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Unravelling environmental influences on children's physical activity

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SUMMARY

The evidence-base and importance of regular Physical Activity (PA) for children's health and well-being is becoming increasingly understood, both worldwide and in the Netherlands. PA has direct benefits for general cognitive performance, bone health and social capabilities. PA also has long term indirect health benefits via the primary prevention of overweight and obesity. In addition, children's inactivity tends to track from childhood into adolescence and adulthood. Therefore, it is of great interest and societal relevance to investigate how to effectively promote children's daily PA behavior.

Previous studies generally studied PA using either objective measurements (e.g. accelerometers) or questionnaires. The eight studies presented in this thesis address four main objectives: **1)** investigating the relationship between objectively measured PA and the subsequent development of (over)weight in children, **2)** investigating the influence of individual-level determinants (e.g. psychological determinants and socio-demographical factors) on measurements of children's PA, **3)** understanding determinants of children's outside play as reported by their parents, how these determinants interact with each other, and in which way the influence of these determinants develop over time, **4)** understanding how objectively measured factors in the physical environment relate to measurements of daily PA patterns in children, and how these PA patterns develop in transition from primary to secondary school.

Chapter 1 describes the direct and indirect benefits of regular PA in children and introduces current empirical evidence on determinants of PA at both the individual and environmental level. Subsequently, this chapter presents main challenges in measuring PA and potential determinants in the environment, and addresses potential methodological (and technological) advances regarding how these challenges can be dealt with. Finally, this chapter describes the outline of this thesis and introduces the specific studies that were performed.

Chapter 2 describes a study on the relationship between PA and the subsequent development of Body Mass Index of 4-9-year-old children. In this study, we have performed analyses based on existing objective measurements of PA (i.e. accelerometer data) carried out within the KOALA Birth Cohort Study. We found that in heavier boys and girls, an increment of 6.5 minutes of MVPA was associated with a subsequent decrease of 0.03 standard deviation BMI scores. In normal weight boys, an increment in moderate-to-vigorous PA was associated with lower BMI standard deviation score. These findings underline that promoting PA in heavier boys and girls should remain a major long-term health promotion strategy in 4-9-year-old children.

Chapter 3 describes a study on the relationship between PA enjoyment and measured PA in 9-year-old boys and girls. Here we have analyzed previously collected accelerometer data from the KOALA Birth Cohort Study. We found that children with higher scores on PA enjoyment, did not perform more daily PA. This is because the relationship differed for boys compared to girls and for children with different personality-characteristics (i.e. impulsivity). In this case, gender and impulsivity are so-called moderating factors in the relationship between PA enjoyment and PA behavior. This study therefore shows that relationships between psychosocial factors and PA behavior are not straightforward, and that information on gender and personality increases our understanding of how these factors interrelate.

The study in **chapter 4** investigated the influence of the perceived physical- and social environment on children's outside play. Here we used existing data from the 'Be Active Eat Right' study, where total duration of outside play was assessed by parental questionnaires. We found that social environmental determinants were generally stronger compared to perceived physical environmental determinants, at both five and seven years. Habit strength towards parental promotion of outside play, the presence of parental rules regarding outside play, and having physically active siblings were stable correlates of outside play. These findings demonstrated that the social environment, and especially parental rearing variables, were a strong correlate of outside play in five and seven-year-old children.

The study in **chapter 5** also focusses on determinants of outside play in the physical- and social environment. We have analyzed existing data from the KOALA Birth Cohort Study, where the duration of outside play was assessed by questionnaire. Following up on the results found in chapter 4, we investigated whether the relationship between the perceived physical environment and children's outside play was influenced by parenting influences and social capital. We found that parent-perceived accessibility to PA facilities, social capital in the neighborhood, and positive parental attitudes towards PA were associated with more minutes outside play. In contrast, concern regarding their child's PA and restriction of screen time was associated with fewer minutes outside play. The influence of the perceived environment was less important if parents did not perceive responsibility towards their child's PA levels. This means that parent's responsibility is an important moderating factor in children's outside play.

The last four chapters focused on objective measurements of factors in the physical environment related to measurements of children's PA. The study presented in **chapter 6** examined the influence of daily weather elements (e.g. rain, temperature) on children's PA patterns across the four seasons of one year, reflecting day-to-day variations over time within children. We analyzed data from an existing dataset of the Institute of PA and Nutritional Sciences in South-East Australia. Daily meteorological data was obtained from weather station registries that were closest to a child's residential location. Meteorological data was subsequently merged with daily accelerometer data. Results showed that temperature and day type (weekdays) were the strongest factors related of increased PA, followed by daily hours of solar radiation and humidity. In addition, temperature showed a strong curvilinear relationship, with optimum moderate-to-vigorous PA levels around 20-25 degrees Celsius. Apart from implications on providing infrastructure for appropriate PA on hotter days, this study also shows researchers how to retrospectively account for weather elements in future studies.

Chapter 7 presents a study investigating the relationship between PA opportunities (i.e. playability) of school environments and objectively measured afterschool PA. Here we analyzed PA by existing accelerometer data obtained by the 'Active Living' study, in Zuid-Limburg, the Netherlands. Playability of school environments was measured by systematically auditing the number of quality of playgrounds (defined by an 800-m buffer area) of 21 primary schools. Time- and distance filters were applied to understand where and when these school environment influence children's PA. Although children from schools with higher playability-scores spent more light PA and moderate-to-vigorous PA directly afterschool until 6 PM, the strength of this association attenuated at time-segments later in the evening. In addition, we found that results were strongest for children that lived within 400-m of their primary school, and no longer significant for children that lived more than 800-m from their school. These results underline the empirical importance of the quality and quantity of playgrounds in school environments. In addition, these results support that relationships between attributes of the environment and PA can be elucidated by increasing specificity of time and place.

Chapter 8 describes a study on relationships between attributes of the objective physical environment and children's afterschool PA. In this study, we have collected and analyzed accelerometer and GPS data from the PHASE-kids study in 's-Hertogenbosch, the Netherlands. This project was initiated to analyze measurements of PA in the transition from primary to secondary school and its relationship with factors in the physical environment. Based on information from both Global Positioning Systems (GPS) and Geospatial Information Systems (GIS) this study was able to study specific contexts of the afterschool time-segment such as leisure time, bicycling, walking, and organized sport participation. As children are exposed to multiple environments in the afterschool time period, this study focused on the influence of the combined home-, school-, and daily transport environment between their home and school. We found that afterschool leisure time PA was associated with environments containing more greenspace (i.e. lawns and shrubs), buildings and pedestrian paths, and with environments containing smaller home-school distances. In addition, cycling was associated with larger home-school distances and environments with more pedestrian areas and sports terrains, while fewer minutes of cycling was associated with more buildings, lawns, and pedestrian paths. Walking was associated with environments containing more agriculture, shrubs, main roads and pedestrian paths, and smaller home-school distances. Collectively, this study revealed relevant environmental determinants of afterschool leisure time and transport-related PA by combining accelerometer, GPS and GIS data.

Chapter 9 describes a longitudinal study on the development of PA patterns in the transition between primary and secondary school. Here we used data from the PHASE-kids study and selected children with accelerometer and GPS measurements collected both in the last year of primary school and first year of secondary school. Based on information from GPS and GIS data, this study was able to specify multiple contexts: participant's residence, school, sports grounds, and other places. In addition, analyses were separated for the time-segments before school, during school, after school and weekend days. We found that light PA and moderate-to-vigorous PA declined, especially after school and during weekends. The major components that decreased from primary to secondary school were 1) increased sedentary time at the residence, 2) decreased light PA at sports grounds, and 3) decreased light PA and moderate-to-vigorous PA at other locations. In addition, transport-related activity significantly increased during weekdays, and stronger increases were found for children with greater increases in distance from the residence to their school. This study provided in-depth insights of where, and at which time periods changes in children's PA patterns occur.

Finally. **chapter 10** discusses the findings of the studies presented in this thesis in broader perspective, and highlights some methodological and theoretical considerations in the interpretation of both results presented in this thesis, as well as other comparable PA studies. Furthermore, this chapter presents recommendations for health promotors and policy makers involved in PA promotion, and recommends future directions for researchers involved in children's PA.

The main conclusion from the studies presented in this thesis is that reliable objective measurements of children's PA and analyses in place and time, enable important steps to be taken in understanding how children's PA patterns are influenced by specific determinants in the social and physical environment.