Diagnosing physical activity in 4D

Spatial-temporal physical activity behavior of Dutch adults aged 45-65 years

Een 4D diagnose van beweeggedrag
Tijd-ruimtelijk beweeggedrag van Nederlandse volwassenen
met een leeftijd van 45-65 jaar

(met een samenvatting in het Nederlands)

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To diagnose:

[to classify or determine on the basis of scientific examination;
a critical analysis of the nature of something, and
the conclusion reached by such analysis]

CONTENTS

Chapter 1

General introduction

1.1 THE IMPORTANCE OF PHYSICAL ACTIVITY FOR HEALTH

"To stay healthy, an increase in physical activity levels is required" [1], "Much sitting and lying shortens longevity of older adults" [2], "Fifteen minutes of physical activity per day reduces the risk of premature death" [3]. These are translated headings from Dutch news(paper) articles, and only few examples of the many articles that have been written on the importance of physical activity (PA) for health. For adults, the World Health Organization (WHO) recommends to engage in at least 150 minutes of moderate PA (e.g., cycling with light effort, or tennis doubles), or 75 minutes of vigorous PA (e.g., jogging, fast cycling, or tennis singles), or an equivalent combination of both, per week. However, about one third of the global adult population does not comply with public health guidelines for sufficient, health enhancing PA [4]. Also, sedentary behavior is of frequent occurrence as worldwide 41.5% of the adult population spends at least four hours per day sitting. In Europe, these sedentary levels are even higher as here, 64.1% of adults spend four or more hours sitting [4].

Insufficient PA is seen as a major public health problem, as it is one of the leading risk factors for death and it increases the risk of non-communicable diseases such as obesity, type 2 diabetes mellitus, cardiovascular disease, some types of cancer and mental illness [5-8]. The societal burden of physical inactivity is high, not only through morbidity and mortality, but also through the high related (health-care) costs [9]. For 2013, globally, the estimated health-care costs were $ 53.8 billion [9]. Regular PA is an important factor in the prevention and treatment of the wide range of (age-related) health conditions, and additionally contributes to older adults living independently, healthy aging, reduced levels of depression and anxiety, and higher levels of well-being and quality of life [5-7]. Hence, global agencies such as the WHO and the United Nations (UN) emphasize the importance of increasing PA levels, and sports and PA is high on the agenda of public health policy, also in the Netherlands [10,11]. Stimulating PA levels is not only beneficial in the younger age groups, as PA in childhood and adolescence is a predictor of PA in the adult life [12], taking up PA later in life is also associated with significant health benefits [13]. Moreover, evidence shows that midlife health behaviors are associated with successful aging (i.e., aging with good mental health, good cognitive and physical functioning, and not having disabilities or chronic diseases) [14,15].

Plausible explanations for the high levels of physical inactivity in today's society are the increased use of cars and electronic entertainment (e.g., television, phone), computer-centered work environments, and the development of labor-saving machines [16]. Of particular interest are PA levels of adults aged 45 to 65 years. This midlife adult population is sometimes referred to as a 'sandwich generation', as they are often in the middle of taking care of both their parents and their children [17]. Combining this care taking with a demanding job has great impact on their daily lives, including the time they have for leisure activities such as sports and PA. Hence, the proportion of European midlife adults that never engages in sports or PA is considerably, especially compared to younger age groups (Figure 1.1) [18].

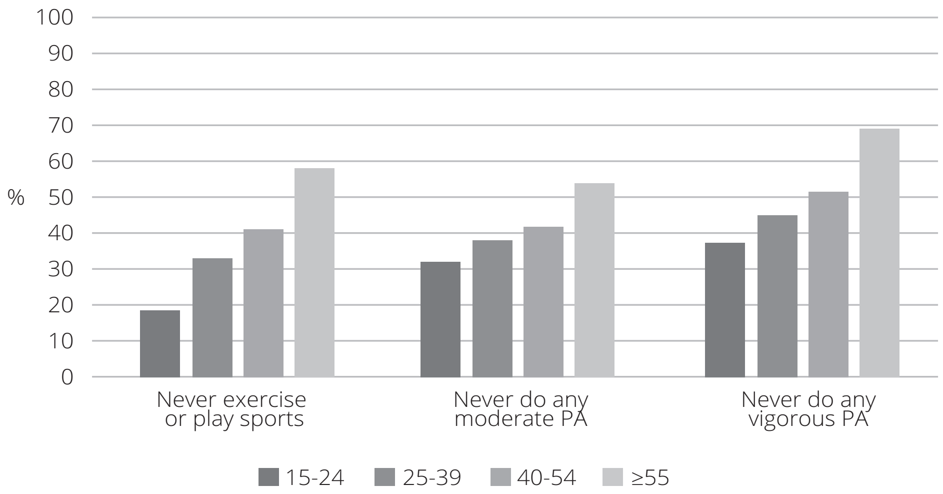

Figure 1.1 Percentages of individuals never engaging in sports or PA (based on figures from the Special Eurobarometer [18]).

Stimulating adults to incorporate PA in their daily lives (e.g., cycling to work, doing groceries by foot or going for a walk or run during lunch at work) is thus an important strategy to improve population-wide PA levels (e.g., [19-21]). An important correlate of PA is the physical environment (e.g., [22,23]), which is for the purpose of this thesis defined as 'any aspect of the physical environment, including both the built and natural environment, that may unconsciously or consciously relate to individuals and their PA behavior (after Foster and Hillsdon, 2004 [24]). Hence, one way to improve PA levels is through environmental interventions. Around the world, certain aspects of urban planning and design such as the important role of motorized transport, have negatively affected PA behaviors [25]. For example, the increase in motorized transport reduced levels of active travel, which is in turn associated with negative health outcomes. For example, countries with the highest prevalence of car use (hence, the lowest prevalence of active travel) have the highest obesity rates (Figure 1.2) [26].

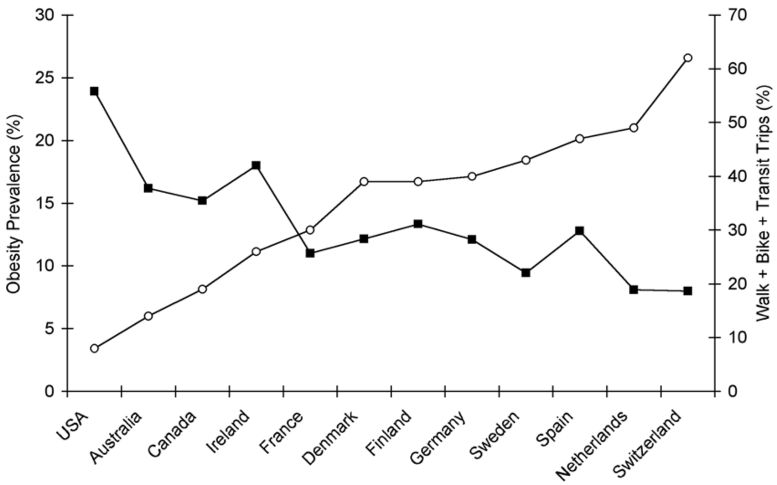

Figure 1.2 Obesity prevalence and active travel rates in different countries. Source: Bassett et al., 2008 [26].

Global agencies such as the WHO and the UN recognize the effect that city planning can have on the livability of cities and hence health of its inhabitants [27], and also researchers have emphasized the importance of the environment for PA (e.g., [22,23,28,29]). More and more, local governments acknowledge the importance of urban planning and design in promoting PA. For example, the New York City Government established a built environment and PA office, which developed Active Design Guidelines [25]. In Western-Australia 'Healthy Active by Design' was developed to provide information and evidence on how to design spaces and buildings that promote active living, and cities such as London, Stockholm and Bogotá have integrated aims to increase cycling levels in their policies [25]. In these examples, research was used to inform policy and intervention development on urban design aimed at the promotion of PA.

Yet, although previous studies have provided important insights in the role of the physical environment in PA behavior [22,23,29-33], there are still some understudied areas due to conceptual and methodological limitations. The next paragraph will elaborate on these gaps in literature, and explains how further investigation can expand existing literature, so that all together the evidence can be used to guide city planning and transport policies to health promoting directions.

1.2 THEORETICAL AND METHODOLOGICAL LIMITATIONS OF PREVIOUS RESEARCH

Due to the increased interest of policy in environmental design to create PA friendly environments, research investigating the relationship between physical environmental characteristics (e.g., access to facilities, aesthetics, quality of amenities and safety) and PA (e.g., total PA, transport-related PA, leisure time PA, walking and cycling) has increased rapidly over the past years.

Physical environmental factors have been measured using various methods. Where most studies used self-report measures such as questionnaires (e.g., NEWS: the Neighborhood Environment Walkability Scale), or observational measures (e.g., neighborhood audits or SOPARC: System for Observing Play and Recreation in Communities), others used GIS-based measures (e.g., land use mix), or a combination of measures [34]. Studies using these measures provide various insights in the relationship between the perceived physical environment and PA. Literature shows for example that perceived presence and proximity of PA facilities, shops, services and sidewalks were consistently positively associated with PA [29,35]. Furthermore, perceptions on walkability and quality of the environment were associated with PA [29]. The perceived environment is known to address different dimensions than the objectively measured environment, even when focused on similar aspects of the physical environment (e.g., perceptions of high-speed and heavy traffic vs. objectively measured speed and noise) [36]. The advantage of using objective measures of the physical environment, lies in the opportunity that concrete measures have in directly linking research findings to the development of policy and interventions in the (built) environment to support active living [37]. Hence, researchers have investigated the role of objective environmental characteristics as well. For example, land use mix and walkability (i.e., based on an index), have been consistently associated with higher PA levels [22].

An important theoretical limitation of current literature is the almost sole focus on the residential neighborhood [38-40]. Most studies have examined the, undeniably important, association between (characteristics of) the residential neighborhood and PA, using administrative units such as census tracts or postal codes to define these areas. However, such a definition of the neighborhood does often not reflect individuals' perceived residential neighborhood and assumes that its inhabitants are equally exposed to that neighborhood, including those living near the boundaries of census tracts [40]. A more accurate reflection of local exposure, related to the perceptions of individuals as to how they see their neighborhoods, is the use of buffers (e.g., Euclidian or network buffers) around the home [40]. Yet, a home-centered approach ignores individualized patterns of mobility (i.e., people often do not stay in only one location throughout the day) [39], and has conceptual and methodological limitations regarding the assessment of exposure to environments [40]. For example, although the neighborhood may indeed be an important barrier to or facilitator of PA behavior, as adults spent on average 109 hours (i.e., about 60%) of a typical week in their neighborhood [41], adults also spend a substantial amount of time outside the neighborhood (i.e., 40%). This so-called 'residential trap' – i.e., reducing the environmental context to the residential neighborhood – overlooks that individuals' environmental exposure is an accumulation of exposure to the residential environment and other geographical environments such as the work environment, leisure-time environments (e.g., sports facilities, or parks), and active travel environments [42].

For example, the work location may affect PA levels through job requirements. Where one job requires adults to be physically active, another job may require more sedentary work. Also, it may facilitate active commuting or a walk during lunch through the presence and quality of cycling lanes and walking trails. Furthermore, availability of natural environments such as parks, has been positively associated with PA levels [31]. As specific forms of PA are often related to specific elements of the physical environment (e.g., the presence and quality of walking and cycling trails effect transport-related PA), understanding the relationship between the physical environment and PA ideally requires to examine context specific PA.

Moreover, PA is not only organized in space, it also has a temporal structure. For example, physical activities have a certain frequency or duration. Research in the PA field has mostly accumulated PA over a week (e.g., to examine whether adults adhere to PA recommendations) (e.g., [43-45]), or over the day (e.g., to calculate the average time spent in total PA or moderate-vigorous PA) (e.g., [46,47]). Some studies compared PA on different days of the week [48], and only limited studies examined PA throughout the day (e.g., [49]). Factors such as obligations, resources, and preferences determine the 'where' and 'when' of physical activities [50]. For example, work obligations do not only require individuals' to be at a specific location, they also require adults to spend a certain amount of their time on working. This affects the time left for activities such as leisure time physical activities. This approach to examine PA in space and time is yet not fully integrated in physical environment-PA research [40].

Such an assessment of PA patterns requires the use of appropriate theories and methodologies. The availability of methods to obtain individual-level data on activity patterns, such as the use of accelerometers and GPS-devices and GIS to incorporate large amounts of geographical data, provides opportunities to accurately assess context specific PA behavior and hence overcomes limitations of current literature such as over- or underreporting of PA due to for example social desirable answers or recall difficulties [51]. Hence, it is the aim of this thesis to use objectively collected data to examine PA in 4D and to provide a more comprehensive insight in (daily) PA patterns.

1.3 THEORETICAL BACKGROUND OF THIS THESIS

Researchers have applied socio-ecological frameworks to consider the relationship between the physical environment and a variety of behaviors, including PA behavior. Various ecological models and theories exist, in which categories and hierarchies of behavioral influences are differently described. For example, Bronfenbrenner (1979) applied a micro-, meso- and exo- environment approach in his Systems Theory, whereas the Ecological Model of Health Behavior of McLeroy and colleagues (1988) distinguishes five sources of behavioral influence: intrapersonal, interpersonal, institutional, community, and policy [52]. One of the core principles of ecological models is that they are most useful if they are behavior specific [52], and an example of an ecological model that is tailored to PA behavior is the Ecological Model of Four Domains of Healthy Living by Sallis and colleagues (2006) [16] (Figure 1.3).

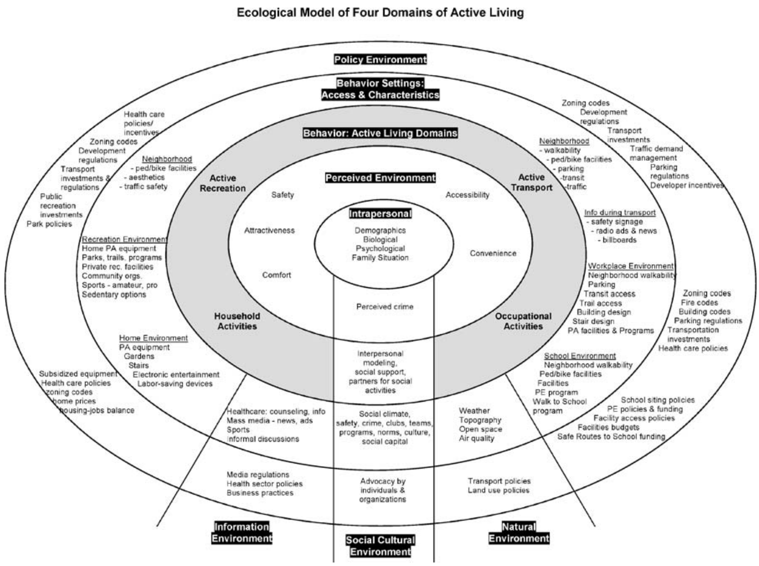

Figure 1.3 Ecological model of four domains of active living [16].

This model has a commonly applied 'onion-structure' (i.e., layered structure), representing different levels that all have their influence on PA. PA, the outcome measure, is depicted in the grey layer. Adjacent layers show the environments that may influence PA behavior, i.e., the perceived environment, behavior settings and their (objective) characteristics, and the policy environment. Moreover, the model integrated intrapersonal factors as these may both affect PA levels, and how one perceives the environment. The authors distinguish different behavior settings: the home, the neighborhood, the work space, and recreational environments. These are environments in which different domains of PA may take place. For example, household activities take place at home, occupational activities take place in the work space, and active recreation takes place in recreational environments such as parks). Such environments have different characteristics (e.g., lay-out, size, facilities) which may therefore provide different possibilities for PA. For example, walkability of neighborhoods facilitates active transport such as walking or cycling to facilities (e.g., shops), whereas trails in recreational areas (e.g., parks) or sports facilities may be ideally suited for active recreation such as jogging or sports activities. Moreover, different spaces that belong to the same category of environments (e.g., recreational environments) may also facilitate different PA levels through differences between these spaces. For example, a park with walking or jogging trails facilitates PA, whereas parks without such trails may be more suited for sedentary or relaxation behaviors.

These aspects of the Ecological Model of Four Domains of Active Living will be helpful in assessing the role of different contexts and their characteristics on PA behavior in this study. However, the theory also has some shortcomings. First, the PA domains and hence the related contexts may be too broad. For example, active recreation may be related to PA in both green spaces and sports facilities, but PA levels in both environments may be considerably different. Where parks may be especially used for walking or low-intensity activities, sports locations may be more used for high-intensity activities. Second, activities are presented as 'stand-alone' or 'isolated' activities, whereas an activity is part of a certain activity pattern. That is, activities are often related to or even dependent on other (previous and subsequent) activities. Hence, some activities may determine where and when an individual is physically active. For example, because person X has to go to work every day, he may only have time to participate in sports in the evening hours or in the weekends.

A theory that does provide opportunities to adopt this notion of daily activity patterns is the theory of 'Time Geography' as developed by Hägerstrand and colleagues (1970) [40,50]. The key argumentation in this theory is that individuals' daily activity and travel patterns constitute a path through space and time that is determined by capability constraints (i.e., biological needs such as the necessity of sleeping or eating, and the tools someone has at his/her disposal), coupling constraints (i.e., the obligation and need to be in the company of others for joint activities), and authority constraints (i.e., rules and regulations that make certain locations only available during authorized times, e.g., opening hours of shops). Many of these constraints are reflected in socio-demographic factors, both on the individual and household level, and can play an important role in shaping PA behavior. For example, adults with a poor health status or increased Body Mass Index (BMI) may suffer from physical limitations to engage in PA, and adults with children may experience time constraints. Adults who do not own a car may be more restricted in their opportunities to engage in PA in specific locations as compared to car owners whose increased mobility may lead to an increased access to PA facilities (e.g., sports accommodations). Given these constraints, one can describe the locations that can be accessed during the time in between obligatory activities, depending on the speed of travel and the geographical locations of facilities. An example of such a path through space and time is illustrated in Figure 1.4.

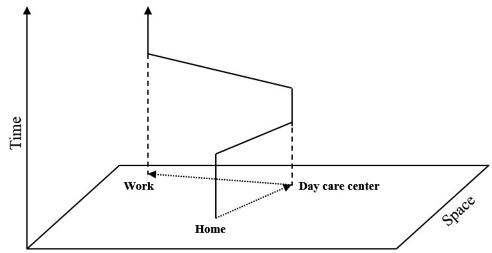

Figure 1.4 An individual path through space and time. (Adapted from Miller [53]).

In time-geography, fixed activities are distinguished from flexible activities. Some activities have a more fixed character, that is they cannot easily be rescheduled (e.g., working), whereas other activities may be less restricted to specific time frames (e.g., recreational activities) [50]. Given the duration and location of the fixed activities, and the mobility of an individual (i.e., travel speed), one can measure the locations that can be accessed. This can be illustrated in a space-time prism (Figure 1.5).

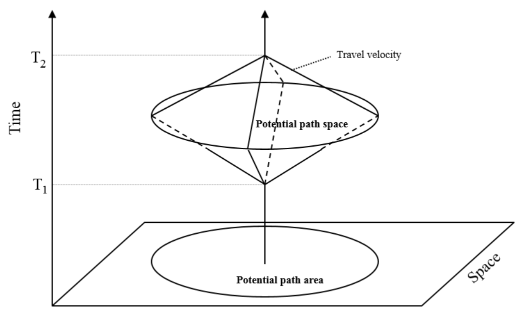

Figure 1.5 A space-time prism (Adapted from Miller [53]).

In Figure 1.5, an individual has to be at a specific location until T_1 (e.g., home) and he has to be back at T_2. During the time interval in between these fixed activities, the potential path space represents the path opportunities one has in this T_1-T_2 period - considering time, distance to a location, and travel speed - and the potential path area represents all geographical locations that can be accessed during the time interval T_1-T_2. PA may occur both during the more fixed (or 'obligatory') activities (e.g., at work), and during the more flexible activities. With regard to the more flexible activities, the use of certain physical environments for PA (e.g., sports facilities, or public space) may depend on the distance to those environments measured from the home location, but also measured from other anchor points such as the work location. Moreover, participation in sports and PA depends on the time an individual spends on activities such as work and household obligations. Although not necessarily through applying time geography, researchers in the physical environment-PA field have addressed the concept of "accessibility". For example, studies have associated access (mostly from the home location) to public open spaces, shops, public transport, facilities, and natural environments (especially parks) to higher levels of (transport-related) PA (e.g., [23,29-31]). However, these studies have mostly extracted only one domain of PA and one location, while studies could benefit from a more comprehensive insight in how PA is structured across different physical environments and through time (i.e., in 4D).

In addition, both the Ecological model and Time Geography emphasize the role of individual and household factors. Where time-geography describes constraints, of which many can be directly translated to socio-demographic and household composition, the Ecological Model of Four Domains of Active Living also shows the (potential) role of intrapersonal factors, which are mostly socio-demographic factors and household composition. Using aspects from both time-geography and the ecological model led to the following conceptual model (Figure 1.6).

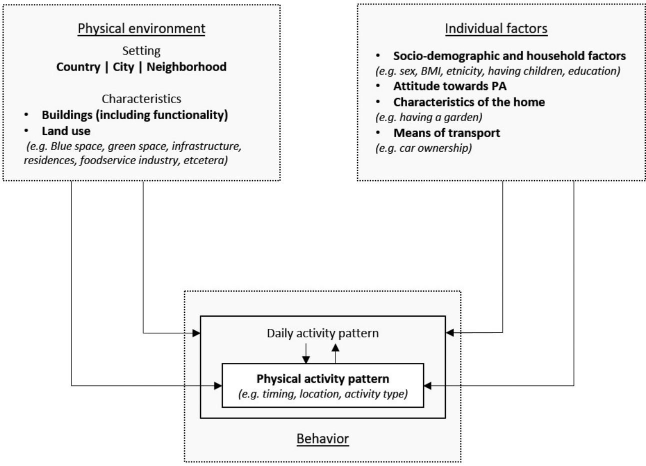

Figure 1.6 Conceptual model of the thesis.

This conceptual model shows how the physical environment and personal factors may be barriers to or facilitators of opportunities for individuals' daily activity patterns. The use of accelerometers and GPS-devices allowed us to measure physical activities of all aspects of adults' daily lives. Hence this included both more fixed activities of these so-called 'paths through space and time' during which PA may occur such as PA during work, or PA during household activities, as well as more flexible activities of which location and time are often shaped by constraints (e.g., time spent on obligatory, fixed activities, having a car, and opening hours of facilities) such as sports participation. Where the PA pattern is part of the daily activity pattern, this daily activity pattern may also shape the PA pattern. For example, the activities 'working' and 'taking care of children' leave only a specific amount of time and possibly a specific time window for leisure time PA activities. Also, engaging in PA may shape daily activity patterns. For example, an individual who has to take care of his/her children may choose to wake-up early to go for a run, before taking care of the children – which in turn affects the time spend on sleeping. In this conceptual model, the physical environment refers to both the residential environment, as well as to other environments that were used by adults during their daily life activities.

1.4 RESEARCH AIM AND QUESTIONS

Integrating an approach that examines PA as a pattern in space and time, hence investigating context and time specific PA, yields a variety of new opportunities to gain a more detailed and comprehensive insight in PA behavior. This provided the rationale for this thesis, which had the aim:

To examine how PA of adults aged 45-65 years is distributed across space and time (i.e., in 4D), and to assess how physical environmental and personal factors are related to the spatial and temporal organization of PA behaviors.

In this thesis, we use various PA outcomes. We distinguished: sedentary behavior, light PA (LPA), and moderate-vigorous PA (MVPA), as well as spatially concentrated PA, walking/jogging, and cycling. The aim will be addressed by answering the following research questions.

1) *What typical temporal PA patterns exist, and what groups of adults have similar PA patterns?*
   PA behavior is often accumulated as average daily PA or total PA per week. In contrast, we currently know much less on the distribution of PA through time, and the possible existence of typical hour-by-hour PA patterns. As literature has for example identified “weekend warriors” (i.e., adults with limited PA on weekdays, and most PA on weekend days) [48], it is plausible to assume that there may also be (different) typical patterns throughout the day. For example, one day an individual may have sedentary behavior throughout the day with high levels of PA in the evening because of sports participation, whereas on another day an individuals’ PA levels may consist of active commuting. Differences between such PA patterns may exist due to differences in personal factors, household composition, neighborhood characteristics (e.g., facilities to engage in PA such as green space) and hence opportunities or constraints to engage in PA. Especially among the group of adults aged 45-65 years, constraints such as having a demanding job, and taking care of children, may impact the time left for leisure time PA. Hence, it is plausible that some patterns may be more prevalent among sub-populations with similar characteristics. Identifying hour-by-hour PA patterns increases our understanding of how PA behavior is integrated in daily patterns, and allows to distinguish time-windows to intervene in (i.e., specific moments of the day during which PA levels are very low), and it increases the understanding of PA behaviors of specific subpopulations.

2) *How is PA distributed across various daily life physical environments?*
   PA is not only structured in time, but also in space. The most studied ‘space’ is the

residential environment, and its characteristics were often assessed in relation to total PA behaviors (i.e., PA that occurred within and outside the residential neighborhood). Although the neighborhood plays an important role in adults' daily lives, physical activities take place in a wider geographical context than the neighborhood alone. As Sallis and colleagues stated in their Ecological Model of Four Domains of Active Living, individuals interact with different environments when they are physically active in varying domains (e.g., work-related PA or a walk during lunch takes place in the work location, whereas sports and leisure time activities are more likely to take place in a recreational environment) [16]. With this second research question we elaborate on the limited knowledge on the locations that adults actually use for PA, and how this is related to personal factors.

3) *What role do objectively measured residential neighborhood characteristics have in neighborhood-based PA behavior?*
   Although activity patterns of adults exceed their neighborhoods, the residential neighborhood is an environment in which adults spend a substantial amount of their time. Hence, it is one of the most studied environments in relation to PA behavior. Literature has shown associations between neighborhood characteristics and various forms of PA (e.g., [29]). However, the majority of studies have assessed the role of the neighborhood in relation to 'overall PA' – which includes both PA within and outside the neighborhood. This conceptual mismatch between physical environmental exposure and PA may lead to underestimated associations. To gain a more comprehensive understanding of the role of the residential neighborhood and its characteristics in PA behavior, it is important to better understand how objective neighborhood characteristics relate to neighborhood-based LPA and MVPA.

4) *What is the role of type and size of natural environments in PA behavior?*
   Another frequently assessed type of physical environments in relation to PA behavior, due to the important role it has in a variety of health aspects as well (e.g., stress-reduction) [54], is the natural environment (also often referred to as green space). Most studies focused on one particular type of natural environment, mainly on parks and some on coastal areas (e.g., [55-64]). However, as natural environments provide opportunities for a wide variety of behaviors, including relaxation, social interaction, and PA [28,65,66], different natural environments may be related to different PA behaviors. For example, it may be that parks facilitate physical activities such as Frisbee, whereas forests may facilitate walking. Hence, the size of natural environments may play a role in PA as well, as Frisbee is for example rather concentrated in space, whereas walking may require more space through trails of sufficient length. Hence, different types and sizes of natural environments may afford different modalities (i.e., spatially

concentrated PA, walking, and cycling) and intensities (i.e., sedentary behavior, LPA, and MVPA) of PA. To assess this hypothesis, comparisons of objectively measured PA behavior within specific natural environments have to be made. To improve our understanding of the importance of natural environments and to inform policy makers and urban designers on which green facilitates which PA behaviors, we formulated this fourth research question.

1.5 METHODOLOGY OF THE STUDY

The cross-sectional study, named PHASE (Physical Activity in public Space Environments), was conducted in Rotterdam (623 652 inhabitants) and Maastricht (122 397 inhabitants), the Netherlands. Four neighborhoods - i.e., Oude Noorden and Kralingen-West in Rotterdam, and Zuid-Oost and West in Maastricht - were selected for participant recruitment based on differences in their geographical characteristics, to increase the variety in environmental exposure (Figure 1.7). These characteristics were surface area, distance to the city center, the proportion of blue- and green spaces, presence of (sports) facilities, and population density.

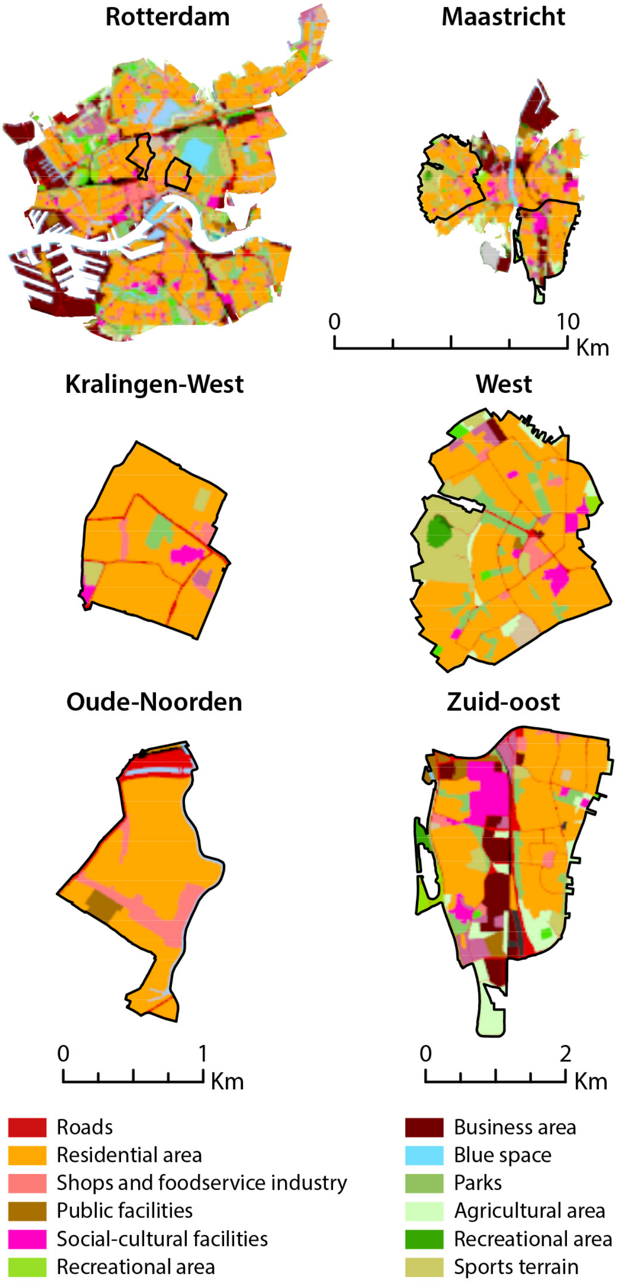

Figure 1.7 Neighborhoods Kralingen-West and Oude Noorden (Rotterdam), and West and Zuid-Oost (Maastricht), according to land use characteristics (Dutch Statistics 2012 dataset).

Participant recruitment
Home addresses of adults (45-65 years) living in Oude Noorden, Kralingen-West, Zuid-Oost or West, were randomly selected from the municipal population registers of Rotterdam and Maastricht by a municipal official. An information letter (see Appendix A), in which adults were asked to participate in the study, was sent to the selected sample (N = 14 889; N = 7389 in Rotterdam and N = 7500 in Maastricht). Adults who were willing to participate in the study could register through an online form on the PHASE website or by telephone, this contact information was provided in the letter. Subsequently, all registered adults (N = 516) were contacted by phone or e-mail to plan the distribution of the GPS- and accelerometers, which are used to measure intensity and location of PA. Trained staff members distributed the devices to participants (N = 406) on weekday evenings (i.e., 6 PM to 9 PM) in community centers that were located within participants' neighborhoods. The staff-members explained monitor wear and placement and provided participants with an information sheet that summarized the instructions. Participants in Rotterdam received an incentive of 10 euro per person and participants in Maastricht were included in a raffle method with 15 prices of 100 euro each. Data collection took place from April 2014 to December 2014, with exclusion of the holidays (i.e., Easter, Ascension Day, Pentecost, and Christmas). Also, participants were asked to participate during a week that represented a 'normal' week. That is, a week which did not differ substantially from other weeks by for example vacation or work-related trips to abroad. All participants signed informed consent. The review board of the faculty of Social and Behavioural Sciences of the Utrecht University approved the study.

Representativeness of the study sample
Compared to national Dutch figures on weight status of adults aged 45-65 years, the percentage of overweight adults in the study sample is about 15% lower, and the percentage of obese adults is about 5% lower [67]. The national Dutch percentage of non-western immigrants is approximately 10%, which is a few percent higher than in the study sample [68]. The percentage of lower educated adults is about 20% lower in this study, compared to the national Dutch percentage of adults aged 45-65 years. The percentages of adults with a middle or higher education in this study population are both about 10% higher than the national percentages of adults aged 45-65 years [68].

Background information
Background information, such as age, gender, ethnicity, education, having children, and health status, were obtained through an online questionnaire. For adults who did not have internet and/or an e-mail address, a printed version was available. The questionnaire can be found in Appendix B.

PA intensity and location

To measure activity patterns of individuals into detail, individualized and objective measures are needed. Hence, PA was measured using Actigraph GT3X+ accelerometers (Actigraph, Pensacola, Florida, USA). These monitors provide objective measurement of human activity, and the recorded data included vertical axis-, horizontal axis- and perpendicular axis acceleration data in 5 second epochs [69]. The GT3X accelerometer has been shown to be a valid measure of PA [70].

PA locations were measured using BT-Q1000XT GPS-devices (QStarz, International Co, Taipei, Taiwan). This device was shown to be an appropriate measure of locations, and possible inaccuracy (e.g., due to canyoning) is within acceptable ranges [71]. The devices provided the coordinates of the geographical locations every 5 seconds. GPS- and accelerometer data were linked based on their date and time stamps using a procedure written in Python 2.7.2. The accelerometer and GPS-device were attached to an elastic, adjustable belt. Participants were asked to wear this belt, with the devices placed on their right hip (Figure 1.8), for seven consecutive days during waking hours but not during water-based activities (e.g., swimming, or when taking a shower) [72].

Figure 1.8 The GPS-device and accelerometer worn on the right hip.

The physical environment

Two different datasets on physical environmental characteristics were used in the PHASE study. One dataset included information on the exact locations of buildings and their functionality (e.g., residence or sports facility), which was available from the Dutch Cadaster (this study used data of 2014). This data was used to calculate the nearest buildings to geographical locations. The other dataset included information on land use, available from Statistics Netherlands (this study used data of 2010 and 2012). Arc Map (Esri, Redlands, California, USA) was used to link these data to the collected GPS-data. This data was used to calculate proportions of different land use types within buffers around participants' homes and around other locations.

1.6 THESIS OUTLINE

The Chapters 2, 3, 4 and 5 of this thesis were written as separate journal articles. Chapter 2 describes how LPA and MVPA were distributed across the course of a day, and latent class analyses were used to distinguish both typical hour-by-hour PA patterns, and - based on their PA patterns - groups of individuals. Chapter 3 aimed to provide insight in how MVPA was distributed across various daily life environments and hence provided an overview of the locations that adults actually use for PA. Chapter 4 contributes to the discussion on the role of neighborhood characteristics in PA behavior by assessing the relationship between neighborhood characteristics and neighborhood-based LPA and MVPA. In Chapter 5, we zoom in to a specific domain of physical environments, i.e., the natural environment. This Chapter provides insight in how size and type of natural environments relate to various forms (i.e., spatially concentrated PA, walking and cycling) and intensities (i.e., sedentary behavior, LPA and MVPA) of PA. Finally, Chapter 6 summarizes key findings of the PHASE study, answers its research questions, discusses opportunities for future research, and reflects on practical implications.

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Chapter 2

Hour-by-hour physical activity patterns of adults aged 45 – 65 years: a cross-sectional study

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ABSTRACT

Limited information exists on hour-by-hour physical activity (PA) patterns among adults aged 45-65 years. Therefore, this study aimed to distinguish typical hour-by-hour PA patterns, and examined which individuals typically adopt certain PA patterns. Accelerometers measured light and moderate-vigorous PA. GIS-data provided proportions of land use within an 800 and 1600 meter buffer around participant's homes. Latent class analyses were performed to distinguish PA patterns and groups of individuals with similar PA patterns. Four PA patterns were identified: a morning light PA pattern, a mid-day moderate-vigorous PA pattern, an overall inactive pattern and an overall active pattern. Groups of individuals with similar PA patterns differed in ethnicity, dog ownership, and the proportion of roads, sports terrain, larger green, and blue space within their residential areas. Four typical hour-by-hour PA patterns, and three groups of individuals with similar patterns were distinguished. It is this combination that can substantially contribute to the development of more tailored policies and interventions. PA patterns were only to a limited extent associated with personal and residential characteristics, suggesting that other factors such as work time regimes, family life, and leisure may also have considerable impact on the distribution of PA throughout the day.

2.1 INTRODUCTION

Globally, 31.1% of adults does not comply with recommendations for physical activity (PA) [1]. This suggests that it may be difficult to integrate sufficient PA in one's daily life. Although moderate-vigorous PA (MVPA) has been known for its positive health effects [2], recently, researchers have emphasized the importance of light-intensity PA (LPA) for health as well [2], and LPA is often easier to integrate in daily life. Various studies found that adults spend indeed more time in daily LPA than in daily MVPA [3,4].

Apart from the amount of LPA and/or MVPA per day or per week, it is relevant to investigate how PA is distributed in time. For instance, interrupted sedentary behavior is less harmful to health than prolonged sedentary behavior [5]. Also, investigating patterns of adults' PA behaviors throughout the day may give insight into critical time-windows to intervene in [6]. Especially time constraints may restrict adults to integrate PA in their daily lives [7], and insight in their hour-by-hour PA patterns and their characteristics may contribute to understanding why their PA levels are low. Moreover, integrating PA in daily life may be more difficult for specific sub-populations (e.g., adults with (full-time) employment) [7], and information on their hour-by-hour PA patterns may provide insight in whether time periods that may be used for PA (e.g., employed adults who participate in sports or PA during the evenings or on weekend days) are actually used.

There are few studies that have investigated how adults' PA behavior was structured throughout a week [8-10], or throughout the day [11-17]. Those studies mostly compared PA levels between specific a priori determined subpopulations, for example: women workers vs. women at home [15], patients vs. healthy adults [13], normal weight vs. overweight and obese adults [12], least, medium and most active adults [14], and adults with different neighborhood walkability scales [11]. Due to this focus on specific subpopulations, and the a priori assumption that the composition and behavioral preferences of such groups are homogeneous, little is known about the hour-by-hour distribution of light PA and moderate-to-vigorous PA of a more general adult population, and the variation in such distributions.

Of particular interest are adults aged 45 to 65 years, the so called 'sandwich generation', who face the challenge of combining work responsibilities with the care for both their children and their aging parents [18]. This impacts their daily activities, including time left for PA. Determining what PA patterns exist, and how these are related to socio-demographic factors (e.g., sex, ethnicity, and employment) is important to tailor PA interventions. Besides, environmental opportunities for PA may also play a role in hour-by-hour PA patterns [6,11]. For example, adults living in neighborhoods with many sports facilities may have higher (MV) PA levels in the evening and on weekend days. However, evidence on how residential environmental characteristics are linked to certain daily PA patterns is currently not available.

Therefore, this study aims 1) to investigate which typical daily hour-by-hour PA patterns (i.e., indicated by levels of LPA and MVPA) exist in an adult population aged 45-65 years, and 2) to identify individuals (based on socio-demographic factors and land use characteristics of residential areas) that typically adopt certain PA patterns.

2.2 METHODS

Study sample

This cross-sectional study is part of the PHASE (Physical Activity in public Space Environments) project, which aimed to investigate PA behavior of adults aged 45-65 years [19]. Participants were randomly recruited among residents aged 45-65 years, living in Rotterdam and Maastricht, the Netherlands. After sending an invitation letter to a sample of 14889 adults, N = 516 registered for the study, and N=406 wore an accelerometer and GPS-device for 7 days from April to December 2014. All participants signed informed consent. This study was approved by the review board of the Social and Behavioural Sciences faculty of Utrecht University.

Measures

Actigraph GT3X+ accelerometers (Actigraph, Pensacola, Florida) measured PA, and data were downloaded using Actilife v6.11.2. Vector magnitude cut-points for triaxial accelerometer counts were used to define light PA (150-3208 cpm), moderate PA (3208-8564 cpm) and vigorous PA (≥ 8565 cpm) [20,21]. MVPA was the sum of moderate and vigorous PA. The 70/80 rule was used to define a valid day [22]. For the analyses, only days that had sufficient data for the hours between 9 AM and 9 PM (i.e., at least 360 epochs per hour) were included. Including hours before 9 AM and/or after 9 PM led to considerable data loss as the amount of days that had sufficient data for each of those hours substantially reduced. After applying these criteria for valid data, 562 days of 222 participants (141 Maastricht, 81 Rotterdam) were included.

The coordinates of participants' home addresses were mapped in ArcMap 10.2.2 (Esri, Redlands, California), around which buffers of 800 and 1600 meters were drawn. For each buffer the proportions of nine different land uses (Statistics Netherlands, 2012) were calculated: residences, roads, shopping facilities and hospitality industry (e.g., supermarkets, hotels), public social-cultural facilities (i.e., educational institutes, hospitals), sports terrain (e.g., football fields, swimming pool), recreational area (e.g., picnic places, zoos), city green (e.g., city parks, allotments), larger green (e.g., forests, moorlands), and blue space (e.g., rivers, lakes). Background information was obtained through a questionnaire (e.g., socio-demographics, health, and home address).

Statistical analyses

To distinguish typical hour-by-hour PA patterns, we evaluated respondents' daily LPA and MVPA patterns, defined by the percentages LPA and MVPA in each hour. To assess whether there were similarities in the observed patterns, LatentGOLD 5.1 software (Statistical Innovations, Belmont) was used to fit a latent class regression (LCR) model which clusters the N=562 days into a smaller number of latent classes which have similar daily patterns [23]. Second, LatentGOLD was used to assess clusters of individuals that typically adopted certain PA patterns. Since we observed multiple days within most individuals, a multilevel extension was used to accommodate for correlations between observed PA patterns due to person-specific characteristics. The multilevel LCR model was used to classify each respondent according to the distribution of particular PA patterns within that person. For example, all respondents who had many active daily patterns and only few inactive daily patterns could be clustered into one class. Each individual was assigned to the class they most likely belonged to.

To find the best fitting model, we estimated models with different specifications regarding the number of classes for the daily patterns and the respondents. To model the class-specific patterns, we used regression splines which are more flexible than traditional polynomials. We estimated models with 1-9 latent classes for the daily PA patterns and 1-7 classes for the clusters of individuals. Three criteria were used to select the best fitting models, and hence the final number of classes [24]. The first criterion was the BIC, which indicates the trade-off between model-fit and model-complexity, with lower values meaning a better trade-off [25]. However, in LCR models, the BIC is known to select a very large number of classes, because the complexity of the model increases little when adding an extra class. To limit the chances of over fitting (i.e., selecting more classes than necessary), the second criterion was to require each class to comprise at least 15% of all observations. The third criterion included a visual inspection to retain interpretability of what each class represented. SPSS was used for descriptive statistics, ANOVA, chi-square and Kruskall-Wallis analyses.

2.3 RESULTS

Participants

Participants had an average age of 56.8 (SD 6.1), and 52.7% were female (Table 2.1). Almost half of participants were overweight or obese, and more than 80% reported a good or very good health status. The majority was native Dutch, and had a middle or higher education. Over half of the participants was employed. One third had at least one child aged < 18 years living at home, and 18.5% had a dog. Land use within both buffers mainly consisted of residences.

Table 2.1 Study sample (N = 222).

Socio-demographic factors		
Age in years		
Mean (± SD)	56.8 (± 6.1)	
Female (%)	52.7	
BMI (%)		
Healthy weight	56.3	
Overweight	34.7	
Obesity	9.0	
Health status (%)		
Very good	20.7	
Good	60.4	
Fair	14.0	
Poor	4.5	
Very poor	0.5	
Ethnicity (%)		
Autochthonous	85.1	
Western immigrants	5.9	
Non-western immigrants	7.7	
Missing	1.3	
Education (%)		
Low	4.1	
Middle	53.2	
High	42.3	
Missing	0.4	
Employed (%)	57.7	
Having children (living at home) (%)	33.3	
Having a dog (%)	18.5	
GIS-based land-use characteristics	***Median %***	***Interquartile range***
Residences		
800m	54.24	(44.46; 62.21)
1600m	37.03	(30.24; 45.40)
Roads		
800m	5.51	(3.78; 7.13)
1600m	5.56	(4.67; 6.32)

Table 2.1 Continued.

Shopping facilities and hospitality industry		
800m	2.01	(1.55; 3.78)
1600m	1.89	(1.27; 4.49)
Public social cultural facilities		
800m	2.61	(1.16; 6.05)
1600m	4.07	(2.27; 6.90)
Sports terrain		
800m	2.33	(1.08; 3.48)
1600m	3.07	(2.20; 5.75)
Recreational area		
800m	0.00	(0.00; 1.04)
1600m	0.44	(0.11; 1.87)
City green		
800m	6.12	(3.79; 8.35)
1600m	5.49	(3.82; 8.53)
Larger green		
800m	3.08	(0.00; 10.98)
1600m	8.54	(1.52; 26.46)
Blue space		
800m	0.00	(0.00; 8.94)
1600m	2.83	(0.00; 16.05)

Note: SD = standard deviation. BMI = Body Mass Index. GIS = Geographical Information System.

Hour-by-hour PA behavior

Four different types of daily hour-by-hour PA patterns were distinguished (i.e., days with similar patterns, further referred to as 'day types') (Figure 2.1). Day type one describes a pattern of medium-high LPA percentages, with a peak between 10 and 12 AM, and a steep decline of LPA after 6 PM. The MVPA percentages of day type one are continuously very low throughout the day. Hence, day type one is referred to as a morning LPA pattern, which occurred relatively more often on Saturdays (Table 2.2). Day type two describes a pattern of medium-low LPA levels, with a steep decline after 6 PM. Day type two has the highest MVPA percentages. This pattern starts with an increase of MVPA till the highest level is reached between 11 AM and 1 PM. Then, MVPA continuously declines until it stabilizes from 7 - 9 PM. Day type two is referred to as a mid-day MVPA pattern, which occurred relatively more often on a Saturday (Table 2.2). Day type three has the lowest LPA percentages. The highest LPA percentage is reached between 6 and 7 PM, and a steep decline after 7 PM. MVPA percentages of day type three are second lowest. Day type three is referred to as an overall inactive pattern, which occurred relatively more often on a Friday (Table 2.2). Day type four has the highest LPA percentages and the second highest MVPA percentages. LPA and MVPA increase in the morning, with the highest levels between 11 and 12 AM. Day type four is referred to as an active pattern, which occurred relatively more often on Mondays and Thursdays.

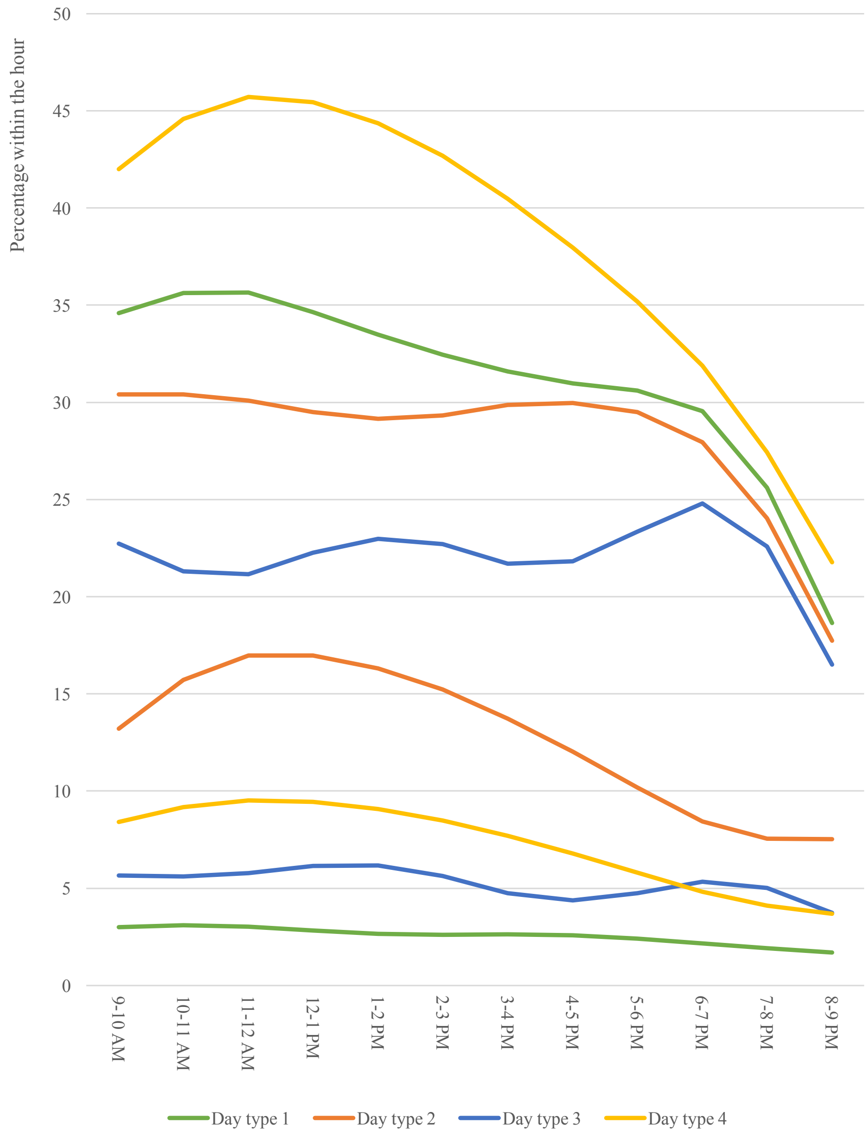

Figure 2.1 Four different pattern clusters of hour-by-hour LPA (top) and MVPA (bottom)

Table 2.2 Overview of the four day types.

	Prevalence of day type	Percentages of LPA and MVPA			Days of the week (%)							Pattern description
		Lowest	Medium	Highest	Mo	Tu	We	Th	Fr	Sa	Su	
Day type 1	*25.4%*				*14.9*	*10.1*	*8.3*	*16.7*	*11.3*	*20.2*	*18.5*	*Morning LPA pattern*
LPA			X									Highest in the morning
MVPA		X										Constant, lowest levels
Day type 2	*30.2%*				*13.9*	*10.3*	*11.5*	*17.0*	*17.6*	*20.6*	*9.1*	*Mid-day MVPA pattern*
LPA			X									Rather constant, but with a steep decline in the evening
MVPA				X								Increase in the morning, peak between 11 AM and 1 PM
Day type 3	*15.2%*				*16.8*	*15.4*	*9.1*	*16.8*	*18.2*	*14.0*	*9.8*	*An overall inactive day pattern*
LPA		X										Low, irregular undulating, peak between 6 and 7 PM
MVPA			X									Overall medium-low
Day type 4	*29.2%*				*20.9*	*7.0*	*7.0*	*20.9*	*18.6*	*9.3*	*16.3*	*An overall active day pattern*
LPA				X								Overall highest, increase in the morning
MVPA			X									Medium-high levels, increase in the morning

Hour-by-hour LPA and MVPA patterns in different groups of individuals

Three different groups of individuals were distinguished that typically adopted certain PA patterns (Table 2.3). These groups differed significantly with respect to their ethnicity, whether or not they had a dog, and some characteristics of their residential areas, i.e., proportions of larger green space within an 800 meter buffer, proportions of roads and sports terrain within a 1600 meter buffer, and proportions of blue space within both an 800 and 1600 meter buffer.

Table 2.3 Descriptive statistics of the different groups of adults (based on their PA patterns).

	Group 1 (N = 114)	Group 2 (N = 63)	Group 3 (N = 45)
PA behavior			
Hour-by-hour PA			
Day type 1 – morning LPA pattern	0.10	0.63	0.01
Day type 2 – mid-day MVPA pattern	0.49	0.11	0.15
Day type 3 – overall inactive pattern	0.24	0.09	0.04
Day type 4 – overall active pattern	0.17	0.17	0.80
Socio-demographic characteristics			
Age in years Mean (± SD)	57.4 (± 6.0)	56.1 (± 6.6)	56.2 (± 5.6)
Female (%)	48.2	54.0	62.2
BMI (%)			
Healthy weight	60.5	49.2	55.6
Overweight	32.5	41.3	31.1
Obesity	7.0	9.5	13.3
Health status (%)			
(Very) Good	81.6	82.5	77.7
Fair	14.9	11.1	15.6
(Very) Poor	3.5	6.4	6.7
Ethnicity (%)			
Autochthonous*	93.0	82.5	68.9
Western immigrant	4.4	9.5	4.4
Non-western immigrant*	2.6	6.3	22.2
Missing	0.0	1.6	4.4
Education (%)			
Low	3.5	3.2	6.7
Middle	46.5	57.1	64.4
High	49.1	39.7	28.9
Missing	0.9	0.0	0.0
Employed (%)	57.0	55.6	62.2
Missing	1.8	1.6	0.0

Table 2.3. Continued

	Group 1 (N = 114)	Group 2 (N = 63)	Group 3 (N = 45)
Having children (%)	28.1	44.4	31.1
Having a dog* (%)	24.6	4.8	23.3
Participates in sports (%)	71.9	57.1	60.0
Environmental characteristics Median % (IQR)[a]			
Residences			
800m	58.87 (44.46; 62.76)	52.18 (44.83; 61.18)	56.09 (37.86; 64.29)
1600m	37.82 (32.26; 46.46)	35.84 (30.10; 41.21)	38.11 (29.01; 48.83)
Roads			
800m	5.48 (4.46; 7.35)	5.00 (3.24; 6.65)	5.79 (3.56; 7.22)
1600m*	5.71 (4.83; 5.71)	5.24 (3.18; 5.85)	5.67 (4.91; 6.35)
Shopping facilities and hospitality industry			
800m	2.24 (1.55; 4.46)	1.98 (1.09; 2.89)	1.77 (1.45; 4.73)
1600m	2.07 (1.34; 4.51)	1.76 (1.04; 2.91)	1.88 (0.91; 4.79)
Public social cultural facilities			
800m	2.74 (1.21; 6.73)	1.64 (0.88; 3.75)	3.24 (0.89; 6.39)
1600m	4.13 (2.27; 6.85)	3.43 (1.66; 6.92)	4.48 (2.52; 6.94)
Sports terrain			
800m	2.14 (1.01; 3.19)	2.77 (1.36; 4.84)	2.63 (1.21; 3.21)
1600m*	3.00 (2.18; 4.42)	3.56 (2.63; 8.08)	2.74 (1.93; 5.84)
Recreational area			
800m	0.0 (0.0; 1.67)	0.0 (0.0; 1.04)	0.0 (0.0; 0.73)
1600m	0.44 (0.04; 1.36)	0.44 (0.18; 1.36)	0.85 (0.22; 2.42)
City green			
800m	5.98 (2.43; 8.76)	5.74 (3.01; 8.56)	6.78 (5.11; 7.82)
1600m	6.07 (3.83; 10.83)	5.42 (3.82; 7.74)	4.83 (3.52; 7.60)
Larger green			
800m*	1.23 (0.0; 8.12)	4.19 (0.0; 21.92)	3.90 (0.0; 15.77)
1600m	5.20 (1.13; 21.77)	12.38 (2.20; 32.59)	9.70 (2.46; 30.20)
Blue space			
800m*	1.40 (0.0; 12.53)	0.0 (0.0; 6.39)	0.0 (0.0; 3.78)
1600m*	3.86 (0.15; 20.87)	0.14 (0.0; 12.37)	2.79 (0.0; 7.63)

Note: SD = Standard Deviation. IQR = Interquartile Range. [a]Medians are presented as these variables were not normally distributed. *Significant differences were found between groups.

None of the three groups had day type three as the predominant pattern. Individuals in group one were most likely to have hour-by-hour PA patterns of day type two. This group had a significantly higher percentage of native Dutch adults than the other groups. The group had the lowest proportion of larger green within an 800m buffer, and the highest proportions of blue space in both buffers. Individuals in group two were most likely to have hour-by-hour PA patterns of day type one. This group had a significantly lower percentage of dog owners than the other groups. The group had the lowest proportion of roads, and the highest proportion of sports terrain, within a 1600m buffer. It also had the highest proportion of larger green within an 800m buffer. Individuals in group three were most likely to have hour-by-hour PA patterns of day type four. The percentage of non-western immigrants in this group was significantly higher than in the other groups. This group had significantly less sports terrain within a 1600m buffer.

2.4 DISCUSSION

Main findings of this study

This study enhances the field by using multilevel latent growth models to distinguish hour-by-hour PA patterns in objectively collected LPA and MVPA data, and by classifying individuals based on their PA patterns without making a priori assumptions on group composition. Four typical hour-by-hour PA patterns were distinguished: 1) a morning LPA pattern, 2) a mid-day MVPA pattern, 3) an overall inactive pattern, and 4) an overall active pattern. Individuals with similar combinations of these patterns over the course of several days also appeared to be similar regarding some individual characteristics (i.e., ethnicity and having a dog) and residential area characteristics (i.e., proportion of roads, sports terrain, larger green space, and blue space).

What is already known on this topic, and what this study adds

Whereas most previous studies reported total daily PA levels, the time-specific data of the current study draws attention to periods of the day when adults are less active which could be targeted for intervention. The hour-by-hour analyses indicated that evenings may be an important intervention opportunity as for this time period the lowest levels of both LPA and MVPA were observed in all four daily PA patterns. Furthermore, the overall inactive PA pattern is of concern for adverse health outcomes, and more than 15% of the observed days in our sample were of the inactive type. Although none of the three groups of individuals with distinctive combinations of certain day types had the inactive PA patterns as their predominant pattern, group 1 still has a considerable change of having an inactive day pattern. As high PA levels can attenuate the adverse health effects of prolonged sitting time [26], it is important that inactive days are compensated by more active days (i.e., day type 4), or by day types that have higher PA levels in specific time windows (e.g., day types 1 or 2). Well-targeted interventions may replace inactive days by for example morning LPA patterns or mid-day MVPA patterns (e.g., by integrating more PA at work and more active transport to work).

Adults of group 2, who were most likely to have a morning LPA pattern (i.e., day type 1), less often owned a dog compared to the other groups. As dog ownership is known to positively relate to (MV) PA [19,27], this may partly explain their lower PA levels compared to other adults. Moreover, although not significantly different from the other groups, group 2 had the highest prevalence of having at least one child living at home. Their low levels of MVPA are in line with evidence showing a negative association between MVPA and having children [19]. Perhaps these adults' MVPA levels can be increased by interventions that aim to stimulate MVPA during the evenings and weekend days. Besides, group 2 had the highest proportions of sports terrain within a 1600m buffer and larger green spaces within an 800m buffer. This may explain why the morning LPA pattern mostly occurred on Saturdays, as sports and visits to e.g., forests often take place during the weekends.

The mid-day MVPA pattern (i.e., day type 2) was most likely for native Dutch adults (group 1). This is consistent with previous studies showing lower levels of PA for ethnic minority groups [28]. Day type 2 mostly occurred on Saturdays, which may be because of higher levels of sports participation on Saturdays compared to other days of the week. Additionally, the results showed that group 1 (i.e., which had most chance of this day type 2) had the highest proportions of blue space in their residential environments. Although current literature shows that blue space can be seen as activity-promoting, it is often associated with low-intensity activities (e.g., walking) [29]. Perhaps in the Netherlands blue space also elicits high-intensity activities such as jogging. However, the design of the current study does not allow for causal inferences to be drawn between environmental characteristics and PA. Future research may examine whether the presence of blue space in residential environments contributes to more active PA patterns, or that adults who prefer an active lifestyle choose to reside in a neighborhood with blue spaces.

Furthermore, day type 4, consisting of both high LPA and MVPA levels, was most likely among the group with a significantly higher prevalence of non-western immigrants (i.e., group 3). Although this may seem unexpected, as being of ethnic origin has been related to lower levels of PA [28], it may be (partly) explained by the prevalences of employed and lower educated adults within this group. Previous studies have shown that education was inversely associated with (occupational) PA [19,30]. That is, lower educated adults might more often have jobs that require PA. This thought is supported by the high prevalence of lower educated, employed adults in this group, and by the finding that this pattern mostly occurred on weekdays. Another somewhat unexpected finding is that this group had the lowest levels of sports terrain within a 1600m buffer. Although one may expect that the presence of sports facilities contributes to an increase in PA (intensity), these findings suggest that other public, or work spaces may be of equal or even more importance. This is in line with previous findings which showed that different locations are used for (MV) PA [19].

Where previous studies found associations between various socio-demographic and environmental factors and PA, this study found that typical PA patterns were only to a limited extent associated with personal (i.e., ethnicity and having a dog) and residential characteristics (i.e., roads, sports terrain, larger green space, and blue space). This suggests that when it comes to hour-by-hour PA patterns, other factors such as time regimes of work, family life, and leisure may also have a considerable impact on the distribution of PA throughout the day. Hence, time-interval specific interventions cannot just be applied to 'traditional' target groups such as lower educated or non-native adults, but should consider evidence on daily PA patterning.

Limitations of this study

It should be noted that, while clusters of PA patterns are identified, considerable variation exists within clusters. For example, one may find PA peaks during the evening for some adults, despite the average declining trend in PA during the evening. When such a pattern is not frequent enough among the study population, these peaks will not be reflected in the average hour-by-hour PA patterns of each cluster depicted in Figure 2.1. A larger study sample may yield more diverse PA patterns that give rise to additional time specific interventions.

This rich data provides many opportunities for further investigation, and future research may for example assess the association between individual characteristics of adults who had during the day at least one hour of 100% LPA or MVPA, or distinguish the locations where peaks and troughs of LPA or MVPA take place.

2.5 CONCLUSIONS

This study used a novel approach to examine adults' daily PA patterns. Where previous studies mostly aimed to compare PA patterns of a priori defined sub-populations, this study used the detailed and objectively collected PA data as a starting point to examine what daily PA patterns could be distinguished, and additionally to assess what different groups of individuals could be distinguished, based on these patterns. This data driven approach may offer new clues of how to define target groups for time specific PA interventions, which take into account individuals' daily and weekly time regimes. For instance, this approach revealed that to increase PA, evenings may be important opportunities for intervention.

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Chapter 3

Sports facilities, shopping centers or homes: what locations are important for adults' physical activity? A cross-sectional study

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ABSTRACT

Physical activity (PA) is influenced by the built environment. However, little is known about the types of built environment where adults spend their time, and at what levels of PA they engage in those environments. Understanding the effect of the built environment on PA requires insight into PA behavior at different types of locations (e.g., home, work, shopping centers, and sports facilities). Therefore, this study describes where adults aged 45–65 years were active with moderate-to-vigorous intensity (MVPA), and examines associations of socio-demographic factors and neighborhood with MVPA at these locations. Participants' (N = 308) PA was measured for seven days using accelerometers and GPS-devices. Adults spent most minutes of MVPA at home and work. Highest MVPA-ratios of total time spent at a location were achieved in sports facilities and during transport. Neighborhood characteristics and socio-demographic factors such as work status, health status and household structure, had significant effects on MVPA at various locations and on total MVPA. Understanding PA behavior at various locations may provide insights that allow professionals in different domains (e.g., health, landscaping, urban planning) to develop strategies to stimulate PA.

3.1 INTRODUCTION

The positive effects of physical activity (PA) on physical and mental health [1,2], health-related quality of life [3], and healthy ageing [4] have been extensively documented. However, worldwide, the percentage of adults who do not meet World Health Organization recommendations for PA is still 31.1% [5]. Insufficient PA is seen as a major public health problem, which puts a high demand on society due to the high costs it generates [1,6].

The built environment (i.e., the spatial organization of residential, work, shopping- and recreational areas, their layout and appearance, and the transportation system connecting them) has been identified as a factor that influences PA levels [7,8]. For example, neighborhood walkability and street connectivity have been found to be associated with active transport, and factors such as safe crossings, pavement, greenness, attractiveness, and proximity to facilities for recreation have been identified as correlates of leisure activity [8]. Most research into the relationship between the built environment and health behaviors such as PA has focused on the residential environment [9] and its effect on total PA or on a specific type of PA, such as walking or cycling [7,10,11]. However, as Sallis et al. (2006) stated in their ecological model of active living [12], individuals interact with various environments as they participate in different types of activities at different places throughout the day (active transport, occupational activities, household activities and active recreation). This suggests that researchers should study PA behavior in a broader geographical context than the neighborhood alone. Since specific physical activities are often related to certain elements of the built environment such as parks, infrastructure, and building complexes (e.g., infrastructure can influence transport-related PA), understanding the effects of the built environment on PA ideally requires that levels of PA are assessed for specific locations.

The increasing awareness that the impact of the built environment on PA should be understood and measured for specific locations has recently spawned a stream of studies that used accelerometers and GPS-devices to assess location specific PA. Most of these studies have investigated children's PA behavior. These studies distinguished indoor and outdoor PA behavior, PA within and outside children's neighborhoods, and (MV)PA at various locations such as the home, gardens, green spaces, schoolyards, playgrounds, sports facilities and streets (e.g., [13–19]). In addition, Dunton et al. (2013) investigated the locations (e.g., residential locations, public facilities and open spaces) of joint MVPA of children and their parents [20]. As for adults, less evidence is available about the types of built environments where they actually spend their time, and what levels of PA they engage in at different locations [21,22]. Rodriguez et al. (2005) described adults' PA levels indoors and outdoors within and outside the neighborhood [23]. Other studies assessed at what distance from home adults were physically active [24,25], or described the size and characteristics (fast food outlet density, number of supermarkets, and park land use) of activity spaces (i.e., the subset of all locations with which individuals interact during their daily activities) in relation to PA behavior [26,27]. However, these studies used a relatively rough classification when determining the geographical locations where adults were physically active. Larson et al. (2014) studied a more extensive set of specific locations that were used for PA: they assessed the frequency of use of the home/backyard, neighborhood sidewalks, neighborhood parks, workplace, state parks and gyms [28], but they used self-report measures (surveys). Moreover, most studies of the effect of the environment on PA describe the distribution of PA across location types for the population as a whole, or for a limited number of subgroups. However, it is important to consider a broader set of socio-demographic factors since both PA behavior and the use of locations for PA are likely a reflection of various personal factors such as preferences and needs, access to transport options, social norms, and constraints (e.g., having children, work obligations). A proper insight into how locations are used for PA and by which population groups, requires the inclusion of a broad set of variables using multivariate analyses.

Therefore, this study aims (1) to provide insight into the locations where adults engage in MVPA; as well as (2) to assess the extent to which individual demographics influence the amount of MVPA at different locations, as well as the overall amount of MVPA.

3.2 MATERIALS AND METHODS

Study Design, Participants and Setting

This cross-sectional study is part of PHASE (Physical Activity in public Space Environments), a research project that was conducted in the Netherlands, to investigate how PA is distributed across the home location, the neighborhood and more remote locations.

Adults aged 45–65 years were recruited in four neighborhoods in Rotterdam (623 652 inhabitants) and Maastricht (122 397 inhabitants), in the Netherlands. These neighborhoods (Kralingen-West, Oude Noorden, Zuid-Oost and West; Figure 3.1) were selected based on their geographical differences, which were presence of green and parks, distance to the city center, type of buildings, and population density. Table 3.1 presents neighborhoods characteristics.

Figure 3.1 Selected neighborhoods in Rotterdam and Maastricht.

Table 3.1 Neighborhood characteristics.

	Rotterdam		Maastricht	
	Oude Noorden	**Kralingen-West**	**Zuid-Oost**	**West**
Surface area *(hectometer)*	107	102	1089	884
Land	101	102	970	884
Water	6	0	119	0
Inhabitants *(N)*	16,815	15,115	21,760	37,865
Population density *(N inhabitants per km²)*	16 658	14 778	2 244	4 285
Housing density *(N addresses per km²)*	≥ 2500	≥ 2500	1500-2500	1500-2500
Land use (%)				
Residential area	69.3	85.7	26.1	51.6
Parks, public garden	0.0	3.1	3.5	5.9
Agricultural area, recreational area, forest	0.0	0.0	34.2	19.9
Sports facilities	0.0	3.1	2.2	12.2
Roads, streets	7.8	0.2	6.6	3.0

Note: Source: Statistics Netherlands [29].

Addresses of inhabitants (45–65 years) were randomly selected from the municipal population registers of Rotterdam and Maastricht. Selected adults (N = 14,889) were contacted by an information letter in which they were asked to participate in the study. Adults who were willing to participate registered through a website or by telephone (N = 516). Subsequently, they were contacted by phone or e-mail to plan the distribution of an accelerometer and GPS-device. Staff members distributed the devices in community centers, and explained monitor wear and placement. Participants received an information sheet, with a summary of instructions. Data were collected between April 2014 and December 2014 and all participants signed informed consent. Participants in Rotterdam received an incentive of 10 per person, and participants in Maastricht were entered into a raffle method: 15 prizes of 100 each were raffled. Data of 308 adults could be included for analyses after applying criteria for valid data. Figure 3.2 illustrates the recruitment procedure.

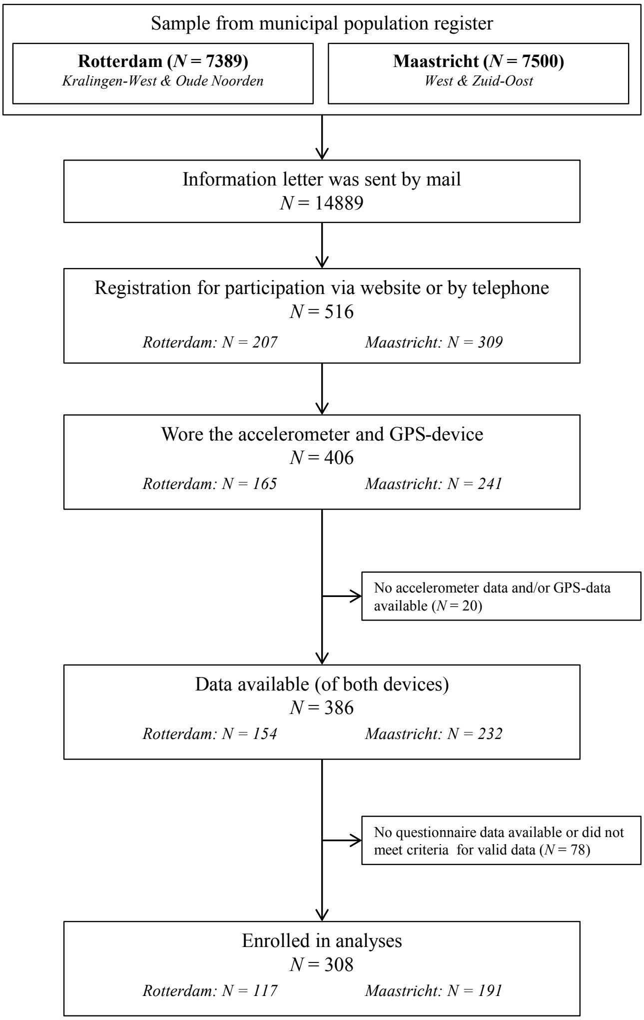

Figure 3.2 Flowchart of participant recruitment.

Measures

PA. PA was objectively assessed using the Actigraph GT3X+ accelerometer (Actigraph, Pensacola, Florida, FL, USA). The accelerometer was attached to an elastic, adjustable belt. Participants were instructed to wear the device on the right hip for seven consecutive days during waking hours (except during water-based activities). Actilife v6.11.2 (Firmware 2.2.1, Actigraph, Pensacola, Florida, FL, USA) was used to download accelerometer data.

Triaxial accelerometer data were collected in 5 s epochs, and summed as counts per minute (cpm) during data processing. Vector magnitude cut-points for cpm were used to define moderate PA (3208–8564 cpm) and vigorous PA (¥8565 cpm), which were derived from a study population similar to this study's population [30]. MVPA was calculated as the sum of moderate PA and vigorous PA.

Because of the slightly older population, non-wear time was defined as episodes of at least 90 min of consecutive zero counts [31], with allowance for up to two consecutive minutes of 1–100 cpm. Non-wear episodes ended when the cpm exceeded 100, or when three or more consecutive minutes accumulated between 1 and 100 cpm [32]. To determine the length of a valid day, the 70/80 rule was used. This rule defines a valid day as having non-missing counts for at least 80% of a measurement day [33]. A measurement day reflects the length of time in which at least 70% of all participants wore the accelerometer device [33], which was 611 min for this study. Calculating 80% of this episode of 611 min yields a valid day of 488.8 min. Only valid data of participants with at least four of these valid days were included for analyses [34].

PA locations and trips. Participants' geographical locations were measured using BT-Q1000XT GPS-devices (QStarz International Co, Taipei, Taiwan). The GPS-device was attached to the same belt as the accelerometer and wearing instructions were similar to those for wearing an accelerometer. QStarz QTravel software (v1.45, Qstarz International Co., Ltd, Taipei, Taiwan) was used to download GPS-data. GPS- and accelerometer-data were date and time linked using Python software to create combinations of PA intensity and location of PA.

To gain insight into the locations where adults are actually physically active, GPS-data had to be categorized into various types of activity locations. To do so, all GPS-data were first subdivided into either stop episodes or trips. This identified a first category of activity locations, namely: trips, as being in transit can be considered a "location" where PA may take place. Trips are clusters of successive GPS data points of which (1) the average speed was 3 km/h or more; (2) the trip length was 100 m or more; and (3) the minimum duration of a trip was 1 min. "Trips" are further referred to as "transport".

Stop episodes are clusters of successive GPS data points that met the following three criteria: (1) the maximum range of data points was 150 m; (2) the average speed of data points was under 3 km/h; and (3) the minimum duration of a stop episode was 2 min. For each stop episode, the center of gravity was calculated. The coordinates of these centers of gravity were used to map all stop episodes (stops) in ArcMap 10.2.2 (Esri, Redlands, California, CA, USA). To further categorize stops into specific types of locations, ArcMap was used to link data on land use (available from Dutch Statistics, 2010) and buildings (available from Dutch Cadaster, 2014) to these stops. For each stop, we calculated in what type of land use it was located, what types of land use (and in what proportions) occurred within a 25 meter buffer (from the center of gravity), and what functions the three nearest buildings had. Based on this information, stops were further classified into nine different categories. Table 3.2 shows the conditions for categorization of the stops into the activity location types “home”, “other residential area”, “residential and shopping area”, “shopping area”, “workplace”, “small green area”, “larger green area”, “sports facilities” and “other”. Since we had only access to data on land use and buildings of the Netherlands, stops with their center of gravity located outside the boundaries of the Netherlands were excluded from analyses (approximately 4% of the data). For this purpose, the centers of gravity of trips were also calculated: only trips with their center of gravity within the Netherlands were included for analyses.

Background variables. A questionnaire was used to collect information on home address, details on the home location (e.g., having a garden), having a car, work address, health status (SF36), and socio-demographic factors. Socio-demographic factors were age, gender, education (low, middle, high), employment (i.e., yes, no), household structure (i.e., having a partner, having children), neighborhood, and ethnicity (i.e., autochthonous, western-, and non-western immigrants). Non-western immigrants are people who were born and/or of whom at least one parent was born in Turkey, an African country, a country in Latin-America, or in a country in Asia (except for Japan and Indonesia). Western immigrants are people who were born and/or of whom at least one parent was born in Japan, Indonesia, a European country (except for Turkey), a country in North-America, or a country in Oceania.

Meteorological data. Data on daily temperature (°C), sunshine (hours), and average wind speed (m/s) were obtained from Royal Dutch Meteorological Institute measurement stations in Maastricht and Rotterdam [35]. Dummy variables were created to take these variables into account in analyses. Cut-points for four equal groups were obtained using descriptive statistics in SPSS.

Table 3.2 Categorization of stops into various activity locations.

Activity locations (AL)	AND/OR	Classification conditions
Home		AL within 25 meter buffer from home address, obtained through questionnaire.
	OR	AL within 25 meter buffer from home address, obtained by using GPS-data: if the first and last coordinates of multiple days were identical, these coordinates were considered the home location - only when the home address missed or was incomplete
Other residential area		BF_{25} = residence
	AND	BF_{25} ≠ shops or foodservice industry
	AND	LU_{25} = residences > 70%
Residential & shopping area		BF_{25} = shops or foodservice industry
	AND	BF_{25} = residence
	AND	BF_{25} ≠ other functions
Shopping area		BF_{25} = shops or foodservice industry
	AND	BF_{25} ≠ other functions
	OR	BF_{25} = shops or foodservice industry
	AND	LU_{0} = shops or foodservice industry
	AND	LU_{25} = shops or foodservice industry > 70%
Workplace		AL within 50 meter buffer from work address obtained through questionnaire.
	OR	AL located within 25 meter from health care institutions, offices, educational institutions, lodging, industry or shops according to building data, and if participants spent at least 240 min at that location.
Small green area		LU_{0} = parks and public garden or allotment garden
Larger green area		LU_{0} = recreational area, agricultural area, forest, or natural terrain
Sports facilities		LU_{0} = sport terrain
	OR	BF_{10} = sport facility
		Sports facilities in the Netherlands require membership or subscription, this comes with certain costs that differ per type of sport.
Other		If not classified as any other category

Note: BF_{25} = Building function within 25 meter buffer from stop. BF_{10} = Building function within 10 meter buffer from stop. BF_{50} = Building function within 50 meter buffer from stop. LU_{0} = Type of land use in which the stop is located. LU_{25} = Type(s) of land use (%) within a 25 meter buffer around the stop.

Statistical Analyses

To assess the effect of various independent variables (socio-demographic factors and neighborhood) on the interval-ratio variables total MVPA, and MVPA at different activity locations, multiple regression analyses were performed. Most of the dependent variables were not normally distributed and neither log transformations, nor taking the square root of these variables led to normal distributions. Since the normality assumption was violated, bootstrapped (resampling method) multilevel regression analyses were performed. Multilevel analyses were used to correct for clustering of days within respondents. "Income" had to be excluded from multilevel analyses to avoid multicollinearity with other variables. Statistical analyses were performed using SPSS 22.0 for windows.

3.3 RESULTS

Sample Characteristics

Table 3.3 presents participants' characteristics. The mean age of adults in this study sample was 56.4 (SD 6.2) years. More than half (52.9%) of participants has a healthy weight, 37.0% is overweight and 10.1% is obese. Percentages of overweight were higher in "Zuid-Oost" (45.7%) and "West" (36.0%) in Maastricht, as compared to "Oude Noorden" (25.5%) and "Kralingen-West" (33.3%) in Rotterdam. Most participants were native Dutch (84.4%). The neighborhoods of Rotterdam had the highest percentages of non-western immigrants, whereas the neighborhoods of Maastricht had the highest percentages of western immigrants. This trend is similar to percentages of immigrants in the selected neighborhoods according to Statistics Netherlands [29], but both non-western and western immigrants were underrepresented in this study population. Most participants had middle (52.9%) or higher (41.2%) education. Over 60% of the total study population was employed. In total, 1804 days were included for analyses. Participants wore the devices on average 830.7 (SD 168.1) minutes per day.

Average Daily PA

Total MVPA represents on average 34.0 min of the day (Table 3.3). Inhabitants of Oude Noorden (Rotterdam, The Netherlands) spent least time in total MVPA per day: 31.4 min, whereas inhabitants of Kralingen-West (Rotterdam, The Netherlands), Zuid-Oost (Maastricht, The Netherlands), and West (Maastricht, The Netherlands) spent 35.8, 35.3, and 33.1 min in MVPA, respectively.

Use of Activity Locations

Table 3.4 shows that all participants engaged in transport (i.e., active or motorized transport) on at least one measurement day. The activity locations home, other residential area, and other were visited on at least one day by more than 90% of participants. Small green areas were visited the least (20.8%). The table also shows that most time per day is spent at home (310.6 min) and at workplaces (297.8 min). Least time per day is spent in residential- and shopping areas (18.8 min).

MVPA at Various Locations

Participants accumulated most minutes of MVPA at home (10.4 min) and at work (9.9 min) (Table 3.4). Least minutes of MVPA were accumulated in larger green areas (0.9 min) and residential and shopping areas (0.6 min). When taking total time spent at the location into account, the share of MVPA was largest in sports facilities (5.9%) and during transport (5.7%). Table 3.5 shows bootstrapped multilevel regression results on the effect of neighborhood and socio-demographic determinants on total MVPA and on MVPA at various locations.

Table 3.3 Population characteristics.

	Total study sample (N=308)	Oude Noorden (N=51) (Rotterdam)	Kralingen-West (N=66) (Rotterdam)	Zuid-Oost (N=105) (Maastricht)	West (N=86) (Maastricht)
Age in years					
Mean (SD)	56.4 (6.2)	55.1 (5.9)	55.5 (5.8)	56.7 (6.3)	57.6 (6.4)
Female (%)	54.9	62.7	50.0	58.1	50.0
BMI (%)					
Healthy weight	52.9	60.8	62.1	43.8	52.3
Overweight	37.0	25.5	33.3	45.7	36.0
Obese	10.1	13.7	4.5	10.5	11.6
Ethnicity (%)					
Autochthonous	84.4	82.4	80.3	86.7	86.0
Western immigrants	6.8	5.9	4.5	7.6	8.1
Non-Western immigrants	7.5	11.8	13.6	3.8	4.7
Missing	1.3	0	1.5	1.0	1.2
Education (%)					
Lower	4.2	7.4	4.5	3.8	2.3
Middle	52.9	54.9	27.3	59.0	64.0
Higher	41.2	35.3	65.2	37.1	31.4
Missing	1.6	2.0	3.0	0	2.3
Employment (%)					
Employed	61.7	68.6	65.2	60.0	57.0
Not employed	37.3	31.4	33.3	39.0	41.9
Missing	1.0	0	1.5	1.0	1.2
Days included in analyses (N)	1804	282	380	626	516
Wear time in minutes per day					
Mean (SD)	830.7 (168.1)	823.9 (159.4)	832.3 (159.4)	833.5 (169.0)	829.9 (178.0)
Levels of MVPA in minutes per day					
Median (IQR)	34.0 (38.8)	31.4 (39.4)	35.8 (38.7)	35.3 (40.8)	33.1 (36.9)

Table 3.4 Total time spent, and time spent in MVPA at various locations by neighborhood.

	Total study sample (N=308)		Oude Noorden (N=51) (Rotterdam)	
Home				
Adults who visited the location[a] (%)	94.5		96.1	
Time spent at the location[b] (min/day)	310.6	(352.0)	246.4	(303.6)
Time spent in MVPA at the location (min/day)	10.4	(16.8)	9.2	(17.0)
MVPA-ratio of total time spent at location[c] (%)	3.8	(4.1)	4.0	(5.3)
Other residential area				
Adults who visited the location[a] (%)	94.2		96.1	
Time spent at the location[b] (min/day)	116.9	(222.5)	131.5	(171.1)
Time spent in MVPA at the location (min/day)	5.0	(14.2)	6.1	(12.0)
MVPA-ratio of total time spent at location[c] (%)	4.5	(6.3)	4.5	(7.3)
Residential and shopping area				
Adults who visited the location[a] (%)	40.6		41.2	
Time spent at the location[b] (min/day)	18.8	(56.6)	18.3	(122.0)
Time spent in MVPA at the location (min/day)	0.6	(2.8)	0.4	(5.9)
MVPA-ratio of total time spent at location[c] (%)	2.9	(6.6)	3.0	(7.0)
Shopping area				
Adults who visited the location[a] (%)	76.3		64.7	
Time spent at the location[b] (min/day)	21.6	(52.0)	53.1	(149.7)
Time spent in MVPA at the location (min/day)	1.0	(4.1)	2.0	(9.2)
MVPA-ratio of total time spent at location[c] (%)	5.0	(10.6)	4.0	(9.1)
Small green area				
Adults who visited the location[a] (%)	20.8		27.5	
Time spent at the location[b] (min/day)	24.0	(160.5)	97.0	(241.9)
Time spent in MVPA at the location (min/day)	1.0	(10.1)	2.5	(18.0)
MVPA-ratio of total time spent at location[c] (%)	4.5	(10.9)	3.5	(10.2)
Larger green area				
Adults who visited the location[a] (%)	43.2		35.3	
Time spent at the location[b] (min/day)	35.6	(106.9)	76.1	(206.0)
Time spent in MVPA at the location (min/day)	0.9	(6.6)	6.2	(24.6)
MVPA-ratio of total time spent at location[c] (%)	3.6	(8.8)	7.2	(18.7)
Sports facilities				
Adults who visited the location[a] (%)	36.0		23.5	
Time spent at the location[b] (min/day)	73.6	(128.9)	31.4	(78.4)
Time spent in MVPA at the location (min/day)	4.2	(19.6)	2.8	(7.6)
MVPA-ratio of total time spent at location[c] (%)	5.9	(21.6)	5.0	(12.5)
Workplaces				
Adults who visited the location[a] (%)	46.1		51.0	
Time spent at the location[b] (min/day)	297.8	(349.0)	333.0	(329.7)
Time spent in MVPA at the location (min/day)	9.9	(19.6)	13.5	(26.8)
MVPA-ratio of total time spent at location[c] (%)	4.2	(5.2)	5.2	(7.4)
Other				
Adults who visited the location[a] (%)	96.8		100.0	
Time spent at the location[b] (min/day)	46.9	(129.9)	77.7	(152.5)
Time spent in MVPA at the location (min/day)	1.8	(7.1)	3.6	(10.8)
MVPA-ratio of total time spent at location[c] (%)	4.3	(8.5)	5.3	(8.9)
Transport				
Adults who visited the location[a] (%)	100.0		100.0	
Time spent at the location[b] (min/day)	78.5	(89.9)	72.4	(86.6)
Time spent in MVPA at the location (min/day)	4.6	(11.4)	3.6	(8.4)
MVPA-ratio of total time spent at location[c] (%)	5.7	(10.9)	4.5	(6.6)

Note: Time spent (in MVPA) and MVPA-ratio is represented as medians and interquartile ranges: median (IQR). [a]On at least one day during the time of measurement. [b]Calculated over the days that participants were actually at the specific location. [c]MVPA-ratio was calculated as time spent in MVPA at the location (minutes) divided by total time spent at that location (minutes), and then multiplied by 100%.

	Kralingen-West (N=66) (Rotterdam)		Zuid-Oost (N=105) (Maastricht)		West (N=86) (Maastricht)	
	97.0		92.4		94.2	
	317.8	(371.0)	348.0	(355.8)	295.9	(316.0)
	11.5	(21.0)	11.8	(17.4)	8.8	(14.6)
	4.2	(5.2)	3.8	(3.6)	3.7	(4.2)
	90.9		94.3		95.3	
	141.3	(218.9)	105.3	(232.3)	108.4	(254.7)
	5.8	(15.8)	4.2	(13.5)	4.7	(15.9)
	4.6	(6.1)	4.3	(5.9)	4.5	(6.6)
	33.3		49.5		34.9	
	55.4	(150.1)	20.9	(52.6)	9.8	(15.9)
	2.3	(5.8)	0.8	(2.2)	0.3	(0.9)
	2.2	(5.0)	4.2	(6.7)	2.4	(5.6)
	80.3		80.0		75.6	
	12.4	(33.4)	20.7	(42.9)	26.5	(52.6)
	0.3	(2.6)	1.0	(3.8)	1.4	(4.5)
	2.8	(8.0)	6.1	(13.0)	5.3	(12.1)
	42.4		9.5		14.0	
	22.9	(115.3)	26.3	(95.0)	13.1	(124.5)
	1.0	(12.6)	0.3	(5.9)	0.6	(9.6)
	5.3	(14.2)	3.0	(13.8)	4.2	(5.4)
	34.8		57.1		37.2	
	139.3	(338.1)	28.8	(74.1)	21.8	(67.8)
	7.0	(24.1)	0.7	(2.4)	0.3	(1.1)
	5.3	(8.8)	3.8	(10.5)	2.1	(4.9)
	36.4		35.2		44.2	
	89.9	(216.5)	69.3	(115.5)	75.6	(105.3)
	9.3	(22.1)	2.5	(16.9)	6.0	(29.6)
	6.8	(17.7)	4.0	(20.2)	9.5	(26.0)
	50.0		43.8		43.0	
	260.7	(365.7)	285.3	(378.8)	319.1	(311.9)
	9.8	(20.6)	8.3	(11.1)	14.0	(17.9)
	3.6	(4.9)	4.1	(7.4)	4.3	(3.8)
	100.0		97.1		91.9	
	45.3	(126.7)	39.0	(120.8)	42.3	(117.3)
	2.1	(8.0)	1.4	(5.7)	1.4	(5.6)
	4.2	(8.2)	4.2	(8.1)	3.8	(9.3)
	100.0		100.0		100.0	
	86.0	(98.4)	79.0	(89.1)	76.4	(85.7)
	4.1	(9.2)	5.3	(15.1)	5.1	(13.8)
	5.0	(7.4)	6.6	(14.7)	6.8	(14.4)

Table 3.5 Associations between individual determinants, type of day, weather, neighborhood, and daily MVPA.

	Total[b]	Home[b]	Other residential area[b]	Residential & shopping area[f]	Shopping area[b]
Intercept	50.23	8.73	18.31	3.53	17.48
Socio-demographics					
Age (Ref.: 45-50 years)					
51-55 years		+0.16	-0.06		
56-60 years		+2.13*	+1.20		
>60 years		+2.08*	-2.94**		
Ethnicity (Ref.: autochthonous)					
Western	-10.69**	-3.43**	-2.68**		-3.07**
Non-Western	+1.43	-0.31	-2.12*		-0.12
Health-related determinants					
Health status (Ref.: Very good)					
Good	-2.40	-3.90**	-2.32**		-3.65**
Fair	-5.19**	-2.21**	-3.74**		-2.62**
Poor	-9.70**	-0.17	-6.52**		-2.40
Very poor	-27.83**	-2.71	-12.08**		-6.20**
BMI (Ref.: healthy weight)					
Overweight	-10.02**	-3.98**			-0.56
Obesity	-11.90**	-7.45**			-2.68**
Work and education					
Employed	-6.67**	-3.98**	-6.11**		
Education (Ref.: lower education)					
Middle	-6.48**				-7.69**
Higher	-5.72*				-10.29**
Household structure					
Female		+2.48**	+1.68**		
Having a partner			-1.87**		
Partner is employed		+3.53**			
Having a child aged ≤ 4	- 16.41**	-7.18**		-2.33**	-3.17**
Having a child aged 4-11					
Having a child aged 11-17	-2.29*				
Having a dog	+16.11**	+7.19**	+5.32**		-3.23**

	Work-place[b]	Small green area[f]	Larger green area[f]	Sports facilities[f]	Trans-port[b]	Other[b]
	21.17	14.83	4.63	5.54	11.64	14.37
		-0.77				
		-4.88				
		-7.61**				
	-3.26		-3.82**		-4.64**	
	-3.32**		-4.82*		-1.99**	
					+0.52	+0.59
					-3.21**	+6.00**
					-3.66**	+6.82**
					-5.40**	-3.03**
					-4.51**	-2.28**
					-2.89**	-5.43**
					-2.29**	
	+0.80					-3.06
	-6.17**					-4.66**
	NA				-3.30**	
	NA					-2.09**
	NA					-1.84**
	NA	-4.42*		+5.62**		-8.03**
	NA			-10.74**	-2.87**	+3.56*
	NA				-2.73**	
	NA		-4.21**		+4.28**	

Table 3.5 Continued.

Car ownership, garden					
Car ownership					
(Ref.: no car)					
1 car					
≥ 2 cars					
Having a garden					
(Ref.: no garden)					
Garden at home	-3.83**		-3.60**		
Garden elsewhere	+9.53**		-1.43		
Day of the week					
Weekend day (Ref.: weekday)	+8.76**	+4.43**			+2.17*
Neighborhood					
Neighborhood					
(Ref.: Oude Noorden)					
Kralingen-West	+1.70	+7.17**	+2.19*	+5.44	-4.27**
Zuid-Oost	+8.68**	+7.17**	+0.29	-0.58	-2.74**
West	+5.55*	+3.65*	+2.44**	-2.08*	-3.20**
Weather					
Max. temperature (°C)					
(Ref.: ≤ 7.6°C)[a]					
7.6 < °C ≤ 13.2	+0.77	+2.61**			
13.2 < °C ≤ 16.6	+5.56*	+3.66**			
°C > 16.6	+6.17*	+3.66*			
Sunshine (hours)					
(Ref.: h ≤ 0.3)[a]					
0.3 < h ≤ 2.8					
2.8 < h ≤ 6.9					
h > 6.9					
Wind speed (m/s)					
(Ref.: ≤ 2.5)[a]					
2.5 < m/s ≤ 3.3	-5.14**				
3.3 < m/s ≤ 4.3	+2.34				
m/s > 4.3	+2.30				

Note: * P-value < 0.1, ** P-value < 0.05. NA = not assessed. [a]Dummy variables were created based on cut off values for 4 equal categories, as obtained in SPSS. [b]Backward selection procedure. [f]Forward selection procedure: backward procedure could not be performed since this blew up the model.

+0.43	-11.61**	+7.17**		+1.32	+0.92
+5.69**	-16.11**	+8.33**		-2.59**	+5.01**
NA					
	+5.70**			-1.55**	+1.82**
	+21.21**			+2.32	+2.30
NA				+6.41**	
-4.15*		-1.40	+8.95**	+0.20	-3.73**
-8.63**		-8.80*	+6.91**	+7.47**	-6.14**
-7.06**		-11.59**	+10.04**	+5.32**	-6.19**
		+3.11*			
		+6.87**			
		+6.72			
				+2.03*	
				+1.29	
				+0.46	
				-3.66**	
				-0.14	
				+0.17	

Total MVPA. Negative correlates of total MVPA were being a western immigrant, fair, poor, and very poor health status, overweight and obesity, employment, middle and higher education, having children ≤4 years, having children aged 11–17 years, having a garden at home, and a wind speed of 2.5–3.3 m/s. Positive correlates were having a dog, having a garden elsewhere (e.g., allotment), weekend days, living in Zuid-Oost or West, and higher temperatures (≥13.2 °C).

Home. Being a western immigrant, having a good or fair health status, being overweight or obese, being employed and having children aged ≤4 years, were negatively associated with MVPA at home. Aged 56–60 years, aged >60 years, being female, having an employed partner, having a dog, weekend days, living in Kralingen-West, Zuid-Oost or West, and higher temperatures (≥7.6 °C), were all factors that were positively associated with MVPA at home.

Other residential area. MVPA in other residential area was negatively associated with age >60 years, western and non-western ethnicity, good health status, fair health status, poor health status, very poor health status, employment, having a partner, and having a garden at home, whereas it was positively associated with being female, having a dog, and living in Kralingen-West or West.

Residential- and shopping area. Having children aged ≤4 years and living in the neighborhood West were negative correlates of MVPA at this location type.

Shopping area. Negative correlates of MVPA in shopping area were being a western immigrant, good health status, fair health status, very poor health status, obesity, middle and higher education, having children aged ≤4 years, having a dog, and living in Kralingen-West, Zuid-Oost or West, whereas weekend was a positive correlate.

Workplace. Being non-western immigrant, having a higher education, and living in Kralingen-West, Zuid-Oost or West, negatively affected MVPA at the workplace. Positive effects were found for having ≥2 cars.

Small green area. Aged >60 years, having children aged ≤4 years, and car ownership were negatively associated with MVPA in small green area, whereas having a garden at home or elsewhere was positively associated with MVPA in small green area.

Larger green area. Negative correlates of MVPA in larger green area were western- and non-western ethnicity, having a dog, and living in the neighborhood Zuid-Oost or West. Positive correlates were car ownership, and temperatures between 7.6 and 16.6 °C.

Sports facilities. Having children aged 4–11 years negatively influenced MVPA at sports facilities. Having children aged ≤4 years and living in the neighborhoods Kralingen-West, Zuid-Oost, or West, positively influenced MVPA at sports facilities.

Transport. Negative correlates of MVPA during transport were western and non-western ethnicity, fair, poor, and very poor health status, overweight and obesity, being employed, being female, having children aged 4–11 years, having children aged 11–17 years, having ≥2 cars, having a garden at home, and a wind speed of 2.5–3.3 m/s. Positive correlates of MVPA during transport were having a dog, weekend days, living in Zuid-Oost or West, and 0.3–2.8 h of sunshine.

Other. Very poor health status, overweight and obesity, higher education, having a partner, having an employed partner, having children aged ≤4 years, and living in Kralingen-West, Zuid-Oost or West were negative correlates of MVPA at other locations. Positive correlates were fair health status, poor health status, having children aged 4–11 years, having ≥2 cars, and having a garden at home.

3.4 DISCUSSION

Main Findings

This study addressed the need for more detailed and comprehensive insight in objectively measured PA behavior at various locations [21,28]. By assessing PA behavior of adults in a much wider variety of locations than existing studies, and by investigating the effect of a variety of socio-demographic characteristics on PA levels at specific locations, this paper expands existing literature.

Consistent with other studies [36–38], the current study found that adults spent on average 34.0 min (approximately 4% of wear time) per day in MVPA. In congruence with the literature, we found that ethnicity, poorer health status, overweight/obesity, and having children were negative correlates of MVPA [39], and that weekend days and having a dog were positive correlates of MVPA [40,41]. The finding that adults with a middle or higher education had lower levels of MVPA was, however, in contrast with literature since most studies found that lower educated adults have lower levels of MVPA [39]. Besides, it is remarkable that having a garden at home had a negative effect on total MVPA, whereas having a garden elsewhere positively affected total MVPA. To improve understanding of MVPA behavior, we refined MVPA behavior into MVPA behavior at various locations and assessed whether correlations between various factors and MVPA were also found for those locations. MVPA behavior was distributed across many different locations, but most time in MVPA was spent at home and work and least time in MVPA was spent in larger green areas and residential- and shopping areas.

This study found that the home location was an important contributor to PA, which is consistent with findings of the Eurobarometer on Sports and PA, that shows that the home location is the second most common location for PA and sports (after parks and outdoors) [42]. The home is also a place where adults spent most of their total wear time per day, and it may thus be that when total time spent at a location increases, time spent in MVPA at that location also increases. Obviously, this does not mean that staying at home is the solution for increasing MVPA levels, since other locations (e.g., sports facilities and green areas) can be important facilitators for PA as well [43,44]. MVPA behavior at home was found to be higher for adults of older age. Additional analyses may explain this as they show that adults of the two oldest age groups spent significantly more time at home per day, than adults of the two youngest age groups, and therefore accumulated more minutes of MVPA there. Increased levels of MVPA at home were also found for females and adults with an employed partner. This may be due to the influence of role expectations [45]: women may accumulate more minutes of MVPA at home by doing more household activities then men, and an individual whose partner is employed may have to do more household activities because the partner has less time for those activities.

The work location is after the home location, the place where adults spent most MVPA minutes. Adults with a higher education spent less time in MVPA at work than adults with a lower education. An explanation for this may be that adults with a higher education more often have jobs that require them to be seated behind a desk and computer, whereas adults with a lower education might more often have jobs that require them to be physically active. This explanation is supported by existing literature which states that for some occupations (e.g., service workers), the workplace is an important source for total PA, whereas other occupancies or sectors require much sedentary work with only limited PA throughout the day (e.g., computerization) [46,47].

Shopping areas are places where adults spent more MVPA time on the weekends. On weekend days, adults may experience less time constraints and may thus have more opportunities to visit places other than their home or workplace. Besides, shops in the Netherlands (except for grocery stores) close at approximately the same time a working day ends, which also hinders adults in visiting those locations on weekdays.

Green spaces can be important facilitators of PA behavior [44], but varying types of green spaces can contribute to MVPA of diverse subpopulations in different ways. For example, this study found that MVPA levels in small green area were lower for car owners than for adults who do not own a car. On the other hand, levels of MVPA in larger green area were higher for car owners than for adults who do not own a car. This may be explained by previous studies that showed that car owners tend to undertake more PA outside their residential neighborhood [25]. As small green areas (i.e., parks and allotments) are likely to be present within one's residential neighborhood, and larger green area (i.e., forests, recreational areas, moorland) are often located further from the home, it is plausible that car owners use their cars to visit larger green areas and be physically active there, whereas adults without a car visit small green areas within their neighborhood, which they can reach by foot or bike.

Not having a car may thus be a constraint for adults to engage in MVPA in larger green areas, but also in other places. Interestingly, living in the neighborhoods Zuid-Oost and West (Maastricht) was negatively correlated to MVPA in larger green areas, whereas these neighborhoods have the highest amounts of larger green areas as compared to the neighborhoods of Rotterdam. As we found that car owners spent more time in larger green areas, proximity of and travel distance to larger green spaces may thus become of less importance.

MVPA at sports facilities was lowest for adults living in Oude Noorden (Rotterdam). They also spent least time in sports facilities, compared to participants of the other three neighborhoods. This may be influenced by the presence of sports facilities in one's neighborhood, as the amount of sports facilities within the neighborhood Oude Noorden are lower than in Kralingen-West, Zuid-Oost and West. Visual analyses of data on MVPA behavior at sports facilities indicated that adults may have taken off the devices during exercise, as we identified gaps in time. Since data before and after such time gaps indicated that participants were at a sports facility, it seems plausible that during the gap, participants were also at that facility. Results may thus underestimate MVPA levels at sports facilities.

Other residential areas were positively correlated to MVPA behavior of dog owners. This finding is not unexpected, as dog owners are likely to walk their dog in residential areas such as the residential neighborhood or adjacent neighborhoods. Adults of older age and adults with a poorer health status spent less time in MVPA in other residential areas. An explanation for this may be that these adults experience physical limitations (e.g., difficulties with walking) that hinder them to be physically active in these areas. In addition, employed adults spent less time in MVPA in other residential areas, which may be explained by the obligation to spend a certain amount of time at the workplace.

We found that transport-related MVPA differs between native Dutch adults, and western and non-western immigrants. This is supported by figures on cycling in the Netherlands, which show that native Dutch adults cycle more often than individuals with other ethnic origins [48]. Additional analyses revealed that compared to autochthonous adults, significantly less non-western immigrants have a bicycle. Here, cultural differences seem to influence MVPA behavior. Physical limitations seem to be of influence as well, as we found that adults who reported lower levels of health status had lower levels of transport-related MVPA. It may be that adults who reported a very good health status had less difficulties with walking and cycling than adults with a lower health status, for example, because they felt better, or had less health complaints. On the other hand, it may also be that their engagement in MVPA during transport contributed to a better health status.

This study found that some neighborhood, weather, and socio-demographic were correlates of both total MVPA and MVPA at various locations, whereas other factors were found to be only correlates of MVPA behavior at specific locations. The first option not only provides information on the correlates of MVPA behavior, but in addition contributes to the explanation of these findings. The other option, that factors were only associated with MVPA at specific locations, is likely due to substitution effects (i.e., an increase in MVPA levels at one location may lead to a decrease of MVPA at another location). For example, adults of older age spent more time in MVPA at home, whereas they spent less time in MVPA in other residential areas and small green areas. Another example is that women have higher levels of MVPA at home and in other residential areas, whereas their levels of transport-related MVPA were lower. Preferences of such subpopulations may be one reason for this substitution effect to occur, since it is likely that preferences and needs vary between adults with different constraints and different socio-demographic characteristics. Moreover, constraints such as work obligations, taking care of children, or not having a car, may also be a reason for this substitution effect to occur. It may be due to these substitution effects that no effects of those factors on total MVPA were found.

Limitations

This study has some limitations, such as a relatively low response rate, data loss, underestimation of specific behaviors, and unequivocal categorization of activity locations. Although response rates were low (3.5% of the 14,889 randomly recruited individuals agreed to participate, and 78.7% of these individuals actually wore the devices), our final study sample is comparable to other studies [33,49]. Data loss was due to the inability to match all GPS and accelerometer data points, insufficient wear time, and the interference of urban canyons (surrounding high buildings), trees, or building materials (e.g., in a tunnel or at home) with satellite communication. Besides, wearing the accelerometer on the hip may have led to an underestimation of PA, since upper-body movements or non-ambulatory movements (e.g., cycling) are less accurately recorded [50]. The locations were classified based on land use and building data, but classification is not unequivocal. For example, it is likely that walking the dog in larger green areas was classified as transport, and not as an activity that took place in larger green areas. Although this is not misclassification, since it is both correct, future research may consider further classifying transport into categories (e.g., transport in larger green areas). Besides, a diary kept by participants may improve accuracy of the determination of activity locations. Another limitation may be that determinants, which were not controlled for in this study, also determine the effect of neighborhood on PA. For example, social norms were significant predictors of PA in previous studies [51,52]: individuals who often saw other people exercising or walking in their neighborhood had higher levels of leisure-time MVPA and walking than individuals who did not often see other people exercising and walking in their neighborhood [52].

3.5 CONCLUSIONS

The general conclusions drawn from this study are that (a) adults' MVPA is distributed across a variety of location types, including locations that have not received much attention in urban policy, such as the home and work location, and (b) the relative importance of location types differs with factors such as car ownership, work status, health status and household structure. These insights can be used to target specific population groups by making location specific environmental changes. This may increase these groups' levels of PA and, therefore, reduce inequalities across the total population in terms of PA and therefore health. Future studies may investigate what specific (environmental) characteristics (e.g., green, residential density) of these different locations are facilitators of, or barriers to, PA. In this line of research, insight into the role of locations that are important for PA, their accessibility, but also their affordances or barriers in PA behavior, may benefit from combining objectively collected data (i.e., by accelerometer and GPS-device) with subjective data of individual perceptions of, or experiences with, PA at specific locations. Moreover, the relatively small amounts of MVPA at different locations make it plausible to assume that other intensity levels of PA, such as light PA (LPA), also play a role at those locations. For adults aged 45–65 years, LPA may be more feasible and easier to implement in daily life. Since LPA has recently been positively associated with health [53], it would be of great interest for future research to investigate both LPA and MVPA in relation to different location types.

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Chapter 4

Neighborhood-based PA and its environmental correlates. A GIS- and GPS based cross-sectional study in the Netherlands

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ABSTRACT

To improve our understanding of the neighborhood environment – physical activity (PA) relationship, it is of importance to assess associations between neighborhood environmental characteristics and neighborhood-based PA. Participants' (N = 308; 45-65 years) light PA (LPA) and moderate-vigorous PA (MVPA) within a 400, 800, and 1600 meter buffer around adults' homes was measured using accelerometers and GPS-devices. Land use data in ArcGIS provided neighborhood characteristics for the same buffers. Multilevel linear regression models, adjusted for socio-demographic variables and attitude towards PA, were used to assess associations of objective neighborhood characteristics with neighborhood-based LPA and MVPA. LPA was positively associated with the proportions of roads (within a 400m buffer), and negatively associated with the proportions of recreational areas (within an 800m buffer), and the proportion of green space (within the 800m and 1600m buffers). Multiple characteristics of 400m buffers were positively associated with MVPA, i.e., proportions of green space, blue space, residences, shops and foodservice industry, sports terrain, and public social-cultural facilities. Also, characteristics of larger buffers were positively associated with MVPA, i.e., the proportions of shops and foodservice industry, sports terrain, and blue space (within an 800m buffer), and the proportion of public social-cultural facilities (within the 800m and 1600m buffers). Objective neighborhood characteristics of smaller as well as larger sized buffers were associated with neighborhood-based LPA and MVPA. Green and blue spaces seem to be of particular importance for PA in the smallest buffer, i.e., in the direct surrounding of adults' homes.

4.1 INTRODUCTION

Regular physical activity (PA) positively affects health [1,2]. To achieve health benefits from PA, the World Health Organization (WHO) recommends adults to engage in at least 150 minutes of moderate PA, or 75 minutes of vigorous PA per week, or an equivalent combination of both [3]. Worldwide 31.1% of the adult population is insufficiently physically active [4], and increasing population levels of PA is of great importance for population health. However, it is not only moderate-vigorous PA (MVPA) that is of importance for health. Over the past years, researchers have increasingly emphasized the importance for activities of daily living (e.g., household activities, walking, and gardening) or light intensity activities (LPA) as well [5-7]. To adequately inform policy makers, intervention developers and urban planners in designing PA-friendly environments that facilitate both LPA and MVPA, it is important to better understand the relationship between environmental characteristics and PA.

Daily life activities, including PA, take place in many different places (e.g., [8]). Therefore, throughout the day, individuals are exposed to various environments that have different characteristics. One environment of interest is the residential environment. This environment is one of the daily life environments where individuals spend a great amount of their time (i.e., 60% [9]). For example, the use of various services (e.g., banks, restaurants, and post offices) as well as daily (food) shopping, and other activities, such as walking the dog, or jogging may take place in the residential neighborhood.

The majority of studies investigating the relationship between neighborhood characteristics and PA have used self-report methods to measure PA, and included outcomes such as total PA, leisure-time PA, walking, and cycling (e.g., [10-12]). Although some neighborhood characteristics (e.g., walkability, land use mix) have been consistently associated with increased PA levels [11,12], it is largely unknown whether neighborhood characteristics may also contribute to objectively measured LPA, and MVPA. Insight in these relationships may provide useful information to develop adequate interventions that aim to increase (a specific) intensity of PA through environmental changes.

In addition, many studies that investigated the role of neighborhood characteristics in PA behavior assessed the role of neighborhood characteristics on total PA levels (e.g., [13-17]). These PA levels - whether they are walking, overall PA, or leisure time PA – often include both activities within and outside the residential neighborhood. However, this may lead to a conceptual mismatch of PA behavior and environmental exposure [18], which may underestimate the actual physical environment - PA association at the neighborhood level. Thus, there is a need for context-specific PA assessment, where neighborhood characteristics are matched with neighborhood-based PA. One study that examined the association between neighborhood-based PA and neighborhood characteristics, found that higher levels of land use mix, intersection density, and residential population density, and residential housing unit density were positively related to MVPA within a one kilometer buffer around the home [19]. Although this provides useful insights, more specificity on the types of objectively measured land use can provide additional and more concrete evidence that contributes to the development of environmental interventions.

Therefore, the aim of this study was to investigate which objective neighborhood characteristics (i.e., types of land uses) are associated with neighborhood-based LPA and MVPA.

4.2 METHODS

Aim, design and setting of the study

This cross-sectional study was part of the PHASE (Physical Activity in public Space Environments) project that aimed to investigate PA behavior in various environments and how environmental settings and their characteristics are related to PA behavior. Participants were randomly recruited from the municipal population register of the cities of Rotterdam and Maastricht, the Netherlands. Recruitment took place in two different cities to compose a study sample with varying environmental exposures (i.e., presence of green, distance to city center, type of buildings, and population density). A more detailed overview of differences in environmental characteristics between Rotterdam and Maastricht, and the four neighborhoods, was provided elsewhere [8]. Adults aged 45-65 years (N = 14889) received an invitation letter to ask them to participate in the study. Adults could register for participation via a website or by telephone. Those who registered (N = 516) were contacted by phone or e-mail to plan the distribution of an accelerometer and GPS-device. Trained staff members distributed devices and explained monitor wear to participants (N = 406) in community centers close to participants homes. Sheets with a summary of instructions were provided. Data collection took place from April to December 2014. All participants signed informed consent. One participant was excluded from analyses due to insufficient data on the home address. Only participants with sufficient valid accelerometer- and GPS-data were included in analyses. After applying valid data criteria (see below), 308 participants (with a total of 1804 measurement days) could be included in the analyses. The institutional review board of the faculty of Social and Behavioural Sciences of the Utrecht University approved for the study.

Measures

Neighborhood-based PA. Participants were asked to wear an accelerometer and GPS-device, which were attached to an elastic and adjustable belt, during waking hours for 7 consecutive days (except during water-based activities). The Actigraph GT3X+ accelerometer (Actigraph, Pensacola, Florida, FL, USA) was used to measure PA intensity. The epoch length was 5 seconds. Actilife v6.11.2 (Firmware 2.2.1, Actigraph, Pensacola, Florida, USA) software was used to download accelerometer data. As the study population was middle-aged, and therefore more likely to have longer bouts of sedentary behavior than younger adults non-wear time was defined as episodes of ≥ 90 minutes of consecutive zero counts, accepting up to 2 consecutive minutes of 1-100 cpm [20,21]. Vector magnitude cut-points were used to define light (150-3208 cpm), moderate (3208-8564 cpm) and vigorous (≥8565 cpm) PA [22,23]. Moderate-vigorous PA was calculated as the sum of moderate and vigorous PA.

BT-Q1000XT GPS-devices (QStarz International Co, Taipei, Taiwan) were used to measure participants' geographical locations every 5 seconds. The GPS-device was attached to the same belt the accelerometer was attached to. The QStarz QTravel software (v1.45, Qstarz International Co., Ltd, Taipei, Taiwan) was used to download the data. For each GPS data-point it was determined whether it lay within a 25-400, 25-800, or 25-1600 meter Euclidian buffer around participants' homes. We applied the > 25 meter criterion for each neighborhood buffer to exclude the time spent at home. We first calculated the percentage of time spent within each buffer. In addition, GPS- and accelerometer data were date and time linked (using python software), and this combination of data was used to determine the proportion of time spent on light intensity activities (LPA) and moderate-vigorous intensity activities (MVPA) in each buffer. These percentages of time spent on LPA and MVPA in three different buffers (i.e., 400m, 800m, and 1600m) were used as the outcome measures in the analyses.

Valid days. A valid day was determined using the 70/80 rule [24]. Therefore, we first determined a measurement day, which is the time during which at least 70% of participants wore the accelerometer devices. For this study, the length of a measurement day was 611 minutes. The 70/80 rule defines a day to be valid when at least 80% of a measurement day has non-missing counts, which was 488.8 minutes for this study. Data of participants with at least 4 valid days were included in analyses [25].

Objective neighborhood characteristics. The coordinates of the home addresses of participants were uploaded in ArcMap. A 400, 800, and 1600 meter Euclidean buffer (drawn around each home address) was used to define participants' neighborhoods. The proportions of different types of land use (available from Statistics Netherlands, 2012) were calculated for each of these buffers. Nine categories of land use were distinguished:

residences, roads, public social and cultural facilities (e.g., educational institutes, churches), shops and food service industry (e.g., shopping centers, cinemas, hotels, restaurants), blue space (i.e., the sum of all proportions of visible surface waters e.g., rivers, lakes, recreational pools in forests, sea), green space (i.e., the sum of all proportions of green such as city parks, allotments, forests, moorland), sports terrain (e.g., football fields, tennis courts, swimming pool, sports hall), and recreational area (e.g., picnic places, zoo). In this paper, neighborhood characteristics thus refer to the proportions of different types of land use (characteristics) in a 400, 800, and 1600 meter buffer around participants' homes (neighborhood). Although these types of land use covered most of the land use types that were found within buffers, there were some types of land use that were not included in the analyses because these proportions were very low. This included for example cemeteries, or dumps.

Individual factors. A questionnaire was used to collect data on background variables (e.g., age, gender, ethnicity, and education), the home address, and attitude towards PA. Self-reported highest levels of completed education were classified into three levels: 1) lower education (i.e., no education, primary education, lower professional or intermediate general education); 2) middle education (i.e., intermediate and higher general education); and 3) higher education (i.e., higher professional education and university). Attitude was measured by asking participants to indicate on a 5-point Likert scale to what extent they agreed with four statements: PA is good for me, PA is pleasant, PA is important and PA gives variation. These variables were aggregated into the variable 'attitude' by summing the scores of the separate items (Cronbach's alpha: 0.870, this value did not increase if items were deleted).

Statistical analyses

All analyses were performed using SPSS 23.0 for windows (IBM SPSS Inc., Armonk, NY). Descriptive statistics were used to present data on population- and neighborhood characteristics, and the amounts of time spent within neighborhood buffers. To assess the role of neighborhood characteristics (independent variables) in neighborhood-based LPA and MVPA (outcome variables), bootstrapped multilevel linear regression analyses were performed. Regressions were bootstrapped because the outcome variables were not normally distributed and neither log transformations nor taking the square root led to normal distributions. Multilevel analyses were used to consider the multilevel structure of the data: days were organized within respondents (and days of one respondent are more similar to each other than to those of other respondents). Analyses were adjusted for age, gender, BMI (Body Mass Index), education, ethnicity, having a car, having children, dog ownership, city of residence (Rotterdam or Maastricht), and attitude towards PA.

4.3 RESULTS

Descriptive statistics

Of the total study population (N=308), a little more than half was female (Table 4.1). Adults were on average 56.4 (SD 6.2) years, over sixty percent were employed, most adults had a middle or higher education, and more than 80% of the population was native Dutch. About 1/3 of the study population had at least one child, and approximately 1/5 had a dog. The most common type of land use of the buffers surrounding participants' homes was residences (Table 4.2).

Table 4.1 Descriptive statistics of the study population (N = 308).

Individual factors	
Age in years *Mean (± SD)*	56.4 (± 6.2)
Female *%*	54.9
BMI *%*	
Healthy weight	52.9
Overweight	37.0
Obesity	10.1
Education *%*	
Low	4.2
Middle	53.2
High	40.9
Missing	1.6
Ethnicity *%*	
Autochthonous	84.4
Western immigrants	6.8
Non-western immigrants	7.5
Missing	1.3
Having a dog *%*	
Yes	18.8
Missing	0.6
Having children *%*	
Yes	33.1
Having a car *%*	
Yes	82.8
Missing	0.6
City *%*	
Rotterdam	38.0
Maastricht	62.0
Attitude *(score)*	
Mean (± SD)	18.0 (2.4)
Missing (%)	0.3

Note: SD = standard deviation. BMI = Body Mass Index. IQR = interquartile range. [a]This includes the time spent at home.
[b]Excluding the time spent at home. IQR: interquartile range.

Table 4.2 Proportions of participants' (N = 308) with certain neighborhood characteristics (% land use) in different buffers surrounding their homes.

	400 meter buffer			
	Mean	**(± SD)**	**Median**	**(IQR)**
Residences	64.8	(14.1)	67.8	(21.2)
Roads	5.1	(3.5)	4.4	(3.4)
Shops and foodservice industry	4.8	(7.0)	2.7	(6.2)
Public social-cultural facilities	4.0	(6.1)	1.9	(5.8)
Green space	9.8	(10.1)	7.2	(15.0)
Blue space	2.3	(4.8)	0.0	(2.4)
Sports terrain	2.4	(5.7)	0.0	(2.5)
Recreational area	0.9	(3.3)	0.0	(0.0)

Note: SD = standard deviation. IQR = interquartile range. Most land use variables were not normally distributed, hence the median is presented. As for some variables the median was 0, the mean was also presented for interpretation.

Participants spent on average 29.1% of a measurement-day in LPA, and 5.7% in MVPA (Table 4.3). Participants spent more time outside the 400, 800, and 1600 meter buffers than within the buffers. The average percentage of LPA and MVPA within the buffers is approximately similar to LPA and MVPA outside the buffers.

Table 4.3 Daily percentages of total time, light PA, and moderate-vigorous PA spent in different buffers.

	Total time %		**LPA %**		**MVPA %**	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**
Total			29.1	(22.6; 35.9)	5.7	(3.4; 8.9)
At home (0-25m)	40.5	(19.1; 62.8)	27.6	(19.8; 36.0)	3.9	(2.4; 6.6)
Within a 25-400m buffer	11.6	(4.9; 24.0)	27.9	(19.3; 38.2)	4.5	(2.1; 9.6)
Within a 25-800m buffer	13.8	(6.4; 28.6)	28.6	(20.1; 38.9)	4.6	(2.2; 10.0)
Within a 25-1600m buffer	19.8	(9.4; 36.3)	30.0	(21.4; 38.6)	5.1	(2.5; 10.3)
> 1600m from the home	24.2	(5.1; 55.7)	28.6	(21.9; 35.9)	5.0	(3.0; 8.2)

Note: Percentages represent daily averages of measurement days. Percentages in columns (e.g., at home, within 25-400m, and >400m) do not necessarily add up to 100% because medians are presented. Medians were presented due to non-normality. LPA = Light PA. MVPA = Moderate-Vigorous PA.

The role of neighborhood characteristics in LPA and MVPA within the neighborhood

Various objective neighborhood characteristics were significantly associated with LPA and MVPA within the neighborhood (Table 4.4). Neighborhood characteristics that were associated with LPA were different from the neighborhood characteristics that were associated with MVPA. Also, different significant associations were found for buffers of different sizes.

800 meter buffer				1600 meter buffer			
Mean	**(± SD)**	**Median**	**(IQR)**	**Mean**	**(± SD)**	**Median**	**(IQR)**
52.5	(13.0)	54.8	(19.0)	38.2	(9.2)	37.9	(17.1)
5.5	(2.3)	5.6	(3.5)	5.5	(2.0)	5.7	(1.9)
4.3	(6.5)	2.3	(3.1)	3.8	(6.5)	2.0	(3.5)
4.2	(4.4)	2.8	(5.3)	4.6	(2.9)	4.1	(4.6)
13.8	(12.6)	10.3	(14.8)	20.1	(12.9)	17.5	(17.8)
5.1	(7.8)	0.0	(8.2)	7.3	(8.8)	3.0	(14.2)
3.6	(5.0)	2.3	(2.4)	4.3	(3.1)	3.0	(3.6)
1.2	(2.7)	0.0	(0.9)	1.1	(1.4)	0.4	(1.5)

The proportion of roads was positively associated with LPA within a 400 meter buffer. The proportions of recreational area and green space were negatively associated with LPA within an 800m buffer, and the proportion of green space was negatively associated with LPA within a 1600m buffer.

With regard to MVPA, positive associations were found between the proportions of residences, shops and foodservice industry, sports terrain, public social-cultural facilities, green space, and blue space and MVPA within a 400m buffer, whereas the proportion of recreational area was negatively associated with MVPA within a 400m buffer. The proportions of shops and foodservice industry, sports terrain, public social-cultural facilities, and blue space were positively associated with MVPA within an 800m buffer. Further, the proportion of public social-cultural facilities was positively associated with MVPA within a 1600m buffer.

Table 4.4 Associations between neighborhood characteristics and percentage of LPA and MVPA within the neighborhood.

	% LPA within a 25-400m buffer			% MVPA within a 25-400m buffer		
Neighborhood characteristics within a 25-400m buffer	*B*	*95% CI*	*p*	*B*	*95% CI*	*p*
Intercept	26.18			9.54		
Residences	0.01	(-0.07; 0.09)	0.847	**0.05**	**(0.01; 0.10)**	**0.010**
Roads	**0.20**	**(-0.01; 0.42)**	**0.032**	0.02	(-0.13; 0.16)	0.802
Shops and foodservice industry	0.04	(-0.09; 0.16)	0.481	**0.15**	**(0.07; 0.23)**	**0.001**
Sports terrain	0.04	(-0.09; 0.17)	0.468	**0.08**	**(0.00; 0.17)**	**0.023**
Public social-cultural facilities	0.03	(-0.10; 0.18)	0.590	**0.06**	**(-0.01; 0.12)**	**0.042**
Recreational area	-0.17	(-0.39; 0.06)	0.080	**-0.12**	**(-0.23; -0.03)**	**0.005**
Green space	-0.08	(-0.19; 0.02)	0.083	**0.11**	**(0.02; 0.19)**	**0.001**
Blue space	0.10	(-0.08; 0.27)	0.187	**0.19**	**(0.10; 0.28)**	**0.001**

Table 4.4 Continued.

	% LPA within a 25-800m buffer			% MVPA within a 25-800m buffer		
Neighborhood characteristics within a 25-800m buffer	*B*	*95% CI*	*p*	*B*	*95% CI*	*p*
Intercept	25.96			7.88		
Residences	0.05	(-0.03; 0.12)	0.172	0.03	(-0.02; 0.09)	0.166
Roads	-0.05	(-0.36; 0.22)	0.682	-0.00	(-0.19; 0.19)	0.983
Shops and foodservice industry	0.11	(-0.05; 0.25)	0.118	**0.09**	**(-0.00; 0.18)**	**0.034**
Sports terrain	-0.02	(-0.17;0.13)	0.707	**0.15**	**(0.04; 0.27)**	**0.004**
Public social-cultural facilities	-0.01	(-0.19; 0.18)	0.911	**0.12**	**(0.04; 0.21)**	**0.003**
Recreational area	**-0.30**	**(-0.63; 0.04)**	**0.047**	-0.16	(-0.35; 0.07)	0.095
Green space	**-0.09**	**(-0.18; 0.00)**	**0.032**	0.04	(-0.02; 0.11)	0.136
Blue space	0.12	(-0.02; 0.27)	0.057	**0.08**	**(-0.01; 0.16)**	**0.046**
	% LPA within a 25-1600m buffer			**% MVPA within a 25-1600m buffer**		
Neighborhood characteristics within a 25-1600m buffer	*B*	*95% CI*	*p*	*B*	*95% CI*	*p*
Intercept	29.35			11.53		
Residences	0.03	(-0.08; 0.16)	0.567	-0.00	(-0.09; 0.08)	0.905
Roads	-0.31	(-1.29; 0.69)	0.465	-0.40	(-1.10; 0.28)	0.166
Shops and foodservice industry	-0.14	(-0.43; 0.15)	0.289	-0.02	(-0.19; 0.16)	0.824
Sports terrain	-0.10	(-0.52; 0.34)	0.591	0.04	(-0.27; 0.35)	0.787
Public social-cultural facilities	0.16	(-0.32; 0.68)	0.487	**0.38**	**(0.03; 0.72)**	**0.015**
Recreational area	0.23	(-0.61; 0.99)	0.508	0.07	(-0.42; 0.65)	0.787
Green space	**-0.08**	**(-0.16; 0.01)**	**0.045**	0.02	(-0.04; 0.08)	0.394
Blue space	-0.06	(-0.27; 0.15)	0.497	-0.06	(-0.19; 0.07)	0.315

Note: All models were adjusted for: age, gender, BMI, education, ethnicity, having a car, having children, dog ownership, city, and attitude towards PA. LPA = Light PA. MVPA = Moderate-Vigorous PA. CI = Confidence Interval. Bolded text highlights significant associations.

4.4 DISCUSSION

This study found significant associations between objective neighborhood characteristics and neighborhood-based LPA and MVPA, also when adjusted for an extensive set of individual factors, including attitude towards PA. This makes it less likely that the correlation between neighborhood characteristics and neighborhood-based PA is purely a matter of selection (i.e., that those with a more favorable attitude towards PA, and practicing more PA, chose to reside in neighborhoods that facilitate PA), which may indicate that a causal mechanism underlies the correlations found in this study.

The current study showed that more neighborhood characteristics were associated with MVPA than with LPA. A possible explanation for this finding may be that LPA is often part of everyday activities (e.g., household activities, walking), which are integrated in adults' daily activity patterns. That is, these activities may be more likely to occur in any case, whereas MVPA may require more planning, skills, motivation, and specific facilities or environmental features.

Additionally, most effects are found for the smallest buffer around the home (i.e., 400m buffer), whereas less (i.e., for MVPA) or even negative (i.e., for LPA) associations were found for the larger buffers. This suggests that objective neighborhood characteristics may be of particular importance for PA in the area directly surrounding adults' homes. Further, these findings emphasize that size of a buffer matters when assessing the physical environment – PA relationship. Hence, future studies should consider the use of multiple buffers when assessing the relationship between neighborhood characteristics and PA, or choose a buffer that fits specific policy or urban design aims.

The importance of environmental characteristics close to individuals' homes seems to apply in particular to natural environments (i.e., green and blue spaces), as the positive associations found for MVPA within a 400 meter buffer disappear when buffer size increases. Moreover, negative associations were found between green space and LPA within the 800 and 1600 meter buffers. A possible explanation for this may be that adults are more familiar with green and blue spaces within a shorter distance from their home than with green and blue spaces further away. Also, the use of green and blue spaces on short distance to the home is easier to integrate with obligatory activities during the day. With the current findings, this study expands existing literature that found that amount and size of, and distance to urban green space, play an important role in stimulating PA behavior [26,27], by demonstrating that this effect emerges via PA close to the residence. Also, the positive effects of blue spaces on physical activities such as walking (the dog), jogging or cycling at the water's edge [28], apparently occur mostly on short distance to the home.

Proportions of roads was the only type of land use that was positively associated with LPA, and only within a 400 meter buffer. An explanation for this may be that an increased proportion of roads is related to increased walkability and connectivity, and a reduced distance to side-walks or trails; factors that have been positively related to walking (i.e., an important source of LPA [7]) and PA in previous studies (e.g., [10-12]). Also, findings that higher proportions of sports terrain, public social-cultural facilities, and shops and foodservice industry were positively associated with MVPA are in line with existing literature that showed, although not at the level of neighborhood-based MVPA, that sports facilities [29] and presence and accessibility of shops and other facilities (e.g., [10,30]) were associated with (MV) PA.

Perhaps less expected -at first sight- was the finding that a higher proportion of recreational areas within one's residential neighborhood was associated with lower levels of LPA within an 800 meter buffer and MVPA within a 400 meter buffer. However, in this study, the land use category of 'recreational area' did not include parks or sports facilities, which belonged to other types of land uses (i.e., green space and sports facilities, respectively). In the current study, 'recreational area' refers to places such as zoos, amusement parks, open-air museums, playgrounds, and picnic places. Such places likely facilitate mostly sedentary behavior (e.g., social activities) and not so much LPA or MVPA, especially among this middle-aged study sample.

Strengths and limitations

The use of accelerometers and GPS-devices provided accurate and detailed information on neighborhood-based LPA and MVPA levels of adults. In addition, the use of objective land use information added to existing literature that mostly reported perceived environmental factors and/or observed environmental factors [12]. Furthermore, we included an extensive set of individual factors in analyses to correct for possible confounding effects (e.g., those with certain individual characteristics may select PA promoting neighborhoods).

The use of accelerometers and GPS-devices also has limitations. For example, upper-body movements are less well recorded by the accelerometer and water-based activities (i.e., swimming) could not be measured [31]. GPS-devices may suffer from canyoning (i.e., high buildings, or trees interfere with satellite communication), but the QStarz GPS-device that was used in this study has shown to have a high accuracy even in urban canyons [32]. Moreover, the use of GPS-devices and accelerometers often comes with relatively smaller study population as compared to the use of questionnaires. However, although the response rate of this study was relatively low, our final study sample was comparable to other studies [12].

Finally, it is likely that a selective sample, i.e., adults who are interested in PA and like being active, responded to the invitation to participate in this study. Hence, more active adults may be included in this study, which may have led to an overestimation of PA levels. The inclusion of two different cities in the Netherlands contributed to differences in exposure to neighborhood environmental characteristics. Therefore, the findings of this study are more likely to be representative for the Netherlands. However, the findings of this study may not be applicable to other counties as urban design and environmental characteristics of residential areas (e.g., walking and cycling facilities, size of green spaces) may be very different between countries. In addition, the results of this study were found for a specific age group and future research is needed to assess what objectively measured neighborhood characteristics are related to neighborhood-based LPA and MVPA of other age groups (e.g., youth or older adults).

Due to the cross-sectional design of this study, only associations could be assessed and not causal relations. Future research should apply longitudinal, and preferably pre-posttest designs to investigate causal relationship between such neighborhood characteristics and PA.

4.5 CONCLUSIONS

This study responded to the need for more context-specific PA assessment by providing new insights in the role of objective neighborhood characteristics in neighborhood-based LPA and MVPA. Two main conclusions can be drawn from this study: 1) objective neighborhood characteristics play an important role in neighborhood-based PA, also when adjusted for socio-demographic factors and attitude towards PA. Hence, associations between the residential environment and PA found in previous studies can at least partly be explained by the effects on PA in the neighborhood, and 2) these neighborhood characteristics seem to be of particular importance for PA in the areas close to adults' homes (i.e., the smallest buffer around the home). Hence, size of the buffer matters when assessing the relationship between the residential environment and PA. Longitudinal pre-posttest study designs are necessary to assess the causality of the associations between objective neighborhood characteristics and objectively measured PA.

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Chapter 5

How do type and size of natural environments relate to physical activity behavior?

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ABSTRACT

Natural environments (NE) are promoted as places that support physical activity (PA), but evidence on PA distribution across various types and sizes of NE is lacking. Accelerometers and GPS-devices measured PA of Dutch general population adults aged 45–65 years (N=279). Five NE types were distinguished: 'parks', 'recreational area', 'agricultural green', 'forest & moorland', and 'blue space', and four categories of size: 0–3, 3–7, 7–27, and ≥27 ha. Modality (i.e., spatially concentrated PA, walking, jogging, and cycling) and intensity (i.e., sedentary behavior, LPA, and MVPA) of PA varied significantly between NE types. Compared to parks, less sedentary behavior and walking but more spatially concentrated PA was observed in recreational areas and green space. Cycling levels were found to be significantly lower in recreational areas and forest & moorland, but higher in blue space as compared to parks. Larger sized NE (≥7 ha) were associated with higher levels of MVPA, walking, jogging and cycling. Insight in which environments (according to type and size) facilitate PA, contributes to the development of tailored PA promoting interventions with ensuing implications for public health.

5.1 INTRODUCTION

Physical inactivity is seen as a major global public health problem [1] and policy makers, health professionals and urban planners seek for opportunities to increase levels of physical activity (PA). A growing body of evidence indicates that PA levels can be related to environmental factors such as street design, land use mix, street connectivity, access to facilities (e.g., shops) and population density [2-4]. In particular natural environments (NE) such as city parks, beaches, or grasslands, have been found to be frequently used for a variety of PA behaviors [2]. Due to the opportunities such environments provide for PA, and their potential to promote also other aspects of health and well-being, NE have become of increasing interest in land-use planning aimed at promoting PA, and the relationship between NE and PA is increasingly studied [2]. However, previous studies suffer from various shortcomings.

Where most studies have examined whether associations exist between (access to) NE and PA (e.g., [5-9]), only limited research has examined what different types and intensities of PA are actually performed in such natural spaces [10]. As different environments facilitate different behaviors, researchers suggest that type of NE (e.g., forest, parks, moorland) may be an important moderator in the relationship between NE and PA [11]. Since NE fulfil a wide range of roles [2,10,12], i.e., they provide opportunities for social interactions, relaxation, recreation, cultural activities and they facilitate PA behaviors such as walking, cycling, running, and sports (e.g., soccer) [2], it is likely that different types of NE are used for different types and intensities of PA. To assess these hypotheses, a detailed examination of specific PA behaviors across various types of NE is necessary. However, the majority of previous studies has focused on green spaces in general, or isolated only one type of NE: mostly parks, or less frequently, coastal areas (e.g., [5-8,13-18]).

Besides typology, it is assumed that the size of NE may also be related to how these environments are used for PA [2,19]. For example, small inner-city public green spaces seem to be used for social activities and relaxation more often than for PA [19], whereas larger NE may be settings in which people engage in PA more often. However, evidence is largely missing and it is a first step is to describe how NE of various sizes are used for different PA behaviors. Insight in this is necessary to allow urban planners to make informed decisions about the PA behavior they wish to facilitate when designing the environment [10].

A methodological limitation of previous studies on PA and NE, is the use of self-report measures to determine levels of PA and concurrent locations. The availability of newer technologies and measurement methods (i.e., accelerometer and GPS) provides more options to accurately assess context specific PA behavior [12,13] and improves the quality of such studies [13,16]. Some studies that used accelerometers and GPS-devices compared PA locations and included various types of NE, such as overall green space, parks, green verges, gardens and beaches [20,21]. These studies were however conducted among children, whereas there is a lack of evidence for adults [18]. This study adds to current literature by using accelerometers and GPS-devices to investigate different PA intensities and modalities in various NE with different sizes, among an adult population (45–65 years). This study aims to provide insight in the different PA behaviors according to modality (i.e., spatially concentrated PA, walking & jogging, and cycling) and intensity (i.e., sedentary behavior, light PA and moderate-to-vigorous PA) that occur in different NE (i.e., according to typology and size), and to examine the associations of size and type of NE, with PA intensity and PA modality.

5.2 METHODS

Study design, setting, participants

This cross-sectional study was part of the PHASE (Physical Activity in public Space Environments) project [22]. Adults aged 45–65 years were recruited from four neighborhoods in Rotterdam (623 652 inhabitants) and Maastricht (122 397 inhabitants), the Netherlands. These four neighborhoods, two in Rotterdam (Oude Noorden and Kralingen-West) and two in Maastricht (West and Zuid-Oost), differed in presence of green space, distance to the city center, and population density, to increase variations in exposure to (natural) environments. Adults' home addresses (N =14889) were randomly selected from the municipal population registers of Rotterdam and Maastricht. An information letter, in which one was asked to participate in the study, was sent to each adult of the selected sample. Those who were willing to participate could register through a website or by telephone (N =516 adults registered). After registration, researchers contacted the participants by phone or e-mail to plan the accelerometer and GPS-logger distribution. Trained staff members distributed the devices and explained monitor wear to participants (N =406) in community centers on weekday evenings. One community center per neighborhood was selected, to ensure short travel distances for participants. Sheets with a summary of monitor wear instructions were provided. Data collection occurred from April 2014 to December 2014. Participants signed informed consent. Analyses included data of 279 participants (175 Maastricht, 104 Rotterdam) after applying criteria for valid data (see below). The study was conducted with approval of the institutional review board of the faculty of Social and Behavioural Sciences of the Utrecht University.

Measures

The outcome measure was 'PA behavior during NE visits'. To measure PA behavior as well as the locations in which the behaviors occurred, participants were asked to wear an Actigraph GT3X+ accelerometer (Actigraph, Pensacola, Florida) and a BT-Q1000XT GPS-device (QStarz International Co) for seven consecutive days during waking hours. Both devices were attached to an elastic, adjustable belt which participants were asked to wear on the right hip. GPS-devices and accelerometers provided data for every 5 s.

Accelerometer data. Accelerometer data were downloaded using Actilife v6.11.2 (Firmware 2.2.1, Actigraph), and triaxial counts were summed as counts per minute (cpm). Consecutive zero strings of ≥90 min were defined as non-wear episodes, which is similar to other Actigraph accelerometer studies with samples of approximately similar age range (e.g., [23,24]). Short interruptions of up to 2 consecutive minutes of 1–100 counts per minute (cpm) were allowed as non-wear time to account for the possibility of accidental monitor movements (e.g., a monitor being disturbed while left on a table) [24]. Vector magnitude cut-points, that were developed for similar age groups, were used to define 4 intensities of PA: sedentary behavior (< 150 cpm), light PA (150–3208 cpm), moderate PA (3208–8564 cpm) and vigorous PA (≥8565 cpm) [25,26]. Moderate PA and vigorous PA were summed to moderate-vigorous PA (MVPA). We used the 70/80 rule to define a valid day [27]. Therefore, we calculated the time during which ≥70% of participants wore the accelerometer device: 611 min in this study. A day was considered valid if ≥80% of this episode had non-missing counts (488.8 min). If participants had ≥4 of such valid days, their data were included in analyses [28].

GPS data. GPS data were downloaded using QStarz QTravel software (v1.45, QStarz International Co). All GPS data-points that were measured on valid days were uploaded in ArcMap 10.2.2 (Esri, Redlands, California). Since only data on land use of the Netherlands was available (available from Dutch Statistics, 2012), data-points lying in other countries were excluded (about 4% of the data). For each data- point it was determined in which type of land use it was located. Only data-points that lay in NE were selected for this study. Based on the land use data we labelled each data-point with the NE type and NE size in which it occurred. Five different types of NE were distinguished: 'parks' (e.g., city parks, children's farm), 'recreational area' (e.g., zoo, playground, picnic places), 'agricultural green' (e.g., grassland, orchard), 'forest & moorland' (e.g., forest, moorland, dunes), and 'blue space' (e.g., lakes, rivers, water in parks, seas). ArcMap was used to calculate the size (i.e., surface) of each NE. SPSS 23.0 was used to calculate quartiles of NE size (i.e., so that each size category had an approximately equal number of visits). The cut points were rounded to: 3 ha, 7 ha, and 27 ha.

Besides, GPS-data were also used to classify PA behavior during NE visits into three categories of modality: 'spatially concentrated PA' (i.e., PA in one place, e.g., gardening), 'walking & jogging', and 'cycling'. A spatially concentrated activity was defined as a cluster of successive data-points that occurred within a range of 150 m or less, a maximum speed of 3 km/h, and a duration of ≥2 min. Spatially concentrated activities may thus include sedentary behavior (e.g., sitting on a bench in a park), but also include (sporting) activities (e.g., volleyball, soccer). Non-spatially concentrated activities were defined as clusters of successive data-points with a minimum length of 100 m, an average speed of ≥3 km/h, and a duration of ≥1 min. If the speed of GPS data- points was < 12 km/h, modality was set to 'walking & jogging', and if the speed of the GPS data-points was ≥12 and < 25 km/h, modality was set to 'cycling'. For each day of each participant, consecutive GPS data-points linked to a NE area of similar size and type were clustered and considered as one NE visit. However, if the time difference between GPS data-points of similar size and type of NE was 5 min or more, these data-points were assigned to separate visits. Then, the duration of visits was calculated. Visits in NE of less than 5 min were considered too short to have meaningful relations with PA (e.g., cycling through a small inner-city park for 30 s), and were therefore excluded from the analyses.

Linking GPS and accelerometer data. To link GPS-data with accelerometer data, a procedure was written in Python 2.7.2. Based on the time stamps of both types of data, this procedure added the accelerometer counts in each direction (x-, y-, z- axis) to the GPS-data point that was closest in time, where the GPS- data point could be timed before or after the accelerometer data point. A maximum time difference of 10 s was allowed to link GPS- to accelerometer data.

Questionnaire data. Participants received a questionnaire that queried gender, age, ethnicity, highest level of education, employment, health status, height and weight (to calculate body mass index), household structure (i.e., having children, a partner), car ownership, and having a garden. Participants were asked to fill out their highest level of completed education, and three levels of education were distinguished: 1) no education, primary education, lower professional or intermediate general education (i.e., lower education); 2) intermediate and higher general education (i.e., middle education); and 3) higher professional education and university (i.e., higher education). Employment was dichotomized into yes and no, where 'yes' applied to adults with a job and entrepreneurs, and 'no' applied to retired adults, adults with social security payments, adults who were unable to work, job-seekers, and housewife/houseman. Health status was measured using the question 'In general, would you say your health is', with excellent, very good, good, fair and poor as the response categories.

Statistical analyses

Descriptive statistics were used to describe the study population and the levels of PA intensity and modality during NE visits according to type and size of NE. Multiple regression analyses were performed to assess the association between size and type of NE (independent variables), and PA behavior during NE visits (dependent variable). Outcome variables were not normally distributed and neither log- transformations nor taking the square root led to normal distributions. Due to this non-normality of outcome variables, regression analyses were bootstrapped with the sample size set to 5000. Multilevel analyses (linear mixed models) were used to correct for clustering of visits to NE within respondents, as visits within respondents are likely more similar to each other than to visits of other respondents. Herewith, we systematically addressed within and between person variations. Parks were selected as the reference category in analyses as this type of NE has been studied most in literature and comparisons of other types of NE with parks would be of great interest. The regression analyses were controlled for the following confounders: gender, age, health status, BMI, education, employment, ethnicity, car ownership, having children, having a dog, having a garden, and city (Rotterdam vs. Maastricht). Garden was controlled for as it is plausible to assume that adults who have a garden may have different PA behavior than adults who live in a flat without a garden. For example: adults who have a garden are able to have diner or lunch within their garden and may therefore use parks or other NE more for LPA and MVPA activities, whereas adults living in a flat may be more likely to go to parks for a picnic (e.g., with friends) – which is sedentary behavior. This theory is based on findings of a previous study which showed that adults who have a garden had higher levels of MVPA in green spaces such as city parks, than adults without a garden (22). SPSS 23.0 for windows was used to perform all statistical analyses.

5.3 RESULTS

Population characteristics

Participants' mean age was 57.1 years, and a little more than half of the sample was female. Most participants were native Dutch. Almost half of participants were overweight or obese, and most had a middle or higher education. This study sample reflects the national Dutch adult population (45–65 years) as regards gender and BMI, as figures for being female, and being overweight or obese are approximately similar. Western immigrants and non-western immigrants are slightly underrepresented in this study sample (i.e., national figures according to Dutch Statistics are 9.5% and 12.3%, respectively) (Dutch Statistics, 2016). Also, adults with a lower education are underrepresented in this study (i.e., according to Dutch Statistics Public Health 1/3 of adults aged 45–65 years has a lower education). Accelerometers and GPS-devices were on average worn for approximately 14 h per day.

Most visits to NE were park visits and many adults visited multiple NE (i.e., the sum of percentages of adults who visited NE types adds up to over 100%).

Visits to NE according to type and size of NE

Of total visits to NE, most were park visits and least were forest & moorland visits (Table 5.1). Most NE visits occurred in places with a size of 3–7 ha (Table 5.2). Of the visits to parks, most took place in such environments with a size of 3–7 ha. Visits to recreational areas occurred mostly in such environments that had a size of 7–27 ha. Of the visits to agricultural green, forest & moorland and blue space, most occurred in such environments with a size of ≥27 ha.

Table 5.1 Sample characteristics.

	Total study sample (N=279)
Age in years	
Median (IQR)	57.1 (10.9)
Female (%)	54.1
BMI (%)	
Healthy weight *(18.5 < BMI ≤ 25)*	54.1
Overweight *(25 < BMI ≤ 30)*	36.6
Obese *(BMI > 30)*	9.3
Ethnicity (%)	
Autochthonous	85.7
Western immigrants	5.7
Non-Western immigrants	7.2
Missing	1.5
Education (%)	
Lower	4.7
Middle	52.3
Higher	41.6
Missing	1.4
Wear time in minutes per day	
Mean (SD)	843.1 (155.4)
Total visits to NE (N)	3948
Park (%)	41.0
Recreational area (%)	5.6
Agricultural green (%)	31.9
Forest & moorland (%)	5.1
Blue space (%)	16.4
Participants who visited NE[a]	
Park (%)	66.3
Recreational area (%)	16.1
Agricultural green (%)	62.0
Forest & moorland (%)	19.4
Blue space (%)	44.1
Visits per person	
Median (IQR)	9 (16)

Note: [a]Percentages represent the share of the total study sample that visited the NE at least one time.

Table 5.2 Amount of visits in different types of green.

	Total visits	Size 0 – 3 ha		Size 3 – 7 ha		Size 7 – 27 ha		Size ≥ 27 ha	
	N	N	%	N	%	N	%	N	%
Parks	1620	479	58.0	738	65.0	278	27.4	125	12.8
Recreational areas	220	25	3.0	13	1.1	128	12.6	54	5.5
Agricultural green	1260	157	19.0	219	19.3	386	38.1	498	51.1
Forest & moorland	202	21	2.5	36	3.2	40	3.9	105	10.8
Blue space	646	144	17.4	129	11.4	181	17.9	192	19.7
Total	**3948**	**826**	**20.9**	**1135**	**28.7**	**1013**	**25.7**	**974**	**24.7**

Note: Visits had a minimum duration of 5 minutes. Percentages in columns add up to 100%.

Intensity and modality of PA according to type and size of NE

An average visit to a NE lasted 12.3 min. Of the visits to the different types of NE, forests & moorland visits had the longest duration (Table 5.3). As regards the size of NE, visits with the longest duration were observed for 0–3 ha sized NE. Of an average visit, 60.3% was spent sedentary, 24.9% was light PA, and 3.4% was moderate- vigorous PA (Table 5.3). An average visit consisted mostly of spatially concentrated activities, and partly of walking & jogging, whereas observed cycling levels were very low (Table 5.4).

Highest percentages of sedentary behavior were observed in blue space. Parks, recreational areas, and agricultural green were found to have the highest (and approximately similar) proportions of time spent in LPA. Highest levels of MVPA were observed in agricultural green. Generally, percentages of sedentary behavior were found to be lowest in NE of the largest size categories, whereas MVPA levels were found to be highest in these largest size categories (this pattern is even more clear when looking at the mean MVPA percentages). An exception was found for forest & moorland, where the percentage of sedentary behavior was lowest for forest & moorland with a size of 0–3 ha (although the percentages in the 7–27 ha and ≥27 ha categories were also lower than in the 3–7 ha category).

In general, spatially concentrated PA levels were high in all NE types, but lowest in forest & moorland. Highest levels of walking were observed in forest & moorland. Cycling levels were low in all NE types. Furthermore, percentages of spatially concentrated PA were generally lowest in the largest size categories of NE. Highest walking levels were observed in the largest size category. Cycling levels were low in all size categories. When looking at mean percentages, higher cycling percentages were observed in the largest size categories.

Table 5.3 PA intensity per visit, according to type and size of NE.

	Time (minutes)				Sedentary behavior (%)		LPA (%)		MVPA (%)	
	Mean	*(SD)*	*Median*	*(IQR)*	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
Total	30.5	(54.3)	12.3	(21.2)	55.8	60.3	30.2	24.9	13.9	3.4
0 – 3 ha	39.4	(15.1)	64.4	(35.7)	62.4	67.8	30.7	26.6	7.0	3.1
3 – 7 ha	29.6	(55.5)	12.0	(19.0)	62.6	68.8	30.3	25.0	7.1	1.8
7 – 27 ha	30.0	(50.7)	12.3	(36.0)	54.6	58.6	30.2	23.5	15.2	4.2
≥ 27 ha	24.5	(45.6)	11.2	(14.3)	43.6	41.3	29.9	24.6	26.5	5.9
Parks	29.8	(46.9)	12.4	(22.8)	61.4	66.1	29.6	25.6	9.0	2.7
0 – 3 ha	40.9	(60.6)	16.3	(43.4)	62.2	66.2	31.0	27.8	6.8	3.3
3 – 7 ha	25.8	(42.5)	11.0	(16.2)	63.7	69.2	29.4	25.0	6.9	1.8
7 – 27 ha	27.8	(34.9)	14.6	(26.4)	56.7	58.9	28.3	23.2	15.0	4.1
≥ 27 ha	15.3	(17.4)	8.5	(8.6)	55.6	60.0	28.6	25.3	15.8	3.0
Recreational areas	35.7	(73.0)	13.1	(26.1)	56.1	62.2	31.5	25.4	12.4	3.8
0 – 3 ha	45.2	(37.7)	41.0	(67.0)	72.0	71.4	22.2	24.3	5.8	4.4
3 – 7 ha	59.1	(120.1)	15.7	(44.0)	56.7	67.3	34.0	23.3	9.3	4.6
7 – 27 ha	25.3	(45.5)	10.7	(12.5)	53.0	50.5	31.9	23.7	15.1	4.3
≥ 27 ha	50.5	(111.8)	15.9	(30.0)	56.0	62.1	34.3	26.7	9.7	2.1
Agricultural green	33.3	(61.8)	12.6	(22.5)	47.1	48.4	31.1	25.6	21.8	4.5
0 – 3 ha	58.0	(96.5)	18.6	(46.1)	59.5	62.5	33.3	29.4	7.2	2.8
3 – 7 ha	34.1	(65.5)	14.1	(26.7)	58.3	64.2	32.9	25.8	8.8	1.6
7 – 27 ha	35.3	(62.4)	12.1	(26.2)	53.8	59.7	30.4	24.6	15.8	4.2
≥ 27 ha	23.5	(39.6)	11.6	(13.3)	33.1	23.4	30.1	23.2	36.8	14.2
Forest & Moorland	27.6	(49.6)	13.3	(20.3)	52.9	57.7	29.4	23.7	17.7	4.0
0 – 3 ha	27.2	(33.1)	14.9	(21.7)	47.8	31.1	42.5	38.5	9.6	6.1
3 – 7 ha	52.2	(102.3)	17.7	(50.8)	61.3	61.4	32.0	33.3	6.7	2.0
7 – 27 ha	16.1	(14.3)	9.8	(8.9)	55.5	60.8	24.2	15.2	20.3	7.2
≥ 27 ha	23.7	(25.9)	13.5	(19.2)	50.0	50.0	27.9	23.4	22.2	5.4
Blue space	26.0	(49.5)	11.1	(16.2)	59.6	67.7	30.0	22.8	10.4	2.2
0 – 3 ha	15.1	(11.4)	10.8	(13.6)	66.4	75.7	26.5	20.6	7.1	1.5
3 – 7 ha	34.7	(70.8)	12.8	(23.0)	64.7	73.0	30.3	21.9	5.0	1.8
7 – 27 ha	28.2	(51.1)	11.3	(17.6)	54.1	61.3	32.6	22.7	13.3	3.8
≥ 27 ha	26.3	(47.1)	10.2	(13.7)	56.2	63.7	30.1	24.7	13.7	2.2

Note: LPA= light PA, MVPA= moderate-vigorous PA. SD = standard deviation. IQR= interquartile range. Ha = hectare. Percentages of sedentary behavior, LPA and MVPA do not necessarily add up to 100% because medians are reported.

Table 5.4 PA modality per visit, according to type and size of NE.

	Time (minutes)				Spatially concentrated PA (%)		Walking & jogging (%)		Cycling (%)	
	Mean	*(SD)*	*Median*	*(IQR)*	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
Total	30.5	(54.3)	12.3	(21.2)	70.3	99.1	27.1	0.5	2.6	0.0
0 – 3 ha	39.4	(15.1)	64.4	(35.7)	84.7	100.0	14.3	0.0	1.0	0.0
3 – 7 ha	29.6	(55.5)	12.0	(19.0)	81.0	100.0	17.7	0.0	1.3	0.0
7 – 27 ha	30.0	(50.7)	12.3	(36.0)	71.8	98.9	26.0	0.2	2.2	0.0
≥ 27 ha	24.5	(45.6)	11.2	(14.3)	44.2	23.3	50.1	45.5	5.7	0.0
Parks	29.8	(46.9)	12.4	(22.8)	74.3	100.0	23.7	0.0	2.0	0.0
0 – 3 ha	40.9	(60.6)	16.3	(43.4)	83.7	100.0	15.3	0.0	1.0	0.0
3 – 7 ha	25.8	(42.5)	11.0	(16.2)	79.1	100.0	19.6	0.0	1.4	0.0
7 – 27 ha	27.8	(34.9)	14.6	(26.4)	66.6	95.8	31.2	2.8	2.2	0.0
≥ 27 ha	15.3	(17.4)	8.5	(8.6)	27.5	0.0	63.2	93.6	9.4	0.0
Recreational areas	35.7	(73.0)	13.1	(26.1)	82.3	100.0	16.9	0.0	0.7	0.0
0 – 3 ha	45.2	(37.7)	41.0	(67.0)	94.6	100.0	5.4	0.0	0.0	0.0
3 – 7 ha	59.1	(120.1)	15.7	(44.0)	84.6	95.7	14.9	4.3	0.5	0.0
7 – 27 ha	25.3	(45.5)	10.7	(12.5)	78.0	100.0	21.0	0.0	0.9	0.0
≥ 27 ha	50.5	(111.8)	15.9	(30.0)	86.3	100.0	13.0	0.0	0.7	0.0
Agricultural terrain	33.3	(61.8)	12.6	(22.5)	65.7	95.3	31.4	3.1	2.9	0.0
0 – 3 ha	58.0	(96.5)	18.6	(46.1)	84.5	99.0	14.1	0.6	1.4	0.0
3 – 7 ha	34.1	(65.5)	14.1	(26.7)	88.4	100.0	10.8	0.0	0.8	0.0
7 – 27 ha	35.3	(62.4)	12.1	(26.2)	75.8	99.3	22.9	0.3	1.3	0.0
≥ 27 ha	23.5	(39.6)	11.6	(13.3)	41.9	11.5	52.6	57.9	5.5	0.0
Forest & Moorland	27.6	(49.6)	13.3	(20.3)	55.8	75.4	42.8	23.6	1.4	0.0
0 – 3 ha	27.2	(33.1)	14.9	(21.7)	86.2	100.0	13.7	0.0	0.2	0.0
3 – 7 ha	52.2	(102.3)	17.7	(50.8)	74.6	100.0	24.8	0.0	0.6	0.0
7 – 27 ha	16.1	(14.3)	9.8	(8.9)	47.4	52.2	51.1	47.0	1.5	0.0
≥ 27 ha	23.7	(25.9)	13.5	(19.2)	46.4	42.6	51.6	52.9	2.0	0.0
Blue space	26.0	(49.5)	11.1	(16.2)	69.9	100.0	25.8	0.0	4.3	0.0
0 – 3 ha	15.1	(11.4)	10.8	(13.6)	86.6	100.0	12.8	0.0	0.6	0.0
3 – 7 ha	34.7	(70.8)	12.8	(23.0)	80.9	100.0	16.7	0.0	2.4	0.0
7 – 27 ha	28.2	(51.1)	11.3	(17.6)	72.2	100.0	22.6	0.0	5.2	0.0
≥ 27 ha	26.3	(47.1)	10.2	(13.7)	47.9	38.8	44.7	28.2	7.4	0.0

Note: SD = standard deviation. IQR= interquartile range. Ha = hectare. Percentages of spatially concentrated PA, walking & jogging, and cycling do not necessarily add up to 100% because medians are reported.

The association of typology and size of NE with PA behavior

Table 5.5 shows the raw and adjusted associations of typology and size of NE with PA modality and intensity during NE visits. Adjusted analyses showed the following significant results.

Significant differences between types of NE were found for all intensities and modalities of PA, except for MVPA. Recreational areas and agricultural green were associated with significantly less sedentary behavior than parks, whereas LPA levels were observed to be higher in these types of environments. Recreational areas and agricultural green were furthermore associated with significantly more spatially concentrated activities than parks, but walking & jogging levels were significantly lower. For recreational green, cycling levels were also found to be significantly lower than cycling levels in parks. Forest & moorland was associated with higher LPA levels and lower cycling levels. Blue space was associated with higher LPA levels and higher cycling levels.

The largest NE size category (≥27 ha) was associated with significantly less sedentary behavior than the smallest size category (< 3 ha, reference category). Larger sized NE (≥7 ha) were also associated with significantly lower LPA levels. MVPA levels in the two largest size categories were significantly higher than in the smallest size category. Furthermore, larger sized NE (≥7 ha) were associated with less spatially concentrated activities, but more walking & jogging, and more cycling.

Table 5.5 Bootstrapped multilevel regression results on the relationship between size and type of NE and PA.

	Model 1 – raw analyses			**Model 2 – adjusted analyses[a]**		
Sedentary behavior (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	-4.62	(-10.65; 1.04)	0.112	**-6.67**	**(-13.11; -1.05)**	**0.027**
Agricultural green	**-7.98**	**(-11.21; -4.23)**	**0.000**	**-6.76**	**(-10.19; -2.84)**	**0.000**
Forest & moorland	-2.10	(-7.70; 3.76)	0.451	-2.63	(-8.07; 3.22)	0.359
Blue space	-1.34	(-5.39; 2.09)	0.488	-2.69	(-6.65; 1.18)	0.178
(Ref:< 3 ha)						
3 – 7 ha	-0.48	(-4.57; 3.12)	0.808	0.87	(-3.07; 4.66)	0.655
7 – 27 ha	-2.04	(-5.92; 1.70)	0.284	-1.33	(-5.04; 2.70)	0.483
≥ 27 ha	**-9.89**	**(-13.65; -6.00)**	**0.000**	**-10.73**	**(-14.32; -6.28)**	**0.000**
LPA (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	3.15	(-1.03; 7.34)	0.139	**5.32**	**(0.53; 9.86)**	**0.023**
Agricultural green	**3.87**	**(1.32; 6.36)**	**0.002**	**3.98**	**(1.25; 6.62)**	**0.004**
Forest & moorland	**4.34**	**(0.59; 8.42)**	**0.028**	**4.99**	**(1.11; 8.99)**	**0.013**
Blue space	**3.30**	**(0.59; 6.29)**	**0.021**	**3.51**	**(0.59; 6.59)**	**0.020**

Table 5.5 Continued.

LPA (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref:< 3 ha)						
3 – 7 ha	-0.31	(-3.22; 2.84)	0.841	-1.22	(-4.38; 1.82)	0.433
7 – 27 ha	**-4.53**	**(-7.19; -1.65)**	**0.001**	**-5.09**	**(-8.17; -2.19)**	**0.001**
≥ 27 ha	**-3.92**	**(-6.73; -0.68)**	**0.009**	**-3.90**	**(-7.06; -0.82)**	**0.014**
MVPA (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	1.88	(-2.14; 6.25)	0.359	1.99	(-2.23; 6.57)	0.381
Agricultural green	**3.25**	**(0.24; 5.88)**	**0.024**	2.43	(-0.68; 5.18)	0.105
Forest & moorland	-2.92	(-7.37; 1.53)	0.213	-3.10	(-7.55; 1.35)	0.178
Blue space	-1.69	(-4.24; 0.97)	0.201	-0.87	(-3.53; 1.74)	0.525
(Ref:< 3 ha)						
3 – 7 ha	1.05	(-1.62; 3.82)	0.447	0.39	(-2.25; 3.15)	0.792
7 – 27 ha	**6.53**	**(3.80; 9.40)**	**0.000**	**6.11**	**(3.35; 8.91)**	**0.000**
≥ 27 ha	**13.34**	**(10.33; 16.35)**	**0.000**	**13.72**	**(10.37; 16.72)**	**0.000**
Spatially concentrated PA (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	**13.10**	**(5.54; 20.07)**	**0.001**	**11.78**	**(3.42; 18.99)**	**0.003**
Agricultural green	**7.91**	**(3.01; 12.44)**	**0.001**	**7.86**	**(2.45; 12.24)**	**0.002**
Forest & moorland	3.91	(-3.66; 10.90)	0.293	2.46	(-5.05; 9.66)	0.504
Blue space	2.59	(-2.76; 7.46)	0.321	1.44	(-4.08; 6.56)	0.589
(Ref:< 3 ha)						
3 – 7 ha	-1.03	(-5.86; 4.18)	0.692	0.19	(-4.81; 5.46)	0.948
7 – 27 ha	**-11.19**	**(-15.74; -6.41)**	**0.000**	**-9.14**	**(-13.51; -4.02)**	**0.000**
≥ 27 ha	**-31.81**	**(-36.39; -26.22)**	**0.000**	**-30.60**	**(-35.36; -24.74)**	**0.000**
Walking & jogging (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	**-11.45**	**(-18.12; -4.19)**	**0.001**	**-9.62**	**(-16.40; -1.80)**	**0.011**
Agricultural green	**-7.68**	**(-12.13; -2.96)**	**0.001**	**-7.42**	**(-11.92; -2.44)**	**0.003**
Forest & moorland	-2.02	(-8.93; 5.16)	0.569	-0.34	(-7.34; 6.89)	0.924
Blue space	**-5.19**	**(-9.77; -0.48)**	**0.029**	-3.99	(-8.95; 1.04)	0.113
(Ref:< 3 ha)						
3 – 7 ha	-0.06	(-4.97; 4.79)	0.982	-1.04	(-6.12; 3.81)	0.697
7 – 27 ha	**8.63**	**(3.98; 12.94)**	**0.000**	**6.77**	**(1.88; 11.00)**	**0.004**
≥ 27 ha	**25.29**	**(19.87; 29.67)**	**0.000**	**24.33**	**(18.81; 28.71)**	**0.000**
Cycling (%)	*B_1*	*CI*	*P-value*	*B_1*	*CI*	*P-value*
(Ref: Park)						
Recreational areas	-1.67	(-3.04; 0.19)	0.052	**-2.05**	**(-3.67; -0.09)**	**0.028**
Agricultural green	-0.33	(-1.53; 1.27)	0.642	-0.46	(-1.72; 1.14)	0.541
Forest & moorland	**-2.03**	**(-3.85; 0.02)**	**0.043**	**-2.27**	**(-4.11; -0.06)**	**0.030**
Blue space	**2.48**	**(0.89; 4.75)**	**0.014**	**2.42**	**(0.73; 4.85)**	**0.025**
(Ref:< 3 ha)						
3 – 7 ha	0.96	(-0.09; 2.21)	0.098	0.74	(-0.38; 1.89)	0.205
7 – 27 ha	**2.34**	**(1.23; 3.73)**	**0.001**	**2.13**	**(0.93; 3.51)**	**0.002**
≥ 27 ha	**6.15**	**(4.71; 7.79)**	**0.000**	**5.83**	**(4.27; 7.57)**	**0.000**

Note: B_1 = regression coefficient. CI = confidence interval (lower; upper). LPA = light PA. MVPA = moderate – vigorous PA. Bold text indicates statistical significance (P-value < 0.05). [a]Adjusted for the following confounders: gender, age, health status, BMI, education, employment, ethnicity, car ownership, having a garden (at home), having children, having a dog, and city (Rotterdam vs. Maastricht).

5.4 DISCUSSION

Main findings

In contrast to previous studies, which often investigated only one type of NE, this study examined adults' PA behavior (modality and intensity) in different types and sizes of NE. Results showed that walking & jogging, cycling, and especially LPA and MVPA were not typically observed in one type of NE, but across various types of NE. Nevertheless, significant differences in PA behaviors were found between different types of NE. Besides, the study showed higher levels of MVPA, walking & jogging and cycling in larger sized NE (≥7 ha). These new insights provide answers to questions raised in the literature [2,10,16] and inform public health policymakers who are interested in environmental supports for PA, on the types and sizes of NE that facilitate certain PA behaviors [10].

Interpretation

This study emphasizes that PA behavior was distributed across a variety of places, which is illustrated by the percentages in Table 5.1. These percentages, representing the amount of adults who visited the different types of NE, add up to over 100%. Hence, it is clear that there is an overlap: many adults do not just visit one, but multiple types of NE. The findings of the current study are consistent with previous findings of our study on MVPA behavior [22]. The results of that study showed that MVPA was not observed in one particular place such as sports locations, as one may expect, but in various places. Based on those findings and on findings of the current study, it thus seems that PA is not bounded to one specific type of environment, but that people tend to use various environments for PA.

The significant differences in PA modality and intensity between various types of NE, indicate that NE typology may indeed be important to consider in research on the relationship between the environment and PA. However, as our results cannot be used to predict behavior change, it remains unclear whether the presence of all these different NE types is necessary to maintain PA levels. More evidence is needed to understand whether PA levels would decrease when less different types of NE would be available, or whether this would lead to less variation in PA. For example, if agricultural green would no longer be available, it is unclear if PA levels would decrease because adults would be unable to be active in or near agricultural green, or if adults would compensate those activities by using other types of NE for their PA.

Parks were the most frequently visited type of NE compared to other NE. This may indicate that parks are important places for urban residents, but it is also likely that park density is higher than the density of other NE. In both ways, the high amount of visits to parks confirm that research into the association between parks (and their characteristics) and

PA [7,29-33] is indeed relevant. There is however still much insight to be gained regarding the association between parks and PA (levels). For example, the role of the quality of parks, but also of other NE types (e.g., maintenance, aesthetics, and facilities) in PA behavior is still relatively unknown.

Results showed that agricultural green and recreational areas were associated with significantly lower sedentary behaviors, and significantly higher spatially concentrated PA. Besides, in these types of NE, LPA levels were higher where walking levels (and for recreational areas also cycling levels) were lower. In other words, agricultural green and recreational areas appear to be well suited for light activities, with such activities being spatially concentrated PA (i.e., within a certain distance range) rather than walking and cycling. More in depth research (e.g., using PA diaries or interviews) on PA behaviors in and around agricultural green is needed to better understand these findings. Recreational areas such as picnic places may indeed offer more facilities for light PA behaviors (e.g., playing Frisbee) than for walking or cycling. On the contrary, blue spaces are NE types that were associated with significantly higher cycling levels. In the Netherlands there are many cycling lanes alongside rivers, canals, and lakes, and it is likely that adults often use (parts of) such cycling lanes when cycling.

Our findings on differences in PA intensities (i.e., sedentary behavior, LPA, MVPA) between different types of NE and parks, are in line with previous findings of Elliot et al. (2015). They showed that different types of NE support different PA intensities and (thus) different energy expenditures [10]. The authors link differences in type of NE to differences in size of NE as they argue that more expansive types of NE (e.g., coasts) contribute to higher energy expenditure. Although this is a plausible assumption, evidence was lacking. Our study provides evidence on this matter and emphasizes the role that size of NE has in PA behavior. With increasing size, lower levels of sedentary behavior and higher levels of MVPA were observed. Also, in larger sized NE (≥7 ha), walking, jogging, and cycling levels were higher.

Findings that higher walking levels were observed in larger sized NE are in congruence with findings by Giles-Corti et al. (2005), who found that good access to large public open spaces was associated with higher levels of walking. This may be because larger sized NE have more facilities such as walking trails, which contribute to an increase in PA levels [34]. It may further be that smaller sized NE are mostly used for social and relaxation activities (mostly sedentary behaviors) [19]. However, most of the NE types may facilitate social activities and it is not unlikely that the relatively high percentages of sedentary behavior in each type of NE are an indication of such social activities (e.g., picnics).

As we found both higher levels of MVPA and higher levels of walking, jogging and cycling in larger NE, one might argue that this is because more walking, jogging and cycling induces more MVPA. Although this seems plausible, additional correlation analyses showed only small or medium correlations (as the highest Pearson's correlation - found for the correlation between percentage of walking & jogging and the percentage of MVPA - was only 0.462). It would be of great interest to further investigate what types of PA contribute to these higher intensity levels in larger sized NE.

The finding that LPA levels were significantly lower in larger sized NE than in smaller sized NE may seem somewhat contradictive to the findings that levels of MVPA, walking & jogging, and cycling were significantly higher in larger sized NE. However, an explanation for this may be that light physical activities may occur as spatially concentrated activities – of which significantly lower levels were found in larger sized NE. Such spatially concentrated activities require less space, but can still be of light intensity (e.g., playing Frisbee, or toss a ball around).

As explained by Chaix et al. (2013), cross-sectional studies with a so called contemporaneous momentary design (i.e., data on the location, the related context and the outcome (PA) were measured at the same moment [35], such as the current study, are unable to assess the causal effects of the environment on PA behaviors. From the results of this cross-sectional study, it remains unclear whether adults who want to be physically active anyway, simply select certain types and sizes of NE that fit with their choice for a specific modality or intensity of PA, or that certain types and sizes of NE stimulate specific types and intensities of PA. In other words: it may be that adults who are highly motived to walk, will seek for a large-sized green area with good walking trails. However, studies have shown that the presence of a PA facilitating environment may be especially important to increase PA levels among those who are not highly motivated (e.g., those with a negative attitude towards PA) [36].

Policy implications

This study showed that adults walk, jog and cycle in a variety of NE types. Such a variety in environments allows people to visit types of environments that are highly conducive for walking, as well as other environments that are ideally suited for cycling. Moreover, this study emphasizes the importance of large sized NE (especially ≥7 ha), since these places were associated with higher levels of MVPA, walking, jogging, and cycling. Note that the presence of various types and large-sized NE not only positively affects health via PA behavior, but also via stress reduction, increased social interaction, noise mitigation, heat and humidity regulation and air pollution filtration [37]. The finding that PA occurs to the same extent but in different forms in different types of NE, suggests that it is beneficial to provide different types of NE in urban regions, to accommodate taste differences with respect to using green facilities.

Strengths and limitations

The use of objective methods (i.e., accelerometers and GPS-devices) improves accuracy and comprehensiveness of research on time spent in various PA modalities and intensities in NE, compared to the common used questionnaires and diaries. Adults are likely to forget the exact duration of activities or they forget to report certain activities (e.g., the walk to the bus stop) in questionnaires and diaries; information that is registered into detail by the accelerometers and GPS-devices. Moreover, GPS-data provides the opportunity to match PA behavior to objective data on typology and size of NE. However, data loss due to e.g., insufficient wear time, or canyoning could not be avoided. Furthermore, misclassification of intensities, walking, jogging, and cycling may have occurred since cut-off values may not be applicable to each participant (e.g., due to age, health status). Diaries with additional information on activities in NE may reduce misclassification.

Cut-off values for the different size categories were based on the calculation of quartiles. Sensitivity analyses showed that the use of different cut-off values yielded similar results with regard to effect sizes, direction of the effect, and significant associations. Sensitivity analyses were also run regarding the cut-off value (i.e., 12 km/h) for walking/jogging and different cut-off values yielded similar results.

Inherent to the methodology (i.e., use of accelerometer and GPS can be more burdensome to participants than the use of questionnaires), study samples are often smaller than samples of studies using questionnaires. Of 14889 adults who received an invitation letter, only 516 registered to participate in this study.

Although this is a low response rate (± 3.5% agreed to participate), the final sample size is comparable to other studies [28]. It is however likely that adults who registered to participate have an interest in PA and/or healthy living, and it may thus be that adults in this study sample are more active than the average Dutch adult population aged 45–65 years. This may have led to an overestimation of PA. Although the current study did not assess week- and weekend day differences, it is important to be able to include both sufficient weekdays and weekend days in analyses. For example, it may be that specific types of NE are more often visited on weekend days than on weekdays. An overrepresentation of weekend days may then lead to an overrepresentation of visits to these specific types of NE. Therefore, additional analyses were performed to assess the ratio of week- and weekend days that were included in the current study. These analyses showed that 65.5% of the days on which NE visits took place were weekdays, and 34.5% were weekend days. It is therefore unlikely that visits to specific NE were over- or underrepresented in this study.

Future research

For this study, four categories of NE size were distinguished. It may however be necessary for some NE types to further distinct the size categories. This may particularly apply to parks, since the sizes of this type of NE vary widely within and between cities. Future studies may therefore aim to make a further distinction in size to gain more thorough insight in the importance of size for PA behavior in (urban) green and blue spaces.

Moreover, to improve our understanding of the relationship between typology and size of NE and PA, future (longitudinal) research is needed to investigate what specific characteristics and facilities of these environments explain the effects found in the current study. Other research methods, such as observations of NE and (walk along) interviews could be used to provide additional information that, together with accelerometer- and GPS-data, provides a more comprehensive insight in the effect of specific features of NE (e.g., quality aspects) on PA behavior of adults. It would for example be of great interest to compare similar types of NE (e.g., parks) that have different facilities (e.g., sports facilities).

Furthermore, it is known that distance to green spaces may be related to PA behavior in those spaces [38]. It would be of great interest to investigate what distances adults are willing to travel to be physically active in NE, depending on type and size of the NE and the type of PA that adults engage in. For policy makers and urban planners to make well-informed environmental changes, insights in the role of distance to specific types and sizes of NE is necessary. Also, it is plausible to assume that PA which takes place on the journey to NE may be related to availability of and distance to NE. As the purpose of this study was not to assess whether, but how NE are used for PA (i.e., when people are actually within the NE and not on their way to the NE), active travel towards NE was not included in analyses. Future research may focus on active travel to NE, to further expand the knowledge on PA behavior and NE.

As non-native adults and adults with a lower education were underrepresented in this study, findings on PA may be biased due to preferences or motivations for certain PA behaviors or specific NE that may differ between subpopulations. We did not find existing research that provides a basis for speculating about the direction of such bias. For instance, although various studies found lower PA levels for lower educated groups, this gives no indication for the intensity of PA once being in a NE.

The current study provided a first step in investigating the role of type and size of NE in objectively measured PA behaviors and future research may expand the field by examining how the role of type and size of NE differ between various subpopulations (e.g., based on education or ethnicity). The current study did not assess week- and weekend day differences, whereas it may be that PA behavior during weekday visits to NE differ from PA behavior during NE visits on weekend days. For example, on weekend days adults may have more time to make long walking or cycling trips within NE than on weekdays. Future research may therefore aim to assess week- and weekend day differences, taking size and typology of NE into account.

5.5 CONCLUSION

This study showed a new use of GPS- and accelerometer data to provide insight in how NE of different types and sizes are used for PA behavior. Walking & jogging, cycling, LPA and MVPA were not typically observed in one type of NE, but across various types of NE. Larger sized NE were associated with less sedentary behavior and higher levels of MVPA, walking, jogging and cycling. Insight in which environments afford health-enhancing PA, contributes to the development of tailored PA promoting activities with ensuing implications for public health. Future research is needed to gain more insight in the relationship between more specific characteristics (e.g., benches, lighting, or aesthetics) of NE and PA to provide policy makers and urban planners with more specific knowledge on the design of NE.

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Chapter 6

Conclusions and discussion

This thesis centers itself in the ongoing societal debates on the development of PA-friendly environments that aim to stimulate active behavior. With an increasing prevalence of adverse health outcomes related to physical inactivity, such as obesity [1,2], health authorities advocate the importance to increase PA levels. As the physical environment has been shown to relate to PA behavior (e.g., [3,4]), designing PA facilitating environments has received increased attention of policy makers of (local) governments.

This study applied a much needed context-specific assessment of PA behavior and showed associations between objective environmental characteristics and location-based PA, and provided insight in how PA-patterns are distributed over the course of a day. Herewith, it provides useful insights into 1) how PA behavior is integrated in adults' daily lives, 2) locations and time periods that are used for PA, and by whom, and 3) how objective, GIS-based characteristics of specific environments (e.g., the residential neighborhood and natural environments) relate to context specific PA behavior. These insights contribute to an improved understanding of adults' PA behavior, and identifies time-windows, specific environments, and target groups to guide policy making, urban planning, and intervention development.

This chapter draws conclusions from the main findings of each of the four chapters and discusses how the study has contributed to existing literature. Further, this chapter provides directions for future research and discusses its practical implications.

6.1 SYNOPSIS

To address the aim of this research, which was: *to examine how PA of adults aged 45-65 years is distributed across space and time (i.e., in 4D), and to assess how physical environmental and personal factors are related to the spatial and temporal organization of PA behaviors,* four research questions were formulated in the introduction of this thesis. This section summarizes and interprets the findings from Chapter 2 to 5, which have provided answers to these questions.

1) *What typical temporal PA patterns exist, and what groups of adults have similar PA patterns?*
   The high global prevalence of insufficient PA [5], suggests that it may be difficult for adults to integrate sufficient PA in their daily lives. Previous studies have indeed found that most time of an average day is spent sedentary (about 57%), whereas about 39% is spent in light PA (LPA), and only limited time (about 4%) is spent in moderate-vigorous PA (MVPA) [6,7]. This provides useful insights on the total amounts of adults' PA. However, it is also of importance to assess how this PA is distributed throughout

the day, to identify time frames that may be targeted in interventions. For example, interventions may aim to increase PA levels during time frames with low PA levels, or they may target specific populations that may benefit from an increase in PA levels during specific time frames. This first research question addressed the limited knowledge on the temporal distribution of objectively measured LPA and MVPA of an adult population, without making a priori distinctions between sub-populations, in contrast to the few studies that have assessed temporal patterns of PA, that mostly made comparisons between different a priori determined sub-populations (e.g., [8-12]).

As described in Chapter 2, latent class analyses of objectively collected PA data revealed four typical hour-by-hour PA patterns: a morning LPA pattern, a mid-day MVPA pattern, an inactive pattern, and an active pattern. The morning LPA pattern has the lowest levels of MVPA throughout the day, and the second highest LPA levels with a peak in the morning. It is unclear why LPA occurs particularly in the morning. However, since this PA pattern was mostly observed on a Saturday, a possible explanation might be that this LPA reflects mostly active travel to for example the grocery store or to take their children to sports clubs. The mid-day MVPA pattern showed the highest MVPA levels, with a peak around mid-day. LPA levels of this pattern were second lowest. This pattern mostly occurred on Saturdays, and may hence reflect adults' sports activities. The inactive pattern has overall low LPA and MVPA levels throughout the day. The active day pattern has high MVPA levels and the highest LPA levels over the day.

In all four PA patterns, the levels of LPA and MVPA were very low in the evening. Different mechanisms may explain why PA levels are low in the evening. For example, Crombie and colleagues (2004) showed that reluctance to go out in the evening discouraged older adults to engage in PA [13]. This may be related to perceived safety (e.g., due to presence or absence of street lighting, crime, traffic), which has shown to play an important role in PA as well [14,15]. Perhaps this is also for adults aged 45-65 years a reason not to engage in PA during the evening. Moreover, it may be that adults who engage in PA throughout the day – for example at work as their jobs require PA – may be too tired to engage in PA also in the evening. In addition, the finding may partly be inherent to the statistical assessment: when clustering behaviors into classes, some information will not be shown in the results – which may be (at least partly) due to the relatively limited sample size. For example, individual patterns may have shown peaks of LPA or MVPA in the evening, but if there are only few adults who show such patterns in comparison to other patterns, it will not be reflected in one of the final identified typical hour-by-hour PA patterns.

Additionally, based on the hour-by-hour PA patterns that were typically adopted by adults, three groups of adults were distinguished. These groups were described by personal and neighborhood environmental factors, and differed significantly from each other in ethnicity and having a dog, as well as in the proportions of roads, sports terrain, larger green space, and blue space within their residential environment. The group of adults with the highest prevalence of non-western immigrants were most likely to have an active day pattern. This may seem contradictive as being of white ethnic origin has been positively correlated with PA. Nevertheless, current evidence does not provide consensus on the role of ethnicity in PA behavior as there are also inconclusive findings, and findings that suggest that ethnicity is not a determinant of PA [16]. Besides, the group of adults that had the highest share of non-western immigrants, also had the highest share of employed and low-educated adults. As the PA levels were particularly higher during the day, it may be that adults of this group more often have jobs that require them to be physically active. These thoughts are supported by the finding that such active days were most prevalent on weekdays.

The group with the highest proportions of sports terrain and larger green spaces within the residential environment, was more likely to have a morning LPA pattern, which mostly occurred on Saturdays. Although not significantly different from the other two groups, this group also had the highest percentage of adults with children. Perhaps this group may experience some (time) constraints on weekdays related to taking care of their children, whereas engaging in sports or other forms of PA either with or without children may be easier to integrate in activity patterns during the weekend.

Moreover, adults with the highest proportions of blue space within their residential environment were most likely to have a mid-day MVPA pattern. This pattern was mostly observed on Saturdays, which may be because sports activities (of moderate-vigorous intensity) may often take place on Saturdays. Perhaps such activities (e.g., jogging) take place near blue spaces, which may be one explanation for the higher levels of blue space.

With answering this first research question, Chapter 2 showed that individual and environmental characteristics are not only related to the total daily amounts of LPA and MVPA, but also to the manner in which LPA and MVPA are distributed over the course of a day. In other words, adults with varying characteristics may not only have different total PA levels, they are also likely to have different patterns of PA over time due to different socio-demographical and environmental opportunities and constraints. However, as only limited associations were found, it might be that other factors such as work regime, family life, and leisure have an impact on hour-by-hour PA patterning as well.

2) *How is PA distributed across various daily life physical environments?*
   Most research that assessed the role of the physical environment in PA behavior has focused on physical characteristics of the residential neighborhood. Such studies showed that factors such as walkability, access to facilities, and safety have been associated with PA behavior [16]. Although the residential neighborhood is of importance for PA behavior, there are also other environments that may play an important role in PA behavior because adults spend time in such environments as well. This second research question addressed the limited existing knowledge on the distribution of PA across a variety of locations that adults visit over the course of a day and throughout the week.

   Chapter 3 showed that MVPA does not typically take place in just one type of environment, but in a variety of environments. Most minutes of total daily MVPA were accumulated at home and at work. In policy on the development of PA friendly environments, improving green and blue environments, and active transport infrastructure are often emphasized [17], whereas less attention has been paid to the (outdoor) work environment. As regards the work location, PA may be required for the type of job one has. Research has for example shown that individuals who work in agriculture have high levels of PA [18]. Other jobs, such as those in the paper, printing, and publishing industry require only limited PA and are associated with higher sedentary levels [18]. These PA levels at work may be related to education level, with higher educated adults having jobs that more often require sedentary behavior, and lower educated adults having jobs that require more PA. These thoughts are supported by findings of Chapter 3, which showed that higher education was negatively associated with MVPA at work. The indoor environment may reduce sedentary levels through active workstations (e.g., standup desk) and may increase PA levels through promoting stair use [19]. Besides the indoor environment, characteristics of the outdoor physical environment of work locations may also contribute to PA. For example, the presence of well-maintained sidewalks and cycling lanes may facilitate active travel to work, and a natural environment may contribute to walking during lunch [20]. Hence, especially for adults with sedentary jobs, the design of a PA promoting work environment - both indoor and outdoor - may be of importance to increase PA levels.

   Besides the work and home environment, MVPA was observed at various other locations such as green spaces, shopping areas, and sports facilities, in approximately equal amounts. In contrast to what one may expect, i.e., most MVPA minutes at sports facilities, this study showed that a variety of environments is of roughly equal importance for MVPA.

The chapter further showed that various socio-demographic characteristics are not only related to total MVPA, but also to MVPA at diverse locations. For example, women, older aged adults, and dog owners had higher MVPA levels at home than their counterparts, whereas car owners, adults with children < 4 years, and older adults had lower levels of MVPA in small green spaces. These examples show that adults' socio-demographic characteristics - or circumstances related to these demographics, such as time limits - may be barriers or provide opportunities to engage in MVPA at specific locations. Hence, different sub-populations use different environments for PA. It thereby contributes to the debate on the importance of broadening the geographical context, instead of focusing solely on the residential neighborhood, when investigating the physical environment-PA relationship [21].

3) *What role do objectively measured residential neighborhood characteristics have in neighborhood-based PA behavior?*
   In individual daily activity patterns, the residential neighborhood plays an important role since adults spend a substantial amount of their time in their residential neighborhood [22]. Current literature provides ample evidence on the relationship between residential neighborhood characteristics and PA behavior. Such studies have often used 'overall' PA outcomes, i.e., outcomes that include both PA within and outside the neighborhood. Although some associations with PA are consistently found (e.g., for land use mix and walkability [4]), most findings are inconclusive [16]. One explanation for this may be the conceptual mismatch of the environment and PA, where a context-specific approach may lead to a better estimation of actual associations between the environment and PA. By answering this third research question, Chapter 4 addresses the limited knowledge on how objective neighborhood characteristics relate to LPA and MVPA within the neighborhood.

   Based on the findings of Chapter 4, two main conclusions can be drawn. First, residential neighborhood characteristics were related to neighborhood-based LPA and MVPA even when adjusted for socio-demographics and attitude. Green and blue space seem to be of particular importance in the area directly surrounding adults' homes. Most associations were found between neighborhood characteristics and MVPA. Since LPA is often easier to integrate in daily life, it may be that such activities are to a lesser extent affected by neighborhood characteristics than MVPA – activities that often require more facilities, skills, and planning. For example, walking or cycling can be integrated in daily life as active travel to work or shopping facilities, activities that are more or less 'fixed' aspects of adults' daily lives. Such activities may perhaps not necessarily demand much more of the environment than sufficient (and perhaps good quality) walking and cycling facilities – as reflected in the proportion of roads in the analyses. On the contrary, moderate-vigorous activities such as jogging or sports participation, likely require sports facilities and public open spaces (e.g., parks, lakes). These may be possible explanations for the finding that more and different residential neighborhood characteristics were associated with MVPA as compared to the characteristics related to LPA.

Second, the associations between neighborhood characteristics and PA were mostly found for the smallest buffer size (i.e., 400 meter). Where some characteristics may be significantly associated with PA in a 400 meter buffer, these associations were not found in larger sized buffers (e.g., green space). For LPA and especially MVPA, neighborhood characteristics close to the home (i.e., within a buffer of 400 meter) thus seem to be of particular importance. Due to their busy life, most adults aged 45-65 years are likely to spend more time outside the environment directly surrounding their home, for example due to work obligations, it may be that adults with such a busy life prefer to engage in PA close to home.

The use of three buffer sizes (i.e., 400, 800, and 1600 meter) showed that significant associations between neighborhood characteristics and PA differed by buffer size, which confirms findings of current literature (e.g., [23,24]). If we had used only a 400 meter buffer in Chapter 4, we would have drawn different conclusions than with an 800 or 1600 meter buffer. For example, if we look at the associations found between neighborhood characteristics and LPA, we found a positive association for roads within a 400m buffer, whereas we found negative associations for recreational area in an 800m buffer and for green space within an 800m and 1600m buffer. The scale of buffers may thus affect study results and conclusions, and may hence be one explanation for the inconsistency in current literature on the physical environment – PA relationship. Selecting the ideal buffer size should be done with consideration of the relevant scale for the problem investigated as well as the geographical context depending on for instance local density and accessibility levels, and the specific type of PA under study.

4) *What is the role of type and size of natural environments in PA behavior?*
Most research on natural environments (or green spaces) has focused on only one type of environments – mostly parks. Moreover, most available evidence concerns the role of availability or accessibility of parks in PA [15]. Further, current studies have mostly used one type of PA behavior (e.g., total PA, MVPA, or walking) as the outcome measure. Hence, by assessing whether sedentary behavior, LPA, MVPA, spatially concentrated PA, walking & jogging, and cycling varied with type and size of natural environments, this research question addressed the limited knowledge on how natural environments are actually used for a variety of PA behaviors [25].

In Chapter 3, we found that PA of adults aged 45-65 years is not typically observed in one environment, but organized across various environments. Similar results were found in Chapter 5, in which we zoomed in to natural environments. Findings showed that in all types of natural environments (i.e., parks, recreational areas, agricultural green, forest & moorland, and blue spaces), walking, jogging, cycling, LPA, and MVPA was observed. However, the amount of time that a specific type of PA behavior occurred in a certain natural environment differed significantly between the various types of natural environments. This may indicate that the presence of a variety of natural environments may be necessary to facilitate a wide range of PA behaviors. One explanation for these findings may be that individuals have different preferences or opportunities regarding in which natural environment they want, or are able to practice a certain PA behavior. For example, previous research found that preferences for PA may be different for individuals with different socio-demographic characteristics such as sex or age (e.g., [26-28]). Although these studies mainly focused on preferences regarding the social context of PA behaviors (e.g., alone, or in structured groups), it is plausible to assume that such differences in preferences also exist for PA locations. It should however be noted that not every individual can act on such preferences, for example because they do not have the required skills, or tools, or (time and financial) resources to engage in PA at specific locations. Another explanation may be that different natural environments may provide different features or amenities which facilitate different PA behaviors. For example, forests may provide especially walking trails, whereas dunes may have cycling lanes, and beaches may be ideally suited for certain sports (e.g., beach volleyball, Frisbee, or tossing a ball around).

Additionally, larger sized natural environments were associated with higher levels of walking, jogging, cycling, and MVPA. This is in line with, and expands existing evidence, which showed for example that access to large public open spaces such as parks, are associated with higher walking levels [29]. A plausible explanation for higher levels of walking, jogging, and cycling may lie in the length of walking or jogging trails and cycling lanes within natural environments. For example, a large forest provides longer walking trails than a smaller forest. Also, MVPA levels were higher in larger sized natural environments. As additional analyses showed only small or medium correlations between walking, jogging, or cycling and MVPA (i.e., one may expect that - to a limited extent - higher levels of walking, jogging or cycling may induce higher MVPA levels), it remains unclear what sports and physical activities contributed to the higher levels of MVPA in larger sized natural environments.

6.2 THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

Time geography

The physical environment has been recognized as an important correlate of PA [30]. Although many studies have explored the relationships between the physical environment and PA, the approaches to 'put people into place' have suffered from limitations (e.g., recall bias and information of limited accuracy and detail due to the use of self-report measures, and possible exposure misclassification by focusing solely on the residential neighborhood) [21]. Herein lies the danger of reducing the influence of the environment and its characteristics on PA solely to the neighborhood [31], while there are also other environments that matter in PA behavior (e.g., work environment, or recreational environment). Time geography provides a useful approach to consider the environments to which individuals are actually exposed during their daily life activities, and it connects both the spatial and temporal dimensions of behavior.

Where the temporal dimension of PA behavior has a place in existing PA research, it is mostly restricted to duration (e.g., PA per day or per week), and some studies assessed transitions (e.g., changes in PA behavior related to moving houses, school to work). However, only limited research has examined how PA is distributed over different hours of a day, and how such daily PA patterns relate to environmental characteristics. In Chapter 2, we provided some first steps in this direction and showed that the use of accelerometer data allowed for the distinction of different hour-by-hour PA patterns. Neighborhood environmental characteristics were among the factors based on which groups of individuals with similar PA patterns could be distinguished. Where this is a first step to better understand the temporal dimension of PA behavior (and its relation to the spatial dimension), future research may aim to identify the different locations that are used for PA throughout the day. An hour-by-hour pattern may therefore be extended with information on the geographical location and its' characteristics.

Moreover, by applying the time geography perspective, we assessed PA behavior more context specific. For example, in Chapter 3 we assessed the amount of MVPA at specific locations. In Chapter 4 we assessed how objective neighborhood characteristics were related to LPA and MVPA within the neighborhood(s), and in Chapter 5 we investigated LPA, MVPA, walking, jogging, and cycling within natural environments that differed in size and typology. This approach likely provided more accurately estimated associations between the environment or environmental characteristics and PA, as compared to studies that assessed the effect of for example neighborhood characteristics on total PA.

Where this study has made some important steps in applying aspects of time-geography to the field of physical environment – PA research, there are still aspects that need further exploration. For example, a rich dataset such as the one used for this study allows to assess individuals' paths through both space and time into detail. Future research may aim to assess not only how PA is distributed throughout the day, but also explore the physical environments that individuals were exposed to during these diverse activities. This would also allow researchers to assess fragmentation of PA behavior to answer questions such as '*Are activities clustered during specific time frames or more fragmented in time?*'. Additionally, researchers may aim to assess the cumulative effects of PA over time. For example, it may be that one employed individual has low PA levels on weekdays and high PA levels on weekend days, whereas another employed adult engages in PA for 30 minutes every day. Although both may experience time constraints (e.g., due to work obligations or taking care of children), it would be of interest to investigate how the physical environment may also have a role in such behavior.

Putting PA in a broader geographical context

Most individuals engage in PA as part of their daily life patterns, but the amount and intensity is subject to choice and various other factors such as mobility (e.g., physical fitness), access to resources (e.g., walking trails, bicycle lanes, green spaces, car or bicycle ownership), and social networks. Due to these differences, PA and the locations used for PA may vary widely from individual to individual, as well as it may vary over time for a given individual. Hence, individuals describe different PA patterns through space and time. For example, for one person being physically active may be to participate in sports in the weekends, whereas for another it may be to cycle to work five days a week. Findings of this thesis emphasize that PA of adults aged 45-65 years is not typically observed in one specific environment: PA is integrated in many domains of adults' daily lives (e.g., active travel, recreational activities, work, or sports).

For example, MVPA may be mostly expected in sports facilities as these seem particularly well suited for such activities. However, in Chapter 3 we saw that sports facilities were not the only location used for MVPA, as the behavior was distributed across a variety of environments (e.g., at home, at work, during active travel, and in green spaces). These findings indicate that sports participation at sports clubs or registered sports facilities (e.g., fitness centers) forms only a small part of total MVPA, and it shows that a variety of environments is suited for MVPA. For example, parks may facilitate jogging or boot camps, the home may facilitate gardening, and the route from home to work may facilitate cycling. Today, sports activities do not necessarily take place at sports clubs or registered sports facilities. Over the past years, more flexible and informal forms of sports participation have emerged alongside sports participation in sports clubs [32]. These forms of sports or (MV) PA, either individual (e.g., jogging) or organized (e.g., boot camps), take place in environments such as public open spaces. Both this trend in adults' sports participation and the findings of this study emphasize the role of different environments in sports and MVPA.

It is not only the most intensive form of PA that was observed in a variety of environments. In Chapter 5, results showed that LPA, MVPA, spatially-concentrated PA, walking, and cycling were distributed across a variety of natural environments. Though, significant differences were found in PA behaviors between the different natural environments. Preferences to engage in specific forms of PA may determine the use of a specific environment. This may be related to the features of the environments, as specific features may facilitate specific behavior. For example, recreational areas were found to have higher levels of spatially concentrated activities such as Frisbee or soccer, which may be for example because of the open fields provided by this type of environment. On the other hand, parks often provide walking trails, which may explain the higher levels of walking in these types of environments.

However, such differences in levels of PA behaviors between different environments may also be related to other factors such as personal preferences. For example, individuals assign value to environments based on memories, feelings, attitudes, and perceptions on the possibilities they offer for actions (i.e., affordances) [33,34]. Such preferences and values likely differ from individual to individual. Future studies may aim to explore the role of these preferences in PA behavior and the use of different locations for PA, to improve our understanding of the 'why'. Interviews (e.g., walk along interviews), and diaries may be ideally suited to measure preferences and rationales behind certain choices. Together with objectively measured use of locations for PA this would provide a more comprehensive understanding of why certain environments are used for PA and others not, what characteristics of environments play a role in different PA behaviors, and how this varies between sub-populations. Researchers should not restrict to measure only objective environmental characteristics, but also adults' perceptions on aspects such as spaciousness, quietness, and presence or hinder of other people. The findings of this thesis support the thought that the use of insights from Time Geography contributes to improve the understanding of adults' PA behaviors, and to capture the actual exposure of individuals to environmental factors [31].

The role of the residential neighborhood

Although time geography and the findings of this study emphasize the important role of a variety of environments for PA behavior, the residential neighborhood also clearly plays an important role in PA behavior. Hence, developing PA-friendly residential neighborhoods remains of importance and needs consideration in policy as well. Existing literature already showed associations between the neighborhood characteristics. For example, neighborhoods with a higher residential density, mixed land use, and highly connected street patterns, were associated with higher levels of walking and cycling in literature [4]. Moreover, studies found that walkability and quality of the environment were positively associated with PA [3]. Also, accessibility of facilities and neighborhood aesthetics have often been identified as positive correlates of PA [16]. Besides evidence on correlations between neighborhood characteristics and PA, literature also provides evidence on the beneficial effects of neighborhood interventions for PA. For example, in New Orleans, Louisiana (USA), a new walking path and school playground contributed to higher MVPA levels of its inhabitants [35]. Also, environmental interventions and redevelopment of a deprived neighborhood in Saint-Denis, France, (i.e., building pedestrian oriented paths and cycling lanes, providing sports facilities, improving walkability, rehabilitation of buildings and redevelopment of green space) were related to increased levels of adults meeting World Health Organization recommendations for PA [36]. This shows that neighborhood factors may indeed contribute to increased PA levels.

Where most studies thus far have assessed associations between neighborhood characteristics and overall PA – i.e., including both PA within and outside the neighborhood – this thesis showed that objective neighborhood characteristics such as proportions of roads, residences, shops and foodservice industry, green space and blue space are also positively associated with PA that occurs within the residential neighborhood (but outside the home). In other words, characteristics of the neighborhood are related to the PA behavior within it. This relationship between neighborhood-based PA levels and neighborhood characteristics may partly explain the positive association of residential neighborhood characteristics with overall PA. For example, if neighborhood characteristics contribute to an increase of neighborhood MVPA, total MVPA increases as well. Thus, although neighborhood characteristics may particularly play a role in the direct residential environment (i.e., in a 400 meter buffer as found in this study), results on the relationship between neighborhood characteristics and PA may show positive associations as well. Moreover, an increase of PA levels within the neighborhood may lead to an increase of PA levels outside the neighborhood. For example, when the residential environment of an individual is supportive of jogging, e.g., through the presence of green space and roads, the individual may go for a run. This run however, is not necessarily restricted to the residential neighborhood, but may expand this.

Moreover, this study contributed to existing literature by showing in Chapter 2, that neighborhood characteristics are also associated with typical PA patterns, as groups of individuals with similar hour-by-hour PA patterns could be distinguished based on the characteristics of their residential environment. For example, the results in Chapter 2 showed that individuals who were more likely to have a morning LPA pattern, also had highest proportions of sports facilities and green space within their residential environment. Perhaps, having such facilities close to home may provide the opportunity to engage in (light) PA in the morning before doing other activities such as working or shopping. The short distance to such facilities from the home may make it easier to integrate physical activities in one's daily life. These thoughts are supported by Time Geography [37], that considers distance to or accessibility of locations that can be visited in the time between activities that take place at fixed times and locations. For example, a parent may wake up early to go for a run in the nearby green space before having breakfast with his/her partner and children. Would the nearby environment not provide facilities to go for a run (e.g., because the distance to such facilities is too large), this parent may have more difficulties with integrating the activity in daily life. This may result in not engaging in PA, but it may also affect the time during which and the location where this activity takes place in a day pattern. For example, this parent may instead combine his/her PA with working (e.g., after work), by using facilities close to the work location.

The importance of nature

Of particular interest in the physical environment – PA relationship are natural environments, as they have been identified as environments that promote PA through different mechanisms (e.g., [15,38]). First, they provide free and easy accessible locations for individuals to engage in PA [38]. Second, where the incentive to visit natural spaces is often to 'experiencing nature' or 'get some fresh air', PA may be the secondary benefit [38]. For example, to get some fresh air, one may go for a walk in the park. Findings of the current study emphasized the important role of natural environments, by showing that such environments were used for a variety of PA behaviors and that nature (i.e., green and blue space) in the residential neighborhood was repeatedly associated with higher levels of PA. In addition, this study emphasized the importance of larger sized natural environments, especially those > 7 ha, as these were associated with higher levels of walking, cycling and MVPA. Herewith, this study contributed to an improved understanding of the role of proximity, size, and variation of nature in PA behavior.

Though, from this cross-sectional study it remains unclear whether being physically active or another reason such as experiencing nature, was the rationale behind the use of natural environments. This may also vary between different types of natural environments, as one environment may be better suited to experience nature and another may be ideally suited to engage in PA. To gain better insight in the types of green spaces that are intentionally and unintentionally used for PA, future research may aim to assess the rationale behind the use of certain environments.

By promoting PA levels, natural environments contribute to individuals' health. However, facilitating PA is not the only mechanism through which nature can contribute to health (39). Natural environments have also been positively associated with mental health and well-being, perceived health and physical health [15,38-40]. For example, green spaces have been associated with reduced stress levels, lower blood pressure, and feelings of restoration [38]. Exposure to natural environments thus serves other health aspects as well.

Targeting PA interventions to specific subpopulations

To improve the understanding of PA behavior and to tailor PA interventions, researchers have investigated how socio-demographic characteristics are related to PA. Studies have for example found that male sex, and higher education are positively related to PA [16,41]. On the other hand, older age, poor health status, employment, and having children have been identified as negative correlates of PA [16,41,42]. Many of such correlations were also found in Chapter 3 of this thesis.

Although such information provides a first and useful insight in the subpopulations that may require more attention in policy and intervention development, the aim of this thesis was to provide more detailed information to contribute to even more tailored interventions. As we saw in the introduction (Chapter 1) of this thesis, some socio-demographic characteristics may represent certain constraints to engage in specific activities or to use certain locations. Chapter 3 showed that various socio-demographic factors were indeed related to MVPA in specific environments. For example, where no associations were found between age and total MVPA, older age was positively associated with MVPA at home, but negatively associated with MVPA in other residential areas and smaller green spaces. It may be that older age constrains adults (e.g., physically, or regarding aspects such as perceived safety of specific environments) to use environments such as green spaces, whereas the home environment may be more feasible to be active. Another example is that employed adults had lower levels of MVPA at home and in other residential areas. Perhaps their time spent at work is a constraint to engage in MVPA in and around the home. On the other hand, it may be that they have already spent a substantial amount of time in MVPA at work as their job requires PA. With such examples, this study showed that not only PA, but also specific location-based PA is associated with socio-demographics. Herewith, this thesis expands and specifies current knowledge on the correlates of PA behavior.

Moreover, results of Chapter 2 showed that socio-demographic factors that have been associated with PA in previous studies, not necessarily define subpopulations that have specific PA patterns. For example, ethnicity was identified as a factor based on which different groups of adults with similar PA patterns could be distinguished. However, factors such as age and education were not identified as such factors. On the other hand, dog ownership played an important role in distinguishing groups of individuals with similar PA patterns. It is not unlikely that other factors - such as (distance to) the work location, or PA preferences - that have not been assessed in this study may be factors based on which groups with similar PA patterns can be distinguished.

Future research with larger study samples and more observed days are necessary to allow for a better comparison of groups based on socio-demographic characteristics. Also, more research on detailed PA patterns through time are necessary to increase insight in time-windows that may provide opportunities to intervene in. Since PA takes place in a variety of everyday environments, i.e., environments adults visit during their daily activities, it is of great importance to assess how this reflects highs and lows in hour-by-hour PA patterns. These PA patterns can be assessed for intensities of PA, but can also consist of a variety of PA behaviors such as walking, jogging, cycling, leisure time PA, or sports. This may allow researchers to identify specific time frames that are typically used for active travel, whereas other time windows may be typically used for sports activities.

Social-cultural environments

For the purpose of this study, we have restricted our analyses to the assessment of relationships between the physical environment and PA, considering individual factors as covariates or confounders. Herewith, however, we have only included some aspects of ecological models (i.e., the physical environment and personal factors). Aspects of adults' social-cultural environments were not included, as this was beyond the scope of this thesis. Though, it is widely recognized that social environments play an important role in PA behavior as well. For example, social support for exercise from friends and family have been identified as correlate of PA [16]. In addition, social norms have been associated with PA behavior [43]. Future research should consider aspects of the social-cultural environments, using for example questionnaires or diaries to assess how social-cultural factors relate to PA when also taking into account the physical environment. In addition, future research may aim to investigate PA behaviors of families by including all members of the family – as far as feasible regarding the age (e.g., it may not be feasible to include babies or toddlers) or physical condition (e.g., including individuals bound to a wheelchair may require a specific approach in research as these individuals may engage in specific forms of PA that differ from individuals that are not bound to a wheelchair).

6.3 LIMITATIONS

Measurement of PA

The use of accelerometers and GPS-devices allowed for accurate and detailed measurement of both intensity and location of PA. Together with objective data on environmental characteristics, a rich dataset was created that allowed for new approaches in the analyses of the physical environment – PA relationship. Moreover, these objective measures allowed for an individualized measurement of PA patterns through space and time that contributed to a better understanding of how geographical life environments are used for and related to PA.

Objective PA measures have been increasingly used to overcome limitations of self-report measures (e.g., recall bias, interpretation of questions, and social desirable answers) [44-46], in particular when measuring vigorous PA [47]. However, a limitation of accelerometer use is the limited assessment of upper-body movements, weight-lifting, water-based activities, and uphill walking [46]. As self-report and accelerometers can measure different dimensions of PA, they can complement each other. For example, using diaries – in which individuals list the type and time frame of activities they engaged in throughout the day - in addition to accelerometers and GPS-devices to measure individuals' daily activity patterns would allow for meaningful interpretation and clarifying of activities at specific locations. Hence, future studies may use a combination of both measures to obtain the most complete information and to improve the interpretation of objectively collected data [46]. In the future, the use of devices such as smart watches may provide opportunities to incorporate the measurement of geographical locations, steps, acceleration, heart rate, and body temperature. Outcomes such as heart rate in addition to the activity counts measured by accelerometers may improve PA measurement as accelerometers alone may not sufficiently accurately measure some specific forms of PA such as cycling, as well as certain aspects of being physically active that contribute to the intensity of PA (e.g., carrying heavy bags). Hence, combining accelerometer data and information on heart rate may improve the determination of intensity of PA [48]. On the contrary, heart rate monitors may pick up on increases in heart rates that are due to emotions and not PA [48]. The wearing of a smart watch may be less of a burden for participants than the wearing of a belt with a GPS-device and an accelerometer. However, to use devices such as smart watches, research that assesses the feasibility and validity of the devices compared to existing methods for PA assessment, is necessary.

Physical environment measures

Objective environmental characteristics have the advantage of being concrete measures that can be directly linked to environmental interventions and policy on urban planning

[49]. Hence, this study included objective measures of the environment. Although its use provided new and valuable evidence, future research may benefit from more refined objective environmental data. For example, from the datasets that were used in this study, no information was available on the objectively measured presence of for instance street light, benches, width of sidewalks and hustle (e.g., due to presence of people and/or traffic). Such information may be used to assess the correlates of using specific locations, or streets for PA.

Moreover, the perceived environment is also of interest as it may improve our understanding of the rationale behind the (lack of) use of specific environments for PA. For example, a few years ago in The Hague, the municipality built 'fitness-places' (i.e., public spaces with safe, and easy accessible fitness equipment), with the aim to increase PA levels, especially among older adults. However, a study that evaluated the use of these 'fitness places', found that such places were not often used. Individuals that did use such facilities were mostly younger adults, and older adults explained that 'difficulty of exercises' and 'lack of instructors to show its use' were reasons for them not to use the facilities [50]. Although such environmental changes are well-intentioned, it may not reach its aims because there may be more information needed on forehand (e.g., needs and preferences of the targeted group), to adequately develop environmental interventions. For this study, it may mean that the suggestion to 'integrate a variety of large sized natural environments in urban planning' requires additional information on aspects such as preferred vegetation, to inform policy makers and urban planners in more detail.

Future research may thus aim to increase specificity of the environmental characteristics assessed in relation to PA. This may provide opportunities to develop specific environmental interventions. For example, when designing new streets or neighborhoods within cities, it may be essential to consider evidence on the amount of trees or benches, the width of sidewalks, etcetera, in order to facilitate PA. This requires the use of both objective and subjective measures of the environment. Examples of objective data are detailed land use or building data that can be uploaded in ArcGIS, or so-called neighborhood scans with which researchers observe the presence or lack of specific facilities, features and other characteristics per street. Examples of subjective methods to measure the environment are (walk-along) interviews, and photographing barriers to and facilitators of PA. A combination of both would specifically add to current literature as it provides comprehensive and detailed insight in environmental characteristics.

An important aspect of assessing the role of the residential environment in PA behavior is the definition of this residential area or 'the neighborhood'. Researchers have criticized the use of administrative units or census tracts to define the neighborhood, and suggested that buffers (as used in this study) may more accurately reflect local environmental exposure [31]. There is however no consensus on buffer size, and the difficulty of achieving such consensus is confirmed by the findings of Chapter 4 that show different significant associations between environmental characteristics and PA for different buffer sizes.

Causality

Due to the cross-sectional nature of this study, and because we have not included mechanisms to take residential self-selection into account, causality cannot be proven. For example, when a positive association was found between neighborhood green space and PA, it remains unclear whether adults' PA levels are higher due to the presence of (more) green space, or whether adults with higher PA levels choose to live in green neighborhoods, or whether there was another reason for the association. This residential self-selection is one of the most important factors that affects validity of cross-sectional studies [51]. Some studies have attempted to address residential self-selection by including covariates such as 'the reason for moving to their current neighborhood' or 'preferences for certain residential environmental aspects' in analyses, or by using structural equation models [4,51]. Although some significant associations attenuated to non-significant findings after adjustment for residential self-selection [4], there is also evidence that shows associations between environmental characteristics (e.g., land use mix and walkability) and PA even when controlled for residential self-selection [4,51]. Hence, it is unclear whether the inclusion of residential self-selection as a confounder in the analyses would have altered the findings of this thesis. Besides, where residential self-selection is often seen as a positive confounder in the relationship between the physical environment and PA (i.e., individuals with higher PA levels select PA supportive residential environments), it can also be a negative confounder [52]. Boone-Heinonen and colleagues use the example of pay facilities to illustrate this. Pay facilities may stimulate PA, but may be more common in commercial centers which are less likely selected by advantaged families with higher PA levels [52]. In addition, positive confounding of residential self-selection may not necessarily mean that there is no causality as selected environments may still be of importance for active adults to maintain or increase their PA levels [52].

Though, the field of physical environment – PA research could benefit from stronger causal evidence [51]. Hence, prospective study designs and longitudinal studies are necessary. Prospective studies may aim to assess environmental change due to relocation to less or more PA-friendly environments [51]. However, such studies need to consider the time that movers need to adapt to their new environments, as they need to rediscover opportunities for PA [51]. Also, characteristics between adults who move and do not move may differ, which may affect the results [51]. Hence, studies may also aim to compare PA behaviors of movers and non-movers over time, accounting for socio-demographic characteristics.

Additionally, longitudinal studies are necessary to assess causal relations between environmental characteristics and PA behaviors. Of particular interest are pre- and posttest study designs, where the effects of an environmental intervention can be measured. This requires environmental changes or interventions. A relevant example in the Netherlands is the development of 'The Green Carpet' in Maastricht, which is currently under study by Dutch colleagues. With this project, 80% of the current traffic will go underground and on top of these new built tunnels, green space will be developed especially suited for walking and cycling. Moreover, this 'Green Carpet' will also improve connections between neighborhoods of Maastricht that were formerly separated by the highway [53]. Analyzing effects of such projects ideally requires close cooperation between researchers, policy makers, and urban designers to fit research aims to policy interests.

Generalizability

Finally, findings of this thesis may not be directly applicable to other countries. Due to different environmental designs, together with differences in cultures, habits, and norms in different countries, PA may be distributed through space and time in different ways. Further country specific studies, as well as studies comparing PA patterns across counties, are necessary to increase understanding of 4D PA. These studies may aim to assess PA in different locations, and zoom in to specific locations.

In addition, this study focused - as did most previous studies- on cities. However, urban environments likely differ substantially from rural environments, and hence findings regarding the relationship between the physical environment and PA may differ between these geographic areas. For example, the amount and variety of sports facilities in rural environments may be less compared to urban environments. Also, the distance to facilities such as shops, restaurants, schools, and hospitals, but also to the work location, may be larger in rural areas. Future research may aim to compare rural and urban environments when assessing the relationship between the physical environment and PA behavior.

Moreover, this study included adults aged 45-65 years. Findings of this study may therefore not apply to populations of different age. For example, other age groups may experience different constraints or possibilities to engage in PA, which may influence the locations used for PA and the hour-by-hour distribution of PA.

6.4 PRACTICAL IMPLICATIONS

This study aimed to provide insight in how PA behavior of adults aged 45-65 years was actually distributed in space and time (i.e., 4D), and to examine how personal and environmental characteristics were related to the PA behaviors. Although this thesis does not provide urban designers or intervention developers with evidence on a level that would for example allow for recommendations on the number of trees that are needed within streets to increase PA levels, it does provide valuable insights that help improve our understanding of PA behavior. Considering the cross-sectional nature of this study, some recommendations can be made.

Most importantly, this thesis emphasizes the importance of broadening the temporal and geographical context when it comes to policy, urban planning, and intervention development aimed at increasing PA levels. Inherent to individualized 4D activity patterns, is the use of a wide variety of environments for PA. Hence, (local) governments should consider diverse places including work places, shopping centers and natural environments, when developing PA-friendly environments. Although not every environment should become a PA facility (e.g., shopping centers are built to supply food, drinks and clothes), environmental interventions such as the presence of good quality sidewalks, cycling lanes, and bicycle parking may contribute to an increase of PA levels at or towards such locations, through for example active travel.

To optimally facilitate different PA behaviors, the accessibility and availability of a wide variety of PA-friendly locations can be of great importance. This applies particularly to natural environments, which are often considered in urban planning policy. As larger sized natural environments, in particular those > 7 ha, were associated with higher levels of PA, it may be of particular importance to establish large sized natural environments. As it is unlikely that cities have sufficient space to develop for example new forests, policy and urban planning may aim to connect existing natural spaces. Positive secondary benefits of such connections may be that a variety in types of natural environments is warranted and perhaps even emphasized, and individuals living in ‘grey’ spaces (i.e., environments that mostly consist of buildings) may get better access to natural spaces. Such an approach may also ask for more nature within residential neighborhoods, which may on itself contribute to higher levels of PA as well. However, to further specify recommendations to policy makers and urban planners, more detailed information on aspects that determine the use of natural spaces (e.g., accessibility, type of vegetation) are necessary.

Chapter 3 showed the importance of the work location, as after the home environment, second highest levels of MVPA were observed here. This emphasizes the important role the work location may have in facilitating (MV) PA behavior in adults. These (MV) PA levels may be due to one's job requirements, but may also be facilitated through the stimulated use of stairs or lunch walks for instance. Since many adults aged 45-65 years spend a substantial amount of their time at the work location, a PA-friendly work environment may play an important role in increasing PA levels – especially of those who are insufficiently active. Hence, policy may aim to develop PA facilitating work environments, including both the indoor work environment (e.g., encouraging stair use) and the outdoor environment (e.g., facilitating active travel, and lunch walking).

Further, this thesis showed that adults have different PA patterns throughout the day, but in all patterns low levels of LPA and MVPA were observed in the evening. Although it may not be necessary or feasible to increase PA levels on every evening, some adults – especially those who are insufficiently active according to PA guidelines – may benefit from higher PA levels through activities in the evening. Whereas further investigation is necessary to assess the rationale behind these low evening PA levels, there are some possible explanations that can be addressed by environmental interventions. For example, darkness may be perceived as a barrier to go outside and be physically active because it is associated with crime and feelings of unsafety, especially in older adults [54]. Appropriate lighting, or smart lighting (e.g., lights that turn on when movement is detected) may diminish feelings of unsafety, and hence take away a barrier to be physically active in the evening. Further, feelings of unsafety may also rise when the view of surrounding buildings on sidewalks and cycling lanes is limited, due to for example trees and bushes. Although greenery may improve the attractiveness of a street, it may thus on the other hand cause feelings of unsafety. Hence, it is important to consider both aspects in urban designs [54].

Current design of many cities is mostly focused on consuming and good infrastructure for motorized vehicles, and to a lesser extent on stimulating healthy behaviors. However, local governments are increasingly interested in healthy urban living and more and more they exploit opportunities to improve the livability and health enhancing character of their cities. Though, arguments such as the lack of money, or insufficient space to implement spatial interventions may limit further healthy urban living developments. Therefore, an integral approach is necessary, in which policy makers of different disciplines (e.g., sports and PA, health, transportation, spatial planning, and the social domain) work together on the design of healthy cities. Policy aims of these diverse policy domains may be compared and if possible integrated, to discuss options to develop environmental interventions that may address various aims at once. Such a collaboration also allows to gain insight in who benefits how from the environmental changes. For example, creating green and blue spaces within the city may have positive effects on PA levels of its inhabitants, which in turn affects population's health. In addition, it may also affect health through for example stress reduction. The creating of green and blue spaces may also provide opportunities for new and improved infrastructure, and nature within cities or residential neighborhoods may increase housing prices. Finally, when green and blue spaces positively affect attractiveness and livability of a city, new companies and inhabitants may be attracted, which may be beneficial for the economy.

In the process of developing healthy urban living based on evidence (and best practice), it is of great importance that in future research projects, both researchers and policy makers of various policy domains are involved. This allows for research that is more and more applied to relevant, societal issues. Furthermore, such collaborations provide opportunities to translate research findings directly to practice.

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Nederlandse samenvatting

Inleiding

Sporten en bewegen dragen bij aan de gezondheid. De Wereld Gezondheidsorganisatie (WHO) adviseert dat volwassenen per week ten minste 150 minuten matig intensief bewegen (bijvoorbeeld fietsen met lichte inspanning, of een tennis dubbel spelen), of 75 minuten zeer intensief bewegen (bijvoorbeeld joggen of wielrennen), of een soortgelijke combinatie van matig of zeer intensief bewegen. Echter, wereldwijd voldoet 1 op de 3 volwassenen niet aan deze richtlijnen en beweegt dus te weinig. Daarbij komt sedentair gedrag (zitten) steeds meer voor: ongeveer 64% van de Europeanen zit gemiddeld meer dan 4 uur per dag. Met name volwassenen in de leeftijd van 45-65 jaar – ook wel de 'sandwich-generatie' genoemd – bewegen onvoldoende. Door de combinatie van een drukke baan en/of de zorg voor zowel hun kinderen als hun ouders, lijken zij beperkt te zijn in de mogelijkheden om voldoende te bewegen. Onvoldoende bewegen wordt beschouwd als een groot probleem voor de publieke gezondheid, omdat het één van de belangrijkste factoren is die kunnen leiden tot gezondheidsproblemen zoals obesitas, diabetes type 2, hart- en vaatziekten, bepaalde vormen van kanker, psychische klachten en vroegtijdig overlijden. De maatschappelijke last van onvoldoende bewegen is dan ook groot en de geschatte kosten voor gezondheidszorg die dit wereldwijd met zich mee brengt, waren in 2013 $ 53.8 miljard. Het stimuleren van sport en bewegen staat daarom hoog op de beleidsagenda, ook in Nederland, waar de Gezondheidsraad recentelijk (zomer 2017) een nieuw beweegadvies heeft uitgebracht.

Bestaand onderzoek naar factoren die beweeggedrag kunnen stimuleren heeft aangetoond dat de fysieke omgeving een belangrijke rol kan spelen in het faciliteren van beweegactiviteiten. Hoewel dit onderzoek erg waardevol is, heeft het zich voornamelijk gericht op de relatie tussen de woonomgeving (d.w.z. de woonwijk, de buurt) en beweeggedrag. Echter, volwassenen worden in hun dagelijks leven niet alleen blootgesteld aan de woonomgeving, maar ook aan diverse andere omgevingen zoals de (route naar de) werkomgeving, een winkelcentrum, een park, een plein, een sportlocatie, etc. Al deze omgevingen kunnen beschikken over eigenschappen die bewegen belemmeren dan wel faciliteren. Om de relatie tussen de fysieke omgeving en bewegen beter te begrijpen, en daarmee beleidsmakers beter te kunnen informeren, is het van belang om objectief en gedetailleerd in kaart te brengen waar en wanneer volwassenen bewegen, met welke intensiteit ze dat doen, en welke omgevingsfactoren daarbij een rol kunnen spelen.

Het doel van dit proefschrift was dan ook om met behulp van beweegmeters en GPS-meters meer inzicht te krijgen in de tijd-ruimtelijke organisatie (4D) van beweeggedrag van volwassenen van 45-65 jaar, en in kaart te brengen welke fysieke omgevingskenmerken en individuele factoren gerelateerd zijn aan dit beweeggedrag. Dit inzicht wordt verkregen door het beantwoorden van vier met elkaar samenhangende onderzoeksvragen, welke hierna achtereenvolgens worden besproken.

Het beweeggedrag van volwassenen in 4D

1) *Welke typische dagelijkse beweegpatronen kunnen we onderscheiden, en welke groepen volwassenen hebben dezelfde beweegpatronen?*

   Veel onderzoek naar beweeggedrag refereert vaak naar bewegen als gemiddelde hoeveelheid bewegen per dag of per week. We weten echter veel minder over de verdeling van beweeggedrag van uur tot uur over een dag, en het mogelijke bestaan van bepaalde beweegpatronen. Met behulp van beweegmeters werd gedetailleerd en objectief gemeten hoeveel tijd volwassenen elk uur besteedden aan licht intensieve beweegactiviteiten (bijvoorbeeld afwassen, langzaam wandelen of vissen) en matig tot zeer intensieve beweegactiviteiten (bijvoorbeeld stevig doorwandelen, joggen, fietsen, stofzuigen of tennis). Een analyse onderscheidde vier typische dagelijkse beweegpatronen: een licht intensief beweegpatroon waarbij de beweegactiviteit met name in de ochtend plaatsvindt, een matig tot zeer intensief beweegpatroon waarbij de beweegactiviteit met name in de middag plaatsvindt, een inactief beweegpatroon en een actief beweegpatroon.

   Het 'ochtend licht intensieve beweegpatroon' had het laagste niveau van matig tot zeer intensief bewegen gedurende de dag, en het op één na hoogste licht intensieve beweegniveau met een piek in de ochtend. Het is onduidelijk waarom licht intensief bewegen voornamelijk in de ochtend gebeurt. Aangezien dit beweegpatroon het vaakst op een zaterdag geobserveerd werd, is een mogelijke verklaring dat dit met name gaat om activiteiten zoals het doen van boodschappen of het halen/brengen van kinderen naar sportclubs. Het 'middag matig tot zeer intensieve beweegpatroon' had het hoogste matig tot zeer intensieve beweegniveau, met een piek rond de middag. Het licht intensieve beweegniveau was het op één na laagste vergeleken met de andere patronen. Dit patroon werd ook het vaakst geobserveerd op een zaterdag en reflecteert mogelijk de sport activiteiten van volwassenen. Het 'inactieve beweegpatroon' laat gedurende de hele dag weinig licht en matig tot zeer intensieve beweegactiviteiten zien. Het 'actieve beweegpatroon' laat gedurende de gehele dag hoge licht en matig tot zeer intensieve beweegniveau's zien. Alle beweegpatronen lieten lage niveau's van licht en matig tot zeer intensief bewegen zien in de avonduren. Hoewel uit dit onderzoek niet blijkt wat daaraan ten grondslag ligt, zijn een gevoel van onveiligheid (bijvoorbeeld door criminaliteit of de afwezigheid van straatverlichting) en vermoeidheid na dagelijkse verplichtingen, mogelijke verklaringen voor deze lage beweegniveau's in de avond. Hoewel voor elk type beweegpatroon de gemiddelde beweegintensiteit 's avonds laag is, betekent dit niet dat geen enkele respondent 's avonds fysiek actief was. Het is goed mogelijk dat in iedere groep volwassenen zaten die 's avonds wel actief waren, maar overdag een beweegpatroon hadden dat lijkt op anderen in de groep. Echter, het aantal volwassenen met beweegactiviteiten in de avond was dusdanig laag dat dit niet terugkomt in de huidige vier beweegpatronen.

Op basis van deze typische beweegpatronen onderscheidden aanvullende analyses drie groepen volwassenen. De groepen verschilden met name van elkaar in etniciteit, het hebben van een hond, en de hoeveelheid wegen, sportfaciliteiten, groot groen en blauw (bijv. bossen, plassen of rivieren) in hun woonomgeving. Deze analyses laten zien dat individuele en omgevingskenmerken niet alleen gerelateerd zijn aan de gemiddelde hoeveelheid bewegen per week of per dag, maar ook aan de manier waarop licht en matig tot zeer intensief bewegen door de dag georganiseerd is.

2) *Hoe is beweeggedrag verdeeld over verschillende alledaagse fysieke omgevingen?*
Beweeggedrag is niet alleen georganiseerd in tijd, maar ook in ruimte. De meest onderzochte 'ruimte' in relatie tot beweeggedrag is de woonomgeving, en hoewel wetenschappers aantoonden dat factoren van de woonomgeving (bijvoorbeeld beloopbaarheid, toegang tot voorzieningen en veiligheid) een rol spelen in beweeggedrag, kunnen ook karakteristieken van andere omgevingen zoals de werkomgeving een belangrijke rol spelen in beweeggedrag. In hoofdstuk 3 werd dan ook aangetoond dat matig tot zeer intensief beweeggedrag van volwassenen niet typisch in één type omgeving plaatsvindt, maar dat het verspreid is over meerdere verschillende omgevingen.

De meeste minuten van matig tot zeer intensief bewegen vonden thuis en in de werkomgeving plaats. Beleid, gericht op het ontwikkelen van beweegvriendelijke omgevingen, richtte zich tot nu toe met name op het verbeteren van de 'groen-structuur' (d.w.z. de hoeveelheid natuur) en de infrastructuur voor wandelen en fietsen, terwijl er minder aandacht is voor de werkomgeving (buiten). De hoeveelheid beweging op de werklocatie hangt voor een deel af van het type werk dat iemand heeft: vergelijk bijvoorbeeld een kantoorbaan met een baan als verpleegkundige. Meer bewegen tijdens het werk lijkt gerelateerd aan het opleidingsniveau, waarbij hoger opgeleide volwassenen vaker een baan hebben die van hen verlangt dat ze zittend werk verrichten (de kantoorbaan). Deze gedachte wordt ondersteund door bevindingen uit hoofdstuk 3 van dit proefschrift, waarin we zagen dat een hoger opleidingsniveau gerelateerd was aan minder matig tot zeer intensief bewegen op het werk. De werkomgeving kan, zowel binnen als buiten, van invloed zijn op het zitten en bewegen van volwassenen. Zo kunnen omgevingsinterventies zoals actieve werkplekken (standup bureau's), het stimuleren van het gebruik van de trap, goede wandel- en fietsinfrastructuren en mogelijkheden voor lunchwandelingen het zit- en beweeggedrag van werkenden beïnvloeden. Vooral voor volwassenen met banen die vele zituren vragen, kan een beweegvriendelijke werkomgeving van groot belang zijn.

Naast de thuis- en werkomgeving vond het overige matig tot zeer intensieve beweeggedrag in ongeveer gelijke mate plaats in diverse andere omgevingen zoals groene omgevingen, winkelgebieden, en sportlocaties. In tegenstelling tot wat men zou verwachten, namelijk dat matig tot zeer intensief beweeggedrag voornamelijk plaatsvindt op sportlocaties, toonde deze studie aan dat een variëteit aan omgevingen van ongeveer gelijk belang is voor matig tot zeer intensief bewegen.

Tenslotte liet hoofdstuk 3 ook zien dat verschillende sociaal-demografische factoren niet alleen gerelateerd zijn aan de totale hoeveelheid matig tot zeer intensief bewegen, maar ook aan omgeving-specifiek matig tot zeer intensief bewegen. Zo bewogen vrouwen, oudere volwassenen en hondenbezitters meer matig tot zeer intensief thuis, dan hun tegenpolen. Auto bezitters, volwassenen met kinderen < 4 jaar en oudere volwassenen bewogen juist minder matig tot zeer intensief in groene omgevingen zoals parken en volkstuinen. Deze voorbeelden tonen aan dat sociaal-demografische factoren, of omstandigheden gerelateerd aan deze factoren - zoals een tekort aan tijd - zowel barrières als mogelijkheden kunnen zijn voor bewegen in specifieke omgevingen. Verschillende doelgroepen zullen dus verschillende omgevingen gebruiken om te bewegen. Dit hoofdstuk draagt hiermee bij aan het debat over het belang van het toepassen van een bredere geografische context in onderzoek naar beweeggedrag.

3) *Welke rol spelen objectief gemeten kenmerken van de woonomgeving in beweeggedrag dat plaatsvindt in deze woonomgeving?*

Hoewel de geografische context van bewegen groter is dan de woonomgeving, is de woonomgeving nog altijd een omgeving waar volwassenen veel tijd doorbrengen. Een beweegvriendelijke woonomgeving kan dan ook bijdragen aan het faciliteren van (voldoende) bewegen. In veel studies waarin werd onderzocht welke kenmerken van de woonomgeving bijdragen aan beweeggedrag, werden deze kenmerken gerelateerd aan het totale beweeggedrag – d.w.z. zowel bewegen binnen als buiten de woonomgeving. Hoewel er bepaalde verbanden werden gevonden, zijn veel bevindingen niet eenduidig. Om de relatie tussen kenmerken van de woonomgeving en bewegen juist in te kunnen schatten, en deze daardoor beter te kunnen begrijpen, is het van belang te onderzoeken welke kenmerken van de woonomgeving gerelateerd zijn aan beweeggedrag dat daadwerkelijk in deze woonomgeving plaatsvindt.

Op basis van de bevindingen uit hoofdstuk 4 kunnen twee belangrijke conclusies worden getrokken. Ten eerste, diverse kenmerken van de woonomgeving zijn gerelateerd aan beweeggedrag (zowel licht intensief als matig tot zeer intensief bewegen) dat daadwerkelijk in deze woonomgeving plaatsvond, zelfs wanneer in de analyses rekening werd gehouden met verschillende sociaal-demografische factoren en de attitude ten opzichte van bewegen. Kenmerken van de woonomgeving lijken belangrijker voor matig tot zeer intensief bewegen dan voor licht intensief bewegen. Een mogelijke verklaring hiervoor kan zijn dat licht intensief bewegen doorgaans makkelijker te integreren is in het dagelijkse leven en dat deze vormen van bewegen hierdoor minder afhankelijk zijn van de inrichting van de omgeving in vergelijking met matig tot zeer intensieve vormen van bewegen. Bijvoorbeeld, wandelen en fietsen kan geïntegreerd worden in het dagelijks leven wanneer men naar het werk of de supermarkt gaat. Zulke activiteiten vragen waarschijnlijk weinig meer van de omgeving dan voldoende en goed onderhouden voet- en fietspaden. Daarentegen is het aannemelijk dat matig tot zeer intensief bewegen, zoals joggen of sporten, van de omgeving vraagt dat er voorzieningen zijn zoals parken of sportfaciliteiten. Dit verklaart mogelijk waarom meer verschillende omgevingskenmerken gerelateerd werden aan matig tot zeer intensief bewegen dan aan licht intensief bewegen in hoofdstuk 4. Dit geldt met name voor een buffer van 400 meter om de woning, waarvan percentages woningen, winkels en horeca, sportvoorzieningen, publieke sociaal-culturele voorzieningen, recreatief gebied en natuurlijke omgevingen aan matig tot zeer intensieve beweegactiviteiten in diezelfde buffer werden gerelateerd, terwijl alleen het percentage wegen werd gerelateerd aan licht intensieve beweegactiviteiten.

Ten tweede, de meeste associaties tussen kenmerken van de woonomgeving en bewegen werden gevonden voor de omgeving het dichtste bij de woning. In deze studie werd het beweeggedrag in verschillende buffers om de woning vergeleken met omgevingskenmerken uit dezelfde buffers. Associaties tussen omgevingskenmerken en bewegen die werden gevonden voor een buffer van 400 meter, werden niet altijd ook gevonden in buffers van 800 en 1600 meter. Het toepassen van deze drie verschillende buffers liet dus zien dat elke buffer mogelijk andere associaties laat zien. Was er bijvoorbeeld alleen een buffer van 400 meter toegepast, dan werden er andere conclusies getrokken dan wanneer er enkel een buffer van 800 of 1600 meter was toegepast.

Bovenstaande bevestigt bevindingen uit de bestaande literatuur, en laat zien dat het kiezen van de schaal van buffers resultaten en conclusies van studies kan beïnvloeden. Het is mogelijk één van de redenen voor de niet eenduidige bevindingen betreffende de relatie tussen de fysieke omgeving en bewegen in de huidige literatuur. Bij het selecteren van de juiste buffer houdt men dan ook idealiter rekening met de relevante schaal voor het vraagstuk, de geografische context (inclusief lokale bevolkings- en voorzieningendichtheid) en het specifieke beweeggedrag waarin men geïnteresseerd is.

4) *Wat is de rol van type en grootte van natuurlijke omgevingen in beweeggedrag?*
Het belang van natuur voor beweeggedrag is vaak aangetoond. Echter, onderzoek naar de relatie tussen kenmerken van natuur en bewegen richtte zich vaak op één type natuur: voornamelijk parken. Aangezien verschillende natuurlijke omgevingen verschillende functies kunnen hebben, kunnen ze ook elk op hun eigen manier bijdragen aan beweeggedrag. Zo zou je kunnen verwachten dat parken zich vooral lenen voor beweegactiviteiten zoals frisbeeën, terwijl bossen juist met name wandelen faciliteren. Met het beantwoorden van deze vierde onderzoeksvraag geven we meer inzicht in de rol die verschillende typen natuurlijke omgevingen van verschillende grootte hebben in beweeggedrag.

Hoofdstuk 3 van dit proefschrift liet zien dat beweeggedrag van volwassenen in de leeftijd van 45-65 jaar niet geconcentreerd is in één specifieke omgeving, maar dat het plaatsvindt in meerdere omgevingen. Gelijke bevindingen werden gedaan in het vijfde hoofdstuk, waarin werd ingezoomd op de natuurlijke omgevingen. De resultaten lieten zien dat volwassenen in alle verschillende typen natuurlijke omgevingen (d.w.z. parken, recreatie gebieden, agrarisch groen, bos & heide en waterrijke gebieden) wandelen, joggen, fietsen, licht intensief en matig tot zeer intensief bewegen. Echter, de hoeveelheid tijd die aan elke specifieke vorm van bewegen werd besteed in een specifieke omgeving, verschilde significant tussen de verschillende typen natuurlijke omgevingen. Dit suggereert dat de aanwezigheid van een verscheidenheid aan natuurlijke omgevingen nodig is om een variëteit aan beweegvormen te kunnen faciliteren. Dit houdt mogelijk verband met de persoonlijke voorkeuren en mogelijkheden die volwassenen hebben als het gaat om bewegen in specifieke natuurlijke omgevingen. Voorkeuren kunnen bijvoorbeeld anders zijn voor mannen dan voor vrouwen, en mogelijkheden kunnen verschillen tussen mensen die wel of geen auto bezitten. Daarnaast is het aannemelijk dat verschillende natuurlijke omgevingen verschillende voorzieningen bieden en daarmee verschillend beweeggedrag faciliteren. Zo zijn bossen wellicht in het bijzonder geschikt om te wandelen door het aanbod aan wandelpaden, terwijl stranden juist geschikt zijn voor bepaalde sportactiviteiten zoals beach volleybal of een balletje overtrappen.

Tevens toonde hoofdstuk 5 aan dat grotere natuurlijke omgevingen gerelateerd waren aan meer wandelen, joggen, fietsen en matig tot zeer intensief bewegen. Dit komt mogelijk door de grotere lengte van wandel- en fietspaden in grotere natuurlijke omgevingen, in vergelijking met de kleinere natuurlijke omgevingen. Zo kun je een langere wandeling maken in een groot bos, dan in een klein bos. Daarnaast lieten de resultaten ook zien dat matig tot zeer intensief bewegen toenam in grotere natuurlijke omgevingen. Aanvullende analyses lieten zien dat dit niet samenhing met de toename van wandelen, joggen en fietsen. Aangezien vormen van bewegen op een bepaalde locatie (d.w.z. binnen een straal van 150 meter, bijvoorbeeld voetballen) juist minder vaak plaatsvonden in grotere natuurlijke omgevingen, blijft het onduidelijk in welke vorm precies matig tot zeer intensief werd bewogen in grotere natuurlijke omgevingen.

De vertaling naar beleid en praktijk

Hoewel dit onderzoek beleidsmakers en stedenbouwkundigen niet direct voorziet van concrete ontwerpnormen (bijvoorbeeld over het minimale oppervlak aan groen in de omgeving om bewegen onder volwassenen te stimuleren), biedt het wel een aantal waardevolle inzichten die zowel wetenschap als beleid en praktijk helpen beweeggedrag beter te begrijpen.

Eén van de belangrijkste inzichten uit deze thesis is het belang van een bredere tijd-ruimtelijke context als het gaat om beleid en stedelijke planning gericht op het ontwikkelen van beweegvriendelijke omgevingen. De analyses van de individuele 4D beweegpatronen van volwassenen, lieten zien dat volwassenen bewegen en sporten in een verscheidenheid aan omgevingen. Het is dan ook van belang dat (lokale) beleidsmakers diverse omgevingen, zoals de werkomgeving, winkelcentra en natuurlijke omgevingen, meenemen in de planning en ontwikkeling van beweegvriendelijke wijken en steden. Hoewel niet elke omgeving een beweegfaciliteit hoeft te worden (d.w.z. winkelcentra zijn in de eerste plaats bedoeld om consumenten te voorzien in bijvoorbeeld levensmiddelen), kunnen omgevingsinterventies zoals het verzorgen van goede kwaliteit voet- en fietspaden, en voldoende fietsenstallingen, bijdragen aan een toename van bewegen in of naar zulke omgevingen.

Om optimaal verschillende vormen van bewegen te faciliteren, is het belangrijk dat er voldoende verschillende typen omgevingen aanwezig zijn. Dit geldt zeker ook voor natuurlijke omgevingen, die nu al vaak een belangrijk onderdeel zijn van stedenbouwkundig beleid. Aangezien vooral grote natuurlijke omgevingen (met name groter dan 7 ha) bewegen blijken te stimuleren is het creëren van deze grotere natuurlijke omgevingen van belang. Hoewel het niet aannemelijk is dat steden voldoende ruimte hebben om bijvoorbeeld een nieuw bos aan te leggen, zijn er wellicht mogelijkheden om bestaande natuurlijke omgevingen met elkaar te verbinden, bijvoorbeeld door middel van (groene) voet- en fietspaden. Een bijkomend voordeel van zulke verbindingen is dat een variëteit in natuurlijke omgevingen gewaarborgd en wellicht zelfs benadrukt wordt, waardoor diverse vormen van bewegen kunnen worden gefaciliteerd. Daarnaast zou een dergelijke aanpak ertoe kunnen leiden dat inwoners, en juist degenen die in 'grijze' omgevingen wonen (d.w.z. in omgevingen die vooral bestaan uit gebouwen), betere toegang krijgen tot natuurlijke omgevingen. Dit vraagt wellicht ook om meer natuur in de woonwijken, wat op zichzelf ook een positieve bijdrage levert aan bewegen. Om echter meer gedetailleerde informatie te kunnen verstrekken aan beleidsmakers over aspecten die bepalen dat natuur gebruikt wordt voor bewegen (denk aan bereikbaarheid, type vegetatie), is er meer onderzoek nodig.

Dit onderzoek liet zien dat verschillende omgevingen worden gebruikt om te bewegen, en benadrukte het belang van de werkomgeving voor het faciliteren van bewegen onder volwassenen. Aangezien veel volwassenen in de leeftijd van 45-65 jaar een groot deel van hun tijd doorbrengen op het werk, kan een beweegvriendelijke werkomgeving een belangrijke bijdrage leveren aan het totale beweeggedrag van deze werkende volwassenen. Niet alleen de omgeving binnen kan met aanpassingen bewegen stimuleren (denk aan standup bureau's en trapgebruik), ook de buiten omgeving kan door middel van bijvoorbeeld goede wandel- en fietsvoorzieningen en sportfaciliteiten bewegen faciliteren.

De resultaten uit dit proefschrift laten bovendien zien dat er bij volwassenen in dit onderzoek verschillende dagelijkse beweegpatronen bestaan. In al deze patronen is de hoeveelheid licht en matig tot zeer intensief bewegen laag in de avonduren. Hoewel het niet per se voor iedereen nodig of haalbaar is om de hoeveelheid bewegen in de avonduren te doen toenemen, kunnen sommige volwassenen – met name zij die onvoldoende actief zijn volgens beweegnormen – baat hebben bij meer beweegactiviteiten in de avond. Hoewel er meer onderzoek nodig is om de werkelijke rationale van deze lage beweegniveau's in de avonduren te achterhalen, zijn er een aantal mogelijke verklaringen die met behulp van omgevingsinterventies kunnen worden opgelost. Zo kan het zijn dat het donker, met name in de winter, wordt ervaren als een barrière om 's avonds buiten te bewegen omdat men zich onveilig voelt. Het plaatsen van voldoende verlichting, eventueel slimme verlichting (d.w.z. lichten die aangaan zodra er beweging gedetecteerd wordt), kan deze barrière mogelijk wegnemen. Ook kan een gevoel van onveiligheid ontstaan wanneer er weinig zicht is op voet- en fietspaden vanuit omliggende huizen en gebouwen doordat er bijvoorbeeld hoge bomen en struiken langs de paden staan. Hoewel groen enerzijds de aantrekkelijkheid van een straat kan doen toenemen en daarmee ook bewegen kan stimuleren, kan het anderzijds dus leiden tot een onveilig gevoel. Het is daarom van belang dat beide aspecten worden overwogen in het ontwikkelen van beleid.

De huidige ruimtelijke indeling van steden biedt voornamelijk een goede infrastructuur voor gemotoriseerd verkeer maar is nog in mindere mate gericht op het stimuleren van actief transport en recreatief beweeggedrag. Echter, (lokale) overheden zijn in toenemende mate geïnteresseerd in 'leefbare, gezonde, actieve steden' en benutten steeds vaker mogelijkheden om de leefbaarheid en beweegvriendelijkheid van hun steden te verbeteren. Toch zijn argumenten zoals het gebrek aan geld, of onvoldoende ruimte om ruimtelijke interventies te doen nog veel genoemde barrières om steden daadwerkelijk anders in te richten. Een integrale aanpak is daarom gewenst, waarbij beleidsmakers van verschillende disciplines (bijvoorbeeld sport en bewegen, gezondheid, transport, ruimtelijke planning en het sociale domein) samenwerken aan het ontwikkelen van leefbare, gezonde steden. Beleidsdoelen van diverse domeinen kunnen op die manier worden vergeleken en waar mogelijk geïntegreerd, zodat er een discussie op gang komt waarin mogelijkheden om door de juiste ruimtelijke ontwikkeling van gezonde steden meerdere beleidsdoelen tegelijk te halen. Zo'n samenwerking geeft ook meer inzicht in wie profiteert van omgevingsinterventies. Zo kan de aanleg van extra natuur in de stad een positief effect hebben op het sport- en beweeggedrag van de inwoners. Via dit toegenomen bewegen en door bijvoorbeeld het stress-reducerende effect van natuur, kan de fysieke en mentale gezondheid van inwoners positief beïnvloed worden. Meer natuur kan bovendien goed zijn voor het klimaat en waterbeheer. Daarnaast biedt de aanleg van meer natuur wellicht ook mogelijkheden voor nieuwe en verbeterde infrastructuur en heeft natuur in de stad of in de woonwijk mogelijk een positief effect op huizenprijzen. Wanneer de aanleg van natuur een positieve bijdrage levert aan de aantrekkelijkheid en leefbaarheid van een stad, trekt dit wellicht ook nieuwe inwoners en bedrijven aan – die op hun beurt weer goed zijn voor de economie.

Voor het toekomstig proces van het ontwikkelen van 'leefbare, gezonde steden', gebaseerd op wetenschappelijk bewijs (en 'best practice'), is het van belang dat onderzoekers en beleidsmakers van verschillende disciplines betrokken zijn. Dit draagt bij aan onderzoek dat meer en meer toegepast is op relevante, maatschappelijke vraagstukken en mogelijkheden creëert om onderzoeksresultaten direct te vertalen naar en toe te passen in de praktijk.

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In de letterlijke en puur geografische betekenis van die zin ben ik hier natuurlijk per vliegtuig gekomen, en mijn bezoek aan Canada was a priori werk-gerelateerd: ik kwam voor het ISBNPA congres. Na afloop heb ik daar een fijne vakantie aan vastgeplakt. Dat brengt me ook meteen bij de meer figuurlijke betekenis van 'wat mij hier heeft gebracht'. Want hoewel promoveren erg pittig kan zijn, heeft het ook z'n mooie kanten. En terwijl ik dit schrijf besef ik me dat dit mijn eerste 'dankbetuiging' moet zijn: mijn dank voor de kansen die het PhD project mij heeft geboden. Daarnaast ben ik veel mensen dankbaar voor hun hulp en steun tijdens de afgelopen jaren en dus kan ook zeker het bedanken van diverse collega's, vrienden en familie in dit dankwoord niet uitblijven.

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Carel, Stef, Dave, Sanne en Teun, bedankt voor jullie input tijdens de inspirerende en gezellige PHASE-klein-committee overleggen in Maastricht, Utrecht, of Den Bosch. Leden van de leescommissie, Prof.dr. S. Kremers, Dr. S. de Vries, Prof.dr. P. Groenewegen, Prof.dr. F. van Lenthe en Prof.dr. G. Cardon, hartelijk dank voor het lezen en beoordelen van mijn proefschrift. Deelnemers uit Rotterdam en Maastricht, gemeente Maastricht, gemeente Rotterdam, gemeente Utrecht, bedankt voor jullie bijdrage aan dit onderzoeksproject.

Maarten Zeylmans - van Emmichoven en Tom de Jong, bedankt voor het meedenken over de (on)mogelijkheden van GPS en ArcGIS voor dit onderzoek. Maarten, bedankt voor de analyses die je hebt gedaan omdat jouw computer nu eenmaal meer aan kon dan die van mij. Ik wil ook de studentassistenten Liselotte, Daniël, Mark, Nino, Lucas en Vince bedanken voor hun inzet. Wat fijn dat jullie naar Rotterdam en Maastricht zijn afgereisd om de meters te verstrekken aan de deelnemers. Mannen van GEO-ICT: Gerard, Dennis, Maurice, Rick en Rob, wat fijn om jullie om de hoek te hebben. Jullie hebben meegedacht over extra computers voor het verwerken van de data, over het opslaan van de data, hebben software vragen opgelost, en waren altijd in voor een gezellig praatje. Beter een goede buur…

Marianne, jij brengt zoveel gezelligheid en relativeringsvermogen met je mee. Dank daarvoor, ik heb dat én de EHBO/BHV trainingen die we samen hebben gedaan erg gewaardeerd de afgelopen jaren. Ik ben heel blij dat je er straks bij bent in het 'zweetkamertje' als paranimf. Nico, onze trajecten hebben nagenoeg gelijk gelopen: we begonnen op dezelfde dag en zullen nu ook op dezelfde dag promoveren. Het was erg prettig om met iemand te kunnen sparren.

Lieve kantoorbuddies, lieve Ineke, Anouk en Nynke… meermaals zijn we gevraagd of het niet een onwerkbaar 'kippenhok' is – zo'n kantoor met vier dames. Maar hoewel het natuurlijk wel eens wat druk was, hebben we het vooral heel fijn en gezellig gehad. Ik heb ook veel van jullie geleerd. Ineke, mijn roomie vanaf de eerste dag. De dames van de sportprojecten, zoals we al snel bekend stonden, eerst wij twee – later met Nynke erbij. Wat leuk om samen te beginnen, alle moeilijkheden en feestelijke momenten (bijv. je eerste gepubliceerde paper) samen mee te maken. Fijn om te kunnen sparren, en tof dat er een gezamenlijke paper is gekomen! Anouk, ik herinner me onze eerste ontmoeting nog goed. We lunchten buiten en voor we het wisten hadden we een kamerwissel voor je geregeld. Dankje voor je interesse en je luisterend oor. Nynke, na ons tripje naar voetbalclub Brugge was het duidelijk dat we het erg goed konden vinden. Wat heb ik het fijn gehad met jou op kantoor – de vele koffie's, de gesprekken over het weekend, onze gezamenlijke 'drive' om ons als PhD-vertegenwoordigers in te zetten, en onze discussies over statistiek en SPSS. Ik waardeer de vriendschap die is ontstaan.

Linda, Rianne, José, Karlijn, Joep, Iris, Daniëlle, Bram, Thomas en Stefan, dankjewel voor jullie interesse voor mijn onderzoek, mijn werkzaamheden door de jaren heen, en het geven van (on)gevraagd advies. Ook jullie, pap, mam, Pim, Sisi, Elly, Hein, Olaf en Marit, wil ik heel erg bedanken voor jullie betrokkenheid, het meeleven, relativeren, en het luisteren.

Ten slotte, lieve Lars, jouw geduld, begrip, steun en hulp was en is ontzettend fijn. Wat waardeer ik al die momenten dat we hebben gekletst over onze onderzoeken. Je hebt figuren voor me gemaakt en je hebt stukken nagelezen. Jouw passie voor jouw werk inspireerde me. Bovenal stimuleerde en motiveerde je me om er het beste uit te halen, en vertelde je me dat je trots op me bent. Dankjewel.

Marijke

About the author

Marijke Jansen was born on the 28th of December 1989 in Rotterdam, the Netherlands. In 2012, she obtained a Bachelor in Nursing from the Windesheim University of Applied Sciences (Zwolle, the Netherlands). One year later, she obtained a master's degree in Health Sciences at the VU University (Amsterdam, the Netherlands), with a specialization in Prevention and Public Health. In October 2013, she started her PhD research at the department of Human Geography and Spatial Planning at the Utrecht University (the Netherlands). From January till July 2017, she also worked as a junior researcher at the same department for the KiB project (a research project that focused on physical activity behavior of children). In August 2017, she started as a teacher for the bachelor Nursing at the HU University of Applied Sciences Utrecht (the Netherlands).

Marijke Jansen werd geboren op 28 december 1989 te Rotterdam. In 2012 behaalde zij haar HBO-Verpleegkunde diploma aan de hogeschool Windesheim, te Zwolle. Een jaar later behaalde ze haar master Gezondheidswetenschappen aan de Vrije Universiteit te Amsterdam, met een specialisatie in Preventie en Publieke Gezondheid. In oktober 2013 startte ze met haar PhD project op het departement Sociale Geografie en Planologie bij de Universiteit Utrecht. Van januari tot en met juli 2017 werkte ze ook als junior onderzoeker aan het Kinderen in Beweging - project voor hetzelfde departement. Sinds augustus 2017 werkt ze als docent verpleegkunde aan de Hogeschool Utrecht.

APPENDIX

APPENDIX A1
INFORMATION LETTER TO ADULTS AGED 45-65 YEARS (ROTTERDAM)

Faculteit Geowetenschappen

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(030) 253 13 99
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(030) 253 20 37

E-mail:
f.m.jansen@uu.nl
Telefoon (direct)
030 253 1869

Datum: 28 mei 2014

Onderwerp: Onderzoek 'Sport en Bewegen in de Openbare Ruimte'

Geachte heer, mevrouw,

Bewegen en sporten draagt bij aan een goede gezondheid. Onderzoek heeft aangetoond dat de inrichting van de omgeving van invloed kan zijn op het sporten en bewegen van mensen. Daarom onderzoekt de Universiteit Utrecht welke factoren uit de omgeving van invloed zijn op sport- en beweeggedrag, zodat gemeenten hun wijken op basis van bevindingen van dit onderzoek beweegvriendelijk kunnen inrichten. Via deze brief willen we u uitnodigen om deel te nemen aan dit onderzoek.

Het onderzoek

Een groot deel van iemands dagelijkse beweging vindt plaats in de openbare omgeving, bijvoorbeeld in de buurt of wijk waar iemand woont of werkt. Denk bijvoorbeeld aan fietsen naar het werk, of de hond uit laten. Daarnaast zijn er veel sporten die worden beoefend in de openbare omgeving (bijv. hardlopen, wielrennen). Veel gemeenten denken na over hoe woonomgevingen aangepast kunnen worden, zodat bewegen en sporten worden gestimuleerd. Dit onderzoek voorziet de gemeenten van informatie die nodig is om de juiste aanpassingen te kunnen doen.

Het onderzoek wordt uitgevoerd in samenwerking met Gemeente Utrecht, Gemeente Rotterdam, het Nivel, het Nederlands Instituut voor Sport en Bewegen, de Haagse Hogeschool en TNO, en wordt gefinancierd door de Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO). Voor dit onderzoek is er een willekeurige steekproef van personen in de leeftijd van 45 tot en met 65 jaar uit de gemeentelijke basisadministratie getrokken. Ook u werd toevallig getrokken. In totaal zullen er ongeveer 500 mensen deelnemen aan het onderzoek.

Wat wordt er van deelnemers verwacht

Deelname aan het onderzoek houdt in dat u zeven opeenvolgende dagen een beweegmeter en een GPS-meter wilt dragen. De beweegmeter registreert uw bewegingen en met een GPS-meter worden de routes die u aflegt en de locaties die u bezoekt, in kaart gebracht.

Beide apparaatjes zijn aan een elastische band bevestigd en deze draagt u om uw heupen. Daarnaast vragen we u om gedurende één dag een dagboekje bij te houden, zodat we inzicht kunnen krijgen in uw ervaringen tijdens het sporten of bewegen in de omgeving. U wordt ook gevraagd een digitale vragenlijst in te vullen.

We willen benadrukken dat we u niet kunnen volgen terwijl u de apparaatjes draagt. Ook zullen alle door ons verzamelde gegevens anoniem verwerkt worden en de gegevens zullen niet voor andere doeleinden dan dit onderzoek worden gebruikt.

Uw deelname is van groot belang. Door de relatie tussen de omgeving en beweeggedrag te onderzoeken kunnen we aanbevelingen doen aan gemeenten, waardoor de omgeving voor u en anderen kan worden verbeterd. We zouden uw deelname aan het onderzoek zeer op prijs stellen. Als dank voor deelname ontvangt elke deelnemer een VVV-bon ter waarde van €10,-.

U kunt zich opgeven voor deelname aan dit onderzoek via de website: www.phase-onderzoek.nl/utrecht. Op deze website kunt u ook aanvullende informatie over het onderzoek vinden. Voor vragen over het onderzoek kunt u gebruik maken van de contactgegevens.

Met vriendelijke groet,

Prof. Dr. M. Dijst
Professor Universiteit Utrecht

Dr. F. Pierik
Senior onderzoeker TNO

APPENDIX A2
INFORMATION LETTER TO ADULTS AGED 45-65 YEARS (MAASTRICHT)

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030 253 1869

Datum: 28 mei 2014

Onderwerp: Onderzoek 'Sport en Bewegen in de Openbare Ruimte'

Geachte heer, mevrouw,

Bewegen en sporten draagt bij aan een goede gezondheid. Onderzoek heeft aangetoond dat de inrichting van de omgeving van invloed kan zijn op het sporten en bewegen van mensen. Daarom onderzoekt de Universiteit Utrecht welke factoren uit de omgeving van invloed zijn op sport- en beweeggedrag, zodat gemeenten hun wijken op basis van bevindingen van dit onderzoek beweegvriendelijk kunnen inrichten. Via deze brief willen we u uitnodigen om deel te nemen aan dit onderzoek.

Het onderzoek

Een aanzienlijk deel van iemands dagelijkse beweging vindt plaats in de openbare omgeving, bijvoorbeeld in de buurt of wijk waar iemand woont of werkt. Denk bijvoorbeeld aan fietsen naar het werk, of de hond uit laten. Daarnaast zijn er veel sporten die worden beoefend in de openbare omgeving (bijv. hardlopen, wielrennen). Veel gemeenten denken na over hoe woonomgevingen aangepast kunnen worden, zodat bewegen en sporten worden gestimuleerd. Dit onderzoek voorziet de gemeenten van informatie die nodig is om de juiste aanpassingen te kunnen doen.

Het onderzoek wordt uitgevoerd in samenwerking met Gemeente Utrecht, Gemeente Rotterdam, Gemeente Maastricht, het Nivel, het Nederlands Instituut voor Sport en Bewegen, de Haagse Hogeschool en TNO, en wordt gefinancierd door de Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO). Voor dit onderzoek is er een willekeurige steekproef van personen in de leeftijd van 45 tot en met 65 jaar uit de gemeentelijke basisadministratie getrokken. Ook u werd toevallig getrokken. In totaal zullen er ongeveer 400 mensen deelnemen aan het onderzoek.

Wat wordt er van deelnemers verwacht

Deelname aan het onderzoek houdt in dat u zeven opeenvolgende dagen een beweegmeter en een GPS-meter wilt dragen. De beweegmeter registreert uw bewegingen en met een GPS-meter worden de routes die u aflegt en de locaties die u bezoekt, in kaart gebracht.

Beide apparaatjes zijn aan een elastische band bevestigd en deze draagt u om uw heupen. Daarnaast vragen we u om gedurende één dag een dagboekje bij te houden, zodat we inzicht kunnen krijgen in uw ervaringen tijdens het sporten of bewegen in de omgeving. U wordt ook gevraagd een digitale vragenlijst in te vullen. De apparaatjes zullen door onderzoekmedewerkers worden uitgedeeld in buurthuizen of wijkcentra in Maastricht, u hoeft dus zelf niet naar Utrecht om deel te nemen aan dit onderzoek.

We willen benadrukken dat we u niet kunnen volgen terwijl u de apparaatjes draagt. Ook zullen alle door ons verzamelde gegevens anoniem verwerkt worden en de gegevens zullen niet voor andere doeleinden dan dit onderzoek worden gebruikt.

Uw deelname is van groot belang. Door de relatie tussen de omgeving en beweeggedrag te onderzoeken kunnen we aanbevelingen doen aan gemeenten, waardoor de omgeving voor u en anderen kan worden verbeterd. We zouden uw deelname aan het onderzoek zeer op prijs stellen. Als dank voor deelname verloten we onder alle deelnemers 15 VVV-bonnen ter waarde van €100,-.

U kunt zich opgeven voor deelname aan dit onderzoek via de website: www.phase-onderzoek.nl/utrecht. Op deze website kunt u ook aanvullende informatie over het onderzoek vinden. Voor vragen over het onderzoek kunt u gebruik maken van de contactgegevens.

Met vriendelijke groet,

Prof. Dr. M. Dijst
Professor Universiteit Utrecht

Dr. F. Pierik
Senior onderzoeker TNO

APPENDIX B
QUESTIONNAIRE OF THE PHASE STUDY (IN DUTCH)

Vragenlijst PHASE onderzoek

Deze vragenlijst hoort bij het PHASE-onderzoek. De vragen die worden gesteld hebben betrekking op de volgende onderwerpen en zullen ook in die volgorde gesteld worden.

- Uw sport en vrijetijdsbesteding
- Uw woonomgeving
- Uw werksituatie
- Uw gezondheid
- Uw achtergrondgegevens

Sommige vragen lijken op andere vragen in de vragenlijst. Dit is gedaan omdat een combinatie van vragen een beter beeld geeft over een bepaald onderwerp dan een enkele vraag. Daarnaast zijn er misschien vragen die niet op u van toepassing lijken te zijn. Wij zouden het op prijs stellen als u toch zoveel mogelijk vragen wilt beantwoorden.

Uw gegevens worden vertrouwelijk behandeld en zullen alleen voor dit onderzoek worden gebruikt. Alleen de onderzoekers die werken aan dit project hebben inzicht in de gegevens. De gegevens worden gecodeerd verwerkt, zodat ze niet naar u zijn te herleiden.

Instructies:

- Het invullen van deze vragenlijst duurt ongeveer 20 minuten.
- Geef slechts één antwoord per vraag, tenzij anders is vermeld.
- Kies het antwoord dat het best op u van toepassing is.

Mocht u hulp nodig hebben bij het beantwoorden van de vragen, dan kunt u contact opnemen met Marijke Jansen, telefoonnummer: **030 253 1869** , e-mail: **f.m.jansen@uu.nl**.

Persoonsgegevens

Wat is uw geboortedatum?

dag	maand	jaar
		1 9

Wat is uw postcode en uw huisnummer (+ eventuele toevoeging)?

postcode

Huisnummer

1| Sporten en bewegen

De vragen in dit onderdeel gaan over sporten en bewegen.

1. Geef aan in hoeverre u het eens bent met de volgende stellingen.

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Lichaamsbeweging is goed voor mij	○	○	○	○	○
b. Lichaamsbeweging is plezierig	○	○	○	○	○
c. Lichaamsbeweging is afwisselend	○	○	○	○	○
d. Lichaamsbeweging is belangrijk	○	○	○	○	○

2. Kunt u aangeven hoe vaak en hoe lang u onderstaande activiteiten verricht?
Als u een activiteit nooit uitvoert, vult u dan een 0 in bij aantal dagen per week.

	Aantal dagen per week	**Gemiddelde tijd per dag**
a. Lopen van/naar het werk	....	.... uur .... minuten
b. Lopen overig (wandeling, hond uitlaten, lopen naar een winkel, e.d.)	....	.... uur .... minuten
c. Fietsen	....	.... uur .... minuten
d. Licht of matig inspannend <u>huishoudelijk werk</u> (bijv. staand werk zoals koken, afwassen, strijken, kind in bad doen/eten geven, en lopend werk zoals stofzuigen, boodschappen doen)	....	.... uur .... minuten
e. Zwaar inspannend <u>huishoudelijk werk</u> (bijv. vloeren schrobben, tapijt uitkloppen, met zware boodschappen lopen)	....	.... uur .... minuten
f. Licht of matig inspannend <u>werk</u> (op uw werklocatie) (bijv. zittend/staand werk, met af en toe lopen, zoals bureauwerk of lopend werk met lichte lasten)	....	.... uur .... minuten
g. Zwaar inspannend <u>werk</u> (op uw werklocatie) (bijv. lopend werk of werk waarbij regelmatig zware dingen moeten worden opgetild)	....	.... uur .... minuten

Er volgen nu twee vragen over uw totale lichaamsbeweging, zoals wandelen of fietsen, tuinieren, sporten of beweging op het werk of op school. Het gaat om alle lichaamsbeweging die ten minste even inspannend is als stevig doorlopen of fietsen.

3. Hoeveel dagen per week heeft u <u>in de zomer</u> ten minste 30 minuten per dag dergelijke lichaamsbeweging?
Het gaat om het gemiddeld aantal dagen van een gewone week. Is het minder dan 1 dag per week, dan vult u 0 in.
.... dagen per week

4. Hoeveel dagen per week heeft u <u>in de winter</u> ten minste 30 minuten per dag dergelijke lichaamsbeweging?
Het gaat om het gemiddeld aantal dagen van een gewone week. Is het minder dan 1 dag per week, dan vult u 0 in.
.... dagen per week

5. Doet u in uw vrije tijd aan sport?

☐ Nee (ga naar vraag 7)
☐ Ja, namelijk:
(Als u meer dan 2 sporten beoefent, vult u dan a.u.b. de sporten in die u het meeste doet.)

a. Sport 1: [ ]

b. Hoe vaak beoefent u deze sport gemiddeld?
☐ Minder dan 1 keer per week
☐ 1 keer per week
☐ 2 keer per week
☐ 3 keer per week
☐ Meer dan 3 keer per week

c. Hoe lang sport u gemiddeld <u>per keer</u>?
☐ Minder dan 30 minuten per keer
☐ 30 tot 60 minuten per keer
☐ Meer dan 60 minuten per keer

d. Hoe gaat u meestal naar deze plek waar u sport?
☐ Lopend
☐ Met de fiets
☐ Met de auto / motor / bromfiets / scooter
☐ Met het openbaar vervoer (bus, tram, metro of trein)
☐ Ik reis op een andere manier
☐ Ik sport thuis, of ik start thuis

e. In welk verband heeft u deze sport beoefend?
☐ Als lid van een sportvereniging
☐ Als klant/lid/cursist bij een sportschool of fitnesscentrum
☐ Georganiseerd door een bedrijf/bedrijfssport
☐ Georganiseerd door gemeente, sociaal-cultureel werk, sportbuurtwerk of welzijnswerk
☐ Overig (bijv. thuis of op eigen initiatief)

Als u bij vraag e 'overig' heeft ingevuld, ga dan naar vraag g.

f. **Wat is de naam en het adres van de locatie waar u uw sport beoefend?**

Naam: [ ]

Adres:
Postcode + Plaats:..
Huisnummer: ....

g. Sport 2: [ ]

h. Hoe vaak beoefent u deze sport gemiddeld?
☐ Minder dan 1 keer per week
☐ 1 keer per week
☐ 2 keer per week
☐ 3 keer per week
☐ Meer dan 3 keer per week

i. Hoe lang sport gemiddeld per keer?
☐ Minder dan 30 minuten per keer
☐ 30 tot 60 minuten per keer
☐ Meer dan 60 minuten per keer

j. Hoe gaat u meestal naar deze plek waar u sport?
☐ Lopend
☐ Met de fiets
☐ Met de auto / motor / bromfiets / scooter
☐ Met het openbaar vervoer (bus, tram, metro of trein)
☐ Ik reis op een andere manier
☐ Ik sport thuis, of ik start thuis

k. In welk verband heeft u deze sport beoefend?
☐ Als lid van een sportvereniging
☐ Als klant/lid/cursist bij een sportschool of fitnesscentrum
☐ Georganiseerd door een bedrijf/bedrijfssport
☐ Georganiseerd door gemeente, sociaal-cultureel werk, sportbuurtwerk of welzijnswerk
☐ Overig (bijv. thuis of op eigen initiatief)

Als u bij vraag k 'overig' heeft ingevuld, ga dan naar vraag 6 (sla l over).

l. Wat is de naam en het adres van de locatie waar u uw sport beoefend?

Naam:

Adres:
Postcode + Plaats:..
Huisnummer: ....

6. In hoeverre zijn onderstaande aspecten belangrijk voor uw oordeel over de sportvoorziening die u wel eens gebruikt?

	Heel onbelangrijk	Onbelangrijk	Neutraal	Belangrijk	Heel belangrijk
a. De reisafstand tot de sportvoorziening	○	○	○	○	○
b. Het aanbod van training/begeleiding bij het sporten	○	○	○	○	○
c. De kosten van het lidmaatschap/een abonnement	○	○	○	○	○
d. De sociale contacten bij de sportvoorziening	○	○	○	○	○
e. Voldoende parkeergelegenheid	○	○	○	○	○
f. Ruime openingstijden van de sportvoorziening	○	○	○	○	○
g. De mogelijkheid om per keer te betalen	○	○	○	○	○
h. De mogelijkheid om binnen/overdekt te sporten	○	○	○	○	○

2| Woning en buurt

De vragen in dit onderdeel gaan over uw woning en over uw buurt.

7. In welk type woning woont u?

- ☐ Eengezinswoning: (half) vrijstaande woning, hoekwoning of tussenwoning (rijtjeshuis)
- ☐ Benedenwoning of bovenwoning
- ☐ Flat/etage/appartement met lift
- ☐ Flat/etage/appartement zonder lift
- ☐ Boerderij/woning met tuinderij
- ☐ Deel van een woning of wooneenheid
- ☐ Anders, nl.: ……………………………………………………………………………

Indien flat is geantwoord, ga verder met vraag: 8. Indien een ander antwoord is ingevuld, ga verder met vraag: 9.

8. Op welke verdieping woont u?

Verdieping: ....

9. Beschikt u over een tuin?

- ☐ Ja, ik heb een tuin bij mijn huis
- ☐ Ja, ik heb een volkstuin elders
- ☐ Nee

De volgende twee vragen gaan over locaties in uw buurt die u regelmatig bezoekt (tenminste wekelijks).

10. Wat is het adres van de supermarkt(en) die u het meeste bezoekt?

Straat	Huisnummer	Plaats

Straat	Huisnummer	Plaats

11. Wat is het adres van de groenvoorziening(en) (bijv. park, bos, recreatiegebied) die u het vaakst bezoekt?

Straat	Huisnummer	Plaats

Straat	Huisnummer	Plaats

Geeft u bij de onderstaande vragen steeds aan in hoeverre u het eens bent met de stellingen.

12. Uw buurt

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Ik vind mijn buurt aantrekkelijk om te wonen	○	○	○	○	○
b. Mijn buurt ziet er netjes uit	○	○	○	○	○
c. In mijn buurt is over het algemeen schoon (weinig afval, weinig hondenpoep)	○	○	○	○	○
d. Er is weinig lawaai (van verkeer/vliegtuigen/etc.)	○	○	○	○	○
e. Er zijn veel uitlaatgassen in mijn buurt (door bijv. auto's/bussen)	○	○	○	○	○
f. In de meeste straten in mijn buurt zijn voetpaden	○	○	○	○	○
g. In de meeste straten in mijn buurt zijn fietspaden	○	○	○	○	○
h. Als ik wandel bij mij in de buurt voel ik me onveilig door het verkeer (bijv. door verkeersdrukte, of onveilige verkeerssituaties.)	○	○	○	○	○
i. Als ik fiets bij mij in de buurt voel ik me onveilig door het verkeer (bijv. door verkeersdrukte, of onveilige verkeerssituaties.)	○	○	○	○	○
j. Er is zoveel verkeer in de straat waar ik woon of in de nabijgelegen straten, dat het moeilijk of onaangenaam is om te wandelen of fietsen	○	○	○	○	○
k. Ik ben bang voor criminaliteit of om te worden lastig gevallen, als ik bij daglicht door mijn buurt loop of fiets	○	○	○	○	○
l. Ik ben bang voor criminaliteit of om te worden lastig gevallen, als ik in het donker door mijn buurt loop of fiets	○	○	○	○	○
m. De straten in mijn buurt zijn 's avonds en 's nachts voldoende verlicht	○	○	○	○	○

13. Hoe vaak maakt u gebruik van de onderstaande voorzieningen?

	Iedere dag	Meerdere dagen per week	Wekelijks	Maandelijks	Minder dan eens per maand	Nooit
a. Parkje, plantsoen of ander soort groen in uw eigen buurt	○	○	○	○	○	○
b. Grotere parken in de stad en natuur- en recreatiegebieden rond de stad	○	○	○	○	○	○
c. Sportvoorziening	○	○	○	○	○	○
d. Binnenstad	○	○	○	○	○	○

Als u minder dan eens per maand of nooit een parkje, plantsoen of ander soort groen in uw eigen buurt bezoekt, sla dan vraag 14 over.

14. Parkje, plantsoen of ander soort groen in uw eigen buurt

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik bij daglicht gebruik maak van de groenvoorzieningen in mijn buurt	○	○	○	○	○
b. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik in het donker gebruik maak van de groenvoorzieningen in mijn buurt	○	○	○	○	○
c. Als ik loop van mijn woning naar de groenvoorzieningen in mijn buurt, voel ik me onveilig door het verkeer (bijv. door verkeersdrukte of onveilige verkeerssituaties)	○	○	○	○	○
d. Als ik fiets van mijn woning naar de groenvoorzieningen in mijn buurt, voel ik me onveilig door het verkeer (bijv. door verkeersdrukte of onveilige verkeerssituaties)	○	○	○	○	○
e. De straten op de route naar de groenvoorzieningen in mijn buurt zijn ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
f. De groenvoorzieningen in mijn buurt zijn ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
g. De groenvoorzieningen in mijn buurt nodigen uit om er gebruik van te maken	○	○	○	○	○
h. Ik vind de groenvoorzieningen in mijn buurt aantrekkelijk	○	○	○	○	○

Als u minder dan eens per maand of nooit grotere parken in de stad en natuur- en recreatiegebieden rond de stad bezoekt, sla dan vraag 15 en 16 over.

15. Hoe gaat u meestal naar de grotere parken in de stad en natuur- en recreatiegebieden rond de stad?

☐ Lopend
☐ Met de fiets
☐ Met de auto / motor / bromfiets / scooter
☐ Met het openbaar vervoer (bus, tram, metro of trein)
☐ Ik reis op een andere manier

16. Deze vraag gaat over 'Grotere parken in de stad en natuur- en recreatiegebieden rond de stad'. Geef aan in hoeverre u het eens bent met de volgende stellingen

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik bij daglicht gebruik maak van deze parken en natuur- en recreatiegebieden	○	○	○	○	○
b. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik in het donker gebruik maak van deze parken en natuur- en recreatiegebieden	○	○	○	○	○
c. Op de route naar deze parken en natuur- en recreatiegebieden, voel ik me onveilig door het verkeer (bijv. door verkeersdrukte of onveilige verkeerssituaties)	○	○	○	○	○
d. De straten op de route naar deze parken en natuur- en recreatiegebieden zijn 's avonds en 's nachts voldoende verlicht	○	○	○	○	○
e. Deze parken en natuur- en recreatiegebieden zijn 's avonds en 's nachts voldoende verlicht	○	○	○	○	○
f. Deze parken en natuur- en recreatiegebieden nodigen uit om er gebruik van te maken	○	○	○	○	○
g. Ik vind deze parken en natuur- en recreatiegebieden aantrekkelijk	○	○	○	○	○

Als u <u>minder dan eens per maand</u> of <u>nooit</u> sportvoorzieningen bezoekt, sla dan vraag 17 over.

17. Sportvoorzieningen die u bezoekt

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Op de route naar de sportvoorzieningen die ik bezoek, voel ik me onveilig door het verkeer (bijv. door verkeersdrukte of onveilige verkeerssituaties)	○	○	○	○	○
b. De straten op de route naar de sportvoorzieningen die ik bezoek zijn ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
c. De sportvoorzieningen die ik bezoek zijn ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
d. Ik vind de sportvoorzieningen die ik bezoek aantrekkelijk	○	○	○	○	○
e. Het aanbod aan sportvoorzieningen dat ik vanuit mijn woning kan bereiken is voldoende gevarieerd	○	○	○	○	○
f. In de sportvoorzieningen die ik vanuit mijn woning kan bereiken worden veel activiteiten georganiseerd die voor mij interessant zijn	○	○	○	○	○

Als u minder dan eens per maand of nooit de binnenstad bezoekt, sla dan vraag 18 en 19 over.

18. Hoe gaat u meestal naar de binnenstad?

☐ Lopend
☐ Met de fiets
☐ Met de auto / motor / bromfiets / scooter
☐ Met het openbaar vervoer (bus, tram, metro of trein)
☐ Ik reis op een andere manier

19. Binnenstad

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal Mee eens
a. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik bij daglicht in de binnenstad ben	○	○	○	○	○
b. Ik ben bang voor criminaliteit of om te worden lastig gevallen als ik in het donker in de binnenstad ben	○	○	○	○	○
c. Op de route naar de binnenstad, voel ik me onveilig door het verkeer (bijv. door verkeersdrukte of onveilige verkeerssituaties)	○	○	○	○	○
d. De straten op de route naar de binnenstad zijn ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
e. De binnenstad is ’s avonds en ’s nachts voldoende verlicht	○	○	○	○	○
f. Ik vind de binnenstad aantrekkelijk	○	○	○	○	○
g. De binnenstad heeft een aanbod aan activiteiten dat voor mij interessant is	○	○	○	○	○

3| Werk

De vragen in dit onderdeel gaan over uw werk en uw werkomgeving.

20. Welke omschrijving is op dit moment het meest op u van toepassing?
Meerdere antwoorden mogelijk.

- ☐ Ik heb betaald werk
- ☐ Ik ben zelfstandige
- ☐ Ik ben met pensioen
- ☐ Ik leef van een bijstandsuitkering
- ☐ Ik ben arbeidsongeschikt (WAO, AAW, etc.)
- ☐ Ik ben werkzoekende (geregistreerd bij het arbeidsbureau)
- ☐ Ik ben huisman/huisvrouw
- ☐ Ik volg een opleiding

Indien u betaald werk heeft of zelfstandige bent, ga door met vraag 21. Zo niet, ga door met vraag 28.

Om de (reis-)afstand van uw woning tot uw werk te weten, vragen we in de volgende vraag naar het adres van uw werklocatie.

21. Wat is het adres van uw werklocatie?
Indien u op meerdere adressen werkt, en daar tenminste eens per week komt, wilt u de twee meest regelmatig gebruikte adressen opgeven?

Werkadres 1:

Straat	Huisnummer	Plaats

Werkadres 2:

Straat	Huisnummer	Plaats

22. Hoeveel uur per week verricht u betaald werk?
Inclusief overuren en thuiswerk. Reistijd niet meetellen.
Gemiddeld .... uur per week

23. Werkt u meestal op regelmatige of onregelmatige tijden?

- ☐ Regelmatige tijden (ga verder met vraag 24)
- ☐ Onregelmatige tijden (ga verder met vraag 25)

24. Kunt u aangeven op welke dagen en tijden u meestal werkt?
Gebruikt u alstublieft de 24-uursnotatie: kwart over zeven 's ochtends is 7u15m, kwart over zeven 's avonds is 19u15m.

	Begintijd	**Eindtijd**	**Geen werkdag**
Maandag	......uur......minuten	......uur......minuten	☐
Dinsdag	......uur......minuten	......uur......minuten	☐
Woensdag	......uur......minuten	......uur......minuten	☐
Donderdag	......uur......minuten	......uur......minuten	☐
Vrijdag	......uur......minuten	......uur......minuten	☐
Zaterdag	......uur......minuten	......uur......minuten	☐
Zondag	......uur......minuten	......uur......minuten	☐

25. Hoe gaat u meestal naar uw werk?

☐ Lopend
☐ Met de fiets
☐ Met de auto / motor / bromfiets / scooter *(ga verder met vraag 27)*
☐ Met het openbaar vervoer (bus, tram, metro of trein) *(ga verder met vraag 27)*
☐ Ik reis op een andere manier *(ga verder met vraag 27)*

26. Geef aan in hoeverre u het met de volgende stellingen eens bent.

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. Ik ben bang voor criminaliteit of om te worden lastig gevallen, als ik bij daglicht de route van mijn woning naar mijn werk (of andersom) fiets of loop	○	○	○	○	○
b. Ik ben bang voor criminaliteit of om te worden lastig gevallen, als ik in het donker de route van mijn woning naar mijn werk (of andersom) fiets of loop	○	○	○	○	○
c. Als ik loop of fiets van mijn woning naar mijn werk voel ik me onveilig door het verkeer (bijv. door verkeersdrukte, of onveilige verkeerssituaties)	○	○	○	○	○
d. De straten op de route naar mijn werkadres zijn 's avonds en 's nachts voldoende verlicht	○	○	○	○	○

27. Geef aan in hoeverre u het met de volgende stellingen eens bent.

	Helemaal oneens	Oneens	Neutraal	Mee eens	Helemaal mee eens
a. De buurt waarin ik werk ziet er netjes uit	○	○	○	○	○
b. Ik vind de buurt waarin ik werk aantrekkelijk	○	○	○	○	○
c. De buurt waarin ik werk nodigt uit om in te lopen	○	○	○	○	○

De volgende vragen gaan over het werk van uw partner. Indien u geen partner heeft, ga dan verder met vraag 30.

28. Heeft uw partner een betaalde baan?

- ☐ Ja
- ☐ Nee

29. Zo ja, hoeveel uur per week werkt uw partner?
Inclusief overuren en thuiswerk. Reistijd niet meetellen.
Gemiddeld …… uur per week

4| Gezondheid

De volgende vragen gaan over uw gezondheid.

30. Hoe zou u over het algemeen uw gezondheid noemen?

- ☐ Zeer goed
- ☐ Goed
- ☐ Gaat wel
- ☐ Slecht
- ☐ Zeer slecht

31. Heeft u een langdurige ziekte of aandoening (gezondheidsprobleem)?

- ☐ Ja
- ☐ Nee
- ☐ Wil ik niet zeggen

Indien u ja heeft ingevuld, ga verder met vraag 32. In de andere gevallen, ga verder met vraag 33.

32. Welke langdurige ziekte of aandoening (gezondheidsprobleem) heeft u?

Meerdere antwoorden mogelijk.

- ☐ Suikerziekte
- ☐ Hartafwijking/hartfalen
- ☐ Afwijking aan het vaatstelsel (bloedvaten)
- ☐ Epilepsie
- ☐ Migraine of regelmatig ernstige hoofdpijn
- ☐ Duizeligheid met vallen
- ☐ Ernstige of hardnekkige darmstoornissen (langer dan 3 maanden)
- ☐ Ernstige of hardnekkige aandoening aan de nek en/of rug (bijv. hernia)
- ☐ Reumatische aandoening
- ☐ Osteoporose
- ☐ Schildklieraandoening
- ☐ Astma/COPD (chronische bronchitis, longemfyseem)
- ☐ Gezichtsstoornissen (oogaandoeningen, die leiden tot gezichtsuitval)
- ☐ Depressieve klachten
- ☐ Angstklachten
- ☐ Anders, namelijk: ....

33. De volgende vraag gaat over bezigheden die u misschien doet op een doorsnee dag. Wordt u door uw gezondheid <u>op dit moment</u> beperkt bij deze bezigheden? Zo ja, in welke mate?

Kruis in elke regel 1 vakje aan.

	Ja, ernstig beperkt	Ja, een beetje beperkt	Nee, niet beperkt
Forse inspanning (bijv. hardlopen, tillen van zware voorwerpen, sport beoefenen)	☐	☐	☐
Matige inspanning (bijv. fietsen, wandelen, zwemmen, stofzuigen, boodschappen tillen of dragen)	☐	☐	☐
Traplopen of een heuvel oplopen	☐	☐	☐
Bukken, knielen of hurken	☐	☐	☐
Meer dan één kilometer lopen	☐	☐	☐
Een paar honderd meter lopen	☐	☐	☐
Ongeveer 100 meter lopen	☐	☐	☐
Uzelf wassen of aankleden	☐	☐	☐

5| Achtergrondgegevens

Tenslotte willen we u in dit onderdeel nog een aantal vragen stellen over uw achtergrond.

34. Wat is uw geslacht?

- ☐ Man
- ☐ Vrouw

35. Wat is uw lengte?

………. centimeter

36. Wat is uw gewicht?

………. kg

37. Uit hoeveel personen bestaat het huishouden waartoe u behoort, uzelf meegerekend?

.... personen

38. Met wie deelt u uw huishouden?

Meerdere antwoorden mogelijk.

- ☐ Ik woon alleen
- ☐ Met mijn partner
- ☐ Met kind(eren) jonger dan 3 jaar
- ☐ Met kind(eren) in de leeftijd van 4 tot en met 11 jaar
- ☐ Met kind(eren) in de leeftijd van 11 tot en met 17 jaar
- ☐ Met kind(eren) ouder dan 17 jaar
- ☐ Anders, namelijk: …………………………………………..

Indien u thuiswonende kinderen heeft, ga verder met vraag 39. Zo niet, ga verder met vraag 40.

39. Indien u uw kinderen naar school brengt, wat is het adres van de school/scholen?

Schooladres 1:

Naam school	Plaats

Schooladres 2:

Naam school	Plaats

40. Wie doet in uw huishouden doorgaans het volgende?

	Ikzelf	Een ander (bijv. partner)	Dat doe ik even vaak als een ander	Niet van toepassing
a. Het halen of brengen van uw kind(eren) (bijv. naar school/activiteiten)	○	○	○	○
b. Wassen, strijken, schoonmaken, koken	○	○	○	○
c. Boodschappen doen	○	○	○	○
d. Hond uitlaten	○	○	○	○

41. Wat is het <u>netto</u> maandinkomen van uw huishouden in euro's?
(Met netto maandinkomen bedoelen we het inkomen dat u (en uw eventuele partner) ontvangen, dus na aftrek van belasting en premies e.d.)

- ☐ € 1000,- of minder
- ☐ € 1001,- t/m € 1350,-
- ☐ € 1351,- t/m € 1800,-
- ☐ € 1801,- t/m € 3150,-
- ☐ € 3151,- t/m € 4500,-
- ☐ € 4500,- of meer
- ☐ Weet ik niet/wil ik niet zeggen

42. Wat is de hoogste opleiding die u heeft afgemaakt?
Indien u uw opleiding niet in Nederland heeft gevolgd, kiest u dan de opleiding die het meeste overeenkomt met uw opleiding.

- ☐ Geen opleiding (lagere school niet afgemaakt)
- ☐ Lagere opleiding (basisonderwijs, speciaal basisonderwijs)
- ☐ Lager beroepsonderwijs of praktijkonderwijs
- ☐ MAVO, VBO of VMBO
- ☐ MBO (middelbaar beroepsonderwijs)
- ☐ MULO of MMS
- ☐ HAVO
- ☐ HBS, VWO, lyceum, atheneum of gymnasium
- ☐ HBO (hoger beroepsonderwijs)
- ☐ Wetenschappelijk onderwijs (wo) of post-hbo onderwijs
- ☐ Anders, namelijk:……………………………………………………………………………………

43. Wat is het geboorteland van uzelf, uw moeder en uw vader?

		Uzelf	Uw moeder	Uw vader
a.	Nederland	○	○	○
b.	Suriname	○	○	○
c.	Nederlandse Antillen/Aruba	○	○	○
d.	Turkije	○	○	○
e.	Marokko	○	○	○
f.	Kaapverdië	○	○	○
g.	Een ander land in Europa, Noord-Amerika, of Australië	○	○	○
h.	Een ander land in Afrika, Zuid-Amerika, of Azië	○	○	○
i.	Weet ik niet	○	○	○

44. Heeft u een fiets?

- ☐ Ja
- ☐ Nee

45. Hoeveel auto's zijn er in uw huishouden aanwezig?

- ☐ Geen
- ☐ 1
- ☐ 2 of meer

46. Heeft u een hond?

- ☐ Ja
- ☐ Nee

<u>Einde vragenlijst.</u> **Hartelijk bedankt voor het invullen!**

Vergeet u niet de vragenlijst weer in te leveren als u de meters terug brengt.