Mapping and characterising children's daily mobility in urban residential areas in Turku, Finland

NORA FAGERHOLM & ANNA BROBERG

Fagerholm, Nora & Anna Broberg (2011). Mapping and characterising children's daily mobility in urban residential areas in Turku, Finland. *Fennia* 189: 2, pp. 31–46. Helsinki. ISSN 0015-0010.

Independent mobility in a local environment is crucial for a child's development and physical activity, contributing to overall health and well-being. This methodological article describes a study capturing children's daily mobility in two residential areas in Turku, southwestern Finland, by combining the methods of GPS tracking, mobility diaries, interviews and questionnaires. Geographical positioning data enables analysis of spatial characteristics of children's mobility, e.g. the comparison to land use structure and analysis of the travel speed, while the qualitative data sets reveal how, why and with whom the travel was realised and the level of children's independence in mobility.

The results show that children's mobility is clustered around homes and schools and evident gender differences exist; boys travel longer distances and at higher speeds than girls. The children in Turku are relatively independent and have extensive mobility licenses. However, the travel undertaken to practise hobbies or participate in organised leisure activities is realised in adult company and significantly dominated by car transportation. The results strengthen the observation that Finnish children are allowed to travel rather independently and to explore the surrounding environment without adult company, using active forms of transportation. The significant level of independence is a consequence of the high perception of safety, both from the children and the parents in the residential areas. The described mixed methods approach, combining objective measurement of actual mobility with qualitative data sets, is applicable for further mobility studies and the results offer implications for planning child-friendly urban environments.

Keywords: child-friendly environment, GPS, independent mobility, mobility diary, perceived safety, Turku, Finland

Nora Fagerholm, Department of Geography and Geology, Geography Division, University of Turku, FI-20014, Finland. E-mail: nora.fagerholm@utu.fi (corresponding author)
Anna Broberg, Centre for Urban and Regional Studies, Aalto University, Helsinki, Finland

Introduction

Independent mobility in a local environment is considered to be an essential part of a child's development and, hence, a crucial characteristic of a child-friendly environment. By moving independently, children develop an understanding of their environment, build up a personal relationship with it and learn mapping and way-finding abilities (Hart 1979; Moore 1990; Holloway & Valentine 2000). Moving independently, without the presence of an adult, is also significant for the physical activity of children and the development of motor skills (Cooper et al. 2005; Mackett et al. 2007). Lately, concern about the decrease in children's independent mobility and the effect of that on children's health and well-being has been raised by many scholars in Western societies (Hill-

URN:NBN:fi:tsv-oa3877

man 2006; Wooley 2006; Mikkelsen & Christensen 2009; Skår & Krogh 2010; Woolcock et al. 2010). The problems related to overweight children are well documented, for example in the USA (Boarnet et al. 2005). Also, in Finland, the proportion of overweight children has been increasing during the last decades (Kautiainen et al. 2002).

Factors affecting children's mobility include age, gender, distance to school, parents' use of car, place of residence and structure of the physical environment, weekday versus weekend days, season and length of day light and perceived safety, and child-friendliness of the environment (Hart 1979; Hillman & Adams 1992; O'Brien et al. 2000). As space, the daily environment is very much gendered (Massey 1994), mobility as well has a clear gender dimension (e.g. Mackett et al. 2007). Studies on children's mobility show that boys are in general more active and move around more than girls in urban setting (Mackett et al. 2007; Brown et al. 2008; Mikkelsen & Christensen 2009). Fyhri and Hjorthol (2009) conclude that most of the variations in children's independent mobility to school are explained by their age and distance travelled. Furthermore, in our earlier studies concerning active transportation to and from school, we found that younger children commuted actively more than older children – mainly due to the longer trips to upper level comprehensive schools (Kyttä et al. 2010).

Parents are important regulators of their children's mobility patterns. Perceived safety of the residential environment and the so called 'stranger-danger' especially has an effect on the mobility licences that parents give to their children (see review by Carver et al. 2008). In general, boys tend to have more freedom in mobility than girls because of concern about vulnerability to social dangers (Hart 1979). Perceptions of insecurity, whether due to criminality or heavy traffic, lead to increased regulation of children's independent mobility and increase the number of journeys made by car. It is also worth noting that both objectively measured dangers, such as road accidents or crime figures, and subjective perceptions of dangers and insecurity, affect mobility licenses and physical activity levels of children even though the rise in perceived dangers is not necessarily reflected in the actual crime or accident rates. A study including urban and rural areas in the UK found out that parents consider abduction to be the greatest danger faced by primary school aged children leading to spatial restrictions in their mobility (Valentine 1997). However, in Finland the situation is not similar and dangers concerning traffic affect children's independent mobility more than the fear of crime (Kyttä 2003). On the other hand, in Finnish society, which has many characteristics that affirm gender equality and women's independent mobility, power over space is gendered and fear of violence restricts women's mobility (Koskela 1997).

Many studies have noted the characteristics of child-friendly urban environments that promote children's mobility. These include positive relations with dense urban structure, green areas, traffic lanes for cyclists and pedestrians, and good accessibility to play areas and services (de Vries et al. 2007; Frank et al. 2007; Carver et al. 2008). Our study in Turku, Finland, also shows positive correlations between dense urban structure and independent mobility; in such environments children commute more by bicycle and by foot, and independent mobility to places they find meaningful is also greater (Kyttä et al. 2010; Broberg et al. 2011). In addition, the amount of green structures in urban environments has a positive effect on the perceived health of the children.

In order to learn about mobility patterns, various methods have been employed. These include well-established methods such as interviews, questionnaires, diaries, observation and photographing (Cele 2006; Kesby 2007; Veitch et al. 2007; Pluhar et al. 2010; Porter et al. 2010) and the more recent technology of tracking using, for example, satellite based or mobile network positioning systems (Kesby 2007; Fjørtoft et al. 2009; Fyhri & Hjorthol 2009; Millonig & Gartner 2009; van der Speck 2009). It has been observed by many scholars (Mikkelsen & Christensen 2009; Millonig & Gartner 2009; Wridth 2010) that a mixed methods approach combining qualitative and quantitative methods is efficient when studying mobility patterns and physical activity. For instance, Mackett et al. (2007), Mikkelsen and Christensen (2009) and Pooley et al. (2010) studied children's mobility in their local environment in the UK and Denmark with the use of questionnaires, diaries and new technologies such as satellite based positioning systems and mobile phone short message service. These studies offer interesting insights into children's geographies when different types of knowledge, the subjective experience of place and objective measurement of time-space patterns of mobility are combined.

The first objective of this study is to analyse and map mobility patterns in 10–11-year-old children

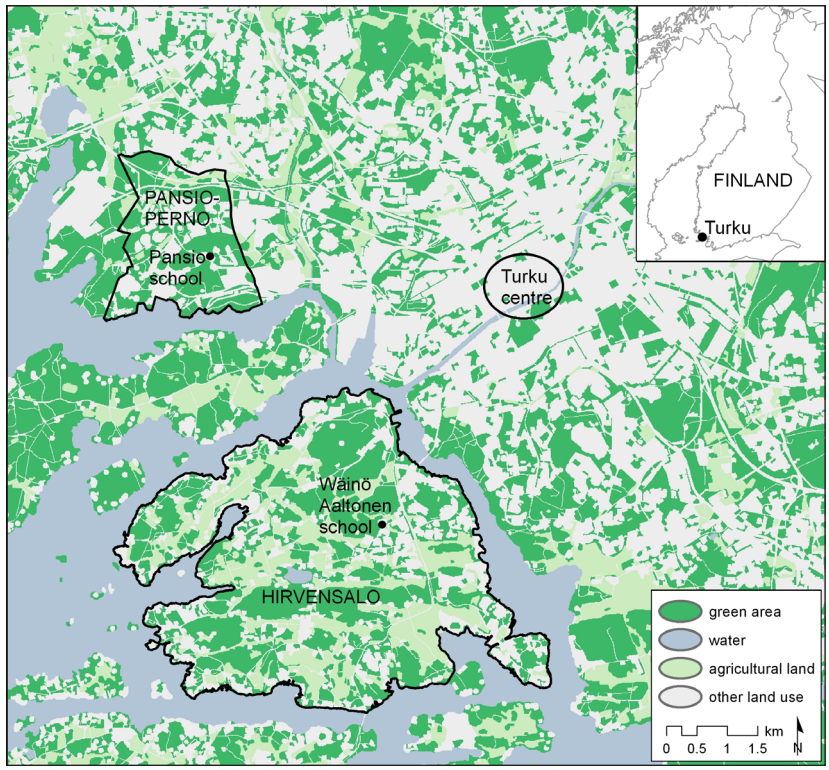

Fig. 1. Study sites Pansio-Perno and Hirvensalo residential areas in the city of Turku in southwestern Finland.

in two residential areas with differing levels of perceived child-friendliness in the city of Turku, Finland. A mixed methods approach combining the use of GPS (Global Positioning Systems) tracking, mobility diaries, interviews and questionnaires is applied. The study is among the first to monitor children's mobility through GPS and mobility diaries (see also Mackett et al. 2007). Secondly, the emphasis of the paper is on the methodological description of the research setting and methods of spatial analysis. The specific research questions can be formulated as: (1) What are the main spatial characteristics of children's daily mobility in the two residential areas of Pansio-Perno and Hirvensalo, in the city of Turku, and how do these reflect the residential environment; (2) How do children travel and with whom, and what are the effects of perceived safety and mobility licences on this, and; (3) How applicable is the applied methodology for understanding children's mobility patterns in urban setting?

Description of the study sites

Two residential areas in Turku, the fifth largest city of Finland with around 175,000 inhabitants, were chosen for study sites (Fig. 1). The criteria for the selection of the study sites of Pansio-Perno and Hirvensalo were the differences in urban structure and socio-economic characteristics and perceived child-friendliness between the areas and their population.

Pansio-Perno is predominantly a residential suburb with some green areas, where the main traffic route runs in an east-west direction. There are approximately 5000 inhabitants of whom 17.4% are children under the age of 15 (Turun kaupungin keskushallinto 2009). The area is one of the most multicultural suburbs in Turku. The levels of education and income are lower and unemployment rate higher than the Turku average (Statistics Finland 2010). In general, the inhabitants are quite satisfied with the close proximity of

public services, shop facilities and the public transportation services (Rasinkangas 2009). However, inhabitants are dissatisfied with the physical environment and green areas, and with the multicultural social structure of the suburb. The majority consider the area to be rather unsafe. Interestingly, regardless of the perceived insecurity, which is among the highest in Turku, the inhabitants are quite satisfied with the child-friendliness of the area.

Hirvensalo is a green island with the majority of the terraced and one-family dwellings concentrated along the main road that runs in a north-south direction from the mainland to the neighbouring island. There is only one bridge connection to the mainland, which carries the increasing traffic of commuting inhabitants. There are approximately 3400 inhabitants in Hirvensalo (Turun kaupungin keskushallinto 2009). One-fourth of the inhabitants are children under the age of 15, which is higher than in Turku in general. Income and education levels in Hirvensalo are higher than the Turku average and the unemployment rate is among the lowest in Turku (Statistics Finland 2010). In general, the inhabitants are very satisfied with the tranquillity and perceived safety of the area (Rasinkangas 2009). The environment is well appreciated and the closeness to the sea is a positive quality factor. Negative opinions arise from the lack of public services and poor public transportation connections. Hirvensalo is especially appreciated among families with children and the perceived child-friendliness of the area is the highest in Turku (Rasinkangas 2009).

Materials and methods

Research setting and data collection through GPS tracking, mobility diaries, interviews and questionnaires

To study children's mobility in an urban context within the two study areas, empirical data was collected through GPS tracking, mobility diaries, interviews and questionnaires. GPS positioning providing objective data of the actual mobility patterns in the real world together with diaries, questionnaires and interviews giving insight into the context and social aspects of mobility were complimentary, each adding important knowledge to the daily mobility of the studied children. Geographical positioning data enabled, for example, comparison to land use structure and analysis of the travel speed, while the qualitative data sets reveal how, why and with whom the travel was realised, as well as the level of children's independence in mobility.

Data was collected from primary schools in the residential areas and the participants in the study were 10–11-year-old 5th grade pupils. In both schools one class of pupils took part in the study. Participation was on a voluntary basis and some of the children chose not to participate. It was considered crucial among the research team that no pressure of participation was put on the children. All interested pupils had an opportunity to participate since the number did not exceed the number of GPS devices. Children had a written consent from their parents.

The data collection was realised between September and early October 2009. During four one-week data collection periods, 35 children (18 boys and 17 girls) collected GPS data and completed a mobility diary. The parents of the children were asked to fill in a questionnaire. Questionnaires were also completed by some parents whose children did not participate in the study; thus, 38 questionnaires were returned. Data collection was done in groups of a maximum of 10 children, who were carrying a GPS device over a one week period. Both school days and weekend days were included in the study period to cover the weekly variation in mobility patterns (see also Trost et al. 2000; Mackett et al. 2007; Mikkelsen & Christensen 2009). Each of the schools had two data collection weeks. One of the girls in Pansio-Perno was ill on the GPS return day and was allowed to carry the device for two weeks. Therefore, the amount of tracking data sets was 36. The researcher gave instructions for the participating children in the school, issued them with GPS devices and mobility diaries, and briefed them on their use.

The GPS device used in the study is technologically a professional device used for positioning services by a commercial enterprise. Positioning on the ground is based on satellite signals, which the GPS receives from 24 satellites orbiting the earth at high altitude. The location is given with some metres accuracy. The GPS used in the study is the Enfora Mini MT GSM2228, a small and lightweight device considered easy to carry by the children in a mobile bag around their neck. The children were instructed to carry the GPS with them all the time during the seven days except when they went to bed in the evenings or when the de-

vice might get wet. During the night, children were instructed to connect the device to a battery charger.

The GPS registered the position as point data every five seconds. A suitable registering interval was tested beforehand and the highest resolution of the device was selected for the study. Similar resolution has also been used in other mobility tracking studies (Fjørtoft et al. 2009). The data set from each device was recorded chronologically and sent to a server through GPRS (General Packet Radio Service) network and saved in a MySQL database. For spatial analysis, data was retrieved in shapefile format using GDAL (Geospatial Data Abstraction Library) tools. The company providing the devices also made available a web map service where the researcher could follow the location of each device in real time. The map service is not for public use, thus securing the privacy of the tracked persons.

One challenge related to satellite positioning systems is the strength of the signal which is weakened by cloudiness, tree cover etc., and in an urban setting the signal can bounce off buildings. The signal is also weakened or cut off when entering a building. This created random points and false locations in the data collected. Within this study, these errors were removed when creating the shapefiles from the database itself, using a filter of less than five for HDOP (Horizontal Dilution of Precision) value. This removed 11.1% of the point observations. In addition to this filtering, corrections were also done manually where abnormal locations were observed and an additional 0.2% of points were removed. This type of pre-processing of the GPS tracking data is essential to reach reliable results (Fjørtoft et al. 2009; van der Speck 2009).

Every child carrying the GPS device was instructed to fill in a mobility diary for each of the seven study days. The children noted where they were going, at what time, by which mode of transportation, with whom and what they were doing there. The diary was intended to capture details of the mobility patterns and assist in the interpretation of the GPS data. One page in the diary also included some background questions such as name, age, address, type of dwelling, height, weight and hobbies of the child. The children were also asked if anything in the surrounding environment made them feel unsafe and, in order to understand the degree of mobility licences, whether they were allowed to go independently to different places. Nearly all the children, 31 out of 35, returned the mobility diary after the week's tracking period was over.

After each GPS-tracking period, children were interviewed individually. The participants were asked if they had been carrying the device with them, charging it and filling in the diary every day. They were also asked if the week had been a normal one or special for some reason and if they had encountered any problems with the GPS device. In addition, children were asked whether they liked the study and what part especially. During the interview the children were also given the opportunity to add complementary information to the diary if needed. Interviews lasted 10–15 minutes. The interviews and diaries revealed that four of the children had been ill for 1–2 days during the tracking period and 48.6% of the children had sometimes forgotten the GPS device at home for some part of the day, for example when going to school in the morning or when going outside after school. In addition, one device in Hirvensalo was accidentally lost and the tracking period of one of the boys stopped after two days. For motivation, children were told in the beginning of the study that they would receive a small compensation after completing the tracking period properly and were given two movie tickets at the end of the interview.

An overall understanding of the children's and their families' daily mobility patterns was achieved through the questionnaire given to the parents. It was sent to them by the schools with an attached letter informing about the study. The questionnaire contained questions about parents' mobility patterns. Questions also addressed the issues of perceived safety in the residential area and how much the children are allowed to move independently, and how many mobility licences are given to them. For background information, the respondents were asked their age and gender, household details, income and education level.

Methods of data analysis

The systematic analysis of the empirical data included diverse methods. The background data and the journeys recorded in the diaries and the questionnaires for the parents were manually coded into digital databases and analysed in qualitative and quantitative way. Our interest in analysis laid in differences between the two differently profiled residential areas and between genders. Focus was

not placed on the diverse cultural backgrounds of the children as this could not be unambiguously derived or generalised from the data.

The positioning data sets collected with the GPS devices during the four weeks were analysed spatially in GIS (geographical information system) using ArcGIS 9.3 software. A GIS database containing the point data set for each child was created and these data sets were grouped according to the residential areas and gender. Location of the children's homes and schools were also digitised into the database. In order to calculate the length of the travelled routes, polyline data sets were created from the point data sets and added to the database. The length of the routes children travelled are, however, longer than the distance actually travelled due to the fact that when staying in one place or near a building, for example, the GPS records points at slightly differing places producing a star-like line pattern. Travelling speed was calculated using the length information between recorded GPS points and the registering interval of five seconds. Speed analysis was used to determine travelling speed and physical activity of the children within their residential area and near their homes i.e. inside 500 metres buffer from home. Features with speed higher than 125 km/h between two recorded GPS points were removed from the analysis.

To understand mobility patterns and the size of the territorial range that children's daily mobility occupies, the location of the GPS points was analysed in relation to their homes. A multiple ring buffer with a 500-metre distance between each ring was created around every child's home and the GPS points were spatially overlaid with the buffer zones to calculate the amount of points in each zone. To examine visually the GPS point pattern and to analyse the clustering of the points, point density was calculated in a raster surface using 50-metre (0.25 ha) cell size. In order not to generalise the data too much, the analysis was based on a 50-metre area of a neighbourhood. Point density analysis enhanced the interpretation of the data and helped to identify point clusters, which identify the areas where children travelled often or had been spending longer times.

Land use characterising the routes children travelled was analysed with SLICES land use classification information. SLICES data set (2006) is produced by National Land Survey in Finland by combining spatial data sets of the physical environment into one raster layer with a 10-metre cell size. For the purpose of this study, SLICES data was reclassified into four classes (green areas, agricultural areas, water and other land use, Fig. 1) to describe land use underlying the GPS tracking points. The green areas class consists of sporting and recreational areas, parks and woodlands. The agricultural areas class includes fields, meadows, plantations, fallow land and other agricultural land, while the other land use class consists mainly of residential, commercial and traffic areas in addition to all other land use classes. Due to the limited accuracy of the GPS, comparison to the features of the physical environment could not include small areas or points of interest, but the analysis was based on the categorisation between the above mentioned four classes. Also, roads were excluded from the classification because the GPS points sometimes followed the travelled road some metres alongside it.

Results

Characteristics of the informants and data

In Pansio-Perno, 17 children participated in the study (8 boys and 9 girls of whom one carried the GPS for two weeks and created two tracking data sets) and in Hirvensalo, 18 children (10 boys and 8 girls) participated. Of the children's parents that responded to the questionnaire, 31 were mothers, six were fathers and one was a grandmother. All the children in the Hirvensalo area live in terraced or one-family houses, while in Pansio-Perno only half live in terraced or one-family houses – the other half live in block houses. This reflects the housing structure of the residential areas. The majority of the children live within a 1 km radius of the school. However, the spatial distribution of the children's homes is more clustered in Pansio-Perno than in Hirvensalo where some children live on the other side of the island. The mean number of persons living in each household is a little over four and the most typical size per household is five persons. Owning a car is relatively common – only 16 % of the families do not own one, 47% own one car and 34% own two. The children have good access to bicycles; the average number of bicycles per person in each household is a little more than one.

The GPS tracking data set contained a total of 404,642 points recorded in both study areas (Table 1). The data set of each child consisted of 11,240 points on average, which means that each GPS

Table 1. Description of the GPS point data (total amount of GPS points, average amount of tracking hours per child and per day per child, average length (km) of the daily route for children during weekdays and weekend).

	n	Count	Ave hrs/child	Ave hrs/day	Route (km) weekday	Route (km) weekend
All	36	404644	15.6	2.5	11.2	20.2
Pansio-Perno	18	177375	13.7	2.2	10.2	21.7
Hirvensalo	18	227269	17.5	2.7	12.3	18.9
Boys	18	216966	16.7	2.6	12.4	25.1
Girls	18	187678	14.5	2.2	10.2	15.4

had been receiving data approximately 15.6 hours during the seven day tracking period. Per day, each device was receiving data for approximately 2.5 hours when the child was moving outside. The average amount of days during which the device received data was 6.3 instead of seven, because some children were ill or forgot to carry the device. The children in Hirvensalo were recording 0.5 hours more data per day than the children in Pansio-Perno and boys 0.4 hours more than girls. The typical mobility patterns of a boy in Pansio-Perno and of a girl in Hirvensalo are represented in figures 2 and 3. In the mobility diaries, the children marked on average four trips per day. A total of 769 trips were filled in the diaries during the four week tracking period.

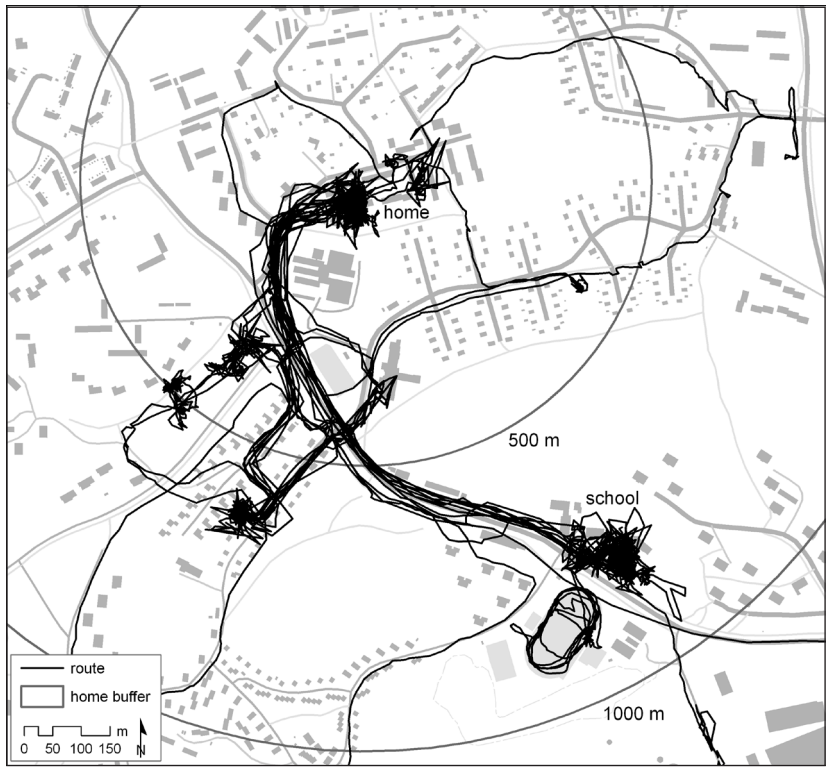

Fig. 2. Typical mobility pattern of a boy in Pansio-Perno. Figure indicates also 500 and 1000 meters buffer zones calculated from child's home.

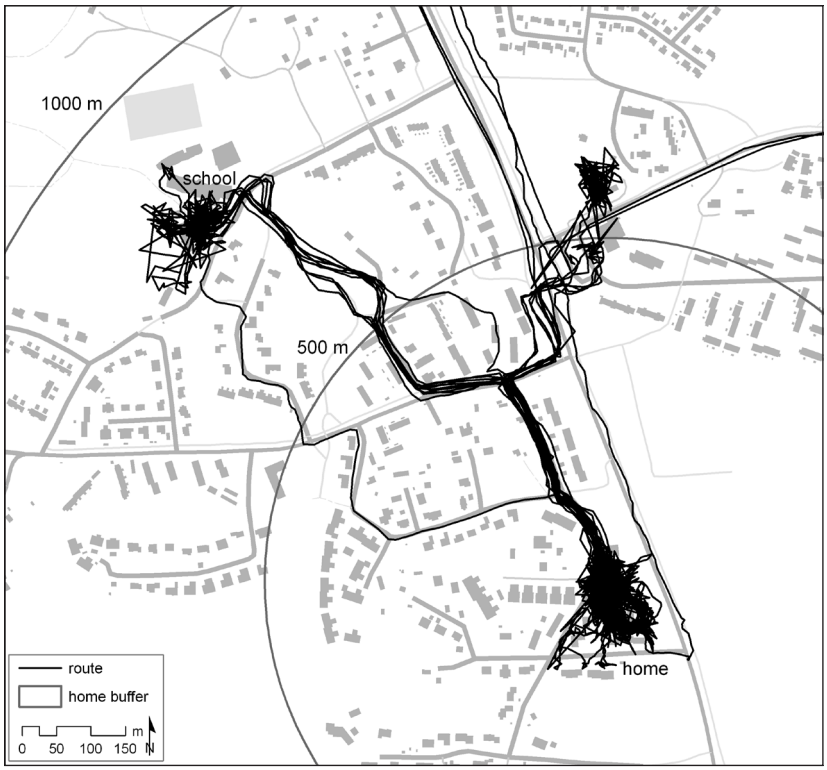

Fig. 3. Typical mobility pattern of a girl in Hirvensalo. Figure indicates also 500 and 1000 meters buffer zones calculated from child's home.

Nearby...

Children's mobility is characterised by proximity to home. The majority (59.4%) of the positioning data is received within a 0.5 km radius from the children's homes, which follows the result of our previous study in Turku, where children located over 50% of experientially meaningful environmental affordances within 0.5 km from home (Kyttä et al. 2010). Also, according to the mobility diaries, the nicest place in the surrounding environment is considered to be at home or in the home yard (22.9%). Weekdays and weekend days have a different type of mobility pattern, though. During weekdays, mobility is concentrated nearer the home and children travel shorter distances than during the weekend when they go, for example, to a football tournament or summer cottages (Table 1).

Visual examination of the point pattern density shows intense clustering of the points around schools and at children's homes (Fig. 4). The highest clusters are found at the two schools, where children normally travel every weekday and spend time in the school yard, and at places where they live close to each other and have overlapping daily routes. Children's mobility outside the residential areas mainly follows the road network. In the centre of Turku, there are some minor clusters at the marketplace and along the main traffic routes through the centre. Minor clusters are also found at the sports centre in the northern part of Turku, which is a popular training site for children's football teams.

The length of the daily route girls travel is shorter than the route taken by the boys (Table 1). However, our previous study about important environmental affordances that children marked on maps did not reveal any significant gender differences in the distances of the places from home (Kyttä et al. 2010). Interestingly, boys also move faster than girls near home and inside the residential area (Table 2). As in the case of the longer length routes, this indicates the activity level of boys. Boys tend to move around more than girls leading to a higher travelling speed. When asked

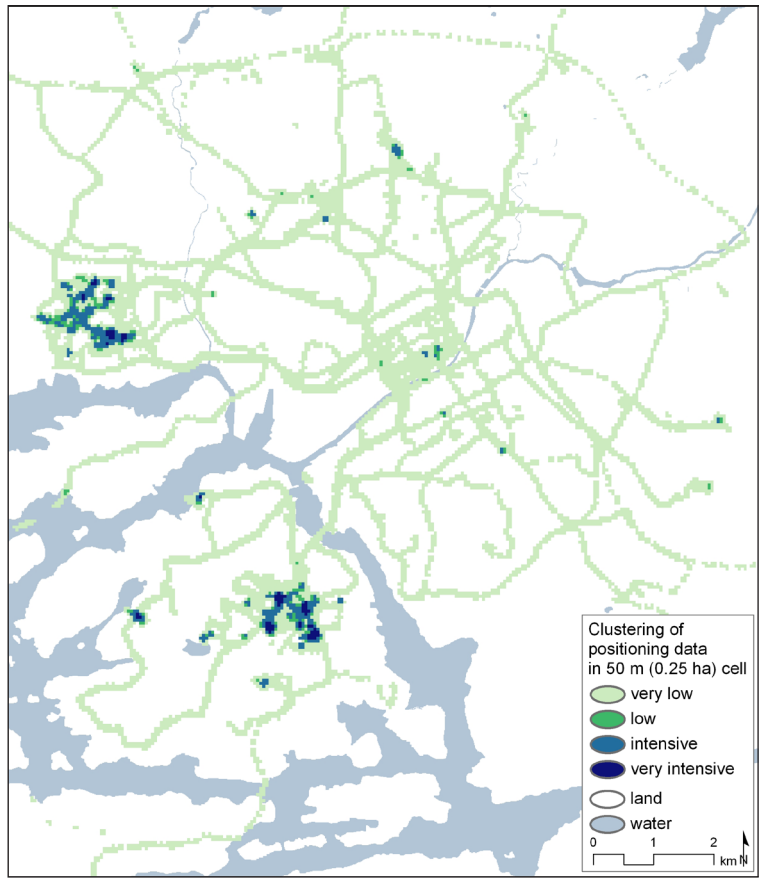

Fig. 4. Clustering of positioning data calculated as density of all GPS tracking points (n=404,644) per hectare in 50 m (0.25 ha) cell area.

about the nicest place in the surrounding environment, the girls prefer places near home more than boys do.

When looking at the land use underlying the routes, it is evident that much of the children's mobility happens in urban environments. The majority of GPS points fall into the other land use class, which is mainly characterised by residential, commercial and traffic areas. Approximately one-fifth (19%) of all the GPS points are found in green areas or agricultural areas (Fig. 5). As a result of crossing bridges, travelling by the river, living by the sea and boating trips, some 0.9% of the points lie on water areas. Almost all of the points in water areas (98.8%) and over 70% of the points in agricultural areas come from participants in Hirvensalo, reflecting the location and land use structure of the area.

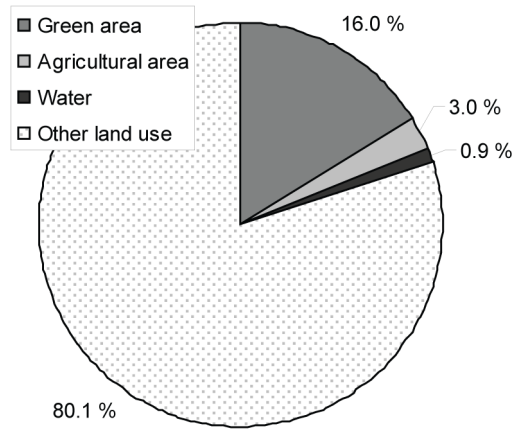

Fig. 5. Land use underlying each recorded GPS point. Land use data is retrieved from SLICES land use classification by National Land Survey in Finland.

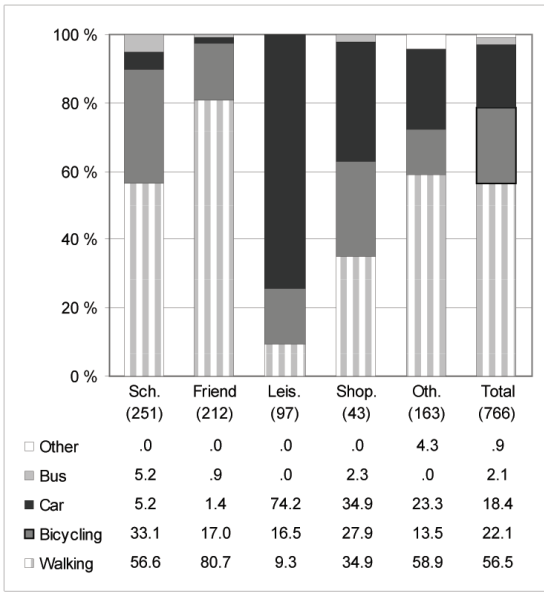

Fig. 6. How children travel. Actualised travels (n=766) and travel mode by travel type (travel type: Sch. = school trip, Friend = visiting friend or playing at home yard or nearby, Leis. = hobby or other organised leisure activity, Shop. = shopping, Oth. = other trip, Total = total amount of trips).

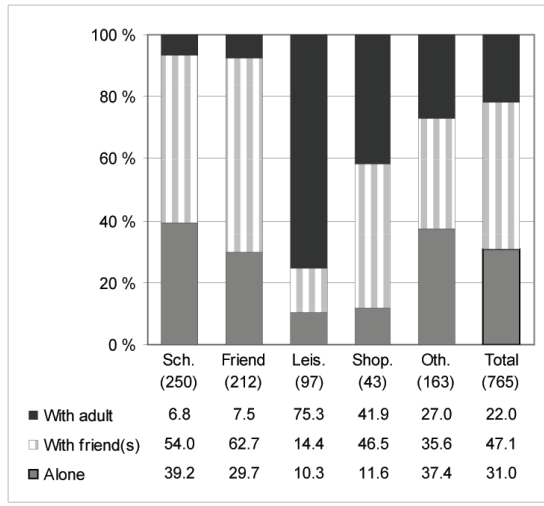

Fig. 7. With whom children travel. Actualised travels (n=765) and company by travel type (travel type: Sch. = school trip, Friend = visiting friend or playing at home yard or nearby, Leis. = hobby or other organised leisure activity, Shop. = shopping, Oth. = other trip, Total = total amount of trips).

...alone or with friends...

The type of travel is very much related to the travel mode and the level of independence in children's daily mobility as has also been observed in other studies (Kyttä 2004; Mackett et al. 2007; Mikkelsen & Christensen 2009). The majority (32.8%) of the children's daily mobility in the studied areas happens between home and school. School trips are mainly taken independently and children tend to walk or cycle to school alone or accompanied by friend(s) (Fig. 6, 7). Of all the trips, nearly 80% are by foot or bicycle and only 22% in adult company (Fig. 6, 7). In line with previous research (Mikkelsen & Christensen 2009), children's mobility is very much social and independent travel is often in the company of one or more friends. Mikkelsen and Christensen also found that the children's first priority is not to move around on their own, but they appreciate more the company of friends or pets, even family members, to share experiences. Moreover, visiting friends or playing outside in the home yard or nearby also accounts for a significant part of the mobility. Independence of mobility on these journeys is very similar to school trips; walking and bicycling are the dominant modes of travel and trips are rarely made in adult company. Children also travel quite independently to go shopping, especially within the residential area where they walk or bicycle to the supermarkets or kiosks. Turku city centre shopping facilities and other shopping malls are visited by car or bus normally in the company of an adult.

The different modes of travel on trips near home and outside the residential area can also be seen in the travelling speeds. The average travelling speed is 4.3 km/h within 500 metres of the children's homes and increases with the distance to home (Table 2). Outside the residential area, speed is 18 km/h on average. Travelling by foot and bicycle is more common near to home, while car or public transportation is used for longer distances. Children in Hirvensalo tend to travel outside their residential area more often and have longer routes during weekdays than the children in Pansio-Perno (Table 1). They also travel faster outside their residential area and outside the 500-metre home buffer compared to the children in Pansio-Perno. This higher speed is probably due to travelling by car. On the other hand, Hirvensalo children have

Table 2. Average travelling speed (km/h) for children within and outside the residential area and within and outside 500 meters distance from home.

	Total		Res. area		Out res. area		Buff. 500 m		Out buff. 500 m	
	Ave	SD	Ave	SD	Ave	SD	Ave	SD	Ave	SD
All	5.7	11.6	4.6	8.8	18.0	22.1	4.3	8.1	9.1	15.4
Pansio-Perno	5.7	11.1	4.5	8.0	15.9	22.6	4.9	8.4	8.7	14.3
Hirvensalo	5.8	12.0	4.6	9.6	19.5	21.7	3.8	7.8	9.4	16.4
Boys	6.1	12.5	5.0	9.6	16.8	21.9	4.6	8.6	8.5	15.6
Girls	5.5	10.8	4.2	8.2	18.7	21.9	4.2	7.7	9.5	14.9

a more concentrated mobility pattern according to the visual representation of the routes.

... though not to hobbies...

Over half of the children in both schools have one or more hobbies of regular physical activity such as football, floorball or dancing. Approximately one out of three children also has other hobbies such as scouting or cooking club. Of the recorded trips in the mobility diaries, 12.7% are to or from a hobby or other organised leisure activity. When looking at mobility to leisure activities, figures 6 and 7 express completely different results from the other types of travel: travelling to and from leisure activities is mainly done by car (74.2%) and in adult company (75.3%). One reason for this is that quite often hobbies are not practised in the vicinity of children's homes. The same predominance of car transportation to leisure activities has also been observed by Fyhri and Hjorthol (2009) when studying Norwegian children.

The parents were asked about their use of active transport in general: whether they walked or cycled to work or the grocery store, to take children to school/daycare and hobbies. A total of 37% said they never use a bicycle or walk to their everyday places, while the place most actively travelled to was the grocery store (42% using active transport to get there). No one used active transport to get to all of the places, and only two parents went to three of the four places actively. It can be concluded that both the study areas depend on private car transportation and this is in connection with the lack of children's independent mobility to leisure activities and shopping outside of residential areas.

… or when it's dark.

Children in both residential areas consider their immediate surroundings to be quite safe. Between 50 and 60% of children are not afraid of cars, cyclists, other people or adults, dogs and other animals. Every third child though is sometimes afraid of darkness or being alone outside, and every fifth child is scared of mopeds and scooters. Girls feel more unsafe than boys, which reflects the much researched gender difference of perceived fears and vulnerability (e.g. Hale 1996; Roh & Oliver 2005).

The daily mobility of the participating children is characterised by extensive mobility licences, which can be said to reflect the perceived child-friendliness of the residential areas. According to the mobility diaries, all the children are allowed to go to school and visit their friends without adult company. The majority (77.1%) are also allowed to go alone to practise their hobbies and to do shopping. However, half of the children are not allowed to go alone after dark. This restriction applies especially for girls. There are no significant differences in mobility licences between the residential areas except that children in Hirvensalo are more restricted from going shopping alone than participants in Pansio-Perno. The adults were also asked about the mobility licences they offer to their children using the same five items as in the children's questionnaire. The average number of licenses the parents gave to their children was 3.8. In total, 29% of children were free to do all of the things listed according to their parents.

As was expected, the parents had relatively positive perceptions of the safety of their home's immediate surroundings for children to move around

during daytime (Rasinkangas 2009); 21% thought that the surroundings were very safe and 79% thought they were rather safe. This perception of high safety is also identified in earlier studies in a Finnish context (Kyttä 2003; Kyttä et al. 2010) and strengthens the view that Turku is a city with no significantly perceived fears.

Conclusions

Children's mobility in the two residential areas in this case study is characterised by proximity to home. Indeed, over 80% of the tracking data of travelled routes were found within one kilometre distance from children's homes. Children mainly travel to school, play outside in the home yard or near home, visit friends and travel to leisure activities. As a result of the small territorial range, children's daily mobility is very much clustered in the vicinity of schools and homes. Especially during the weekdays, mobility is concentrated near home and children travel shorter distances than during the weekend. Boys who participated in the GPS tracking move outside more than girls and also travel longer distances. Boys also travel at a higher speed than girls. These results show conventional gender differences and are in accordance with the earlier understanding of boys being more active than girls in urban environments (Mackett et al. 2007; Brown et al. 2008; Mikkelsen & Christensen 2009). Children in Hirvensalo have a more concentrated mobility pattern, but they tend to travel longer distances than the children in Pansio-Perno. Within this study, the result reflects the extensive structure of Hirvensalo island, the longer distance to school the children have to travel compared to Pansio-Perno and travelling outside Hirvensalo for shopping and leisure activities. Also, the land use structure of the residential area reflects children's daily mobility. Overall, 80% of children's mobility is, however, characterised by residential, commercial and traffic areas.

The type of travel is very much related to the level of the child's independent mobility. Within the residential area near home and when travelling daily routes, children are allowed to walk or bicycle alone or in the company of a friend or friends. It is especially worth noting that school trips are taken independently by foot or bicycle. By contrast, in the USA, for example, bus travel is today the dominant mode of transportation to school as a consequence of the fact that children and parents tend to choose a school located too far from their home (Wilson et al. 2010). To avoid this development in a Finnish context, the school choice policy and urban planning should continue to support the near-home location of primary schools.

In adult company children travel mainly to practise hobbies and to participate in organised leisure activities, which are not located near home, or outside the residential area to shopping malls or to the city centre. The majority of these trips are taken by car and it is interesting to observe how the children are so dependent on adults when travelling to leisure activities. Our results from this case study are similar to those of Kyttä (1997), who found that the licences of children to move around independently are extensive and higher in Finland compared to many other countries. In addition, our previous study in Turku revealed that the majority of meaningful environmental affordances for children are reached without adult company (Broberg et al. 2011). Finnish children are, at least for the time being, in the fortunate situation of being able to travel rather independently and to explore the surrounding environment without adult company, using active forms of transportation. Mobility restrictions are experienced mainly after dark and especially among girls, which is an indication of the geographies of fear and danger (Koskela 1997; Valentine 1997). The generally high level of independence is related to the high perception of safety, both from the children's and the parent's perspective, in the residential areas. Differences can be seen especially in comparison to Australia where the child-friendliness of the urban environment and decreased independent mobility have been stimulating debate lately and safety is much related to social fears, the 'stranger danger' phenomenon (Veitch et al. 2007; Woolcock et al. 2010).

The observed high level of independent mobility also suggests positive developments in children's well-being and tackling the increasing problem of children being overweight. The results of the CAPABLE-project in the UK (Mackett et al. 2007) show that, when not in adult company, children tend to be physically more active and to walk more complicated routes. It is further significant for children's daily activity that those who travel less by car are also more physically active in any other type of activity (Cooper et al. 2005; Mackett et al. 2007).

The fact that children's daily mobility happens mainly nearby the home draws attention to the good and child-friendly planning of these environments. The importance of this is strengthened now when we clearly see how dependent children are on adults to take them to hobbies and organised activities. The planning and development of the immediate surroundings of residential areas must be taken as a priority in urban planning. On policy level, the importance of child and youth work as well as proper infrastructure and facilities for these in sub-urban areas should be promoted. Skår and Krogh (2009) have also pointed out that green natural meeting and play places are needed in urban neighbourhoods to create spontaneous play opportunities within a safe framework i.e. near home. Following the findings of this study, we agree with this argument.

The mixed methods study, combining objective GPS tracking with mobility diaries, interviews and questionnaires, has contributed to the understanding of children's daily mobility in urban environments and the methodology is applicable to further studies. However, our aim is also to share some methodological considerations and challenges, in order to give particular value for researchers studying children's mobility. Firstly, we observed challenges in data collection. Some of the children were very active and thorough in recording the trips travelled in the diary. However, many of the children did not put much effort into it or completed the diary at home in the evenings, which resulted in inconsistencies with the GPS data. The size of the diary (A5) might have been problematic because it could not fit in a pocket, making it difficult for the children to carry it with them all the time. Nevertheless, the size was as small as possible to have enough space for handwriting. Individual interviews after the one week tracking period provided useful information on the tracking data sets. Sometimes it was challenging to reconcile the GPS data with the mobility diaries because some of the trips were missing from the diaries, which was also observed by Mackett et al. (2007). Interviews revealed detailed information on how the children had been carrying the device during the week and could not have been captured otherwise. The real time web map service proved to be valuable as the school could be contacted if the signal from a device was lost. This was observed a couple of times and was mainly related to an empty battery. The school was then contacted and the teacher informed the child with the lost connection.

Secondly, the methods of GIS analysis were adjusted to the data. The accuracy of the GPS device used is restricted to some metres and, as a result of this, comparison of routes to detailed features of physical environments was challenging and left out from the analysis. Our activity analysis using children's travel speed is not very sophisticated but reveals some characteristics of physical activity. Combining the physical activity monitor with mobility tracking could provide even more knowledge on children's mobility in the Finnish urban context as experiences from the UK, New Zealand and Norway exemplify (Mackett et al. 2007; Duncan et al. 2009; Fjørtoft et al. 2009; Pooley et al. 2010). Thirdly, there is no seasonal variation in collected data. Therefore, no seasonal variation in children's mobility patterns is included. However, interesting results in seasonal variation have been proved to exist (Mikkelsen & Christensen 2009) and further research could increase knowledge of these patterns. In the Finnish climate, winter time mobility supposedly reveals different patterns compared to those observed in this study.

Conducting participatory research with children requires many ethical considerations, and especially in our research setting, when applying tracking of mobility patterns, these require special attention.[1] As we have already discussed, children were not pressurised to participate. Participation was on voluntary basis and children's decisions were respected. However, as parents take responsibility for children, participation is ultimately conditioned by them. We cannot be sure if it happened that a child was willing to participate but his or her parents refused, nor can we know whether not participating would have an effect on the child's position in the class. However, negative behaviour was not observed and not reported by the teachers. It was observed that many children were enthusiastic and motivated by the technology and the GPS device.

Both the children and the parents were informed that the collected data was used only for research purpose and not given to schools, parents or any other parties. They were also informed that anonymity is preserved and name data used only to link children to their parents. We decided also not to give any cartographical representations of the data, which would show the exact routes children had travelled to the children themselves nor to schools or parents. The web map service where children could be tracked was accessible through a password and open only to one of the research-

ers in the group. These measures were taken to ensure the confidentiality in the research setting as there exists the possibility that this kind of data on children's routes could also be used to harm them. Tracking mobility patterns creates objective data of the actual routes travelled in daily life. However, we are aware that tracking itself is not an unproblematic source of information in mobility studies, but embedded with ethical dilemmas. We are of the opinion that in each unique research setting researchers must subjectively make the best judgements and the proper ethical choices to ensure good practice.

Finally, to develop the mixed methods approach further, the results could be reflected with the children themselves, for example in a group discussion or workshop setting. Their local knowledge and perceptions are valuable in the planning and management of child-friendly environments (Pluhar et al. 2010; Wridth 2010) and future research on children's independent mobility could utilise a combination of tracking and participatory methods. This would make their voice stronger when it comes to the actual planning processes. However, different stakeholder groups such as children, young people, adults, elderly, disabled, immigrants, etc. should be equally heard to create not only child-friendly environments, but also to encourage living environments that fulfil the needs of a heterogeneous group of stakeholders in urban setting.

NOTES

[1] Existing ethical guidelines to follow are given for example in a Finnish context for research on children (Lagström et al. 2010) and in the fields of anthropology and GIS (American Anthropological Association 1998; URISA Board of Directors 2003).

ACKNOWLEDGEMENTS

The authors wish to thank the headmasters, teachers and naturally the pupils of the participating schools. We are grateful for the staff at TopOne ltd. for their valuable help in processing the data and for lending us the mobile devices in the first place. The project was funded by Tekes, the Finnish Funding Agency for Technology and Innovation and analysis supported by the Laboratory of Computer Cartography (UTU-LCC) at the University of Turku.

REFERENCES

American Anthropological Association 1998. Code of Ethics. <*http://www.aaanet.org/committees/ethics/ethcode.htm*> 4.11.2011.

Boarnet MG, Day K, Anderson C, McMillan T & Alfonzo M 2005. California safe routes to school program. Impacts on walking, bicycling, and pedestrian safety. *Journal of the American Planning Association* 71: 3, 301–317.

Broberg A, Kyttä M & Fagerholm N 2011. Child-friendly urban structures: Bullerby revisited. Journal of Environmental Psychology, in review.

Brown B, Mackett R, Gong Y, Kitazawa K & Pashkins J 2008. Gender differences in children's pathways to independent mobility. *Children's Geographies* 6: 4, 385–401.

Carver A, Timperio A & Crawford D 2008. Playing it safe: The influence of neighbourhood safety on children's physical activity – A review. *Health & Place* 14: 2, 217–227.

Cele S 2006. Communicating place: Methods for understanding children's experience of place. *AUS – Stockholm Studies in Human Geography* 16. Almqvist and Wiksell International, Stockholm.

Cooper A, Anderson L, Wedderkopp N, Page A & Froberg K 2005. Physical activity levels of children who walk, cycle or are driven to school. *American Journal of Preventive Medicine* 29: 3, 179–184.

de Vries S, Bakker I, van Mechelen W & Hopman-Rock M 2007. Determinants of activity-friendly neighborhoods for children: results from the SPACE study. *American Journal of Health Promotion* 21: 4, 312–316.

Duncan JS, Badland HM & Schofield G 2009. Combining GPS with heart rate monitoring to measure physical activity in children: a feasibility study. *Journal of Science and Medicine in Sport* 12: 5, 583–585.

Fjørtoft I, Kristoffersen P & Sageie J 2009. Children in schoolyards: tracking movement patterns and physical activity in schoolyards using global positioning system and heart rate monitoring. *Landscape and Urban Planning* 93: 3–4, 210–217.

Frank L, Kerr J, Chapman J & Sallis J 2007. Urban form relationships with walk trip frequency and distance among youth. *American Journal of Health Promotion* 24: 4, Supplement.

Fyhri A & Hjorthol R 2009. Children's independent mobility to school, friends and leisure activities. *Journal of Transport Geography* 17: 5, 377–384.

Hale C 1996. Fear of crime: a review of the literature. *International Review of Victimology* 4: 2, 79–150.

Hart R 1979. *Children's experience of place*. Irvington, New York.

Hillman M 2006. Children's rights and adults' wrongs. *Children's Geographies* 4: 1, 61–67.

Hillman M & Adams J 1992. Children's freedom and safety. *Children's Environments* 9: 2, 10–22.

Holloway SL & Valentine G 2000. *Children's geographies: Playing, living, learning.* Routledge, London.

Kautiainen S, Rimpelä A, Vikat A & Virtanen S 2002. Secular trends in overweight and obesity among Finnish adolescents in 1977–1999. *International Journal of Obesity* 26: 4, 544–552.

Kesby M 2007. Methodological insights on and from children's geographies. *Children's Geographies* 5: 3, 193–205.

Koskela H 1997. 'Bold walk and breakings': women's spatial confidence versus fear of violence. *Gender, Place and Culture* 4: 3, 301–319.

Kyttä M 1997. Children's independent mobility in urban, small town, and rural environments. In Camstra R (ed). *Growing up in changing urban landscape,* 41–52. Van Gorcum, Assen.

Kyttä M 2003. Children in outdoor contexts. Affordances and independent mobility in the assessment of environmental child friendliness. *Helsinki University of Technology, Centre for Urban and Regional Studies* A 28. Espoo.

Kyttä M 2004. The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments. *Journal of Environmental Psychology* 24: 2, 179–198.

Kyttä M, Broberg A & Kahila M 2010. Urban structure factors motivating active lifestyle among children and youth: a case study in the city of Turku, Finland. American Journal of Health Promotion, in review.

Lagström H, Pösö T, Rutanen N & Vehkalahti K (eds) 2010. Lasten ja nuorten tutkimuksen etiikka. *Nuorisotutkimuksen verkosto & nuorisotutkimusseura, Julkaisuja* 101. Helsinki.

Mackett R, Banister D, Batty M, Einon D, Brown B, Gong Y, Kitazawa K, Marshall S & Paskins J 2007. Final report on 'Children's activities, perceptions and behaviour in the local environment (CAPABLE)'. Centre for Transportation Studies, University College of London. <*http://www.casa.ucl.ac.uk/capableproject/Publications.html*> 16.6.2010.

Mackett R, Brown B, Gong Y, Kitazawa K & Paskins J 2007. Children's independent movement in the local environment. *Built Environment* 33: 4, 454–486.

Massey D 1994. *Space, Place and Gender*. Polity Press, Cambridge.

Mikkelsen MR & Christensen P 2009. Is children's independent mobility really independent? A study of children's mobility combining ethnography and GPS/mobile phones technologies. *Mobilities* 4: 1, 37–58.

Millionig A & Gartner G 2009. Ways of walking – developing a pedestrian typology for personalised mobile information systems. In Gartner G & Rehrl K (eds). *Location based services and TeleCartography II – from sensor fusion to context Models*, 79–94. Lecture Notes in Geoinformation and Cartography. Springer-Verlag, Berlin Heidelberg.

Moore RC 1990. *Childhood's domain: Play and place in child development.* MIG Communications, Berkeley.

O'Brien M, Jones D, Sloan D & Rustin M 2000. Children's independent spatial mobility in the urban public realm. *Childhood* 7: 3, 257–277.

Pluhar ZF, Piko BF, Uzzoli A, Page RM & Dull A 2010. Representation of the relationship among physical activity, health and perceived living environment in Hungarian urban children's images. *Landscape and Urban Planning* 95: 4, 151–160.

Pooley C, Whyatt D, Walker M & Davies G 2010. Understanding the school journey: integrating data on travel and environment. *Environment and Planning A* 42: 4, 948–965.

Porter G, Hampshire K, Abane A, Munthali A, Robsin E, Mashiri M & Maponya G 2010. Where dogs, ghosts and lions roam: learning from mobile ethnographies on the journey from school. *Children's Geographies* 8: 2, 91–105.

Rasinkangas J 2009. Turun asuinalueiden kehittyminen asukkaiden kokemana – muutosten kartoitusta vuosina 1999–2008. Turun kaupungin sosiaalikeskuksen julkaisuja, Turku (not publicly available).

Roh S & Oliver WM 2005. Effects of community policing upon fear of crime.*Policing: An International Journal of Police Strategies & Management* 28: 4, 670–683.

Skår M & Krogh E 2009. Changes in children's nature-based experiences near home: from spontaneous play to adult-controlled, planned and organised activities. *Children's Geographies* 7: 3, 339–354.

Statistics Finland 2010. Official statistics of Finland: Basic and quality criteria. Advisory Board of OSF, Helsinki. <*http://tilastokeskus.fi/meta/svt/svt-laatukriteerit_en.html*> 6.6.2010.

Trost ST, Russell RR, Freedson PS, Sallis JF & Taylor WC 2000. Using objective physical activity measures with youth: how many days of monitoring are needed? *Medicine & Science in Sports & Exercise* 32: 2, 426–431.

Turun kaupungin keskushallinto [Turku city central administration] 2009. *Turun kaupungin tilastollinen vuosikirja – Statistisk årsbok för Åbo stad 2007/2008*. Turun kaupungin painatuspalvelukeskus, Turku.

URISA Board of Directors 2003. GIS Code of Ethics. <*http://www.urisa.org/about/ethics#footer%20i*> 4.11.2011.

Valentine G 1997. "Oh yes I can." "Oh no you can't": Children and parents' understandings of kids' competence to negotiate public space safely. *Antipode* 29: 1, 65–89.

van der Speck S 2009. Mapping pedestrian movement: using tracking technologies in Koblenz. In Gartner G & Rehrl K (eds). *Location based services and TeleCartography II – from sensor fusion to context models*, 95–118. Lecture Notes in Geoin-

formation and Cartography. Springer-Verlag, Berlin Heidelberg.
Veitch J, Salmon J & Ball K 2007. Children's perceptions of the use of public open spaces for active free-play. *Children's Geographies* 5: 4, 409–422.
Wilson EJ, Marshall J, Wilson R & Krizek KJ 2010. By foot, bus or car: children's school travel and school choice policy. *Environment and Planning A* 42: 9, 2168–2185.
Woolcock G, Gleeson B & Randolph B 2010. Urban research and child-friendly cities: a new Australian outline. *Children's Geographies* 8: 2, 177–192.
Wooley H 2006. Freedom in the city: contemporary issues and policy influences on children and young people's use of public open space in England. *Children's Geographies* 4: 1, 45–49.
Wridth P 2010. A qualitative GIS approach to mapping urban neighbourhoods with children to promote physical activity and child-friendly community planning. *Environment and Planning B: Planning and Design* 37: 1, 129–147.