adequate calcium intake are important determinants for peak bone mass, particularly in young girls before menarche (Parfitt 1994) and illustrates how preventive measures early in life promotes bone health in adulthood, lowering the risk of future fractures.
In 11-15 years old children, the degree of physical activity can be related to quality of life and subjective health experience (Nesheim and Haugland 2003), although with certain gender differences. However, physical activity seems to decrease, starting in teenage years or earlier, a pattern somewhat more pronounced amongst girls.
Governmental guidelines for physical activity address the importance of spatial and structural aspects of the environment to increase physical activity (Ministries, 2005). These guidelines identify young people as one of the special target groups, based on the fact that physical activity levels in young people decrease with age, (Bjelland and Klepp, 2000) and because low activity patterns in childhood and adolescence tend to persist into adulthood (Andersen, Wold & Hetland, 2005). This emphasizes the importance of planning for environments where young people can walk or bike to school and that offers good options for indoor and outdoor activities. Similarly, schools should provide areas suitable for physical activity and enforce organized physical activity.

2. Previous research on physical activity and outdoor environments
Previous studies on environment and behaviour in a land use perspective have mainly focused on the walkability and the bikeability of an environment, where environmental determinants for active living as well as policies promoting environments that support walking and cycling have proved positive (Moudon and Lee, 2003). An increasing number of studies published during the last years have their focusing on access to and qualities of the outdoor environment and opportunities for physical activity (Active Living Research Literature Summary 2006). Several of the studies however, seem identify outdoor qualities at a general level (distances to parks, size of areas etc). According to Sallis et al (2006), there is therefore still a need of research to provide detailed findings that can support improved designs for communities, transportation systems, and recreation facilities. Focusing on youth seems to be important since they belong to the understudied groups (Sallis et al 2006).
It is recommended that activities for children should be as diverse as possible in order to provide optimal opportunities for developing all aspects of physical fitness. It is assumed that active children get the exercise they need while playing in the neighbourhood, on school grounds and by participating in sports. Environmental factors may, in other words, have an important influence on children's physical activity, yet children's perspectives of their home and neighbourhood environments have not been widely assessed (Hume et al. 2005).
Schools are particularly important environments for children and adolescents due to the time they spend there. Especially in secondary school, physical activity during recess seems to be low, and also decreases from grade 7 to grade 9 (Bjelland & Klepp 2000). The explanation for this could be the short recess periods or that the schoolyard is deemed boring and do not promote activity (Limstrand 2003). According to Bjelland & Klepp (2000) and Thorén (2003) limitations in space, shortage of equipment and lack of natural environments seem to influence activity level.
Highly equipped schoolyards and playgrounds offer a variety of play forms that challenge physical activity. Lindholm (2003) has documented increased activity patterns in schoolyards that have areas of woods in them or near by. Diversity and natural playscapes are found to promote physical activity and motor development in small children (Fjørtoft & Sageie, 2000), but there is no systematic research describing adolescents' environmental preferences and how they relate to their level of physical activity. Lack of variation seems to have a gender perspective, for example, Schmidt (2004) revealed that school yards are often too small, and the main activity is football with the result that the outdoor environment mainly supports physical activity for boys. We do not know if that is the case even at a neighbourhood level.
To analyze environmental correlates, GIS-based digital maps have been used to quantify environmental parameters. For example the use of buffers around sports facilities to quantify accessibility. According to Saelens et al (2003) objective measures of land use strengthen many of the recently published studies. So far, the correlates studied fail to take account

of qualitative and more detailed landscape information. Existing studies seem to concentrate on single attributes/correlates in the outdoor environment without considering their spatial patterns, landscape context or how these interact.
Physical activity levels seem to be mostly based on self reports, but objective measures using pedometer or accelerometer are increasingly common. So far we have not found published studies using objective measures of physical activity levels combined with objective measures of landscape elements. Analysis of the relationship between objective measures of physical and environmental correlates of physical activity will benefit our understanding of the contextual relationship between people in action and the environment that promotes such actions. In the proposed study we focus on what kind of physical structures in the environment promote or hinder physical activity in children (youth 14 years old) to develop new integrative research tools and, through a PhD student, contribute to competence building in this field. The environment is here defined as the school surroundings, local neighbourhood and the road to school. The project will provide guidance for planners related to landscape design from a child's perspective.

3. Theoretical framework

Behaviour - Environmental approach to Physical Activity

The theoretical framework for a behaviour-environmental approach to physical activity is trans-disciplinary and emphasises some conceptual principles that are essential to understanding and influencing physical activity. Intrapersonal, interpersonal, physical environmental and socio-cultural variables function interactively to promote or hinder individuals' engagement in physical activity. Environment-behaviour relationships are transactional in nature - that is, they are characterized by recurring cycles of reciprocal/mutual influence between people and their surroundings (Sallis & Owen, In: Glanz 1996). People interact mutually with their immediate environment due to self-regulating mechanisms operating in behaviour settings, indicating that that people are components of a larger environment.
Behaviour-environmental approach to physical activity places emphasis upon mutual and interdependent relations among the individual, behaviour and the environment. Behaviour settings are regions of the physical environment where activities occur and thus comprise both the physical and social context of behaviour (Sallis et al.1998). Behavioural settings are potentially important to physical activity involvement through the physical structures and the cultivation of social connections between the individuals in the setting. Such settings consist of both environmental and behavioural components, which interact reciprocally. Examples of behaviour settings are public places, such as school, and playground where activities are performed, such as physical activity, games and play.
Through physical activity the children interact with various environmental settings. Children perceive and interpret what landscapes afford as functions for play, games and physical activity. Perceiving environmental objects is to perceive what they afford (Gibson 1979). Children perceive landscape elements as functions and use them in functional ways: trees for climbing, logs for balancing, stones for throwing and so on. Natural landscape characteristics and qualities, such as topography and vegetation, correlate to children's use of landscape features for play and physical activity. Landscape qualities, such as "corridors", meadows, shrubs, trees and rocks may afford different form for activities to children and may be identified as habitats for physical activity (Fjørtoft & Sageie, 2000). Children's interactions with the natural environment through play and physical activity have shown significant, positive effects on their motor development and fitness acquisition (Fjørtoft, 2000).
Environmental determinants are modifiable factors in the physical environment that impose a direct influence on the opportunity to engage in physical activity (Gordon-Larson, McMurray & Popkin, 2000). In this study behavioural patterns and environmental determinants will be studied in physical environments at micro- and meso- scales according to Bronfenbrenner (1979) and Sallis & Owens (1996). As nearly all children attend school and because they spend the larger part of their waken time in school, it seems important to understand the impact of the school environment (micro scale) on children's physical activity. Furthermore, the neighbourhoods (meso scale) are as important behavioural settings to young people in leisure time and will therefore also be included in this study.

4. Research Objectives and Approach

The main aim of the project is to increase our knowledge on which physical factors linked to schools and their neighbourhoods enhance or restrict levels of physical activity in youths and whether these are different for boys and girls. Addition of a PhD student on the project will contribute to competence building in this field of study.
The research objectives are to identify:

- the environmental and social correlates of physical activity in 14 year old children, as expressed through objective mapping of activity patterns and their intensity
- whether these correlates of physical activity significantly differ between boys and girls
- the roles of spatial scale and spatial patterns of the physical landscape, in relation to levels of physical activity, and how these may be used in landscape design.

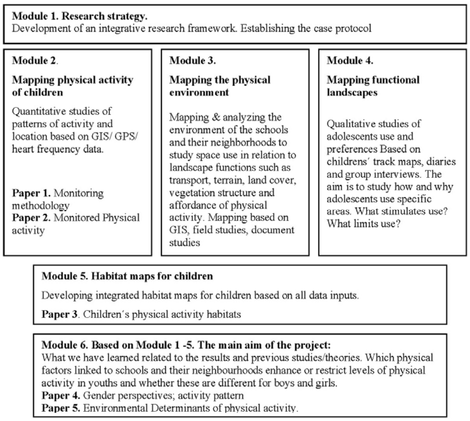
The project consists of 6 different modules described below. The figure presented in module 1 shows the structure of the project and how the different modules are linked together.

5. Research design and methods

Module1. Overall research approach

To be able to conduct and maintain activity-friendly societies for young people, it is crucial to understand how the natural and built environments influence physical activity in adolescents, specifically where young people prefer to stay and play in different environmental setting. Researchers have recognized the limitations of single disciplinary approaches to investigating the many spatial and structural facets of the environment that influence complex behaviour such as physical activity. The need to create bridges between diverse disciplines has therefore been identified (King, Bauman & Abrams, 2002). This transdisciplinray approach rests on the general construct of interactive relationships between human behaviour and the environments (Sallis & Owen, 1996).
The integration goals of this project, especially the analysis of spatial models as determinants of physical activity will be achieved through the development of an integration plan that will be operational from the start. We will develop links between the qualitative and quantitative components of the project through exchanges of concepts and data. Our aim is to

exploit qualitative models to assist in the interpretation of the quantitative results. The themes to be taken up in semi-structured interviews will be developed in part from analysis of the quantitative results of tracking children's movements and their environmental correlates. This strategy involves significant research dependencies that call for a high level of cross-disciplinary communication and understanding. We feel that the team have made a good start in this process and will use internal and external workshops and courses to ensure continued communication between the disciplines involved (see www.intels.cc). This process will provide support for the PhD student as well as further competence building in interdisciplinary research skills.
The six modules of the project and how they are related to each other:



The research design is based on case study methodology at the landscape/ neighbourhood level. Case study methodology provides a good opportunity to accomplish complex and interdisciplinary studies (Yin 2003). The study design will lead to the formulation of causal hypotheses and will give an insight into and deeper understanding of what might promote or hinder physical activity in adolescents. A case protocol will be developed to secure transparency and repeatability of the results obtained (Yin 2003).
In total, 2x 60 ninth grade pupils (14 years) will be studied from 2 schools in similar socio-economic catchments areas in the same municipality but located in different landscapes (e.g. contrasting topography, diversity) will be selected. This will reduce to a minimum effect of the influence differences in economic variables or planning policies. Unpublished studies (referred to in Thorén red. 2003) reveal that barriers to physical activity are greater when settlements are more than 2000 inhabitants. Therefore the selection of neighbourhoods will be from settlements with more than 2000 inhabitants and data rich regarding environmental data. The case study areas will be in a municipality in Østlandsområdet. As a starting point the school catchments areas will constitute the boundaries of each case. The fieldwork will focus on summer season physical activity.

Module 2. Measuring physical activity and movement pattern
Equipment and data catchments: To visualize the patterns of movement in different outdoor neighborhood areas, and to indicate the choice of landscape elements selected for different physical activities, each students movements will be tracked by recording successive coordinates over a time-line. See photo (Fjørtoft, Kristoffersen & Sageie in prep.). Simultaneously, the heart rate of students will be monitored at 5 second intervals as a surrogate measure for the level of physical activity. Sampling of data is made by use of a mobile device, slightly larger than a wristwatch and which combines the properties of a GPS receiver (Global Positioning Systems) and a heart rate monitor. The heart rate (beats/min) is picked up by simple chest electrodes recording the myocardial signal. The recording GPS-device (Garmin Forerunner 305) is thus tied to the child's wrist like a watch and records positions in the terrain as well as heart rate while the child moves.

Storage and analysis: The individual registration of coordinates (GPS tracking) and heart rate will be intermediary stored in a solid state memory and later transferred to a study data base (via a standard programs from Garmin) for further analysis in statistical packages and GIS software (ArcGIS 9.2) (Lo & Yeung 2006, Worboys 1995). Sites of different activities will be analyzed in relation to characteristics of participating students, such as gender, age and body weight, and by type of activity in relation to preferred sites.
GIS analyses and Spatial statistical analyses: By combining the GPS-collected movement patterns with thematic maps the correlation between structural determinants, spatial location factors and physical activity intensity are identified. The core areas for physical activity can thus be identified. The figure above shows the movement pattern of a single child (Fjørtoft, Kristoffersen & Sageie in prep).
Furthermore a digital elevation model (DEM) in raster format will be used to further classify the surrounding landscape by general properties such as distance, slope, vegetation structure and aspects which may also impact the choice of physical activity type. To produce a continuous surface map of physical activity, heart rate will also be analyzed at an aggregated level for groups of study participants by use of so called kriging interpolation (Cressie 1991) based on the average level of relative heart rate at different vocational coordinates. This approach will allow for analysis of both the interactions between individual participants and the environment, as well as between individuals and peers. GIS analyses will be performed by ArcGIS 9.2, Geostatistical analyst and Spatial analyst.
General statistics: Statistical analyses will be performed using the Statistical Package for the Social Sciences, SPSS/PC+. Behavioral software is available for the analysis of socio-ecological patterns and will help interpret the transactional aspects of the human-landscape interaction.

Module 3. Mapping and classifying the physical environment
Methods from landscape architecture will be applied to describe and analyse the physical environment in neighbourhoods and schoolyards. Geographic Information Systems (GIS) are increasingly being used for studying and identifying objective

environmental data related to physical activity behaviour. In the present study spatial information from existing land use/land cover maps, colour orthophotos and other sources will be utilised in GIS to objectively map environment aspects of the 2 school neighbourhoods.
The outdoor areas of the neighbourhoods selected will be mapped in high resolution using the digital maps of the municipality, aerial photos and field inventory of the outdoor and landscape structures (buildings, road systems, topography, slopes, vegetation structure, etc.), accessibility to outdoor areas, content and spatial arrangement of playgrounds sports fields etc. as well as fixed play equipment and sports facilities.
The aim will be to identify predictors of affordance for physical activity based on the analysis of physical landscape elements and structure. The approach will be based on the earlier methodological approach of Fjørtoft & Sageie (2000), recent developments in socio-ecological landscape modelling (Palang & Fry 2003; Sallis et al. 2006) and methods traditionally used in landscape planning/design.

Module 4. Mapping the children's landscape
Mapping of the landscape of children - a human centred approach. Children's landscapes will be mapped through interviews, diaries and activity maps drawn by children. Incorporating information based on the GPS tracking and the role of social interactions. The main reason for conducting a qualitative study on the use and interpretation of the outdoor environment is to gain a better understanding of the behavioural settings; what promotes and hinders physical activity. Three kinds of approaches will be used: 1) Adolescents will draw their own maps showing the way they use and interpret the outdoor environment, 2) Diaries explaining the activities written during one week (summer season), 3) Semi-structured group interviews with adolescents discussing why they use/ do not use specific areas and how they interpret them compared with results of the quantitative studies in the same area. Interviews will be based on measured physical activity and movement patterns, diaries and maps
A landscape ecological approach will be used to identify the functions of specific landscape elements. Concepts from landscape ecology will be used to map significant biotopes and sociotope patches (Ståhle & Sandberg 2003), their shape, form, spatial pattern and the social meaning of the patches. We will focus on the flows of children through the landscape and movement corridors between important resources patches such as the home and school, recreational space and rest place. The spatial configuration of landscape elements, especially of key patches (bio- and sociotopes) will be analysed to reveal relationships to test interactions between activity patterns and the spatial pattern/design of landscape at detailed and neighbourhood scales.

Module 5. Mapping habitat and the landscape of children
A combination of modules 2, 3 and 4 will be used to produce maps of the habitat of children, combining both the quantitative location and activity data from mapping children's location, and qualitative data on the way children use the landscape.

Module 6. Analysis and interpretation of the correlates of physical activity
What have we learned and how can we relate this to the results to previous studies and theories. An analytical framework for physical activity and environmental correlates will be developed. The PhD programme will continue into the final half year analyzing the results and publishing papers with members of the project group.

PhD Education.
UMB will be responsible for the PhD student education via a supervisor group (Kine Halvorsen Thorén main supervisor, with support from the other project members). The PhD student will join the UMB Research Group on Nature, Health and Well Being as well as taking part in courses with other research groups at UMB and through international exchange with time spent in Scotland (Open Space project – Edinburgh University/Macaulay Land Use Research Institute, Aberdeen). The PhD student will take an active part in Modules 3-6, and a lead role in analysing the landscape of children, especially in the cross-disciplinary challenge of combining qualitative and quantitative approaches and mixed methods. We have already worked with these issues and have experience of supervising students in integrative research (www.intels.cc).

6. Ethical aspects
Information will be given to pupils and their parents that the project has been approved by a research ethical committee and that participation is completely voluntary and require permission from parents. Collected data will be handled confidentially and working data files will be lack of personal identification numbers (PIN). Presentation of results will be given in aggregate form making identification of the single participant it impossible. Permission from the Data Inspectorate will be requested.

7. Environmental concerns
This project will not have any environmental impact except for children using the schoolyards, playgrounds and neighbourhood environments that are regulated for common traffic.

8. Resources in the project group and outcomes of the study
An interdisciplinary research group involving three different research environments described below will be established to work out the project.
Dep. Of Landscape Architecture and Spatial Planning (ILP), The Norwegian University for Life Sciences (UMB): The main responsibility of ILP-UMB is management of the project, mapping and analyzing the physical environments and the functional environments of the adolescents. Modules 1, 3, 4, 5 and 6.
Dept. of Mathematical Sciences and Technology (IMT), The Norwegian University for Life Sciences (UMB): The contribution from IMT-UMB includes data catchments and implementing the data in a geographical information system for spatial analyses and modelling. Modules 1, 2, 5 and 6.

Telemark University College (HiT) Department of Folk Culture and Teacher Education: The main responsibility of HiT is conducting the quantitative studies on physical activity using GIS, GPS and heart rate monitoring. Modules 1, 2, 5 and 6. Participating in the project also involves project planning and the responsibility of reporting achieved results in a scientific form (International scientific publications), writing of popular scientific papers and arranging external workshops. More details are available in the project publication plan.

9. Project timetable
Details in Esøknad: Project and timetable

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8.5. Data collection and processing

GPS/heart rate monitoring

Leader of the data collection: Ingunn Fjørtoft, HiT

Duration:

Gudeberg: Tuesday, 9 – Thursday, 11.10.2007

Begby: Monday, 15 – Thursday, 18.10.2007

Participants: 81 pupils. Due to problems with the equipment 8 individuals had to be excluded; registrations of 73 participants were analysed.

Contact for data processing: Håvard Tveite, UMB IMT

Data filtering criteria for the afternoon registrations:

The registrations that have been removed from the dataset:

- all observations with 0 coordinates
- observations with >10 m/s speed
- observations with moderate speed (>5 m/s) and low pulse (<120bpm)
- all before 1pm
- all after 11pm

Data analyzed: 253831 observations, 636 hours activity

Activity levels along the routes:

For each road segments the observations closer than 10m were connected.

Database attributes:

- Type: road type from the NDD road database
- School: B-Begby, G-Gudeberg
- Male: true-male, false-female
- Avg_hr: average heart rate
- Objects: number of different filenames
- Recordings: number of observations

Filtering criteria for the individual activity routes:

- max 1 minute rest time
- minimum HR 120 bpm
- minimum speed: 0,5 m/s
- maximum gap in recordings: 3 minutes
- minimum distance for initiating new line: 25 meters
- minimum section duration: 90 seconds
- minimum diagonal of acceptable section bounding box: 100 meters look-a-head buffer size: 10
- query: select trim(filename), ST_X(the_geom), ST_Y(the_geom), tidspunkt, lap, rec, heartrateb from filteremspeed32 order by filename asc, tidspunkt asc, lap asc, rec asc

Children's habitat maps

Leader of the data collection: Kine Halvorsen Thorén, Renáta Aradi

Contact for data processing: Renáta Aradi

Data collection:

Begby

Preparation: Friday, 10.10.2008

- folders: 48, 26 girls, 22 boys
- paper maps (Figure I-IV):
  - 26 girls, from which 1 empty and 1 not understandable
  - 22 boys, from which 4 empty and 1 not understandable
- photos: 234 (registration sheet: Figure V-VII)

Digital registration: Wednesday, 12 – Thursday, 13.11.2008

- 45, 26 girls, 19 boys

Essays: 10

Gudeberg

Preparation: Friday, 10.10.2008

- folders: 32, 17 girls, 15 boys
- paper maps:
  - 16 girls, from which 8 empty
  - 15 boys, from which 5 empty and 2 not understandable
- photos: 268

Digital registration: Tuesday, 06 – Wednesday, 07.01.2009

- 43, 22 girls, 21 boys (in this 1 boy didn't finished)

Essays: 34 (18+16)

Figure I Children's habitat maps. Preparation phase. Paper maps. Overview map

BEGBY

Figure II Children's habitat maps. Preparation phase. Paper maps. Begby area

GUDEBERG

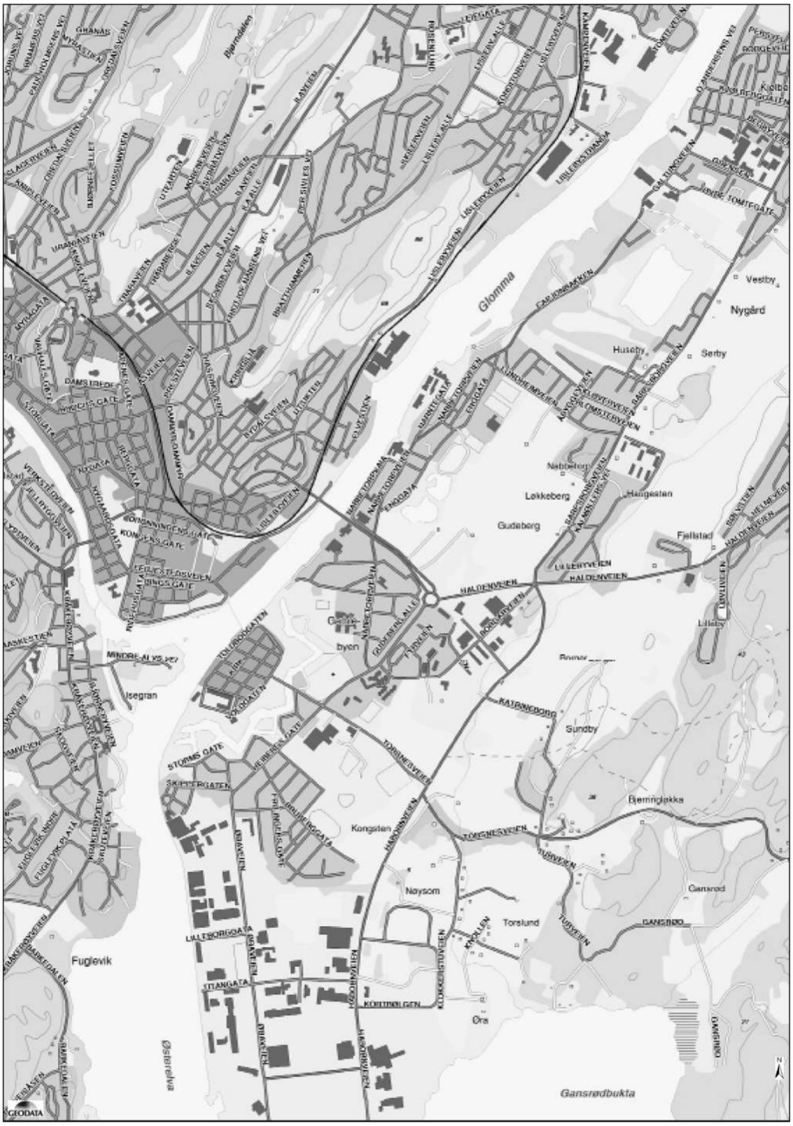


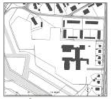
Figure III Children's habitat maps. Preparation phase. Paper maps**.** Gudeberg area

SENTRUM

Jente

Figure IV Children's habitat maps. Preparation phase. Paper maps**.** Fredrikstad centre

Gutt



Beskrivelse til fotografiene

Ta bilder av strekninger og/ eller steder du liker å bruke, og noter hvorfor du liker å bruke disse stedene/ strekningene.
Ta bilder av steder eller strekninger du ønsker å forbedre og beskriv hvorfor og hvordan de kan bli bedre.
NB: Det letteste er at dere tar bilder og beskriver fortløpende etter hvert som dere beveger dere rundt i området. Husk å markere fotonummer på kartet.

1

2

3

4

5

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Figure V Children's habitat maps. Preparation phase. Photo registration sheet

Gudeberg

22

23

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27

SPØRSMÅL OM AVSTANDER

Noter på kartet steder lengst unna der du bor og som du går til.

Hvor lang tid tar det å gå dit?........................

Hva heter det der?..

Noter på kartet steder lengst unna der du bor og som du sykler til.

Hvor lang tid tar det å gå dit?........................

Hva heter det der?..

Figure VI Children's habitat maps. Preparation phase. Photo registration sheet

Gutt

OM FRITIDSAKTIVITETER

Spørsmål om hvor du går og/eller sykler	Antall ganger pr uke NB: for alt du er med på		Antall timer pr uke NB: Samlet for alt du er med på						Er du vanligvis *(Merk med x! Du kan sette kryss i flere ruter)*		
	I sommer-halvåret	I vinter-halvåret	I sommerhalvåret			I vinterhalvåret					
			total	ute	inne	total	ute	inne	alene	med venner	med familie
Organiserte idretts- og treningsaktiviteter *(Fotball, aerobic osv)*											
Andre organiserte aktiviteter *(spiller piano, er med i teatergruppe osv)*											
Ikke organiserte idretts- og treningsaktiviteter *(trener alene, jogger osv)*											
Andre ikke organiserte aktiviteter *(spiller dataspill, ser på TV, går rundt, er ute, er sam-men med venner, familie osv)*											

Spørsmål om hvor du blir kjørt eller tar buss	Antall ganger pr uke NB: for alt du er med på		Antall timer pr uke NB: Samlet for alt du er med på						Er du vanligvis *(Merk med x! Du kan sette kryss i flere ruter)*			Er det mulig for deg å gå eller sykkel dit ?
	I sommer-halvåret	I vinter-halvåret	I sommerhalvåret			I vinterhalvåret						
			total	ute	inne	total	ute	inne	alene	med venner	med familie	ja/nei
Organiserte idretts- og treningsaktiviteter *(Fotball, aerobic osv)*												
Andre organiserte aktiviteter *(spiller piano, er med i teatergruppe osv)*												
Ikke organiserte idretts- og treningsaktiviteter *(trener alene, jogger osv)*												
Andre ikke organiserte aktiviteter *(spiller dataspill, ser på TV, går rundt, er ute, er sam-men med venner, familie osv)*												

Hva ville du aller helst gjøre på fritiden din hvis du kunne velge helt fritt:

....

Kan du gjøre dette i nabolaget der du bor? Ja....... Nei......

Hvis nei, hvorfor ikke?..

Hvilke områder ute på Begby er det aller best å være på fritiden:

Navn:..................

Hvorfor?..

Figure VII Children's habitat maps. Preparation phase. Questionnaire

Database and data processing:

General attributes of the digital child track database:

- navn: Name of the registered object, given by the pupils. For the line features it was the name of the school, i.e. Begby or Gudeberg.
- beskrivelse: Description of the registered object.
- userid: 72=Begby, 73=Gudeberg
- Specific attributes:
- Point features:
- stedtstype: change/try to avoid
- Polygon features:
- antgutter: number of boys
- antjenter: number of girls
- arstid: season
- skolebruk: school use
- sommerbruk: summer activities
- vinterbruk: winter activities
- Line features:
- vegtype: type of the way (schoolway/freetime)
- fare: danger (yes/no)
- farebeskri: description of the perceived danger
- annenfare: other perceived danger

Collected data:

- Point features: 55 Begby + 33 Gudeberg
- Polygon features: 27 Begby + 37 Gudeberg
- Line features: 123 Begby + 125 Gudeberg

Processing the line features (Figure IX-X):

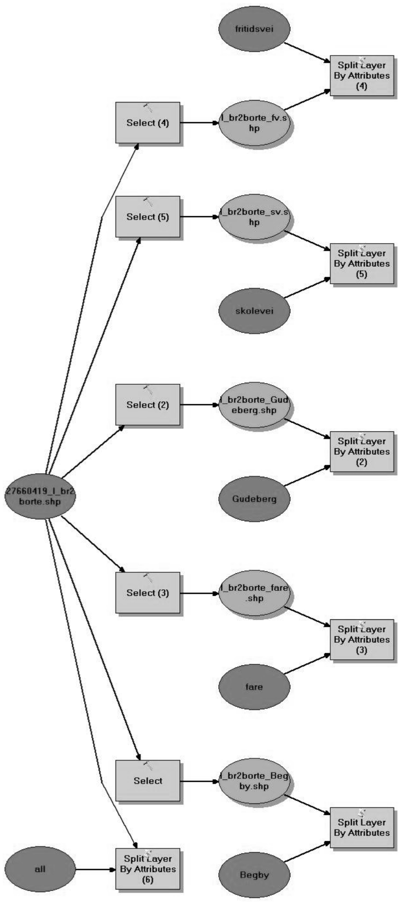

Figure VIII Data processing of the line features. Step 1. Thematic selection

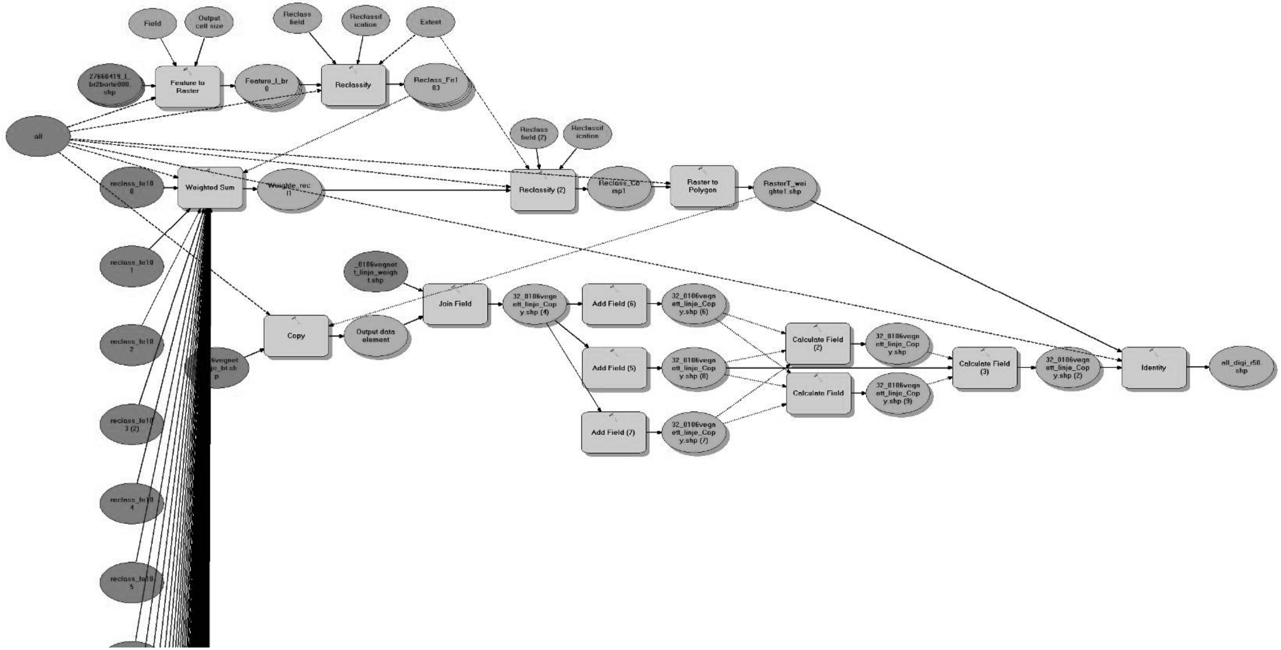

Figure IX Data processing of the line features. Step 2. Rasterizing, aggregating the data for the cells and converting back to vector data.

8.6. Main space syntax measurements

Table I Correlation between local integration measures and number of users from the digital child track mapping

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
HH_R3	61712	0	61712	0,333	3,648	2,220	0,595
sum_digi	61712	0	61712	1,000	36,000	5,597	6,517

Correlation matrix (Spearman):

Variables	HH_R3	sum_digi
HH_R3	**1**	**0,102**
sum_digi	**0,102**	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	HH_R3	sum_digi
HH_R3	**0**	**< 0,0001**
sum_digi	**< 0,0001**	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (Spearman):

Variables	HH_R3	sum_digi
HH_R3	**1**	0,010
sum_digi	0,010	**1**

Table II Correlation between control measures and number of users from the digital child track mapping

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
CONTROL	61712	0	61712	0,063	6,387	1,470	0,870
sum_digi	61712	0	61712	1,000	36,000	5,597	6,517

Correlation matrix (Spearman):

Variables	CONTROL	sum_digi
CONTROL	**1**	**0,064**
sum_digi	**0,064**	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	CONTROL	sum_digi
CONTROL	**0**	**< 0,0001**
sum_digi	**< 0,0001**	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (Spearman):

Variables	CONTROL	sum_digi
CONTROL	**1**	0,004
sum_digi	0,004	**1**

Table III Correlation between choice measures and number of users from the digital child track mapping

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
CHOICE	58738	0	58738	1,000	3649841,000	311722,595	642418,840
sum_digi	58738	0	58738	1,000	36,000	5,685	6,634

Correlation matrix (Spearman):

Variables	CHOICE	sum_digi
CHOICE	**1**	**0,170**
sum_digi	**0,170**	**1**

Values in bold are different from 0 with a significance level alpha=0,05

p-values:

Variables	CHOICE	sum_digi
CHOICE	**0**	**< 0,0001**
sum_digi	**< 0,0001**	**0**

Values in bold are different from 0 with a significance level alpha=0,05

Coefficients of determination (Spearman):

Variables	CHOICE	sum_digi
CHOICE	**1**	0,029
sum_digi	0,029	**1**