Physically activity is associated with a large number of health benefits, also for school-aged children. Therefore, the World Health Organization (WHO) recommends that children should participate in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) every day. Ideally, this should be combined with strength exercises three times a week. Unfortunately, it seems that only a small proportion of children worldwide meets these recommended levels of physical activity (PA). Thus, insight in children's PA patterns is warranted in order to develop effective interventions to promote children's PA. This thesis focused on examining the PA levels of children aged 8-12 years old in the primary school setting. With a novel method, i.e. the combination of GPS and accelerometry the following was investigated: (1) children's PA on the schoolyard; (2) children's active transportation on the journey between home and school, and; (3) the effect of infrastructural traffic safety changes in the school environment on children's PA levels.

Data was collected within two different study samples. The first sample was measured as part of the Spatial Planning and Children's Exercise (SPACE) study. For this study, children (n=97) were recruited at 6 schools that were located in 5 cities in the Netherlands (>70,000 residents). All children were asked to wear for one week a GPS receiver and an accelerometer. Measurements were conducted between December 2008 and April 2009. The second sample was measured as part of the ‘Schoolzone’ study. This was a natural experiment with a pretest-posttest design and two follow-up measurements. Baseline measurements started in April-June 2014. Follow-up measurements were conducted 6 months and exactly 1 year after baseline. Recruitment of the 11 primary schools in the ‘Schoolzone’ study was done in 5 suburban municipalities located in the Randstad; i.e. an urban agglomeration in the Western part of the Netherlands. This procedure resulted in a group of 463 children, 8-11 years old, out of which 299 children (64.6%) received parental consent to participate in the study. Children in the study were asked to wear a GPS receiver and an accelerometer during all 3 measurement weeks. Parents of the children filled in a questionnaire regarding questions about their neighborhood and changes in the school environment. In addition, semi-structured interviews were held with the school board and municipality employees.

**Schoolyard physical activity**

Based on GPS and accelerometer recordings in the SPACE study, insight was established in children's amount of MVPA on the schoolyard and inside the school building. Time on the schoolyard was broken down into different segments of the school day: pre-school, school recess, lunch break and post-school. During an average school day, children recorded 40.1 minutes on the schoolyard. PA levels on the schoolyard were significantly higher than their daily average PA level. Although children were only present on the schoolyard for 6.1% of the total recorded time, this time contributed towards 17.5% and 16.8% of boys' and girls' minutes of MVPA. The children were most active on the schoolyard during school
Summary

recess, during which boys recorded 39.5% and girls recorded 23.4% of the time as MVPA. Boys were more active on the schoolyard than girls, with 27.3% of their time spent as MVPA compared to 16.7% for girls. Also remarkable are the low numbers of MVPA that were accumulated when children were inside the school. For boys, only 2.1% of time that was recorded inside the school building was spent as MVPA, girls recorded 2.8% of their time inside school as MVPA. Thus, interventions are needed to interrupt this physical inactivity during class hours (e.g. by in-class physical activity breaks, environmental cues and equipment, such as standing easels).

Children’s active transportation between home and school
Children’s active transportation on the school journey was examined based on GPS data collected in both the SPACE study and the Schoolzone study. An automated procedure was used to extract GPS trips between home and school. The mode of transport of these trips (i.e., walking, cycling, motorized transport) was then determined using the average and maximum speed of the GPS tracks. First, the SPACE study data was used to explore active transport to school in relation to the distance between home and school. Then, baseline measurements of the Schoolzone study were used to examine the relationship between parental perceptions of the neighborhood and active transport to school. These baseline measurements were also used to investigate route characteristics of children’s active transportation routes.

Out of all school trips that were recorded in the SPACE study (n=812), 79.2% were classified as active transportation. Similar numbers were observed in the baseline measurements of the ‘Schoolzone’, where out of a total of 1,297 school trips 83.0% was classified as active transportation. In both studies, the proportion of walking trips declined significantly with increased school trip distance, whereas the proportion of cycling trips and motorized transport increased. In practice, this proportion of active trips as a function of the distance could be relevant for urban planners involved in decisions where to site schools and residences. Primary schools should preferably be located within 400 meters from the children’s home, since almost no motorized transport was recorded on trip lengths below this distance. Moreover, other environmental characteristics should also be considered. For example, primary schools should not be located near main roads. When parents perceived traffic speed in the school environment to be low, this was associated with higher odds of walking on the school trips. Also, perceptions of car parking availability in the school environment was correlated with fewer cycling trips between home and school.

Route characteristics of children’s active transportation routes were investigated by comparing characteristics of actual walking and cycling school trips with the GIS-derived shortest possible route to school. GPS recorded actual routes were on average 5.6% longer than the shortest routes, but this difference was not significant (p=0.38). Although length of the actual route was comparable to the shortest route, children did not follow the exact same route as the shortest GIS-route. Route characteristics were compared by creating a 25 meter buffer of the
routes. Median overlap between the two buffered routes was 69.3% (interquartile range: 48.8%-86.2%) for cycling routes, and 64% (interquartile range: 33.4%-81.7%) for walking routes. Children mainly traveled through residential areas on their way to school (>80% of the route). Compared to the shortest routes, traffic lights were more often present along the actual routes. Also, percentage of visible surface water along the actual route was higher compared to the shortest routes, and streets with a high occurrence of accidents were less often used during cycling to school. Most of the results of the study seem to suggest that children avoid to walk or cycle along busy roads on their way to school.

**Infrastructural changes in the school environment**

The ‘Schoolzone’ study was one of the first longitudinal experiments to investigate the effect of environmental changes on children’s PA with objective methods, i.e. a combination of accelerometry and GPS. At baseline, children recorded 50.3 (±19.5) minutes of MVPA per school day on average. Out of these minutes, 17.9 (±10.6) minutes were recorded in the school environment (< 100 meter from the school building). Overall, both at the control and at the intervention schools, children recorded less minutes of MVPA during follow-up measurements. When corrected for wear time, the difference with baseline measurements was around 7 minutes. Similar declines in PA have been shown in other longitudinal studies; children generally become less physically active when they age. Unfortunately, no significant effects between intervention and control group were found for ‘Schoolzone’ construction on MVPA recorded during the total day, nor on MVPA recorded in the school environment. This apparent lack of effects may be explained partially because of the high percentage of active transportation when the study started. During baseline measurements, more than 80% of school trips was classified as active transportation. Also, the change from a passive to an active consent procedure resulted in a lower participation rate (64.6%) than anticipated at the start of the study. Such a participation rate hampered the power and generalizability of the results, but was comparable to other studies using such an active consent procedure.

Barriers and facilitators of ‘Schoolzone’ implementation were identified for (i) innovation characteristics (e.g. the amount of environmental changes, uniformity and recognizability), (ii) school characteristics (e.g. high workload, lack of parental engagement), and (iii) municipality characteristics (e.g. staff turnover, lack of policy). Moreover, key process outcomes of implementation (reach, perceived effect and satisfaction) were measured using parental questionnaires. A majority of parents (88%) was aware of the environmental changes in the school environment. After the ‘Schoolzone’ was constructed, significantly more parents agreed that it was safe to cycle to school, safe to walk to school, that the speed of traffic around school was reduced, and that there were possibilities to cross the street safely in the school environment. A majority of parents (68.9%) was satisfied with the ‘Schoolzone’ that was constructed, but only one third of the parents (33.6%) was satisfied with solutions that attempted to reduce the amount of traffic during school opening and closing hours.
**Conclusions**

Although most children participating in the studies used active transportation on their way to school, most of the children did not meet the MVPA recommendations by the WHO. On the schoolyard, children’s PA levels were higher than on average over the whole day. PA levels were particularly high during school recess. Furthermore, ‘Schoolzones’ succeeded in improving parental perception of traffic safety in the school environment, but the environmental changes did not result in a higher amount of MVPA recorded by the children. To promote children’s PA, it is crucial that environmental changes are part of a multi-component strategy that includes policy decisions, communication with all stakeholders, strategies to increase parental engagement and a traffic education program focused on children’s cycling skills. However, considering the high percentage of children in the Netherlands that already use active transportation on the journey to school, environmental changes aimed directly at increasing outdoor play (such as schoolyard renovations, playground markings, play equipment, teacher supervision) may be a more effective method for promoting children’s PA in the school environment. Moreover, future research is warranted to develop standardized methods for the processing and analysis of combined GPS and accelerometer data, while continuing the development of innovative data processing and measurement methods to explore children’s PA patterns.