Healthy Design Principles in Property Development

A quantitative study

M. van Muijden
Master's Thesis in Spatial Planning
Specialization: Planning, Land, and Real Estate Management

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This document is a master's thesis for the completion of a Master of Spatial Planning degree specializing in Planning, Land, and Real Estate Development at the Radboud University of Nijmegen, the Netherlands.

Colophon

Author: Milou van Muijden
Student Number: 1029633
Internal First Supervisor: Prof. Dr. E. van der Krabben
Internal Second Reader: Dr. Ir. H.J. Kooij
Internship: BPD (Bouwfonds Property Development)
External Supervisor: Martijn van Gelderen, BPD
University: Radboud University, Nijmegen
Faculty: School of Management
Master's Program: Master of Spatial Planning
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Summary

"Everywhere, modernist ideas of freestanding, monofunctional buildings surrounded by vaguely defined no-man's-lands became the way to go. All in all, these new principles represent the most radical course change in the history of human settlement. And, by and large, there was never a proper assessment of whether these changes actually worked for mankind."
Jan Gehl, Copenhagen, 2019

Demographic mega-trends such as population ageing, population growth, international migration, and urbanization exert a profound influence on the quality of life of people around the globe. More than half the world's population now lives in urban areas; by 2050, this number will have climbed to 65%. At the same time, non-communicable diseases, including obesity and cardio-vascular disease, are also on the rise in urban areas. The increase in obesity rates is linked to inactivity; the European Commission has observed that as the number of hours a person sits per day increases, so their overall level of inactivity, and thus their chance of becoming obese, also increases. This fact calls for greater insight into the relationship between urbanization and non-communicable diseases. The connection between urbanization and general health is more commonly considered in spatial planning. A new law in the Netherlands called "Omgevingswet", which will be implemented in 2022, requires that city planners and property developers ensure that their projects promote a safe and healthy living environment for citizens.

How are we going to develop these healthy living environments? Taking a closer look at this question, multiple possible interventions to create healthier environments in urban areas come to mind. This line of inquiry resulted in the following research question:

"What is the impact of urban design interventions in neighborhoods on the physical activity (focusing on walking and bicycling) of residents?"

To answer this question, an in-depth review of the literature on the built environmental factors that influence physical activity—focusing, as mentioned above, on bicycling and walking—was conducted. In addition, a survey was conducted, the results of which both elaborate upon and support the findings of the existing literature. A total of 599 individuals were surveyed in the process of answering the main research question. The respondents were chosen due to their residing in or having an interest in either Waalfront (Nijmegen) or Nieuwe Kade Kwartier (Arnhem). Inactivity is a problem in both the surveyed locations, with one in three respondents lacking sufficient movement in their everyday lives. The results of the research show that design principles influence the physical activity of the respondents. Green routes for relaxation and benches placed along these routes have a positive influence on physical activity. Easily accessible parking for bicycles in built up spaces is preferred by respondents. Additionally, respondents prefer frictionless streets and places, and wide sidewalks. These findings have led to the recommendation of three design principles: accessible bicycle parking in public and built up spaces; frictionless streets and wide sidewalks; and green routes with a sufficient number of rest areas.

KEYWORDS: URBAN AREAS, HEALTH, SUSTAINABLE, ACTIVE LIFESTYLE

Preface and Acknowledgement

This thesis is for the finalization of my Master's degree in Spatial Planning, specializing in Planning, Land, and Real Estate Management at Radboud University, Nijmegen. The subject of the thesis combines my interests in healthy living environments and spatial planning. I became interested in the subject of healthy environments during my Bachelor studies at Wageningen University. Taking on the challenge of pursuing a master's degree in spatial planning integrated these two topics for me. Multiple projects during my master's studies called for the consideration of health issues; thus, making 'Healthy Design Principles in Property Development' the subject of this thesis seemed like a natural evolution. The research was conducted during an internship at Bouwfonds Property Development (BPD).

I would like to thank several people who were important during the research and writing process. First of all, my supervisor at Radboud University, Erwin van der Krabben. His feedback helped me to get the most out of the research process and pushed me to think beyond boundaries. Our conversations opened my eyes and showed me what is possible in the field of spatial planning. Secondly, I want to thank BPD for the opportunity I was given to take a look at this wonderful company. I would particularly like to thank my supervisor, Martijn van Gelderen, who provided valuable feedback and asked challenging questions that helped me make critical improvements to this thesis. I also want to thank everyone else at BPD for distributing the questionnaires.

Finally, I want to thank my family for supporting and believing in me during this period.

Milou van Muijden
Nijmegen, November 2020

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1. Introduction

In this introductory chapter, the need for the consideration of health in spatial planning will be elaborated. An explanation of the scientific and societal relevance of this topic will be followed by an overview of the knowledge gap this paper aims to address, which in turn will lead to the formulation of the research aim and research question. Finally, at the end of the chapter, the overarching structure of this paper will be explained.

1.1 Problem Statement

Around the globe, more than half the world's population lives in urban areas. In 2018, 55% of the population lived in urban areas; models have predicted that in 2050 more than 65% of the world's population will live in urban areas (Desa, 2019b; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006). The level of urbanization differs between different geographic regions. In Europe, 74% of people live in urban areas, which is higher than the global average (Desa, 2019b). Along with global population growth, international migration, and population ageing, urbanization is one of the four most important demographic mega-trends (Desa, 2019b).

Urbanization is linked by Desa (2019b) to three dimensions of sustainable development: environmental, economic, and societal. Also worth mentioning in this context are the Sustainable Development Goals (SDG) 2030, which are seventeen interlinked goals aimed at achieving a more environmentally sustainable future. For example, the third of these seventeen goals aims to promote well-being and healthy lives all around the world, a goal in which all ages are included (Desa, 2019a). The eleventh goal aims to make cities and human settlements inclusive, sustainable, resilient, and safe (Desa, 2019a). When urban areas are growing, city planners must keep an eye on the eleventh goal and ensure this growth happens in a sustainable way.

A great example of how the functioning of cities influences residents can be seen by looking back at the time of the cholera epidemic in 1840s London (Leon, 2008; McLeod, 2000). Water sources in the locations where the epidemic was at its worst were cut off, resulting in changes in the behavior of residents, who now needed to get their water in other parts in the city. Due to this cutting off of selected water sources, the epidemic declined (Mackenbach & Stronks, 2012). According to Grant (2015), creating a healthy environment is critical to achieving positive broad-spectrum health outcomes in European cities.

Leon (2008) states that there are four main factors that influence the health of people living in modern cities. The first concern has to do with the health and social problems of inner-city areas, particularly those of high-income countries. These problems are HIV/AIDS, drug addiction, and violence. Secondly, the welfare and health of a growing number of people in low- and middle-income countries who live in urban areas is an important factor. Third, epidemic diseases can thrive easily because there are more people living close to one another. Finally, there are rising levels of non-communicable diseases that are related to urbanization. This plausible connection between non-communicable disease and urbanization is affirmed by Wild, Roglic, Green, Sicree, and King (2004), who state that the number of people with diabetes is increasing due to population growth, ageing, urbanization, and an increasing prevalence of obesity and physical inactivity.

The European Commission also recognizes physical inactivity as a problem. In Europe, the average person sits for between two and eight hours a day (European Commission, 2017). As stated by Koyanagi, Stubbs, and Vancampfort (2018) "behaviors that involve sitting or reclining positions and low levels of energy expenditure (≤1.5 metabolic equivalents) during waking hours" can be described as sedentary. The connection between sedentary behaviors and negative health consequences has been made by Bize, Johnson, and Plotnikoff (2007), Koohsari et al. (2015), and Koyanagi et al. (2018) among others. These negative health consequences are seen in the increasing prevalence of type 2 diabetes mellitus, obesity, and various cardiovascular diseases.

Sallis, Linton, and Kraft (2005) have shown that the fourth era of physical activity research has begun. Their research focuses on a broad range of factors that may influence physical activity. These include urban planning, parks and recreation, transportation, and housing. All these factors are believed to have an influence on the high prevalence of sedentary lifestyles in modern times. The opposite of sedentary behavior, according to Sallis

et al. (2005), is "active living", in which habits of physical activity are incorporated into a person's daily routine. Sedentary behavior is part of an individual's lifestyle. However, in research the connection between sedentary behavior and the built environment is not often made (Maas et al., 2006). This is a neglected area of research despite the fact that the design of the built environment can be a very important factor in determining residents' lifestyles.

Combining an understanding of the built environment with an understanding of the design factors that determine civilian health could be beneficial. Rydin et al. (2012) state that the design and nature of the built environment is important for the health of residents; those features of city design that support health are increasingly considered to be of vital importance. From this perspective, an ideal approach to spatial planning would involve the collaboration of built environment professionals with health experts to develop city systems in which the health of residents is the central point of focus (Grant, 2015). Rydin et al. (2012) concur, stating that there is a need to direct effort toward creating and maintaining a city environment that produces beneficial health outcomes.

It hardly seems controversial to say that the everyday routines and settings a person moves through affect their health (Grant, 2015; WHO, 1986). Walkable neighborhoods are great examples of this fact, as they help to reduce overweight and obesity by promoting factors in the built environment that increase the physical activity of residents (Mayne, Morgan, Jalaludin, & Bauman, 2019; J. Yang & Zhou, 2020). The impact of design interventions in the urban built environment that stimulate physical activity will be the central focus of this master's thesis.

1.2 Scientific and Societal Relevance

1.2.1 Scientific Relevance

Since the early 2000s, there has been a notable increase in research and political interest regarding urban interventions that support physical activity (Ding & Gebel, 2012; Salvo, Lashewicz, Doyle-Baker, & McCormack, 2018). Most of this research has focused on cross-sectional studies. Cross-sectional studies have inherent weaknesses; they cannot provide temporal evidence, and the assumptions under which they operate can be biased (Salvo et al., 2018). According to Kaczynski and Henderson (2007) there is a need for case studies that examine the processes involved in the design of parks and recreation settings and their subsequent promotion for use for physical activity. Such case studies could also be used to evaluate the overall influence of urban environments on the physical activity of citizens. Rydin et al. (2012) also recognize the importance of research that elaborates on how the urban environment affects health outcomes. An example of these urban environmental factors influencing the health of residents is found in a study conducted by Creatore et al. (2016), who found that higher neighborhood walkability is associated with a decreased prevalence of overweight and obesity. But as is stated by Creatore et al. (2016) there is a need for studies that can show a causal relationship between the design of more walkable urban neighborhoods and an increase in physical activity. To investigate this hypothetical relationship, it may be worth looking to behavioral science theories. Within the behavioral sciences, there is still a lack of definitive evidence as to which strategies are most effective when it comes to influencing the physical activity of a person. Prins, Panter, Heinen, Griffin, and Ogilvie (2016) state that "[w]e are only just beginning to understand the pathways by which environmental changes may bring about changes in physical activity behaviors."

1.2.2 Societal Relevance

A study conducted as early as 1998 by Sallis, Bauman, and Pratt (1998) stresses the increasing number of people not meeting the recommended guidelines for physical activity. In 2016 at least five million deaths a year were attributed to physical inactivity (Sallis et al., 2016). The lack of physical activity is a problem that is more severe than is often thought. In the Netherlands, 45% of the population is doing the recommended amount of physical activity (Dutch Health Council, 2017). This means that more than half of the Dutch population is not physically active enough to meet the recommendations. As previously mentioned, insufficient physical activity can lead to negative health consequences such as type 2 diabetes mellitus, obesity, and cardiovascular diseases (Bize et al., 2007; Koohsari et al., 2015). A healthier society could be created and sustained through research

on the influences of the environment on health and the implementation of such research's recommendations in the construction or renovation of the built environment. Furthermore, there is a need for attention to be paid to health inequalities within urban areas (Rydin et al., 2012). Focusing on these inequalities could help in the process of designing or redesigning neighborhoods as living environments that improve health outcomes.

1.2.3 Knowledge Gap

Firstly, according to Grant (2015) research is needed that can analyze multi-disciplinary groups and communities in the process of gathering knowledge of the neighborhood characteristics that support health. Secondly, there is a need for interdisciplinary collaboration (Adlakha et al., 2017) when creating neighborhoods and cities that promote active living. Research also needs to include walking and bicycling as forms of leisure and transportation to understand physical activity behaviors (Frank, Hong, & Ngo, 2019; Porter, Salvo, Perez, Reininger, & Kohl III, 2018). Mertens et al. (2014) state that research is needed in different geographic areas to confirm their findings on cycle path infrastructure. Additionally, future studies should evaluate different built environmental determinants and the influence they have on the amount of cycling residents do (Mertens et al., 2017). There is a need for more studies in European cities that focus on providing information about the relationship between the built environment and different types of physical activity (McCormack et al., 2019; Robertson et al., 2012; Thornton et al., 2017). Lastly, when looking at the research literature on behavioral science theories, most of them observe influences at an individual level—the influence factors have on a single person. But research is needed on a much larger scale according to Forberger, Reisch, Kampfmann, and Zeeb (2019), especially when behavioral science is combined with spatial planning. Within this study there is a need for gaining knowledge regarding whether and how behavioral science approaches using specific architectural interventions influence the physical activity of residents.

1.2.4 Connecting Space2Move

This study will be connected to a research project conducted at the Radboud University in Nijmegen. Space2Move aims to redesign the built environment of region Arnhem-Nijmegen, with the purpose of increasing low-intensity physical activity levels across the sedentary population. Focusing on the stimulus needed to get people to become more active in their daily behavior, there are two possibilities. First, the design of the built environment could be more user-friendly when it comes to activity-based mobility. On the other hand, measures could be taken in the design of the built environment that would force people to become more physically active. The first solution involves nudging someone toward a certain behavior; the second involves designing the built environment such that a certain behavior is no longer possible—so that only the healthy and active way of moving is possible. Through the use of both techniques during the research conducted for Space2Move, an understanding of the most effective way to get people to become more active in daily life should begin to emerge. This thesis aims to develop design principles that can nudge people into more active daily behaviors. It also serves as an addition to the Space2Move research, while residents and people interested in living in Waalfront (Nijmegen) and Nieuwe Kade Kwartier (Arnhem) could be asked about their (future) preferences in active living neighborhoods.

1.2.5 Policy

In urban planning, health is taking a place of increasing importance in policy documents (Kamphuis, Schop-Etman, Oude Groeniger, & Van Lenthe, 2014). Policy frameworks that suggest an active lifestyle mostly focus on the need for change in physical, natural, and social environments (J. Barton & Pretty, 2010). J. Barton and Pretty (2010) also state that physical activity needs to be a part of people's daily routine.

Notable among such policy documents is a new law to be implemented in the Netherlands in 2022. Called the *Omgevingswet* (environmental law) this law states in Article 1.3 that it is important to achieve and maintain a safe and healthy physical living environment and good environmental quality (Ministerie van Infrastructuur en Milieu, 2016). This new law is in harmony with the third and eleventh SDG (Desa, 2019a). For this reason, it is important to know how to obtain these goals, which is one objective of this research.

1.3 Research Aim and Research Question

The aim of this study is to contribute to the realization of sustainable development by providing insight into the relationship between the built environment and the physical activity of residents in the neighborhoods to be developed. To ensure that all the possible effects of the built environment are taken into consideration, a detailed overview of the characteristics of the built environment will be provided (see Chapter 4).

The main research question is:
What is the impact of urban design interventions in neighborhoods on the physical activity (focusing on walking and bicycling) of residents?

A few sub-questions are needed to answer the main research question:

1. *What are the built environmental characteristics of an active living environment?*
2. *What different design principles can be found in the literature that, if followed, promote active living?*
3. *What are the target groups that are interested in or are currently living in the different locations?*
4. *How many respondents have lack of movement and are there differences between target locations?*
5. *To what extent has the physical activity of the respondents an impact on their preferences for an active living environment when choosing a new neighborhood?*
6. *What relationships are there between the physical activity of the respondents and the characteristics of the built environment in which they live?*

1.3.1 Hypothesis

This study has already made reference to a large quantity of information and theories. Additionally, a few questions have been raised. To answer these questions, two hypothesizes have been formulated. It will be possible to test and evaluate these hypotheses on the basis of the outcomes of the literature and survey research.

- The first null hypothesis to be tested is as follows: "There is no impact from urban design interventions in neighborhoods on the time residents spent walking and bicycling".
    - The alternative hypothesis associated with the first null hypothesis to be tested is as follows: "There is an impact from urban design interventions in neighborhoods on the time residents spent walking and bicycling".

- The second null hypothesis to be tested is as follows: "There is no relationship between the present physical activity and preferences for an active living environment of the respondents and their choices when selecting a new neighborhood."
    - The alternative hypothesis associated with the second null hypothesis to be tested is as follows: "There is a relationship between the present physical activity and preferences for an active living environment of the respondents and their choices when selecting a new neighborhood."

The concluding arguments in this report will indicated which hypotheses are to be rejected or accepted.

1.4 Document structure

The research question and sub-questions will be the guiding thread throughout this report. Chapter 2 will further elaborate on the societal and scientific relevance of these questions, with a more in-depth literature review of multiple concepts used in this research. In Chapter 3 the methodology used in this study will be explained, following which Chapter 4 will provide a literature review of the characteristics of the built environment. The results of the survey research will be presented in Chapter 5; these results will then be discussed in Chapter 6. Conclusions, along with recommendations for practice and further research, will be presented in Chapter 7.

2. Theoretical Framework

This chapter begins by explaining various concepts, including those of the built environment, urban design, health, and physical activity. This is followed by a look at the connections between these concepts, with a focus on walking and bicycling in the built environment. The nature of these connections will be elaborated with reference to behavioral sciences theories that explain how these conceptual factors relate to and influence each other. This discussion will result in a conceptual framework by the end of this chapter.

2.1 Explaining Concepts

What is the impact of urban design interventions in neighborhoods on the physical activity (with a focus on walking and bicycling) of residents? To answer this question, the different concepts within this question need to be defined. These can be listed as follows: the built environment, urban design, health, and physical activity.

2.1.1 Built Environment and Urban Design

According to Mittelmark et al. (2017, p. 172) the built environment is a complex system. Within this complex system there are various smaller systems, such as neighborhoods, schools, and workplaces. Besides these smaller systems, a large number of different factors are present in the city system. These factors, such as nature, people, and places, all influence one another. An example of the influence nature exerts is provided by Maas et al. (2006), who found that living in a neighborhood with a lot of green space correlates with a lower risk for mortality. Besides this they found evidence that the urbanity of one's surroundings makes a significant contribution to one's perceived general health. People living in a more rural environment tend to have better perceived general health (Maas et al., 2006). Rydin et al. (2012) state that the urban environment is the "physical context within which urban activities take place, including the material fabric of buildings and infrastructure and their spatial organization". Whenever the concept of healthy cities is mentioned, this means that the people living in the urban environment of such cities develop and experience good health (Mittelmark et al., 2017, p. 172).

The urban design of a place also exerts a strong influence on residents. The classical rational objective view of urban design is centered on the physicality of design styles, such as the way buildings open out into spaces, as well as the appearance of landmarks, ornamentation, and featuring (Montgomery, 1998). Urban design is thus the production of space (Carmona, 2014). In addition Carmona (2014) states that space is a social phenomenon that is created by everyone. This means that space, as a product of social interaction, is dynamically constructed by means of actions, things, ideas, representations, and experiences. Carmona (2014) states that "we all make the public realm and the public realm makes us". To take this one step further, urban design is a combination of critique and reflection, with a mixture of interpretation, analysis, and creativity producing new urban socio-spatial environments. It is a combination of the social sciences, the arts, and other humanities fields (Carmona, 2014). In addition to shaping and reflecting the social experience that is part of people's everyday lives, it is also linked to the natural environment and the physical spaces in which residents live.

A more recent perspective on urban design is brought to our attention by Sim (2019), who states that there are nine criteria for livable urban density. The nine criteria for a resilient, high-density, livable area are as follows: diversity of built form; diversity of outdoor spaces; human scale construction; flexibility; walkability; more diverse biodiversity; a pleasant microclimate; a lower carbon footprint; and a sense of control and identity (Sim, 2019). The diversity of outdoor spaces is a vital factor to support outdoor life, which is enabled by the presence of useful living spaces in compact urban environments (Sim, 2019). Walkability is another important factor, and relates to the smallest movements that people make every day (Sim, 2019). To make a comfortable and walkable city, it must be easy to move between buildings and neighborhoods. When a city has a pleasant microclimate, this can encourage people to go outside, walk, and bicycle around (Sim, 2019). It is important to look at high-density developments to improve the city (Sim, 2019). Schoner et al. (2018) state that dense, mixed, and compact built environments either promote or inhibit physical activity. According to Kamphuis et al. (2014) there is a plausible connection between physical activity and reviving dense and mixed areas. In this research different design principles will be used; these will be elaborated in Section 4.3.

2.1.2 Health, Lifestyle and Physical Activity

What is health? Health is a frequently used word, but what do people actually mean by it? In the literature there are various definitions of health. According to Sartorius (2006) there are three definitions of health. The first definition considers health to be "*the absence of any disease or impairment*". The second definition refers to health as "*a state that allows the individual to adequately cope with all demands of daily life*". The third definition states that "*health is a state of balance, an equilibrium that an individual has established within himself and between himself and his social and physical environment*".

The first definition mentioned by Sartorius (2006) corresponds with the definition provided by the World Health Organization (WHO), which defines health as "the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 2014). The second definition Sartorius (2006) provides has similarities to the salutogenic approach put forward by Antonovsky (Mittelmark et al., 2017, p. 7). The salutogenic approach to health assumes a focus on what makes people healthy, rather than on causes of disease. When applying the salutogenic model to thinking about the urban environment, it shifts the focus to be on the improvement of living conditions through the planning of health-promoting urban environmental developments (Mittelmark et al., 2017, p. 171). This corresponds with the work of Ward Thompson (2016), who concurs with the third definition provided by Sartorius and embraces the environment as a factor that influences the ability of a person to manage life.

In this research a combination of the second and third definitions of health will be used. It will be assumed that the built environment can influence the health of a resident in a positive or negative way, thus affecting the ability of that person to manage life. Therefore the health map created by H. Barton and Grant (2006) will be used to understand the relationship between health and the built environment (see Figure 1).

As reported by H. Barton and Grant (2006) modern city planning begun in the nineteenth century, starting as a reaction to basic health problems, though the strength of the connection between health concerns and city planning subsequently decreased. In modern times, numerous concerns have been raised by multiple researchers about the impact of the built environment on the health of residents (Bize et al., 2007; Leon, 2008; Sallis et al., 2005). In the health map (H. Barton & Grant, 2006) all the different factors of an environment are displayed as occupying different layers or spheres of socio-economic and environmental functioning. Additionally, the global region, including the cultural, economic, and political forces that are present in the area, also influence the residents living in these environments. The built environment sphere includes the planners who design it. Their design can influence the quality of the environment. For instance, a new road can influence the natural environment through air pollution. The design of the built environment can also influence the lifestyle people have, which might cause them to use their cars more or less.

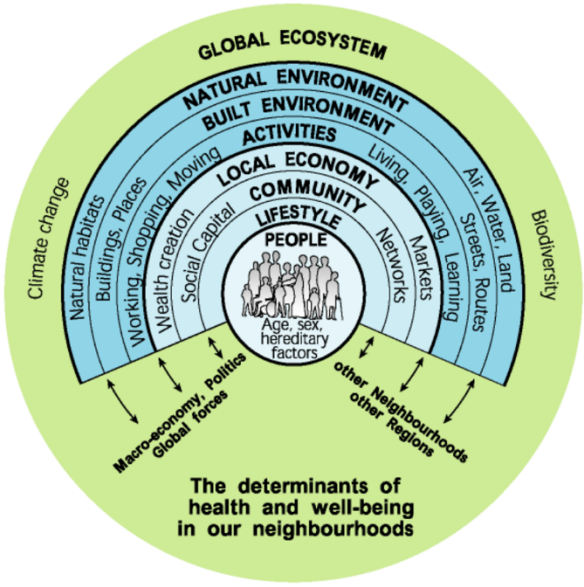


Figure 1: The Health Map (H. Barton & Grant, 2006)

Lifestyle is an important part of health. According to Antonovsky (1996) lifestyle is "the consciously chosen, personal behavior of individuals as it may relate to health." But it can also be seen as "a composite expression of the social and cultural circumstances that condition and constrain behavior, in addition to the personal decisions" (Antonovsky, 1996). Many health problems, such as obesity, cardiovascular diseases, and mental disorders are considered to be related to the lifestyles lived by those in western countries (Ward Thompson, 2016). One component of the lifestyle someone has is their level of physical activity. Physical activity in this

study will be measured as the number of minutes per day spent walking or biking for the purposes of transport or recreation. In the context of this study this is seen as the most informative information. As reported by Ball, Bauman, Leslie, and Owen (2001) physical activity has benefits for both psychological and physical health.

Connecting the concepts

The meaning of the terms *built environment*, *urban design*, *health*, and *lifestyle* has now been clarified. But how do these factors influence each other? First of all, to understand how these concepts influence each other, two behavioral science theories need to be explained. After this the impact of the built environment on health will be made clear, and a conceptual framework for understanding this impact will be presented.

2.2. Behavioral Sciences Theories

2.2.1 Nudging

A nudge "is any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any option or significantly changing their economic incentives" (Hansen, Skov, & Skov, 2016; Thaler & Sunstein, 2009). A nudge could be seen as a gentle push to make decisions that are in line with our wishes in the long term (de Ridder & Tummers, 2019). There are several ways in which nudging could be used in the environment to influence people. For example, when there are signs that lead to a garbage bin, people will be encouraged to put their trash in the bin (Vonk, 2013). According to Vonk (2013), a nudge is a boost or a reminder of desired behavior; thus the message needs to be clear and concise so that people can process the message without having to think deeply about it.

According to Saghai (2013) and de Ridder and Tummers (2019) there are two systems that explain how the mind processes information. Because of these two systems there are also two ways a nudge can influence a person's mind. The first system involves automatic decision processing (de Ridder & Tummers, 2019; Saghai, 2013). This system is heuristic, unconscious, uncontrolled, fast, and cognitively parsimonious (Saghai, 2013). The second system is based on conscious reasoning, which is associated with more cognitive effort; this system is analytical, controlled, slow, reflective, and conscious (de Ridder & Tummers, 2019; Saghai, 2013). The second system involves people thinking or even learning the skills needed to make difficult choices (de Ridder & Tummers, 2019). Both systems promote certain choices by making them easier than alternatives (Hansen et al., 2016). This means that there are three important nudge possibilities according to de Ridder and Tummers (2019). Firstly, there is the possibility of changing the default option with which residents are presented when performing certain actions. Secondly, the standard action with which residents are familiar can be used. Thirdly, the best option in a given situation could be made the simplest option.

According to Hansen et al. (2016) implementing a nudge could provide policy makers with an effective way to change the behavior of citizens without restricting freedom of choice, introducing new taxation or tax reliefs, or imposing mandatory obligations. But the implementation of a nudge could also be seen as a limitation of autonomy (Saghai, 2013). Autonomy is the ability to make authentic decisions and so express one's personal identity (de Ridder & Tummers, 2019). The implementation of a nudge is only acceptable when the prominent option can easily be resisted and the non-nudge option is accessible without much effort (de Ridder & Tummers, 2019). A nudge to improve the healthy behavior of citizens could be the accessibility of bicycle lanes and bicycle storage, or the offer of physical spaces to exercise in near where one lives (Duivenvoorden, 2018).

2.2.2 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) developed by Ajzen (1991) is shown in figure 2. According to Sun, Acheampong, Lin, and Pun (2015), the TPB could be used to develop interventions that promote walking. In this study the theory will be used to analyze why certain design principles (including those that stimulate walking) will work while others will not be effective. The TPB is based on three important factors that influence the intention a person has to eventually show a certain behavior; these will now be explained.

Attitudes towards the behavior

First of all, attitude needs to be explained. "An attitude is a disposition to respond favorably or unfavorably to an object, person, institution, or event" according to Ajzen (2005, p. 3). Attitude is in fact a hypothetical construct,

because is cannot be observed directly. It is the sum of the positive and/or negative beliefs a person has regarding a certain behavior (Ajzen, 2005). The *attitude towards the behavior* concerns how a person thinks about a certain behavior. If they have a favorable perspective of a behavior, they will mostly perform the behavior; if not they mostly will not perform the behavior (Ajzen, 1991). A person's attitude is always coupled with their perception, which, according to Alfonzo (2005), acts as a mediator of the need to walk and the eventual choice to walk.

Subjective norm

The *subjective norm* is a social factor. If there is social pressure to perform the behavior people will be more willing to perform a certain behavior. If there is no social pressure to perform a behavior, people will be less motivated to perform the behavior (Ajzen, 1991). According to Alfonzo (2005) the cultural belief system under which someone operates is an important determinant regarding whether someone sees the walking behavior as subjectively normal. In a culture where people understand the importance of walking, more people might walk. But in a culture where the importance of walking holds less weight, people will walk less.

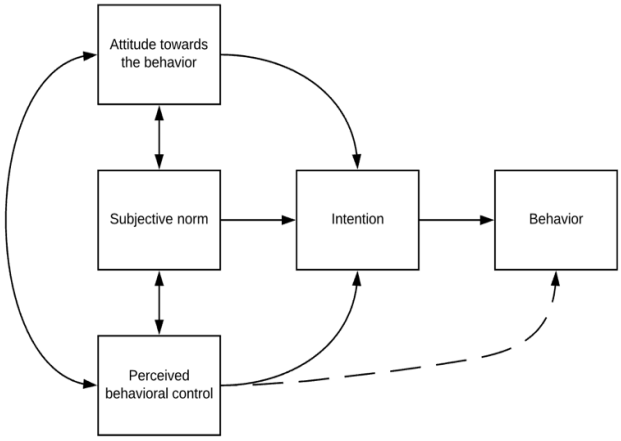


Figure 2: Theory of planned behavior (Ajzen, 1991)

Perceived behavioral control

Perceived behavioral control describes how strongly a person believes they can perform a certain behavior. If a person believes they can perform a certain behavior, typically they will be more likely to perform the behavior. If a person doubts themselves, then they most likely will not perform the behavior (Ajzen, 1991). An individual's perceived behavioral control is usually based on past experiences with that particular behavior. Sun et al. (2015) reported a consistent finding that perceived behavioral control is the strongest predictor for walking behavior and intentions. An important finding from Sun et al. (2015) stated that the perception of the ease of walking in a neighborhood was a strong indicator for people to go for a walk. This finding suggests that interventions to promote walking behavior as a flexible mode of transport could be successful (further elaborated in section 4.3). Ensuring the safety of walkers and placing benches along the street could also be seen as a trigger to walk more (Sun et al., 2015). A factor mentioned by Alfonzo (2005) that influences *perceived behavioral control* is the amount of barriers a person sees on the path to the destination. If a person believes that there are a lot of barriers, their perception of their own behavioral control is influenced in the direction of thinking that they cannot perform the behavior.

Intention

A motivational factor should also be present. Intentions are the indicators of how much effort a person is willing to give to change their behavior (Ajzen, 1991). Intentions also contribute to the realization of behavioral goals as they are to some degree within our free will. But intentions are not the only determinant of a behavior; as previously mentioned, being motivated does not necessarily mean that a person will perform a certain behavior (Alfonzo, 2005).

Behavior

All the factors mentioned above lead to a certain behavior (see Figure 2). In this study the behavior that is studied is the amount of walking and bicycling a person does and how this could be influenced by the environment, as well as how residents think about the infrastructure that might promote this behavior. The TPB could be valuable for explaining why certain people do walk and bicycle while others do not. In the next section

the personal factors that influence walking and bicycling will be explained, but first the impact of the built environment on physical activity will be elaborated upon.

2.3 Impact of the Built Environment on Physical Activity

Multiple researchers have looked for connections between the built environment and physical activity. A study conducted by McDonald et al. (2012) found that neighborhood density had no influence on physical activity and sedentary behavior, while another study found that a higher mix of land-use strengthens the walkability of a neighborhood, and that the number of people using a bicycle for transportation will be greater in more dense neighborhoods (Committee on Environmental Health, 2009). According to Lopez and Hynes (2006) there is a large quantity of research on suburban areas and a lack of research on inner cities regarding the connections between the structure of the built environment and physical activity. Paradoxically, in the suburban built environment, there is a connection found between low densities, lack of sidewalks, poor street connectivity, and the increased risk of obesity (Lopez & Hynes, 2006); however, inner city populations have higher rates of obesity despite there being better sidewalks and street connectivity (Lopez & Hynes, 2006). The relationship between built environment density and physical activity is established, but research is still needed to determine the impact of the built environment on physical activity. To understand the relationship between physical activity and the built environment better, physical activity will be separated into walking and bicycling behaviors.

2.3.1 Walking

Physical environmental factors that influence walking

Alfonzo (2005) proposed a hierarchy of walking needs (Figure 3). This hierarchy explains what is needed for people to walk. The most basic question to answer about the physical environment and its influence on walking behavior is "Is walking feasible?" This is a question about the practicality of a walking trip. Feasibility is an important factor because it influences the decision to either walk or use other forms of transportation. How much time a person has to walk is important, as this influences a person when deciding, for example, whether to walk, bike, or take the car to work or school. Accessibility is, according to Alfonzo (2005), the second most important factor influencing the decision to walk. If a walk is feasible then a person will decide if walking is accessible, which can be thought of in terms of the functional aspects listed in the model by Pikora et al. (2003) shown in Figure 4.

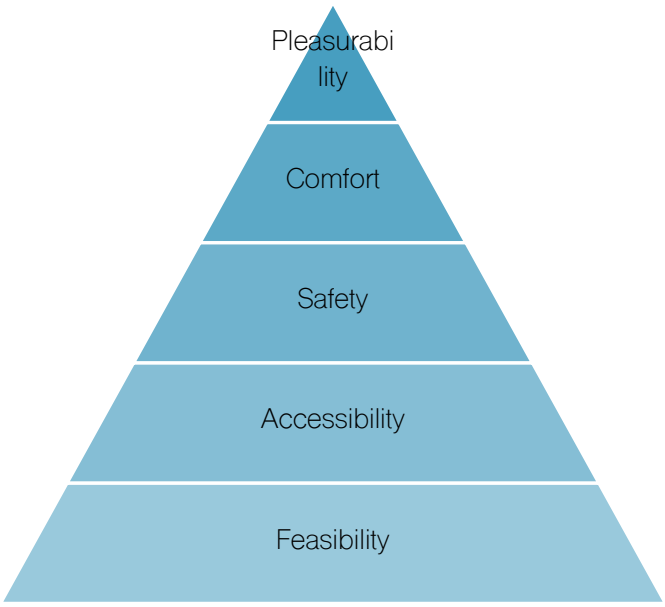


Figure 3: Hierarchy of walking needs (Alfonzo, 2005)

Pikora et al. (2003) use their model to determine the individual, social environmental, and physical environmental determinants of walking behavior based on the social ecological model of influences on physical activity, developed by W. Giles-Corti (1998). The functional factors named by Pikora et al. (2003) and the factors influencing accessibility by Alfonzo (2005), both include sidewalks, paths, surfaces, and trails. Safety is mentioned by both Alfonzo (2005) and Pikora et al. (2003), who see safety as a trigger for people to perform a physical activity. If a person does not feel safe in their neighborhood, they are less likely to walk. A safe environment needs to be provided, which includes safe pedestrian crossings and enough space to walk. A person also needs to feel safe enough in the environment to perform walking; in the late evening good lighting could influence the number of people who choose to take a stroll. Additionally, crime-ridden neighborhoods would have an influence on a resident's sense of safety while walking. According to Alfonzo (2005) nature in a neighborhood can increase the sense of safety a resident feels.

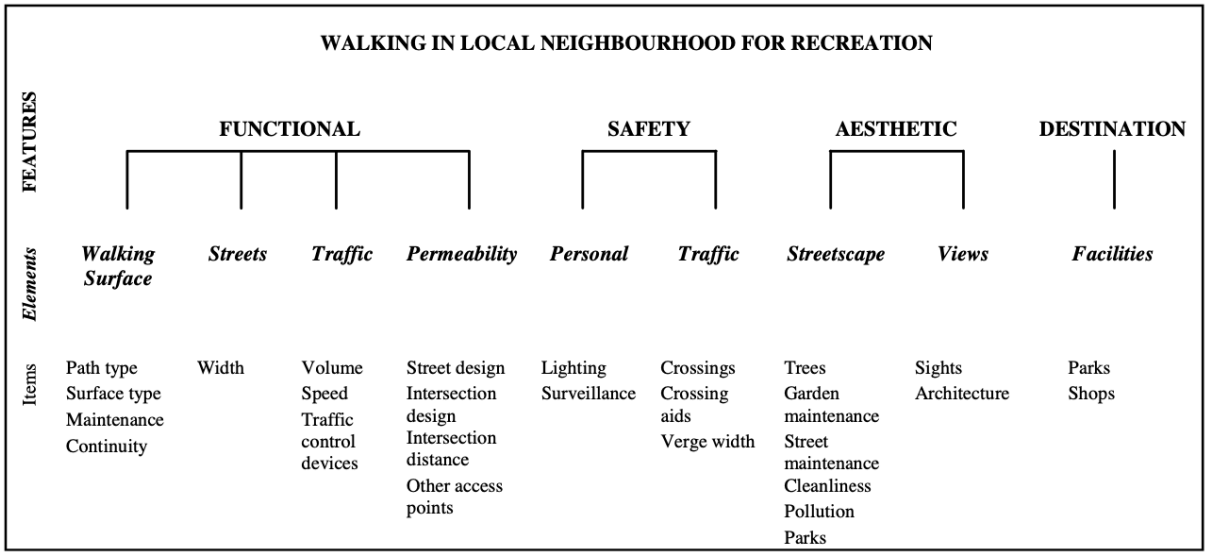


Figure 4: Model of the physical environmental factors that may influence walking for recreation in the local neighborhood (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003)

The fourth layer of Alfonzo's pyramid refers to the comfort a person experiences when walking around; here "comfort" refers to the level of ease, contentment, and convenience they experience. This is in line with the functional factors listed by Pikora et al. (2003), but contentment is in Pikora et al.'s view more congruent with aesthetic features. This means that the comfort a person experiences depends on environmental qualities, which can either promote or obstruct walking behavior (Alfonzo, 2005). The volume of the sound traffic produces is associated with the satisfaction a resident experiences; living in a low volume area is associated with walking behavior (Alfonzo, 2005). Sidewalks are an excellent example; when there are obstacles present they become barriers for the elderly and those travelling in buggies, whereas when there are few obstacles and sidewalks are perceived to be easy walkable the amount of walking increases (Alfonzo, 2005).

The fifth and last level of Alfonzo's pyramid refer to pleasurability. As reported by Alfonzo (2005), the environment is pleasurable when the setting is appealing for a person to walk in. This is in line the views of Pikora et al. (2003) regarding the aesthetic aspects of the environment. According to researchers, trees help to produce a better environmental perception.

The difference between Alfonzo (2005) and Pikora et al. (2003) is that Alfonzo sees the different factors that influence walking as a pyramid. The layers lie on top of one another, meaning that the criteria for one level need to be met before the next layer is worth considering. Pikora et al. (2003) sees the various factors as equal rather than hierarchically layered.

Personal factors that influence walking

The decision to walk, may be affected by a person's age (Alfonzo, 2005). Psychological health, physical mobility issues, and other health problems could make walking less feasible and influence the decision to walk, or mean that the option to walk is not available (Alfonzo, 2005). A person's weight is also an important factor in the decision to walk, as actual weight and the person's perception of their own weight can be a significant barrier to physical activity (Alfonzo, 2005).

2.3.2 Bicycling

Figure 5 shows the factors associated with the use and ownership of a bicycle (Handy et al., 2010). This figure will be used to explain the physical environmental and personal factors that influence bicycling. The individual and social environmental factors mentioned in the figure are the personal factors that influence bicycling behavior.

Physical environmental factors that influence bicycling

First of all, there are many different factors that influence bicycling behavior. As mentioned by Handy et al. (2010) land-use mix, retail, and service density are also important in stimulating bicycling behavior. If in a neighborhood there is more variety in terms of the use of land, there will be an increase in bicycle use. Secondly, bicycle lanes, separated bike paths, and bike friendly design are necessary for residents to bike safely or for bicycling to even be a feasible option (Handy et al., 2010). The case is the same for walking. If there is a lack of good infrastructure, people will see the danger in using a bike and therefore choose not to use a bike. Besides these factors, other circumstances over which little influence is to be had, such as the weather and hilliness of an area also impact the amount a person will be likely to bicycle (Handy et al., 2010; Stinson & Bhat, 2004). Riding a bicycle uphill is a difficult task for someone who is physically unhealthy. Bicycling in rainy weather or overly hot weather may make bicycling unpleasant or dangerous. A fourth important factor is the distance a person needs to bicycle (Handy et al., 2010; Stinson & Bhat, 2004). For a person to use a bike for the purpose of transportation to work the distance should not be too great; if it is, a car would be considered more favorable. Finally, safe and conducive traffic conditions are also important (Handy et al., 2010). This is in accord with the findings of Alfonzo (2005) and Pikora et al. (2003) on walking behavior. There is a need for safe pedestrian crossings and good street lighting to increase residents' bicycle use.

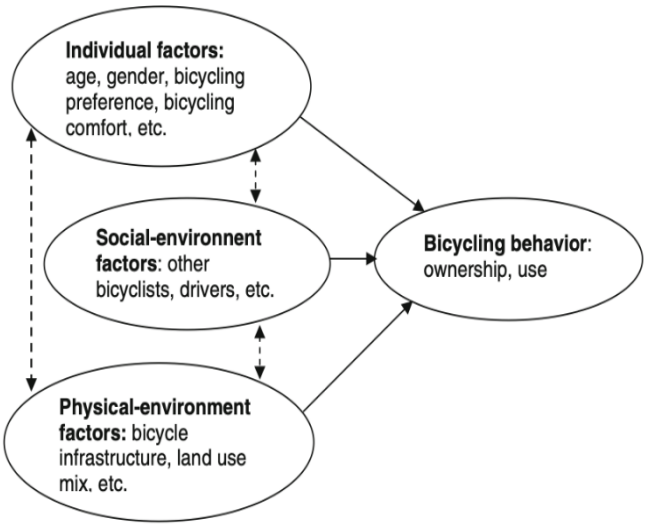


Figure 5: Factors associated with bicycle ownership and use (Handy, Xing, & Buehler, 2010)

Personal factors that influence bicycling

Gender, age and health are very important factors that influence a person in the decision to bicycle (Handy et al., 2010). The person needs to own a bike, otherwise bicycling is not possible. They could also be more stimulated to travel by bike if there are relatives who also bicycle. Because using a bike is more environmentally friendly than driving a car, ecological awareness could also weigh into the decision to use the bicycle (Handy et al., 2010).

2.4 Connection between Planning and Health

In this part of the chapter the connections between the above-mentioned concepts will be laid out. Making these connections is important since a study conducted by BPD (2019) mentions that the ideal livable neighborhood must include a green, natural environment; good connection to public transport; and acceptable infrastructure for bicycling and walking. These are the decisive factors for residents when choosing a new home. Besides these aspects BPD (2019) elaborates that of the top five housing requirements listed by respondents, living close to stores scores the highest. Developer BPD has included health as one of the four key aspects in realizing sustainable development (BPD, 2018a). The goal in developing neighborhoods that accord with these principles is to provide a healthy and livable area where people can thrive

As a starting point, to make the connection between planning and health, the schematic overview developed by Rydin et al. (2012) will be used (see Figure 6). According to Rydin et al. (2012) there are features in the built environment that influence health outcomes. They state that features in the built environment can facilitate physical activity by offering an infrastructure that is supportive. Such a supportive environment could be produced intentionally by following design principles in which nudges are implemented (Vonk, 2013). Aside from these

factors, Rydin et al.'s research also elaborates on why characteristics of land morphology, such as hilliness and land use, are important when looking at how to increase physical activity (Rydin et al., 2012).

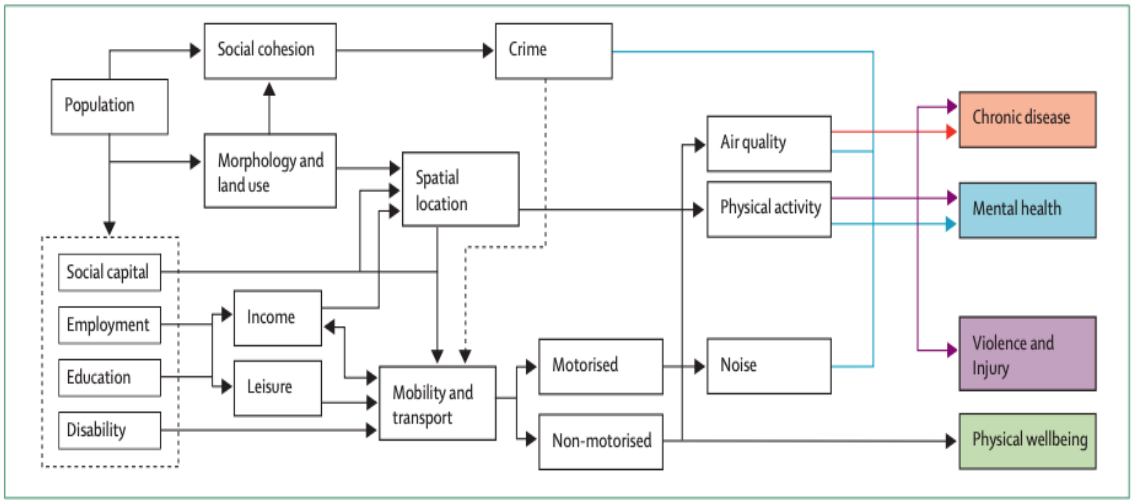


Figure 6: Urban connections between transportation and health (Rydin et al., 2012)

Based on this understanding of the built environment, urban design, the health map (H. Barton & Grant, 2006), physical activity (Handy et al., 2010; Pikora et al., 2003), behavioral science theories and the theory of Rydin et al. (2012), a conceptual model can be formulated. This model should also account for influences from the natural environment. Hartig et al. (2014) provide insight into how the natural environment can influence people to become more physically active. There are different pathways through which the natural environment can affect health, as an example being in contact with nature could increase walking for recreation (Hartig et al., 2014).

The conceptual model will explain why certain changes in the built environment will be effective in producing a positive influence on health outcomes. The conceptual framework presented in Figure 7 shows how some of the factors mentioned above influence each other. In Figure 7, the green squares represent factors associated with the TPB Ajzen (1991). The orange squares represent points at which a nudge could be implemented (Thaler & Sunstein, 2009; Vonk, 2013).

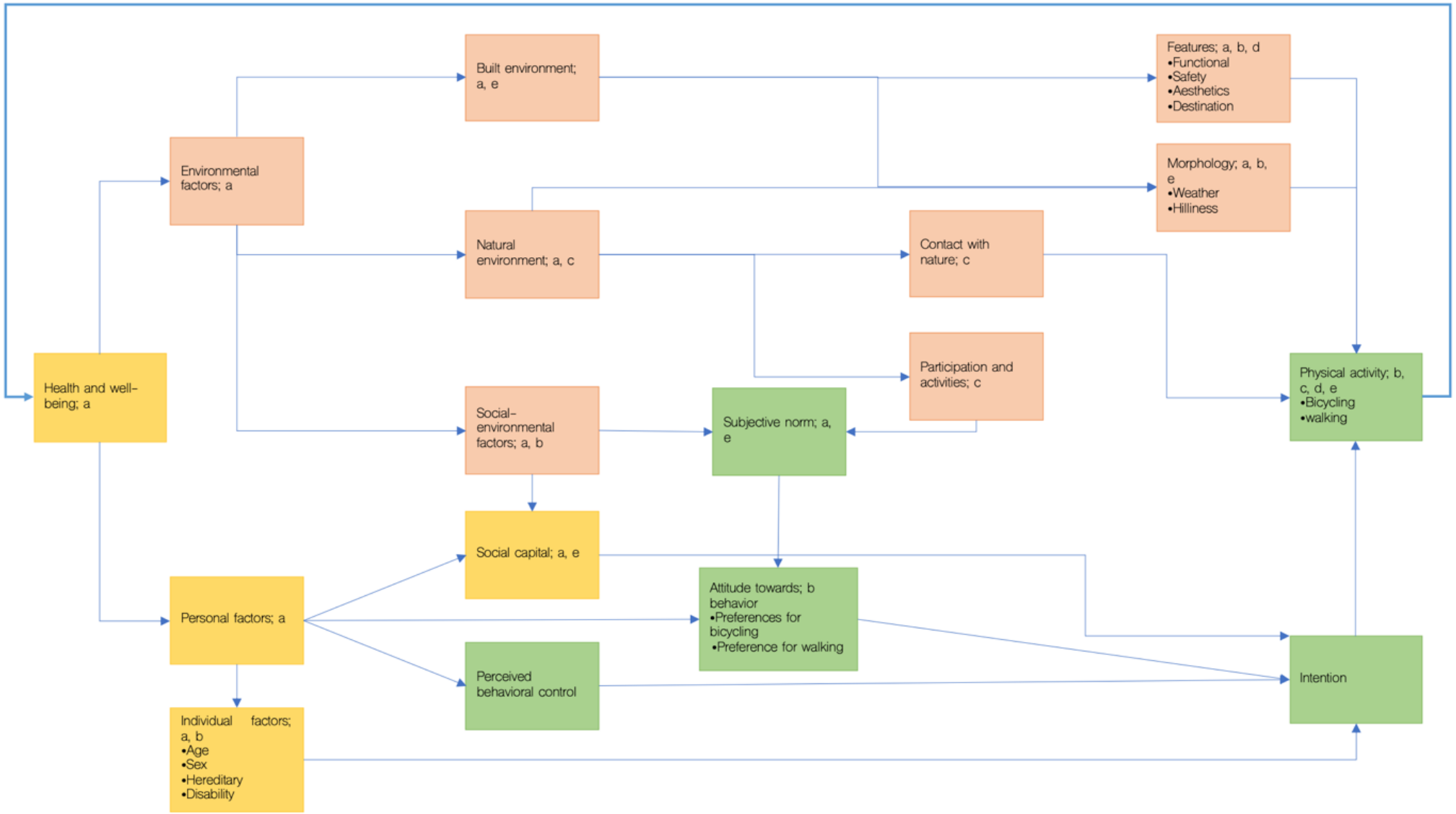


Figure 7: Conceptual model, a (H. Barton & Grant, 2006), b (Handy et al., 2010), c (Hartig, Mitchell, de Vries, & Frumkin, 2014), d (Pikora et al., 2003), e (Rydin et al., 2012), f (Ajzen, 1991)

3. Methodology

3.1 The Research Onion

Choosing the right research strategy is a difficult task. The "research onion" displayed in Figure 8 can assist us in making the right decision (Saunders et al., 2019). The figure shows the possible approaches in terms of data collection techniques and analysis. This figure will provide structure to the research process as we proceed, layer-by-layer, to outline the most favorable research strategy.

This chapter will begin with a section detailing the research process, following which the research onion will be dissected. Subsequently the validity and reliability of the research to be conducted will be addressed. Finally, ethical considerations will be discussed.

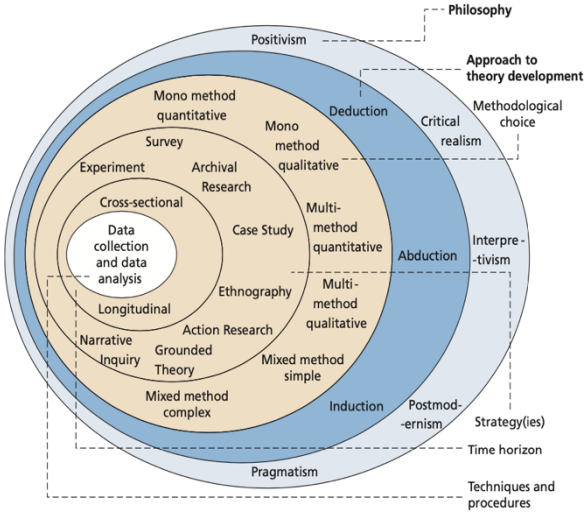


Figure 8: The "research onion" (Saunders, Thornhill, & Lewis, 2019)

3.1.1 Understanding the Research Process

According to Crotty (1998) there are two important questions that should serve as a starting point in developing research. The first question is "What methodologies and methods will be employed in the research we propose to do?" The second question is "How do we justify this choice and use of methodologies and methods?" To answer these two important questions a few additional questions need to be answered (Crotty, 1998).

- What *methods* do we propose to use?
- What *methodology* governs our choice and use of methods?
- What *theoretical perspective* lies behind the methodology in question?
- What *epistemology* informs this theoretical perspective?

These questions reflect the four elements of scientific research listed by Crotty (1998) in Figure 9.

Figure 9: Four essential elements of scientific research (Crotty, 1998, p. 4)

But what do we mean by the terms contained in these four questions? Clear definitions are necessary if we are to proceed.

- *Methods* are the procedures or techniques used to collect the data that is needed to answer the research questions; this term could be said to refer to the technical procedures of a discipline (Crotty, 1998, p. 3; Moses & Knutsen, 2012).
- *Methodology* is the strategy behind the choice of a particular method, also called the study of methods (Crotty, 1998, p. 3; Moses & Knutsen, 2012). Often the question "*How do we know?*" could be answered with reference to the appropriately selected methodology (Moses & Knutsen, 2012).
- The *theoretical perspective* provides the necessary context for the process; it is the basis for the evaluation criteria and logic (Crotty, 1998).

- *Epistemology*—the chosen theory of knowledge—is embedded in the theoretical perspective and the methodology (Crotty, 1998). Often the questions raised here are "*What is knowledge?"*(Moses & Knutsen, 2012) and *"How do we know what we know?"* (Crotty, 1998).

To understand the four essential elements of scientific research, there is the need for an explanation of the concept of *paradigms*. A paradigm is "a model or frame of reference through which to observe and understand" (Babbie, 2010). To recognize a paradigm is difficult; usually they are unconsciously embedded in one's view of the world. According to Babbie (2010), recognizing and deliberately selecting the paradigm we are using has two benefits. Firstly, it can help us better understand the actions and views of those who are, in our eyes, behaving irrationally. Secondly, stepping outside our own paradigm can help us to find a new understanding of how things are. When a paradigm is chosen, this displays the basic beliefs of the researcher and will serve as a guide to understanding the philosophy of the researcher.

3.1.2 Research Strategy

Research philosophy

First of all, the research philosophy is important; it specifies a system of beliefs and assumptions about the creation and nature of knowledge (Moses & Knutsen, 2012; Saunders et al., 2019). This research will make use of the post-positivist view of human knowledge. According to Creswell (2003) post-positivist assumptions reflect the traditional view of research. Research philosophy depends on *ontology*—assumptions about the nature of reality (Saunders et al., 2019). When asked "What is reality?", the post-positivist points to the notion of "critical realism". Critical realism states that 'real reality' is a thing that can never be found; it can only be imperfectly observed (Guba & Lincoln, 1994). This leads to research that is based in falsification of different theories. Epistemology deals with beliefs about knowledge—what we see as valid, acceptable, and legitimate knowledge, and how we communicate this knowledge to others (Saunders et al., 2019). The epistemology of post-positivism, sees new knowledge as being either created from existing knowledge, or gathered through observation of reality (Guba & Lincoln, 1994). A post-positivist will want to reduce ideas into small, discrete hypotheses that can be tested (Creswell, 2003). The theories and hypotheses that are tested aim to explain the things we see (Babbie, 2010). The knowledge they create is dependent on carefully made observations of the real world.

In this study, multiple theories will be tested and explained. These theories could help us to understand the choices a person makes when choosing a new neighborhood. They could also help us improve neighborhoods for the people who already live in them. The post-positivist view is ideal for a research project that aims to understand contexts in which the "real reality" is different for different people.

Research approach

Within scientific research there are multiple different research approaches to be found. These include inductive, deductive, and abductive approaches (Babbie, 2010; Saunders et al., 2019). A good example of deductive reasoning is the traditional model of science, in which, "[f]rom a general theoretical understanding, the researcher derives (deduces) an expectation and finally a testable hypothesis" (Babbie, 2010). Deductive reasoning occurs when the conclusion drawn is a logical next step from multiple premises; in such a situation, only when all premises are true is the conclusion true (Saunders et al., 2019). When deductive reasoning is used in research, the researcher most often begins with a literature search and then tests the theories found in the literature (Babbie, 2010; Saunders et al., 2019). Inductive reasoning is seen as the reverse to the approach taken in deductive research. In inductive reasoning, the data found during research supports the development of new theories (Saunders et al., 2019) that will later on be associated with the literature. For an inductive approach, it is advised to use a smaller sample than one might for a deductive approach. The third research approach, abduction, uses a bit of both of the other approaches. An abductive approach moves back and forth between theory and data (Saunders et al., 2019). Often such research will begin with an observation that will lead to a plausible theory that explains the observed phenomenon.

This study will make use of the deductive reasoning approach. First the academic literature will be consulted for information about particular topics and theories; these findings will be formulated into hypotheses which can be tested through the research process.

Methodological choice

Moving on to the next layer in the research onion, the choice of methodology must be explained. Two possible methodologies suit the purposes of this study: mono method quantitative and mono method qualitative. The difference between quantitative and qualitative is easy to understand. *Quantitative* studies typically use numerical data (closed-ended questions in a questionnaire), while *qualitative* studies typically uses non-numerical data (open-ended questions in an interview) (Saunders et al., 2019). It is also possible to mix quantitative and qualitative research; this is called a mixed methods research design.

For this study a quantitative research design will be used. According to Saunders et al. (2019) quantitative research is often seen in combination with a post-positivist view of human knowledge. Within quantitative research the relationship between variables is examined. Variables are measured numerically and analyzed using a range of statistical techniques. In this study, multiple questionnaires will be used, but as the study uses a single data collection technique this will be a mono-method quantitative data study (Saunders et al., 2019).

Strategy

The next layer of the research onion is the research strategy. For quantitative research there are two possible research strategies, experimental and survey research. Within this study, a survey strategy will be used; this is also often associated with the deductive research approach (Saunders et al., 2019; Van Thiel, 2014). According to Babbie (2010), for a typical survey there are a few steps that need to be taken. First, the researcher selects a sample of respondents. Within this study there will be two different groups of respondents; consequently two different questionnaires will be used. Most often the questions in a questionnaire start with 'what', 'who', 'where', 'how much' and 'how many'. The questionnaires will be standardized with minor differences, which are elaborated in Section 3.1.3. Using a survey strategy will provide more control over the research process, and is also advantageous in that population data can be easily collected (Saunders et al., 2019). The units of analysis in this study will be the individual people who complete the questionnaire (referred to as "the respondents"). A survey can be used to collect new factual information, but can also be used to collect people's opinions of and attitudes towards a certain phenomenon (Van Thiel, 2014). Because of the two different questionnaires used in this study, two different relationships can be researched. On the one hand it will be possible to gather information about the impact of built environmental characteristics on the physical activity of the respondents. On the other hand, the preferences of the respondents with regard to an active living environment and its importance in their minds when choosing a new neighborhood can be evaluated.

Time horizon

As a researcher there are two options for the time horizon of a study: longitudinal and cross-sectional. Within the time limit of a master's thesis only a cross-sectional study is possible. The collection of data took place at one point in time (Babbie, 2010). Most often a cross-sectional study has an exploratory or descriptive character (Babbie, 2010). An exploratory study is often used to clarify the understanding of an issue, problem, or phenomenon (Saunders et al., 2019). A descriptive study is used to gain information about a certain situation. It is necessary to have a clear view of the phenomenon a study is intended to investigate so that the data collection can be specifically focused on that phenomenon (Saunders et al., 2019). A study may also be characterized as explanatory. Within explanatory research, the study is focused on a phenomenon or situation, and wants to explain the relationship between the variables it involves (Saunders et al., 2019).

This study will be both descriptive and explanatory in nature. As pointed out by Saunders et al. (2019), often studies in management research combine these two approaches into a 'descripto-explanatory' study. This research will describe certain phenomena while seeking and hopefully gaining new information about the relationship between the variables those phenomena involve.

Answering the research questions

In Section 1.3 a few sub-questions were raised. This section will explain which part of the research answers each question. The first sub question, *"What are the built environmental characteristics of an active living environment?"* is answered through the literature search in Sections 4.1 and 4.2. "*What different design principles can be found in the literature that, if followed, promote active living?"* is answered in Section 4.3. A third question

that was raised, "*What are the target groups that are interested in or are currently living in the different locations?".* To answer this question, Questionnaire I and II (Appendix I and II) were used. The outcomes are elaborated in Section 5.2. The fourth question, *"How many respondents have lack of movement and are there differences between target locations?"* is answered in Section 5.3, also with the use of Questionnaire I and II. The fifth question, *"To what extent has the physical activity of the respondents an impact on their preferences for an activing living environment when choosing a new neighborhood?"* is answered in Section 5.4, leaning on the data provided by the answers to Questionnaire II. Finally, the sixth question, *"What relationships are there between the physical activity of the respondents and the characteristics of the built environment in which they live?"* is answered in Section 5.5. Questionnaire I and II were very important in answering this question. A combination of the answers to the sub-questions will provide an answer to the main research question of this study, "*What is the impact of urban design interventions in neighborhoods on the physical activity (focusing on walking and bicycling) of residents?*".

3.1.3 Research Methods

Techniques and procedures

To gather the necessary result for this research, multiple validated questionnaires were combined. These questionnaires will be elaborated upon in this chapter.

- SQUASH-questionnaire (SQUASH stands for "Short QUestionnaire to ASsess Health-enhancing physical activity") (de Hollander, Milder, & Proper, 2015)
- The Place Standard (Scottisch Government, 2018)
- Neighborhood Environment Walkability Scale (NEWS) (Saelens & Sallis, 2002)

SQUASH-questionnaire

The first questionnaire used is the SQUASH questionnaire (de Hollander et al., 2015). This questionnaire is used to assess a person's physical activity. It is based on the Dutch norm for healthy physical activity, "Nederlandse Norm Gezond Bewegen". The questionnaire asks questions about the frequency, duration, and intensity of four physical activities; travel; household chores; sports; and spare time. The higher the score at the end, the more time a person is investing in physical activity.

In appendix I (Q13, Q14, Q15, Q16, Q17) and II (Q9, Q10, Q11, Q12, Q13) the questions are used to get to know the amount of physical activity a person engages in each week. It is important to know how physically active a person is, as this greatly influences their overall health (see Section 2.1 *Health, Lifestyle and Physical Activity*).

The Place Standard

The "Leefplekmeter" (Acda & van Bruggen, 2019) is the Dutch version of the "Place Standard" used by the Scottisch Government (2018) (see Figure 10). This is a questionnaire that has residents of a particular neighborhood rate the area in which they live. The Place Standard is meant to detect the positive and negative attributes of a neighborhood; the results can be used to understand what needs to be improved. Within the Place Standard there are 14 themes, as shown in Figure 10. For this study almost all the elements are examined—only work and local economy are excluded ("werk en werkgelegenheid"), as they are not of importance to this research. To make the questionnaire more usable, some questions have been combined or asked in a different way.

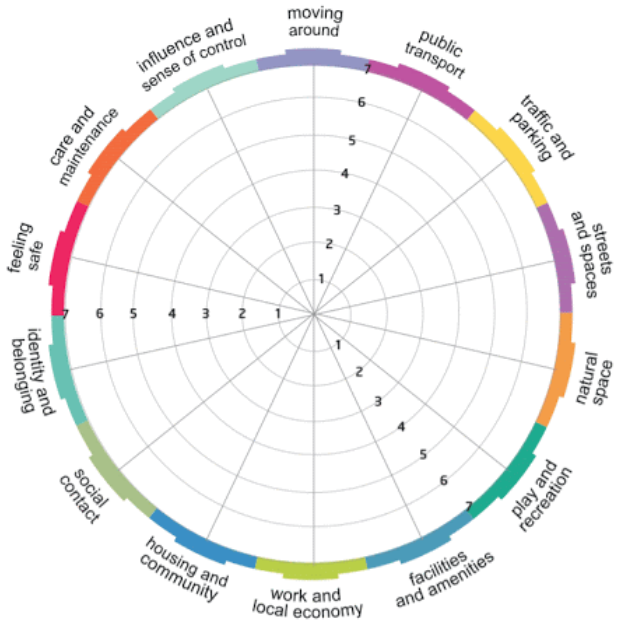


Figure 10: The Place Standard (Scottisch Government, 2018)

In Appendix I, from Q18 up to and including Q26 and in Appendix II, from Q14 up to and including Q23, the

questions are based on the questions used in the Place Standard. In Appendix II, Q14 is about the perception of the current neighborhood of the respondent. Questions Q15 up to and including Q23 (Appendix II) are designed to uncover the desires of the respondents for their future neighborhood. In Appendix I the questions are designed to establish whether the residents are satisfied with their neighborhood it its current state.

NEWS

As an addition to the Place Standard, the rating scales of the Neighborhood Environment Walkability Scale (NEWS) (Saelens & Sallis, 2002) are used to make the Place Standard easier to analyze. The scales used in Questionnaires I and II present the following options: *strongly disagree*; *disagree*; *agree*; *strongly agree*; *very unimportant*; *unimportant*; *important*; *very important*.

Combined Questionnaires

Through a combination of the three questionnaires listed above, two new questionnaires were developed. These questionnaires are made for two different target groups—the "interested" (Appendix I) and the "residents" (Appendix II). The questionnaire for the "interested" group were distributed among future residents of the two locations chosen for this research. The "residents" questionnaire will be used for residents already living in Waalfront, Nijmegen. The questionnaires will be distributed among respondents by means of the online survey program Qualtrics.

Because of the differences between the two target groups, a few changes to the questionnaires were required. To understand the "interested" target group, there is a need to gain knowledge about the environment they are currently living in. Therefore, this questionnaire has an additional question in Appendix I, Q14. Questions asked about their current living environment are important, as the current neighborhood characteristics could be affecting their physical activity.

Data collection

Questionnaire I was distributed to people interested in living in these locations. This was done by means of the mailing list used for the BPD newsletter. Recipients of this newsletter were asked to fill in the online questionnaire. A link to the questionnaire was also placed in the news section of the location specific websites. To survey respondents living in Waalfront, personal connections of the researcher were used. Questionnaire II was distributed online through WhatsApp and Facebook.

Participants

The two locations used in this research are Waalfront (Nijmegen) and Nieuwe Kade Kwartier (Arnhem). Further on in this section these two locations will be described in more detail.

Waalfront, Nijmegen

On the first of January 2020 there where 177,670 people living in Nijmegen (Gemeente Nijmegen, 2020). The population is growing and new homes are needed. Housing market research in Nijmegen showed that the housing market is under intense pressure (Klaver, 2020b).

Development of the former industrial area Honigterrein in Nijmegen—marked in red in Figure 11—is part of the solution. The development of this location is being done by a joint venture called "Ontwikkelingsbedrijf Waalfront" (OBW) (Nozeman, Fokkema, Laglas, & van Dullemen, 2008). This joint venture is a collaboration between the municipality of Nijmegen and BPD. Within this joint venture, both parties put in equal financial investments and share the risks involved. BPD hold 75% of the development rights; the other 25% will be divided through a tendering process (Nozeman et al., 2008).

Figure 11: Development of Waalfront Nijmegen (BPD, 2020b)

The area is divided into six sub-areas: Handelskade, Dijkkwartier, Waalkwartier, Park Fort, Krayenhoff;, and Koningsdaal, each of which have their own characteristics (BPD, 2020b). Nature will be a primary consideration within the developed area; ensuring that the Waal (which is the river next to the development area) is integrated into the area is part of the planned development. Green spaces will be connected throughout the entire area. Focus in the sub-areas will be on multiple target groups with their own characteristics. Different target groups, are already present in the areas of Koningsdaal and Handelskade (Klaver, 2020b). The current population in Koningsdaal is mostly of the "Plan and Run" variety. Handelskade, by contrast, has a population in which "Young and Hopeful" residents are over-represented. These categories will be further explained in section 3.2.

Nieuwe Kade Kwartier, Arnhem

At the beginning of 2020, there were 161, 322 persons living in Arnhem. The amount of people living in Arnhem is projected to continue increasing (AlleCijfers.nl, 2020; Rothoff, 2020). Growth in the population will occur mostly among those aged 45 years and older. Among residents aged 65 and older there will be growth from 17,000 to 22,700 in the year 2030 (Klaver, 2020a). The current population in Arnhem can be divided into four main target groups: "Dreaming and Getting By"; "Young and Hopeful"; "Community and Outspoken"; and "Just Average". These categories will be further explained in Section 3.2.

The former industrial area "de Melkfabriek Coberco" (the red area in Figure 12) is going to be developed. New homes will be constructed in order for the area to catch up with the growth of the population. BPD (2018b) has three important pillars on which they are focusing in the process of developing the Nieuwe Kade Kwartier. They are aiming to build a healthy city, with an environment that offers a mixture of character and inspiring trendsetters. Sustainability is also considered to be a very important factor in the development of this new neighborhood. Four sub-areas will be developed—"Het Cobercoterrein", "De Melkfabriek", "Het Gashouderkwartier", and "Rijnwijk" (BPD, 2020a). There will be a total of 800 new homes. In this development the municipality occupies the role of facilitator, whereas BPD is the owner of the plot.

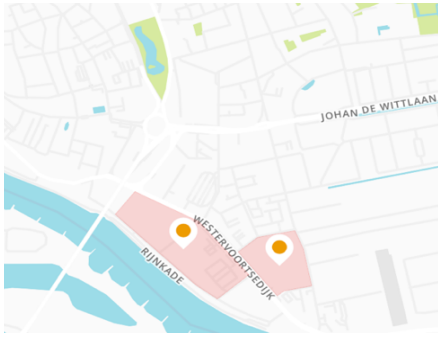


Figure 12: Development Nieuwe Kade Kwartier, Arnhem (BPD, 2020a)

Connecting the locations

These two different locations were chosen because of their similarities in terms of developer ambition to create a healthy and livable neighborhood. Another important factor is that the same design principles could affect people differently in different environments. For this reason it is important to look at more than one location.

3.2 Data Analysis

Preparing the data for analysis

The data analysis began with exporting the data from Qualtrics to the statistical program SPSS. Respondents not interested in living in Arnhem/Nijmegen were excluded. Respondents who filled in 0% of the questionnaire were also excluded. The missing values were added before analysis began. Changing some variables was necessary for analysis. The variable representing the answer to the question that asked respondents for their year of birth was changed into a variable showing their age. To create categories for the ages of the respondents, a new variable was created with age categories, which spanned from <24 up to 75+. After these alterations the target groups the respondents belonged to could be determined. Using the Whize method (WhoozBV, 2019) a new variable was created that included all possible target groups. This variable was a combination of the questions about the number of persons in the household, the education level of the individual, their average monthly income, what kind of house they preferred, and the age category to which they belonged. In Table 1 and Figure 13 the different target groups are shown.

A	Dromen en Rondkomen	Dreaming and Getting By
B	Jong en Hoopvol	Young and Hopeful
C	Volks en Uitgesproken	Community and Outspoken
D	Bescheiden Ouderen	Modest Elderly
E	Stedelijke Dynamiek	Urban Dynamics
F	Gewoon Gemiddeld	Just Average
G	Gezellige Emptynesters	Cozy Emptynesters
H	Landelijke Vrijheid	Rural Freedom
I	Plannen en Rennen	Plan and Run
J	Zorgeloos Actief	Carefree Active
K	Luxe leven	Luxury living

Table 1: Target Groups—Whize Method

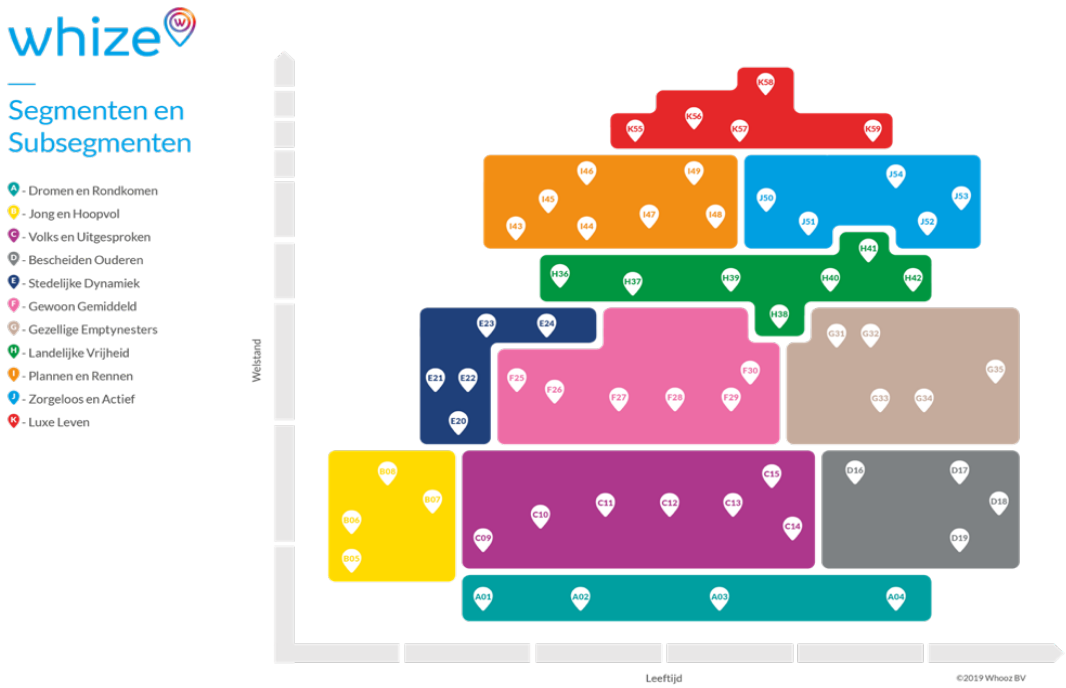


Figure 13: Target Groups—Whize Method (WhoozBV, 2019)

Descriptive statistics

Initial analysis of respondents segmented them using the descriptive data gathered and frequencies of demographic specifics. This was followed by the determination of the target groups using the newly made variable as explained above. Because an outcome represented multiple target groups, the focus was on the location-specific target groups. When multiple target groups could be coupled to an individual the location-specific target group was chosen.

MET-score

The next analysis was performed using the outcomes of the SQUASH questionnaire. The MET-score needed to be calculated for three factors: sports, travel, and spare time. First of all, the MET-scores for the different sports needed to be determined. Using the Compendium of Physical Activity the MET-scores were established. The average amount of minutes spent engaged in each activity was entered into each equation. The MET-scores could be calculated using the following equations:

$$METscore(sports) = (METscore\ sport\ 1 \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ sport\ 2 \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ sport\ 3 \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ sport\ 4 \times average\ amount\ of\ minutes \times days\ per\ week)$$

$$METscore(travel) = (METscore\ walking \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ bicycling \times average\ amount\ of\ minutes \times days\ per\ week)$$

$$METscore(Spare\ Time) = (METscore\ walking \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ bicycling \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ gardening \times average\ amount\ of\ minutes \times days\ per\ week) + (METscore\ DIY \times average\ amount\ of\ minutes \times days\ per\ week)$$

$$METscore(total) = METscore(sports) + METscore(travel) + METscore(Spare\ Time)$$

Establishing whether a person had lack of movement was done using their MET-score. A score below 1000 MET is related to lack of movement, a score between 1000 and 1500 MET indicates a person who moves just enough. A MET-score above 1500 means that a person is physically active during the week.

The Place Standard

The Place Standard was used to determine the preferences of the respondents regarding their future neighborhood. For this analysis the answers gathered using the "interested" questionnaire' (Questionnaire II) were used. Because of the answer categories (*very unimportant*; *unimportant*; *important*; *very important*) preferences could be easily determined. To measure the internal consistencies between multiple questions asked in the questionnaire, the Cronbach's alpha was calculated. In Table 2 the Cronbach's alpha is provided for the questions that are combined. These categories were used to analyze the preferences of the respondents.

	Question	Cronbach's alpha
Greenery	16.3, 16.4, 16.5	0.834
Public space	16.1, 21.3, 21.4, 21.5	0.778
Public transport	17.1, 17.2, 17.3	0.824
Feeling safe	15.6, 21.1, 21.2	0.730
Participation in decision making	23.1, 23.2, 23.3	0.855
Recreation	20.1, 20.2, 20.3	0.776
Facilities	19.1, 19.2, 19.3, 19.4	0.783
Infrastructure for walking and bicycling	15.1, 15.3, 15.4, 15.5, 15.7, 16.2	0.754

Table 2: Cronbach's Alpha

To answer the question *"To what extent has the physical activity of the respondent and impact on their preferences for an active living environment when choosing a new neighborhood?"* an ordinal regression analysis with the use of SPSS was performed. To perform this analysis a few assumptions had to be checked:

- Dependent variable is ordinal
- Independent variable is continuous, ordinal, or categorical
- There is no multicollinearity
- There are proportional odds

The dependent variables are the results from the various questions about the respondent's preferences regarding their future neighborhood. This is an ordinal variable because of the different possible outcomes (very unimportant; unimportant; important; very important), so the first assumption is valid. The independent variable was "bewegingsarmoede", which is a categorical variable, so the second assumption is valid. The third assumption regarding a lack of multicollinearity is also valid as no more than one independent variable is used. The fourth assumption was tested for every analysis. This was done using the "test of parallel lines"—if the

outcome was bigger than .05 than the last assumption was considered to valid and the ordinal regression analysis could be conducted. Only the analyses that met these assumptions will be further elaborated.

Answering the question "*What relationships are there between the physical activity of the respondents and the characteristics of the built environment in which they live?"* a correlation was calculated between the current living environment of the respondents and the MET-score they received due to their activity levels.

3.3 Validity and Reliability of the Research

There are three possible sources of interference with the reliability and validity of a questionnaire: non-response, inadequate operationalization of variables, and respondents exhibiting confounding answering tendencies (Van Thiel, 2014).
The external validity of the questionnaire could be influenced by non-response. If someone decides to not respond to the questionnaire, this could have an influence on how representative the sample really is (Van Thiel, 2014). If a lot of respondents decide not to respond, there is the chance of gathering too small a sample for statistical analysis. The internal validity of the questionnaire depends on the adequate operationalization of variables (Van Thiel, 2014). Thus it is important to properly formulate the items in the questionnaire. Respondents could also display confounding answering tendencies due to being aware that they are in a research situation and so choosing to give socially desirable answers (Van Thiel, 2014).

According to Van Thiel (2014), to conduct reliable research there needs to be accuracy and consistency in how variables are measured. If variables are measured accurately and consistently, there will be more certainty that the results will not be coincidental. Therefore, this study made use of validated questionnaires. Also, there is a need for a sufficient number of respondents. To improve the reliability of the research, a database was created in which the answers of the respondents were stored. Furthermore, the steps taken in the study are provided in the data analysis section above. The combination of the database and the steps taken during the analysis will ensure that the research can be reviewed and checked later (Van Thiel, 2014). Due to the use of literature supporting the methods used, and the use of questionnaires, triangulation could take place (Van Thiel, 2014).

According to Regmi, Waithaka, Paudyal, Simkhada, and van Teijlingen (2016) there are a few ethical considerations that need to be taken into account while conducting this research. First of all, the privacy of the participant in the questionnaires needs to be handled with care, and participants need to be informed about the possibility of withdrawing from the process of completing their questionnaire whenever they want. Participants also need to be properly informed regarding the content of and reasons for the research. Consequently this study's respondents were informed that the data collected may be used for further research by Space2Move.

4. Operationalization

In this chapter, in-depth desk research will be conducted to evaluate the impact of the built environment on physical activity, especially walking and bicycling. This desk research is important both to understand which built environment characteristics influence the physical activity of residents, and to understand what the different built environment characteristics are. Based on these findings the built environment characteristics that are found will be used in the questionnaire based on questions taken from the Place Standard and the NEWS. After the built environment characteristics have been explained, a few design principles will be illustrated.

4.1 The Academic Literature

4.1.1 Literature Search in Web of Science

To answer the sub-question "*What are the built environmental characteristics of an active living environment?"* there first needs to be an in-depth literature review. A search-question was developed to find the current literature focusing on both the built environment and physical activity. Because different articles may use different terminology, the terms were first operationalized, and multiple different terms were used. Wherever the term "health" was used, "well-being" was added to the search string. To narrow the search in Web of Science, only the term "built environment" was added, as expanding it with "environment*" OR "physical environment" yielded a total of 2,136 articles. The term "NOT food" was added as many articles included diet research, which was not the focus of this study. The search term "intervention" was also added to narrow down the articles found; if this was not included the search returned 2,328 articles.

The following search string was used in Web of Science:
((health OR well-being) AND (influenc* OR impact* OR relation* OR pathway* OR associate*) AND (built environment) AND (physical activity) AND (intervention) NOT (food))

The search string was entered on March 24, 2020, and resulted in 486 articles. The first selection was made, based on the title and the abstract. If these included "built environment", "health", or "physical activity" the articles were read. Articles published in the years 2010-2020 were included from the research. When the age of the participants was below eighteen the study was excluded. After this selection was made there were 248 articles that matched the criteria. The articles were scanned, 56 articles were indeed relevant for the research and remained for the literature review.

On 27 April 2020 there was an addition made to the search string to verify that the search string included all built environment characteristics needed for the research. If the search term for "physical activity" included "OR bicycl* 'OR walk*", a total of 516 articles were found. After examining the different articles returned by this search, 21 articles were found that had not appeared in the previous search, one of which was included in the research. The other articles were not relevant for this research. However, no new built environment characteristics were found, meaning that the current selection of built environment characteristics is all inclusive.

Based on the work of Adlakha et al. (2017), the following environmental characteristics were used in the examination of articles and the perceived quality of the environment: residential density, land use mix diversity, land use mix accessibility, street connectivity, infrastructure and safety for walking and bicycling, aesthetics, traffic safety, and safety from crime. Christian et al. (2013) and Liao, Shibata, Ishii, Koohsari, and Oka (2018) and many others also mentioned access to public transport as an influencing factor, so this has also been included in the list of characteristics. "Access to green space" was added during the literature research as Pearson, Bentham, Day, and Kingham (2014), Y. Yang et al. (2019), and Koohsari et al. (2017) all found a relationship between physical activity and green space. Walkability is most often split in different characteristics of the built environment, but some articles include walkability as a characteristic Therefore walkability was include as a built environmental characteristic (Bourke, Hilland, & Craike, 2018; McCormack et al., 2019). Street lighting was also mentioned as an environmental characteristic by Stewart et al. (2016), Zwald, Hipp, Corseuil, and Dodson (2014), and Foster et al. (2016). In Appendix III a table containing the literature overview of 57 articles can be

found. In Appendix IV a table with the various built environmental characteristics and their influences on walking and bicycling are shown.

4.2 Built Environmental Characteristics

4.2.1 Residential Density

According to Saelens, Sallis, and Frank (2003) *residential density* refers to "[t]he number of residential dwelling units per unit of land area." Using the questionnaires, occupants of various types of neighborhood residences were surveyed (see Appendix II, Q14a). Evaluating the characteristics of each of the four locations could help determine the residential density of these areas.

Residential density and walking

Literature about residential density and walking led to the uncovering of a few associations and significant outcomes. First of all, Adlakha et al. (2017) and Van Dyck et al. (2013) found a significant correlation between residential density and walking for leisure purposes. Higher residential density in an area are correlated with more walking among residents. Multiple other researchers found an association between residential density and walking for leisure purposes (Christian et al., 2013; Foster et al., 2016; Siu et al., 2012; Stewart et al., 2016; Van Dyck et al., 2014). However, almost as many researchers found no relationship between residential density and walking for leisure purposes (Bourke et al., 2018; Foster, Knuiman, Hooper, Christian, & Giles-Corti, 2014; Liao et al., 2018; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011).

Contradictory outcomes have been found for walking for transport reasons in relation to residential density. Pearson et al. (2014) detected a significant negative correlation between residential density and walking for transport. However, other researchers come upon no such relationship (Berrigan, Pickle, & Dill, 2010; Bourke et al., 2018; Foster et al., 2014; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). This is in contrast with research conducted by Foster et al. (2016), Kerr et al. (2016), Koohsari et al. (2017), Ribeiro and Hoffimann (2018), Siu et al. (2012), Stewart et al. (2016), and Y. Yang et al. (2019) who all found an association between walking for transport and residential density. This is supported by investigations by Adlakha et al. (2017) and Ghani, Rachele, Loh, Washington, and Turrell (2018) who detected a more significant correlation. Nonetheless, the different outcomes mentioned above show that the influence between residential density and walking for transport reasons is debatable.

Residential density and bicycling

No association or significant correlation was observed for residential density and bicycling for leisure purposes by (Bourke et al., 2018) and Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011). But a significant correlation between residential density and bicycling for transport was detected by Nordengen, Ruther, Riiser, Andersen, and Solbraa (2019) and Zhang, Yang, Li, Liu, and Li (2014), while Kerr et al. (2016) also detected an association. But a few others did not find any relationship between residential density and bicycling for transport (Berrigan et al., 2010; Bourke et al., 2018; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). Because of the limited research around the relationship between residential density and bicycling (for either leisure or transport) an examination of this relationship is included in this study.

Connection between residential density and walking, bicycling

As mentioned above, contradictory results regarding the impact of residential density on physical activity have been found. It is important to research this relationship. This has been done through the use of questionnaires (Appendix I, II). Questions taken from the SQUASH-questionnaire coupled with questions focusing on residential area characteristics will show if a relationship is present.

4.2.2 Land Use Mix Diversity

Land use mix is "the level of integration within a given area of different types of uses for physical space, including residential, office, retail/commercial, and public space. Land use is controlled by zoning ordinances that reflect political decisions most often made at the local level" (Saelens et al., 2003). *Land use mix diversity* means that there are many different ways in which land is used in a specified area.

Land use mix diversity and walking

For land use mix diversity in relation with walking for leisure, there were different results detected during the literature research. A contrast is seen between the results: some researchers identified no relation (Adlakha et al., 2015; Adlakha et al., 2017; Bourke et al., 2018; Foster et al., 2014; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). But many others did find an association between land use mix diversity and walking (Christian et al., 2013; Parra, Gomez, Fleischer, & Pinzon, 2010; Sarkar, Gallacher, & Webster, 2013; Stewart et al., 2016; Van Dyck et al., 2014). This association between land use mix diversity and walking is supported by the significant relationship recognized by Lee, Mama, Medina, Ho, and Adamus (2012), Robertson et al. (2012), Thornton et al. (2017), and Van Dyck et al. (2013). These findings indicate that a greater diversity in land use mix will lead to more walking among residents.

Research on walking for transport reasons shows the same contradictions as research on walking for leisure. Adlakha et al. (2015), Bourke et al. (2018), Foster et al. (2014), Ghani et al. (2018), and Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) uncovered no relationship between land use mix diversity and walking for transport. However, an association was detected by Stewart et al. (2016) and Y. Yang et al. (2019), and a significant correlation observed by Adlakha et al. (2017), Mertens et al. (2019), and Thornton et al. (2017). Because of the contradiction relationships found, further research is needed.

Land use mix diversity and bicycling

No negative correlation was detected between land use mix diversity and bicycling (for leisure or transport). One article found a significant relationship between bicycling for leisure and land use mix diversity (Lee et al., 2012).

More research has been done on bicycling for transport reasons. Zhang, Yang, et al. (2014) pinpointed a significant relationship, a finding supported by the association perceived by Braun et al. (2016). But multiple others observed no relationship between land use mix diversity and bicycling for transport (Adlakha et al., 2015; Bourke et al., 2018; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). Thus there is still a lack of evidence regarding what the relationship between land use mix diversity and bicycling (for leisure or transport) really is.

Connection between walking or bicycling and land use mix diversity

Contradictory results were found for the relationship between walking or bicycling behavior and land use mix diversity. In the questionnaire certain questions aim to uncover more about this connection. These include questions in Appendix I (Q22) and Appendix II (Q14). When these are connected to the questions in the SQUASH-questionnaire, the relationship can be more effectively investigated.

4.2.3 Street Connectivity

Saelens et al. (2003) used the following definition for connectivity: "The directness or ease of travel between two points that is directly related to the characteristics of street design." A few questions in this study look at street design—see Appendix I (Q18 and Q19) and Appendix II (Q14, Q15, and Q16). Street connectivity is important as it enables people to move easily form one location to another.

Street connectivity and walking

The relationship between street connectivity and walking shows contradictions. Research shows a negative association between street connectivity and walking for transport (Adlakha et al., 2017) or leisure (Liao et al., 2018) purposes. This negative correlation means that higher street connectivity will lead to reduced walking.

Other researchers found no relationship between street connectivity and walking for leisure (Adlakha et al., 2017; Bourke et al., 2018; Foster et al., 2014; Sarkar et al., 2013) or transport (Bourke et al., 2018; Foster et al., 2014; Koohsari et al., 2017). But an association between street connectivity and walking for leisure purposes was detected by Christian et al. (2013), Foster et al. (2016), and Siu et al. (2012) while Ellis et al. (2016), Foster et al. (2016), Ribeiro and Hoffimann (2018) and Siu et al. (2012) detected an association between street connectivity and walking for transport purposes. These perceived associations are supported by the significant relationships detected between street connectivity and walking for leisure (Lee et al., 2012) and for transport (Berrigan et al., 2010; Ghani et al., 2018; Kerr et al., 2016; Thornton et al., 2017). These researchers concluded that a higher amount of street connectivity will lead to more people walking for leisure and transport reasons.

Street connectivity and bicycling

No research on the connection between street connectivity and bicycling (for leisure or transport) showed a negative correlation. Some researchers detected no significant relationship between street connectivity and bicycling for leisure (Bourke et al., 2018; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011) or for transport purposes (Bourke et al., 2018). Other researchers did recognize either an association (Braun et al., 2016) or a significant relationship between street connectivity and bicycling for leisure (Lee et al., 2012) and transport (Berrigan et al., 2010; Kerr et al., 2016; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). The evidence for the connection between street connectivity and bicycling is minimal and contradictory; further research is needed.

Connection between walking or bicycling and street connectivity

Research on street connectivity shows different results. Consequently it is important to integrate questions relating to street connectivity into the current research. Questions in Appendix I (Q18 and Q19) and Appendix II (Q14) could help to define the relationship between walking or bicycling and street connectivity.

4.2.4 Land Use Mix Accessibility

Land use mix accessibility indicates that different types of people have access to the different areas of their neighborhood.

Land use mix accessibility and walking

Negative correlations were detected between land use mix accessibility and both walking for leisure (Liao et al., 2018), and walking for transport reasons (Pearson et al., 2014). Multiple researchers did not find a connection between land use mix accessibility and walking for leisure purposes (Adlakha et al., 2017; Jia & Fu, 2014; Sarkar et al., 2013) or transport reasons (Adlakha et al., 2017; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). However, an association between land use mix accessibility and walking for leisure purposes was found by Hekler, Castro, Buman, and King (2012), Parra et al. (2010), Siu et al. (2012), and Trumpeter and Wilson (2014). This finding is supported by the findings of Jia and Fu (2014), Serrano et al. (2018), and Zhang, Li, Liu, and Li (2014) who find a significant relationship between land use mix accessibility and walking for leisure purposes. Significant correlations between land use mix accessibility and walking for transport reasons were also found (Jia, Usagawa, & Fu, 2014; Kerr et al., 2016; Mertens et al., 2019). These finding are in line with the association stumbled upon by Koohsari et al. (2017), Ribeiro and Hoffimann (2018) and Siu et al. (2012). A positive correlation between land use mix accessibility and walking means that when there is a high level of land use mix accessibility more people will walk. A negative correlation indicates that greater land use mix accessibility results in less walking among residents in a neighborhood.

Land use mix accessibility and bicycling

Bicycling (for leisure or transport) did not negatively correlate with land use mix accessibility. Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) detected that there was no relationship between bicycling for leisure and land use mix accessibility. This is contradicted by the findings of Kerr et al. (2016) who found a significant positive correlation between land use mix accessibility and bicycling for transport. These two papers alone do not provide enough data to say anything definitive about the relationship between land use mix accessibility and bicycling; further research is required.

Connection between walking or bicycling and land use mix accessibility

As can be seen above there has been more research on the connection between land use mix accessibility and walking than there has been on the connection between land use mix accessibility and bicycling. In this study these relationships are examined using Q22 (Appendix I) and Q19 (Appendix II).

4.2.5 Aesthetics

Defining aesthetics is challenging because of the polysemic character of the word. Following Dale and Burrell (2003), multiple definitions could be provided. In this study aesthetics will be defined as "the measurement and appreciation of the beautiful[...] the appreciation of good design and that which provides good form" (Dale & Burrell, 2003). In short this means that what good design is depends on the perception of the resident.

Aesthetics and walking

Only one negative correlation was discovered between aesthetics and walking for transport (Adlakha et al., 2017). Numerous different researchers recognized no relationship between aesthetics and walking for leisure (Bourke et al., 2018; Jia et al., 2014; Serrano et al., 2018; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011) or walking for transport (Adams, Bull, & Foster, 2016; Adlakha et al., 2017; Bourke et al., 2018; Jia et al., 2014; Mertens et al., 2019). However, multiple other researchers did find an association between aesthetics and walking for leisure purposes (Foster et al., 2016; Hekler et al., 2012; Jalaludin et al., 2012; Parra et al., 2010; Trumpeter & Wilson, 2014); these findings are supported by the outcomes of Jia and Fu (2014), Van Dyck et al. (2013), and Van Dyck et al. (2014), which showed a significant positive correlation. A positive correlation between aesthetics and walking for leisure purposes means that the more appealing the aesthetics of the surroundings are, the more people will walk in their neighborhood. A connection between aesthetics and walking for transport purposes was found by fewer researchers (Foster et al., 2016; Kerr et al., 2016; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). With so little research having been done on the topic, further research is required.

Aesthetics and bicycling

Less research has focused on the connecting between aesthetics and bicycling. Bourke et al. (2018) found no connection between aesthetics and bicycling for leisure purposes, a finding in agreement with the work of Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011). However, for bicycling for transportation purposes Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) did find an association between aesthetics and bicycling behavior. This finding is supported by Kerr et al. (2016), who stumbled upon a significant positive correlation. There is however too little research—too much of which is contradictory—to say anything definitive about the possible connection between aesthetics and bicycling.

Connection between walking or bicycling and aesthetics

The connection between aesthetics and the behaviors of walking and bicycling is not congruent. More research is needed, and the combination of the SQUASH-questionnaire with Appendix I (Q24) and Appendix II (Q14) will make this connection more visible.

4.2.6 Infrastructure and Safety

In this context, "infrastructure" refers to infrastructure for walking and bicycling in the close surroundings of the residents. Appendix I (Q18) and Appendix II (Q14 and Q15) ask residents whether, in their opinion, they have the necessary infrastructure in their surroundings for bicycling and walking. "Safety", on the other hand, indicates that the aforementioned infrastructure is well maintained so that fewer accidents will occur.

Infrastructure and safety for walking

Multiple researchers found no connection between infrastructure and safety when walking for leisure purposes (Adlakha et al., 2015; Adlakha et al., 2017; Bourke et al., 2018; Jalaludin et al., 2012; Liao et al., 2018; Panter, Griffin, & Ogilvie, 2014; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011; Van Dyck et al., 2014). However, even more researchers did find an association (Chang, Miranda-Moreno, Cao, & Welle, 2017; Goodman, Sahlqvist, Ogilvie, & Consortium, 2014; Gustat, Rice, Parker, Becker, & Farley, 2012; Hekler et al., 2012) or a significant positive correlation (Jia & Fu, 2014; Lee et al., 2012; Robertson et al., 2012; Serrano et al., 2018; Van Dyck et al., 2013; Zhang, Li, et al., 2014). The situation is similar when looking at walking for transport purposes. Bourke et al. (2018), Goodman et al. (2014), Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011), and Zwald et al. (2014) did not detect a connection between walking for transport and infrastructure and safety. However, twelve other papers did perceive a connection. A significant positive correlation between walking (transport) and infrastructure and safety was found by Adams et al. (2016), Adlakha et al. (2015), Kerr et al. (2016), Mertens et al. (2019), and Thornton et al. (2017). Their findings are supported by other studies (Adlakha et al., 2017; Aldred, Croft, & Goodman, 2019; Chang et al., 2017; Gustat et al., 2012; Jalaludin et al., 2012; Panter et al., 2014; Van Cauwenberg et al., 2016).

Infrastructure and safety for bicycling

A few researchers did not recognize a connection between infrastructure and safety for bicycling (Bourke et al., 2018; Chang et al., 2017; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). But multiple others did detect

a relationship. Goodman et al. (2014) and Porter et al. (2018) observed that an association could be made between bicycling for leisure purposes and infrastructure and safety for bicycling. This correlation was also found for bicycling for transport purposes by Aldred et al. (2019), Braun et al. (2016), Frank et al. (2019), Goodman et al. (2014), Panter et al. (2014), and Porter et al. (2018). A significant correlation between infrastructure and safety and bicycling for leisure proposes was detected (Adlakha et al., 2015; Lee et al., 2012). Bicycling for transport purposes was also positively correlated with safety and infrastructure in the following papers: Adlakha et al. (2015), Mertens et al. (2017), Mertens et al. (2016), Mertens et al. (2014), and Zhang, Yang, et al. (2014).

Connection between infrastructure and safety for walking and bicycling

A positive correlation between infrastructure and safety on the one hand and walking or bicycling on the other means that when there is sufficient infrastructure for either walking or bicycling there will be more people out on the streets in the neighborhood. Infrastructure and safety are important for walking and bicycling, as is clearly explained in the articles mentioned above. In this study this understanding will be further elaborated, and people will be surveyed regarding whether they find it important that there is good infrastructure. This will be established by means of Appendix I (Q18) and Appendix II (Q14 and Q15).

4.2.7 Traffic Safety

In 2018 in the Netherlands 228 people died due to bicycle accidents. In that same year 54 pedestrians died in traffic accidents (CBS, 2020). Thus traffic safety is an important factor to be considered when designing a residential area. Multiple questions (see Q18 and Q21 in Appendix I and Q14, Q15, and Q18 in Appendix II) focus on this topic.

Traffic safety and walking

There is one paper that found a significant negative correlation between walking for leisure and traffic safety (Jia & Fu, 2014). Multiple other studies did not find any relationship (Adlakha et al., 2015; Adlakha et al., 2017; Jalaludin et al., 2012; Jia et al., 2014; Lee et al., 2012; Serrano et al., 2018; Van Dyck et al., 2013; Van Dyck et al., 2014). When no association or significant correlation is detected, this means that traffic safety and walking do not influence one another. Foster et al. (2016) and Stewart et al. (2016) on the other hand, did find an association between traffic safety and walking for leisure purposes. This finding was supported by a positive significant finding on the part of Robertson et al. (2012). This same contradiction is seen when walking for transport reasons is taken into account. No association was detected by Adlakha et al. (2015), Adlakha et al. (2017), and Jia et al. (2014). But various others did find an association (Foster et al., 2016; Stewart et al., 2016; Van Cauwenberg et al., 2016) or a significant positive correlation (Adams et al., 2016; Kerr et al., 2016; Zwald et al., 2014) between traffic safety and walking for transport purposes. A positive correlation between traffic safety and walking means that when residents can easily walk through their neighborhood without fear of traffic, they will tend to spend more time walking in their area.

Traffic safety and bicycling

For bicycling the connection with traffic safety is in this regard only minimally researched. Adlakha et al. (2015) and Lee et al. (2012) both found no correlation between bicycling for leisure purposes and traffic safety. The findings relating to bicycling for transport reasons are diverse; one article finds no association (Adlakha et al., 2015) while another detected an association between bicycling for transport and traffic safety (Frank et al., 2019). At least four articles did find a positive significant correlation between traffic safety and bicycling (Kerr et al., 2016; Mertens et al., 2017; Mertens et al., 2016; Mertens et al., 2014). Because of the small amount of pre-existing research on this topic, no definitive statements could be made. It would appear that if an area has good traffic safety people will tend to travel more by bicycle, but further research is needed.

Connection between walking or bicycling and traffic safety

Traffic safety and the behaviors of walking and bicycling are important for residents, as shown in the research above. Therefore, questions intended to gather information about these relationships are included in the questionnaires. Questions in Appendix I (Q18 and Q21) and Appendix II (Q14, Q15, and Q18) focus on these issues. In combination with the SQUASH-questionnaire, this connection could be further researched.

4.2.8 Safety from Crime

Safety from crime allows a person to feel safe in their surroundings. In 2008 a study conducted by Foster and Giles-Corti (2008) discovered a connection between crime and physical activity levels. Consequently, it is important that this characteristic is included in this study.

Walking and safety from crime

In research focusing on the relationship between walking and safety from crime there are some apparent contradictions. Seven articles (Adlakha et al., 2017; Jalaludin et al., 2012; Jia & Fu, 2014; Jia et al., 2014; Ou et al., 2016; Van Dyck et al., 2013; Van Dyck et al., 2014) state that there is no correlation at all, while six article state the contrary (Adlakha et al., 2015; Foster et al., 2016; Foster et al., 2014; Serrano et al., 2018; Towne et al., 2016; Trumpeter & Wilson, 2014). Research on the correlation between walking for transport purposes and safety from crime was also divided. Adlakha et al. (2017) stumbled upon a negative association, in contrast to Foster et al. (2016) who detected a positive association. Multiple articles did not find a relationship between walking and safety from crime (Adams et al., 2016; Adlakha et al., 2015; Jia et al., 2014; Kerr et al., 2016; Martinez et al., 2011; Zwald et al., 2014). However, a significant positive correlation between walking for transport and safety from crime was recognized by Foster et al. (2014), Mertens et al. (2019), and Towne et al. (2016).

Bicycling and safety from crime

Research on the connection between bicycling and safety from crime is only present in three articles. Adlakha et al. (2015) found no relationship between bicycling for transport reasons and safety from crime, but did find a significant positive correlation between bicycling for leisure purposes and safety from crime. Kerr et al. (2016) recognized that there is a significant positive correlation between bicycling for transport reasons and safety from crime. This finding is supported by Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011), who could, however, find no relationship between bicycling for leisure purposes and safety from crime.

Connection between walking or bicycling and safety from crime

A wide range of different findings are present in papers researching the connection between the behaviors of walking or bicycling and safety from crime. Because of the contradictions between these findings it is important to examine them in the current study. Q24 in Appendix I, as well as Q14 and Q21 in Appendix II aim to further probe these relationships; in combination with the findings of the SQUASH-questionnaire it may be possible to gain a deeper understanding of how safety from crime connects to rates of walking and bicycling.

4.2.9 Access to Public Transport

Access to public transport is about the accessibility of public transport.

Walking and access to public transport

Two articles discovered a negative correlation between walking for leisure and access to public transport (Liao et al., 2018) or alternative transport of any kind (Panter, Heinen, Mackett, & Ogilvie, 2016). Others observed no association between public transport and walking for leisure (Adlakha et al., 2015; Christian et al., 2013; Foster et al., 2014; Robertson et al., 2012), while three articles did recognize an association (Chang et al., 2017; Siu et al., 2012) or a significant positive correlation (Zhang, Li, et al., 2014) between walking and access to public transport. When looked at walking for transport only two papers (Adlakha et al., 2015; Foster et al., 2014) identified no association, whereas five other articles did find an association (Berrigan et al., 2010; Chang et al., 2017; Siu et al., 2012; Y. Yang et al., 2019), and a significant positive correlation between public transport and walking for transport was recognized by Adams et al. (2016).

Bicycling and access to public transport

Zhang, Yang, et al. (2014) pinpointed a negative correlation between bicycling for transport and access to public transport; no other articles found a negative association or correlation. Bicycling for leisure purposes is only mentioned in two articles that look at access to public transport. No relationship or association between the two concepts was detected by Adlakha et al. (2015) and Chang et al. (2017). For the relationship between bicycling for transport reasons and access to public transport a little more research has been conducted. No association was recognized by Adlakha et al. (2015) and Chang et al. (2017). But Berrigan et al. (2010) uncovered an association between bicycling for transport reasons and access to public transport. This finding is supported by Panter et al. (2016), who found a significant positive correlation.

Connection between walking or bicycling and access to public transport

The connection between access to public transport and walking has been more researched than the relationship between bicycling and access to public transport. The current study could establish if residents believe they have easy access to public transport. Q20 (Appendix I) as well as Q14 and Q17 (Appendix II) aim to gain a better understanding of these connections.

4.2.10 Access to Green Space

Access to green space means that residents can walk or bicycle in natural, green locations. Examples might include a park in the city with plentiful trees and flowers, or a forest.

Access to green space and walking

The relationship between walking and access to green space is often researched. For the relationship between access to green space and walking for leisure purposes, multiple different outcomes have been found. Sarkar et al. (2013) found no relationship between access to green space and walking for leisure reasons. But many others did find an association (Robertson et al., 2012; Siu et al., 2012; Stewart et al., 2016; Van Cauwenberg et al., 2015) or a significant positive correlation between access to green space and walking for leisure purposes (Parra et al., 2010; Zhang, Li, et al., 2014). For the relationship between walking for transport reasons and access to green space, only significant positive correlations (Pearson et al., 2014; Y. Yang et al., 2019) or associations (Ellis et al., 2016; Koohsari et al., 2017; Siu et al., 2012; Stewart et al., 2016) were recognized.

Access to green space and bicycling

Only one article connected bicycling and access to green space. Mertens et al. (2017) did not find a relationship between bicycling for transport purposes and access to green space.

Connection between walking or bicycling and access to green space

The connection between walking and access to green space is more often researched than the connection between bicycling and access to green space. The current research could establish if residents believe they have easy access to green space, as well as if they consider that green space to be attractive and well maintained. Q19 (Appendix I) as well as Q14 and Q16 (Appendix II) will research this connection.

4.2.11 Street Lighting

The adequacy of street lighting is a function of the number of streetlamps present on a street. But also factors like the quality of the light they provide and the distance between the street lighting are part of it. This characteristic is measured in the questionnaires in Q24 (Appendix I) and Q21 (Appendix II). These questions focus on the perception of adequate lighting on streets in the late evening. A positive correlation between street lighting and walking or bicycling means that the more streetlights there are, the more people will walk or bicycle. A negative correlation means that more streetlights will lead to less walking or bicycling.

Street lighting and walking

Foster et al. (2016) and Stewart et al. (2016) discovered a positive correlation between street lighting and walking. But Zwald et al. (2014) did not recognized any correlation with walking for transport reasons.

Street lighting and bicycling

This research found no articles that looked at the connection between street lighting and bicycling.

Connection between street lighting and walking or bicycling

Little research has thus far been conducted on the relationship between street lighting and walking or bicycling. In the current research the question “Is there enough street lighting?” could provide insight into the perceptions of residents regarding the amount of street lighting there is.

4.2.12 Walkability

Walkability is a combination of different urban characteristics, as mentioned above. But some research views walkability at simply one characteristic of the built environment. Therefore, this characteristic has been added to the list of traits to be examined. Typically the Neighborhood Environment Walkability Scale (NEWS) is used to research a neighborhood’s walkability (Saelens & Sallis, 2002). Greater walkability will lead to more walking or bicycling.

Walkability and walking

No negative association or correlation was found between walkability and walking. But a few researchers did not recognize any relationship between walkability and walking for leisure (Bourke et al., 2018; McCormack et al., 2019) or walking for transport purposes (Bourke et al., 2018). Arvidsson, Kawakami, Ohlsson, and Sundquist (2012) did find an association between walkability and walking for leisure. This finding was supported by Towne et al. (2016) and Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011). A relationship between walkability and walking for transport purposes was also observed. Arvidsson et al. (2012) and Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) did find an association between walkability and walking for transport reasons; other studies found a significant positive correlation (McCormack et al., 2019; Nathan, Wood, & Giles-Corti, 2014; Towne et al., 2016).

Walkability and bicycling

Only two articles looked at the relationship between walkability and bicycling. Bourke et al. (2018) did not find any relationship between the two. But McCormack et al. (2019) did find a significant positive correlation between walkability and bicycling.

Connection between walkability and walking or bicycling

In this study, the relationship between walkability and walking or bicycling is researched through the use of the NEWS (Saelens & Sallis, 2002). The questionnaires used in this study are based on the NEWS questionnaire.

4.2.13 Concluding

This chapter mentions many characteristics of the built environment that influence walking and bicycling behavior. In summary these are residential density, land use mix diversity, street connectivity, land use mix accessibility, aesthetics, infrastructure and safety, traffic safety, safety from crime, access to public transport, access to green space, street lighting, and walkability.

4.3 Design Principles

According to Tacken (2019) there are different design principles that can be used to create a healthier public place. During his research, he used the design principles from various studies. This study will only make use of the design principles that were considered relatively easy or low-effort to implement and have a strong positive impact on the health of residents (Tacken, 2019). A combination of these different design principles should amplify the overall positive effect on health. This paragraph therefore answers the following sub-question: "*What different design principles that promote active living can be detected in the literature?*"

Urhahn (2017) has developed 58 design principles to promote a "De Beweegvriendelijke Stad" (a movement-friendly city). The design principles used in this research focus on healthy movement throughout the city and accessibility for all. These are as follows:

- Parking bicycles in public and built-up space (2.6 and 2.7 in Urhahn (2017, pp. 82-83))
- Clustered car parking (2.8 in Urhahn (2017, pp. 82-83))
- Frictionless streets, frictionless place, and wide sidewalks (4.2 and 9.7 in Urhahn (2017, pp. 85, 170))
- Green routes for relaxation with enough rest areas, and green areas with impact on climate adaptation and heat stress (4.3, 10.2 and 10.5 in Urhahn (2017, pp. 85, 172-173)
- Marked routes for bicycling and walking (Cammelbeeck, Engbers, Kunen, & L'abée, 2014, p. 30)

Each design principle will be explained. After the explanations connections will be drawn between these principles and the behavioral sciences theories listed in Section 2.2.

4.3.1 Parking Bicycles in Public and Built-up Space

Urhahn (2017) lists four ambitions, one of which is for residents to be able to bicycle and walk in a sheltered city neighborhood. An example of this is seen on the campus of the University of Amsterdam, where car parking has been transformed into bicycle parking; because of this change, there is now enough room for green spots (Urhahn, 2017, pp. 38-39). Enough parking spots for bicycles were necessary; otherwise using bicycles for transportation would not be promoted in the right way.

Looking at the design principle *parking bicycles in public and built-up spaces* (Urhahn, 2017, pp. 82-83) and the nudge concept (de Ridder & Tummers, 2019), it is simple to see how these can be used together. Providing convenient locations for parking bikes in built-up spaces will make residents more likely to use their bikes to travel to those spaces. From the perspective of the Theory of Planned Behavior (Ajzen, 1991) and its notion of subjective norms, it is necessary that the whole neighborhood is behind the idea of the bicycle being used in the built-up space.
To understand the importance of the parking place of the bike, a few questions focus on this. In Q18 (Appendix III) as well as Q14 and Q15 (Appendix II) the questions focus on the ease of getting the bike out for a ride.

4.3.2 Clustered Car Parking

Nowadays there is no need for a parking spot at every house; a clustered parking area at the edge of the neighborhood is sufficient. If the car is further away from the house, and the bicycle is easier to use than the car, people will use the bicycle more often (Cammelbeeck et al., 2014).

Clustered car parking (Urhahn, 2017, pp. 82-83) from a nudging perspective will lead to more walking and/or bicycling (de Ridder & Tummers, 2019), because the car is further away and not as easily accessible. Additionally, the walk to get to the car is already a push to walk more. When the theory of planned behavior is used, the attitude of residents needs to be positive towards the walk to the car (Ajzen, 2005). If there is not a positive attitude then people will only see the clustered car parking as a frustration and not as a push towards a better lifestyle.

This research values the perception of the residents about clustered parking and whether residents would want it in their neighborhood. Q21 (Appendix I) and Q18 (Appendix II) focus on this aspect.

4.3.3 Frictionless Streets, Frictionless Places, and Wide Sidewalks.

Another design principle that will be used is *frictionless streets, places, and wide sidewalks*. Cammelbeeck et al. (2014, p. 66) also support a sidewalk width of at least two meters. Another study in line with these ideas, states that "common physical environmental features, such as flat, smooth walkways or sidewalks, aesthetically pleasing environments or presence of benches, handrails and ramps were identified as facilitators to physical activity" (Mahmood et al., 2012). Pedestrians want short and direct routes (Urhahn, 2017, p. 71), so sometimes new or renewed paths need to be created to entice pedestrians into walking.

An interesting phenomenon is seen when looking at the principle of *frictionless streets, places and wide sidewalks* (Urhahn, 2017, pp. 85, 170) in terms of nudging (de Ridder & Tummers, 2019). The nudge from this perspective is the street or sidewalk that is easy to walk on, especially for the elderly. Little changes in the environment can make walking or bicycling easier and therefore entice people into certain behaviors. From the perspective of the TPB this is more difficult. If streets and sidewalks are easy to walk on, than the resident needs to believe that walking of bicycling behavior is easy for them to perform (this is in accordance with the notion of perceived behavioral control put forward by Sun et al. (2015). If residents do not think they can walk or bicycle easily in their neighborhood then they will not perform the behavior.

Frictionless streets, places, and wide sidewalks are also part of the questionnaire. Q18 (Appendix I) and Q15 (Appendix II) focus on these characteristics.

4.3.4 Green Routes for Relaxation with Enough Rest Areas, with Impact on Climate Adaptation and Heat Stress.

A fourth design principle is *green routes for relaxation with enough rest areas, with impact on climate adaptation and heat stress*. According to Mahmood et al. (2012), one way to facilitate the elderly walking around in their neighborhood is through the presence of enough benches. Cammelbeeck et al. (2014) also found a connection between the number of benches and increased walking in neighborhoods. If residents are stimulated to walk around in their neighborhood, the amount of greenery present could have a positive effect. Hartig et al. (2014) state that walking around in green areas is stress-relieving. Another factor is that when a neighborhood contains more nature, the residents will be more physically active. Green areas help cities to decrease climate impact

and reduce the heat stress of a place (Urhahn, 2017, pp. 116–117). Consequently it is evident that the presence of greenery in a neighborhood will have many beneficial effects.

Looking at things from a behavioral sciences perspective, as mentioned above enough benches could entice people to walk more, which qualifies as a nudge (de Ridder & Tummers, 2019). This can be viewed differently looking through the lens of the Theory of Planned Behavior and the notion of perceived behavioral control (Sun et al., 2015). Because of the benches the elderly will perceive walking as a behavior they can perform, and so will choose to walk more.

In the questionnaires, respondents are asked about the nature and green environment in their neighborhood (Q19, Appendix III and Q16, Appendix II). Their responses will aid a better understanding of the value of nature in this context.

4.3.5 Marked Routes for Bicycling and Walking

Lastly, the design principle of *marked routes for bicycling and walking* will be used. Cammelbeeck et al. (2014, p. 30) found that, through the use of different materials and objects, bicycling and walking routes can be made safer and more attractive for people. The routes need to be interesting for people to want to walk along them.

The marking of routes for bicycling and walking is a nudge (de Ridder & Tummers, 2019). Because of the signs residents see in their surroundings, they will want to discover the places those signs denote by going out for a walk or bicycle ride. Looking at things with reference to the notion of *intention* as put forth in the TPB (Ajzen, 1991), residents need to have the intention to go walking. If residents do not have the intention to walk, they will not go out for a walk. A nudge is in this case not enough to move them towards the desired behavior.

Questions that examine resident perceptions of marked routes for bicycling and walking are included in the questionnaire. Q18, Appendix I and Q15, Appendix II aim to research the perceptions of residents regarding whether there are enough marked routes in their surroundings.

4.4 Characteristics of an Active Living Environment

As an answer to the question "*What are the built environmental characteristics of an active living environment?*" Table 3 summarizes the built environmental characteristics of an active living environment. In this table the articles that mention specific built environmental characteristics are shown in combination with the question and questionnaire of the survey used in this study.

Table 3: Characteristics of Active Living Environments

Characteristics of active living environments		Articles	Questionnaire I	Questionnaire II
residential density	walking	Adlakha et al. (2017); Christian et al. (2013); Foster et al. (2016); Ghani et al. (2018); Kerr et al. (2016); Koohsari et al. (2017); Ribeiro and Hoffimann (2018); Siu et al. (2012); Stewart et al. (2016); Van Dyck et al. (2013); Van Dyck et al. (2014); Y. Yang et al. (2019)	Q25: 1	Q14a & Q22:1
	bicycling	Kerr et al. (2016); Nordengen et al. (2019); Zhang, Yang, et al. (2014)	Q25: 1	Q14a & Q22:1
land use mix diversity	walking	Adlakha et al. (2017); Christian et al. (2013); Lee et al. (2012); Mertens et al. (2019); Parra et al. (2010); Robertson et al. (2012); Sarkar et al. (2013); Stewart et al. (2016); Thornton et al. (2017); Van Dyck et al. (2013); Van Dyck et al. (2014); Y. Yang et al. (2019)	Q22:1,2 & Q23: 1	Q14: 9, 10, 12 & Q19: 1,2 & Q20: 1
	bicycling	Braun et al. (2016); Lee et al. (2012); Zhang, Yang, et al. (2014)	Q22: 1, 3 & Q23: 1	Q14: 9, 10, 12 & Q19: 1,3 & Q20: 1
street connectivity	walking	Berrigan et al. (2010); Christian et al. (2013); Ellis et al. (2016); Foster et al. (2016); Ghani et al. (2018); Kerr et al. (2016); Lee et al. (2012); Ribeiro and Hoffimann (2018); Siu et al. (2012); Thornton et al. (2017)	Q18: 4 & Q19: 2	Q14: 7 & Q15: 4 &Q16: 2
	bicycling	Berrigan et al. (2010); Braun et al. (2016); Kerr et al. (2016); Lee et al. (2012); Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011)	Q18: 4 & Q19: 2	Q14: 7 & Q15: 4 &Q16: 2
land use mix accessibility	walking	Hekler et al. (2012); Jia et al. (2014); Kerr et al. (2016); Koohsari et al. (2017); Mertens et al. (2019); Parra et al. (2010); Ribeiro and Hoffimann (2018); Serrano et al. (2018); Siu et al. (2012); Trumpeter and Wilson (2014); Zhang, Li, et al. (2014)	Q22: 1,2 & Q23: 1	Q14: 9 & Q19: 1, 2 & Q20: 1
	bicycling	Kerr et al. (2016)	Q22: 1, 3 & Q23: 1	Q 14: 9 & Q19: 1, 3 & Q20: 1
aesthetics	walking	Foster et al. (2016); Hekler et al. (2012); Jalaludin et al. (2012); Jia and Fu (2014); Kerr et al. (2016); Parra et al. (2010); Trumpeter and Wilson (2014); Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011); Van Dyck et al. (2013); Van Dyck et al. (2014)	Q 19: 1, 5 & Q23: 2 & Q24: 3, 4, 5	Q14: 6, 11, 15 & Q 16: 1, 5 & Q20: 2 & Q21: 3, 4, 5
	bicycling	Kerr et al. (2016); Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011)	Q23: 2 & Q24: 3, 4, 5	Q14: 6, 11, 15 & Q20: 2 & Q21: 3, 4, 5

infrastructure and safety for bicycling	walking	Adlakha et al. (2015); Adlakha et al. (2017); Aldred et al. (2019); Goodman et al. (2014); Lee et al. (2012); Panter et al. (2014); Thornton et al. (2017); Van Dyck et al. (2013)	Q18: 1,3,4,6,7	Q14: 1 & Q15: 1,3,4,6,7
	bicycling	Adlakha et al. (2015); Adlakha et al. (2017); Aldred et al. (2019); Braun et al. (2016); Frank et al. (2019); Goodman et al. (2014); Lee et al. (2012); Mertens et al. (2017); Mertens et al. (2016); Mertens et al. (2014); Panter et al. (2014); Porter et al. (2018); Zhang, Yang, et al. (2014)	Q18: 1,3,4,6	Q14: 1 & Q15: 1,3,4,6
infrastructure and safety for walking	walking	Adams et al. (2016); Adlakha et al. (2015); Adlakha et al. (2017); Aldred et al. (2019); Chang et al. (2017); Goodman et al. (2014); Gustat et al. (2012); Hekler et al. (2012); Jalaludin et al. (2012); Jia and Fu (2014); Kerr et al. (2016); Lee et al. (2012); Mertens et al. (2019); Panter et al. (2014); Robertson et al. (2012); Serrano et al. (2018); Thornton et al. (2017); Van Cauwenberg et al. (2016); Van Dyck et al. (2013); Zhang, Li, et al. (2014)	Q18: 1,3,4,6,7	Q14: 1 & Q15: 1,3,4,6,7
	bicycling	Adlakha et al. (2015); Aldred et al. (2019); Goodman et al. (2014); Kerr et al. (2016); Lee et al. (2012); Panter et al. (2014)	Q18: 1,3,4,6	Q14: 1 & Q15: 1,3,4,6
traffic safety	walking	Adams et al. (2016); Foster et al. (2016); Kerr et al. (2016); Robertson et al. (2012); Stewart et al. (2016); Van Cauwenberg et al. (2016); Zwald et al. (2014)	Q18: 2 &Q21: 1	Q14: 5 & Q15, 2 & Q18: 1
	bicycling	Frank et al. (2019); Kerr et al. (2016); Mertens et al. (2017); Mertens et al. (2016); Mertens et al. (2014)	Q18: 2 & Q21: 1	Q14: 5 & Q15, 2 & Q18: 1
safety from crime	walking	Adlakha et al. (2015); Foster et al. (2016); Foster et al. (2014); Mertens et al. (2019); Serrano et al. (2018); Towne et al. (2016); Trumpeter and Wilson (2014)	Q24: 1	Q14: 13, 14 & Q21:1
	bicycling	Adlakha et al. (2015); Kerr et al. (2016); Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011)	Q24: 1	Q14: 13, 14 & Q21: 1
access to public transport	walking	Adams et al. (2016); Berrigan et al. (2010); Chang et al. (2017); Siu et al. (2012); Y. Yang et al. (2019); Zhang, Li, et al. (2014)	Q20: 1, 2	Q14: 3 & Q17: 1,22
	bicycling	Berrigan et al. (2010); Panter et al. (2016)	Q20: 1, 3	Q14: 3 & Q17: 1, 2
access to green space	walking	Ellis et al. (2016); Koohsari et al. (2017); Parra et al. (2010); Pearson et al. (2014); Robertson et al. (2012); Siu et al. (2012); Stewart et al. (2016); Van Cauwenberg et al. (2015); Y. Yang et al. (2019); Zhang, Li, et al. (2014)	Q19: 3, 4, 5	Q14: 8 & Q16: 3, 4, 5
	bicycling		Q19: 3, 4, 5	Q14: 8 & Q16: 3, 4, 5
street lighting	walking	Foster et al. (2016); Stewart et al. (2016)	Q24: 2	Q21: 2

	bicycling		Q24: 2	Q21: 2
walkability	walking	Arvidsson et al. (2012); McCormack et al. (2019); Nathan et al. (2014); Towne et al. (2016); Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011)	Q18: 1, 6 & Q20: 2 & Q21: 1 & Q22: 1, 2 &Q24: 1, 2, 4 & Q25: 1	Q14: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15 & Q15: 1, 6 & Q17: 2 & Q18: 1 & Q19: 1, 2 &Q21: 1, 2, 4 & Q22: 1
	bicycling	McCormack et al. (2019)	Q18: 1, 6 & Q24: 2	Q14: 1 & Q15: 1, 6 & Q21: 2

5. Results

The focus of this research is on taking a closer look at how the environment influences the walking and bicycling behavior of residents in the target locations. Within this chapter the results of the questionnaires will be shown. This will begin with an analysis of missing values and sample sizes, followed by descriptives and frequencies of the demographic specifics of the respondents. Later, outcomes regarding the partial SQUASH questionnaire and the Place Standard questionnaire will be shown. Finally this chapter will present the correlations between the current neighborhood the residents are living in and their activity levels.

5.1 Missing Values and Sample Size

Starting with the descriptive of Questionnaire II ("interested", Appendix II), in total 686 respondents filled in the questionnaire. Due to the fact that not all completed at least 2 questions, only 537 could be used for analysis. The questionnaire is divided into four parts; because of the division into these different parts it is not necessary for the whole questionnaire to be filled in for the data to be useable for analysis (Field, 2014). A total of 323 participants filled in Questionnaire II completely, while 214 filled in part of the questionnaire. Questionnaire I ("residents", Appendix I) was filled in by 62 respondents, 9 of whom stopped near the beginning of the questionnaire. In the "interested" questionnaire, there were also respondents who already lived in the area, so these respondents were instead added to the pool of respondents who already lived in the area. Thus the data from a total of 121 respondents was used to analyze those currently living in Waalfront.

Within table 4, 5, and 6 the missing values per each part of the questionnaires are shown.

Question		Location	Waalfront (living)	Waalfront (interested)	Nieuwe Kade Kwartier (interested)
Age	N	Valid	112	302	235
		Missing	9	0	0
Gender	N	Valid	112	302	235
		Missing	9	0	0
Household	N	Valid	112	271	235
		Missing	9	31	0
Education	N	Valid	111	242	228
		Missing	10	60	7
Income	N	Valid	111	242	228
		Missing	10	60	7

Table 4: Missing values—demographic variables part

Questions		Location	Waalfront (living)	Waalfront (interested)	Nieuwe Kade Kwartier (interested)
Commuting	N	Valid	110	231	226
		Missing	11	71	6
Sports	N	Valid	110	204	194
		Missing	11	98	41
Spare Time	N	Valid	110	197	186
		Missing	11	105	49

Table 5: Missing values—squash questionnaire part

Questions		Location	Waalfront (living)	Waalfront (interested)	Nieuwe Kade Kwartier (interested)
Moving around, public space, nature and greenery	N	Valid	101	172	168
		Missing	20	130	67
Public transport, traffic and parking	N	Valid	99	171	166
		Missing	22	131	69
Facilities, play, recreation and social contacts	N	Valid	98	167	159
		Missing	23	135	76
Safety, cleanliness and tidiness	N	Valid	97	166	157
		Missing	24	136	78
Living and talking	N	Valid	96	163	155
		Missing	25	139	147

Table 6: Missing Values—the Place Standard Part

5.2 Descriptive and Frequencies of Demographic Specifics

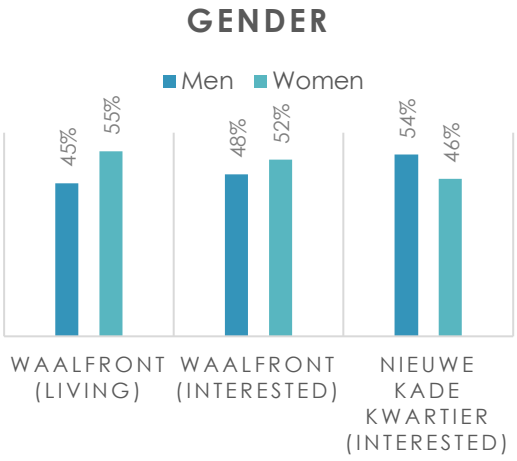
5.2.1 Personal Demographic

For Waalfront (interested) and Nieuwe Kade Kwartier (interested) the age distribution is almost the same. The respondents already living in Waalfront have an average age of 10 years younger.

Looking at the percentages of men and women, we find an almost 50/50 division, as shown in Figure 14. This makes the sample population a good representation of both genders.

As displayed in Figure 15 the majority of people living in or interested in living in the locations is made up of two-person households. The second most common category is that of the single person household. The percentages made up by each group are almost equal when looking at the different locations.

Figure 14: Gender division



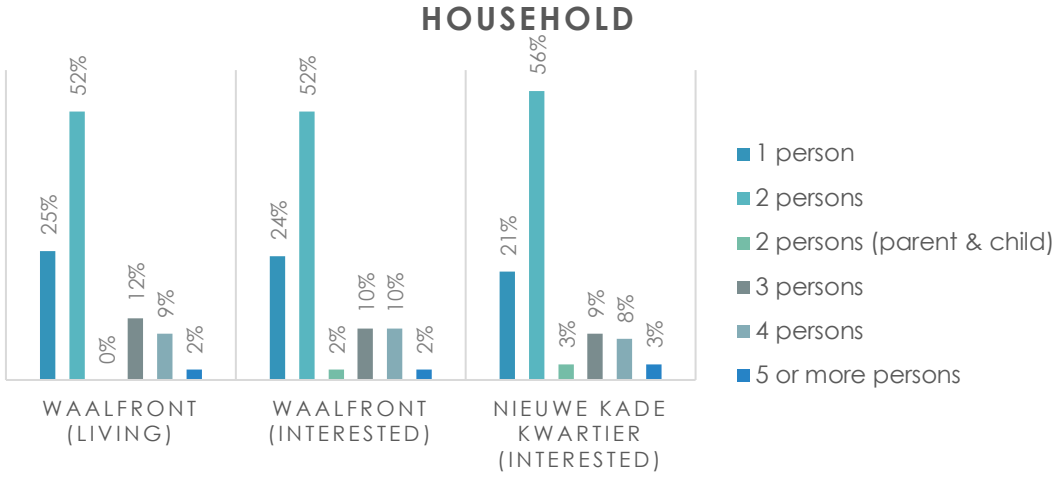


Figure 15: Household Division

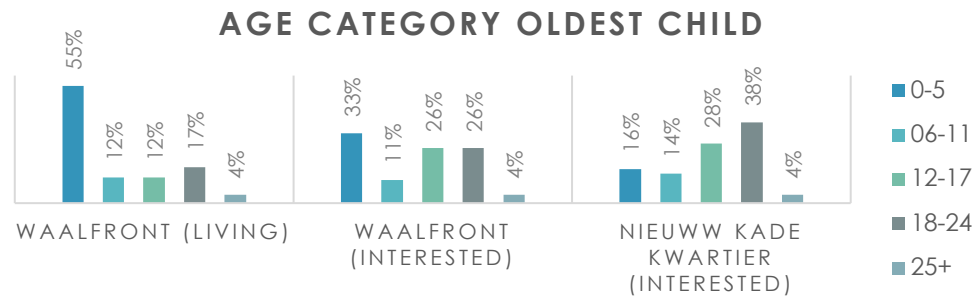


Figure 16: Age Category Oldest Child

Within the age distribution shown in Figure 16 (looking at the oldest child of the respondents) there is a difference seen between the two locations. Most children are between zero and five years of age in Waalfront. In Nieuwe Kade Kwartier the oldest child tends to be between 12 and 24 years of age.

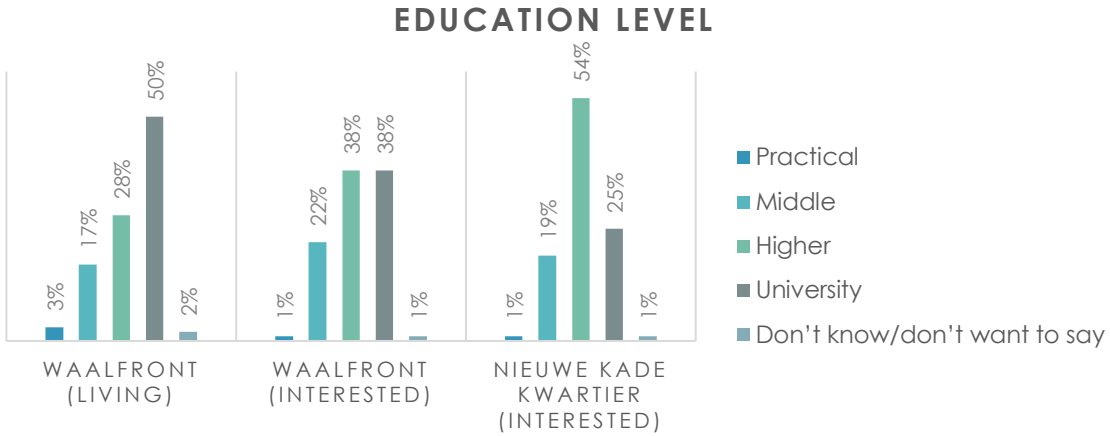


Figure 17: Education Level

Looking at education levels, respondents are mostly higher or university educated. The most interesting difference is to be seen in the cities respondents are interested in or are currently living in. Within Nijmegen more people have a university degree, while in Arnhem more people have a higher educational degree (see Figure 17).

Income distribution (Figure 18) is a bit different between the different locations. The greatest difference can be seen between respondents interested in Waalfront and Nieuwe Kade Kwartier. The average income overall is higher among respondents interested in Nieuwe Kade Kwartier, especially in the group that earns more than average.

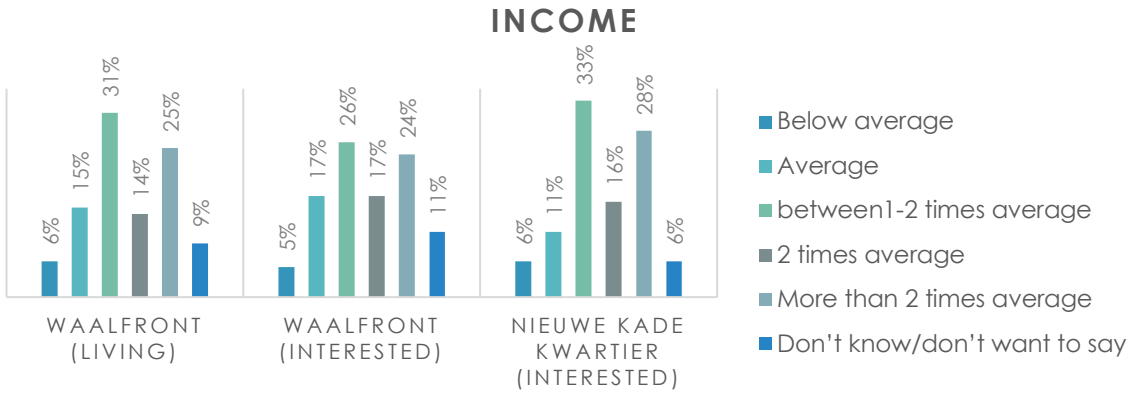


Figure 18: Income distribution

5.2.2 Determining Target Audience

Here the sub-question: *"What are the target groups interested in and currently living in the different locations?"* will be answered. To answer this question, respondents need to be divided into target groups. Using the Whize target groups as explained in Section 3.2 ("Data analysis") the following target groups have been determined.

The respondents interested in Waalfront and Nieuwe Kade Kwartier (Figure 19) have different target groups. The two main groups of respondents interested in Waalfront are I (Plan and Run) and J (Carefree and Active). 40% of respondents fit into those two groups, while 15% of the population fit into the category F (Just Average). The rest of the respondents are divided among the other target groups.

Analyzing the divisions among respondents interested in Nieuwe Kade Kwartier, there are also two main groups. These are F (Just Average) and J (Carefree and Active). Together these groups represent at least 40% of respondents. The next most common group is E (Urban Dynamics), who make up 13% of respondents. Similarly to Waalfront, the remaining respondents are divided between multiple target groups.

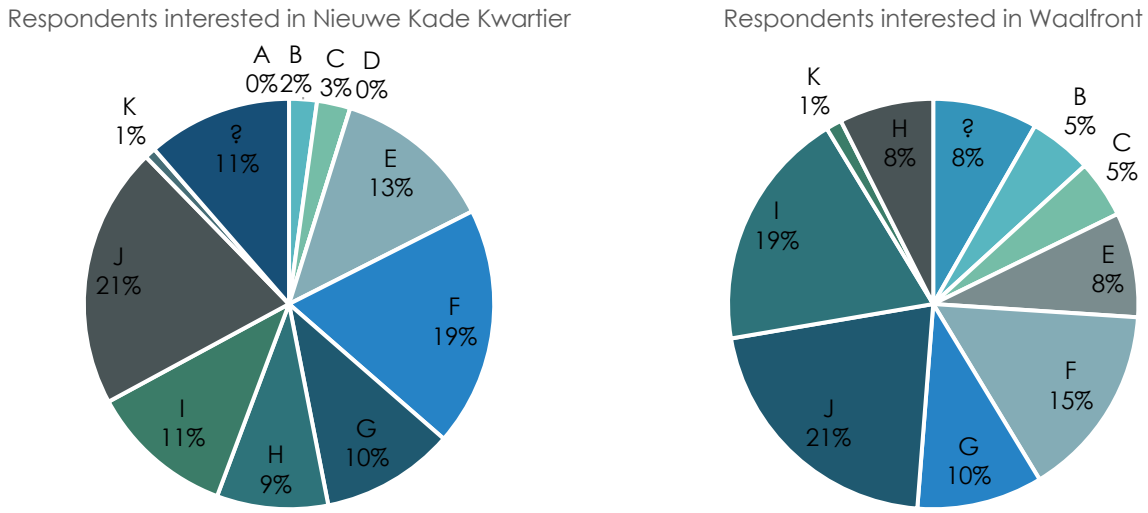


Figure 19: Respondents interested

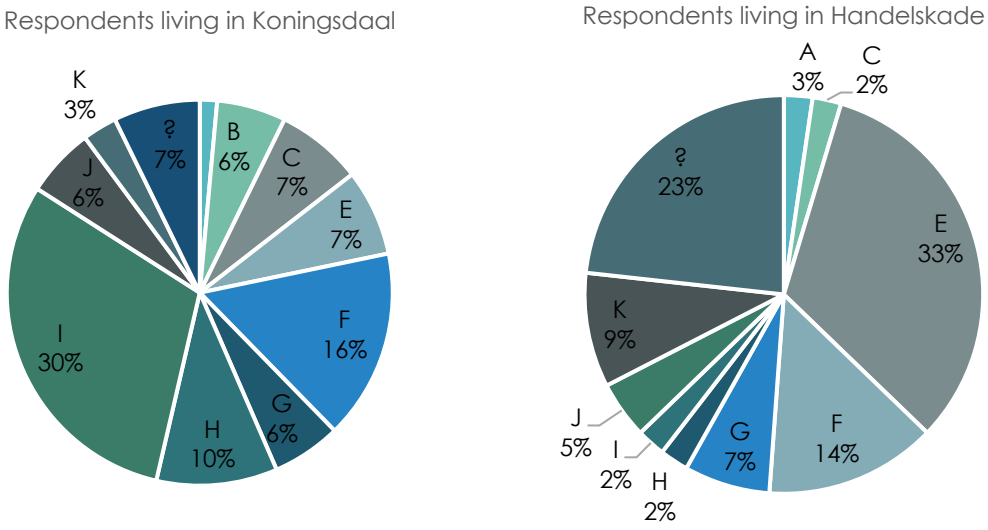


Figure 20: Respondents living in Waalfront

The respondents already living in Waalfront can be divided into two sub-areas, Koningsdaal and Handelskade (see Figure 20). Analyzing these locations, there are different recognizable target groups. The predominant target groups in Handelskade are E (Urban Dynamics) and F (Just Average). Another interesting finding is that 23% of respondents living in Handelskade do not fit into a Whize target group. In Koningsdaal the target group I (Plan and Run) is the most represented group.

5.3 SQUASH Questionnaire

This section will take a closer look at the question: *"How many respondents have lack of movement and are there differences between the target locations?"*. The different parts of the SQUASH questionnaire will be analyzed. This will all be done by dividing the respondents according to the target locations they belong to.

5.3.1 Commuting

Analyzing the data about how people travel to work and/or school (Figure 21), most people use modes of motorized transport four days a week. But respondents also use bikes to go to work and/or school—typically also around four days a week. Multiple respondents use both motorized transport and a bicycle as a means of transportation to go to work and/or school. Only a few respondents travel on foot to work and/or school. Those interested in living in Nieuwe Kade Kwartier walk to work twice as much as those living in or interested in living in Waalfront.

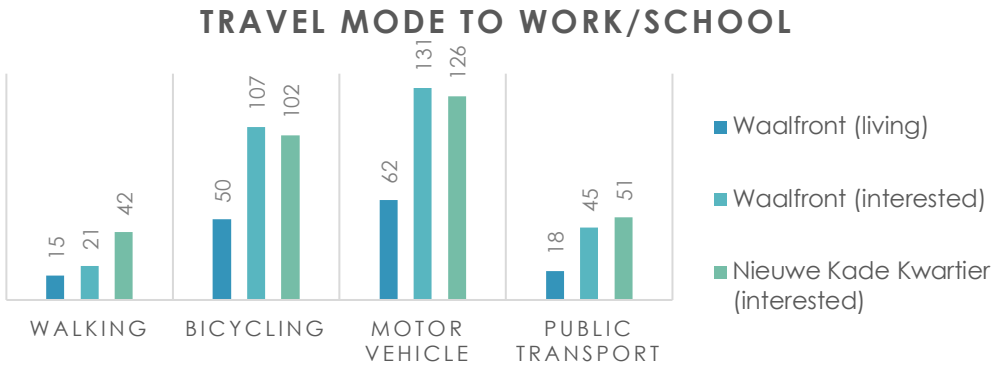


Figure 21: Travel Mode

5.3.2 Sports

Figure 22 has been created by evaluating the results of the questions about the amount of time respondents spend playing sports and how many sports they play. An average of 1 out of 4 respondents does not play sports at all. When respondents do participate in sports, they often do so for around 50 minutes a day, multiple days a week. Between the target locations there is not much difference in terms of the number of sports respondents play or the time they spend participating in sports.

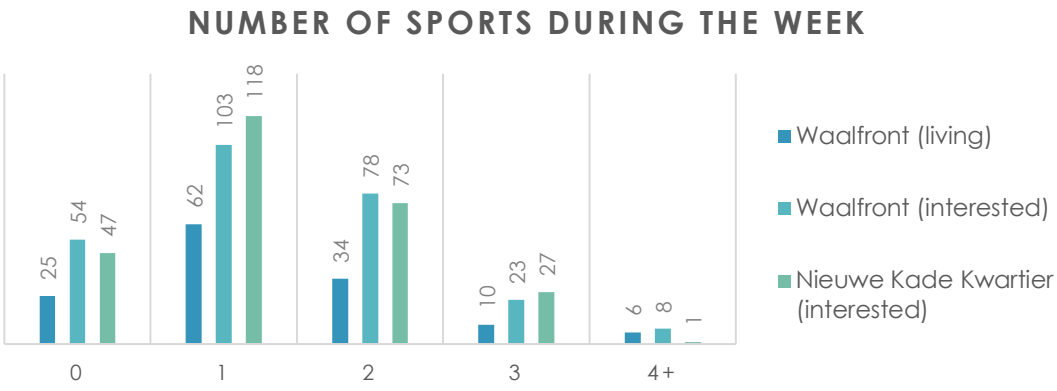


Figure 22: Sports

5.3.3 Spare time

Respondents engage in multiple activities in their spare time. Walking is the most common activity among respondents. Almost every respondent walks at least three times a week for approximately half an hour. Most respondents bike twice a week, for roughly 40 minutes. Gardening and DIY activities are common activities, but when respondents do engage in them they do so between one and two days per week for at least 20 minutes per day. In Figure 23 the exact number of respondents who engage in a particular activity in their spare time can be examined.

Respondents engage in many other activities in their spare time. Reading, baking, and gaming are a few examples mentioned by respondents of the things they do in their spare time. Most of the activities mentioned are not physically active in nature. The majority of activities mentioned are for the purposes of relaxation.

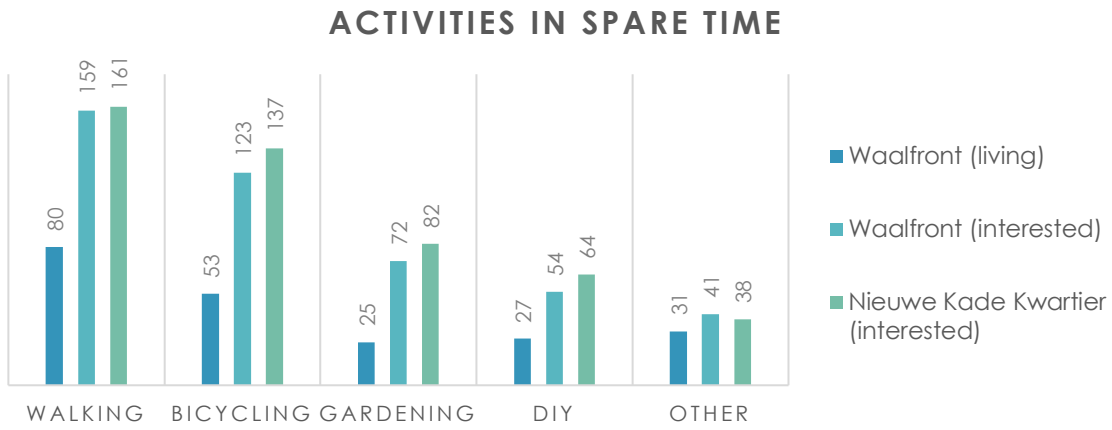


Figure 23: Spare Time

5.3.4 Lack of Movement

"How many respondents have lack of movement and are there differences between target locations?" is the question with which this sub-section is concerned. Lack of movement, as explained in Section 3.2, is calculated using the MET-score. Looking at the different parts of the SQUASH questionnaire could help us determine in which category the most people are lacking in movement. Additionally, the different locations could be compared

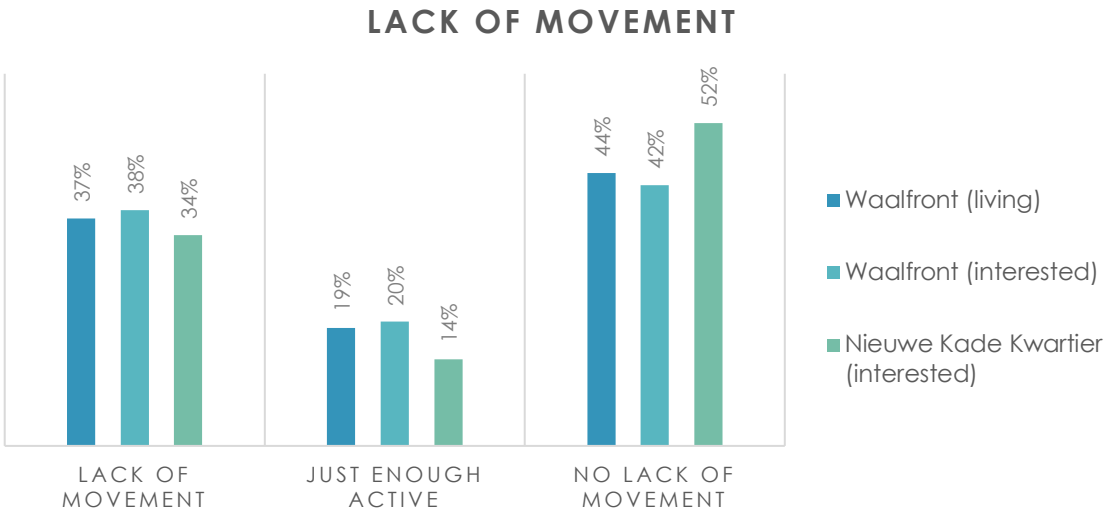


Figure 24: Lack of Movement

to establish if people with different interests also have differences in terms of their lack of movement. Figure 24 shows the percentage of respondents with lack of movement, meaning an MET-score lower than 1000. The people who are considered "just active enough" have MET-scores between 1000 and 1500.
Considering all respondents, one in three lacks enough movement for a healthy lifestyle. When respondents are divided according to the different locations there is not much difference to be seen. Of the respondents already living in Waalfront (Nijmegen) a total of 40 (N=109) respondents have lack of movement. This means that 37% of respondents are not sufficiently active during the week. Of the respondents who are interested in living in Waalfront (Nijmegen), 87 out of 231 respondents are not sufficiently active during the week, while a total of 46 qualify as just active enough. This means that 38% of this group of respondents have lack of movement. Taking a look at the respondents who are interested in Nieuwe Kade Kwartier (Arnhem) 76 (n=221) respondents, or 34% of the group, have lack of movement.

Separating the different parts of the SQUASH questionnaire, the majority of respondents do not use active modes of transportation. In Figure 25, the number show the amount of people who have an MET-score of 0,00, which means that they are not physically active. Respondents living in Waalfront tend to be the most lacking in movement; a large difference is apparent between them and other respondents in this regard. Activities respondents engage in in their spare time, such as walking and bicycling, are roughly even among respondents. The mean MET-score for respondents in most locations is above the lack of movement threshold of 1000 MET, so most people are active in their spare time.

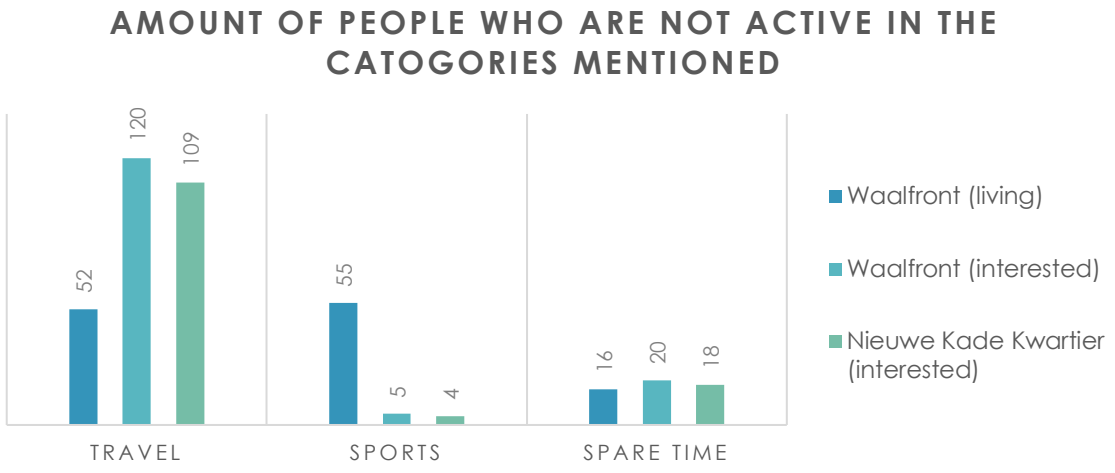


Figure 25: Amount of People Who are Lacking Movement

5.4 The Place Standard

The following section is intended to answer the sub-question "*To what extent has the physical activity of the respondents an impact on their preferences for an active living environment when choosing a new neighborhood?*". This sub-question will make use of the part of the questionnaire that is a combination of the Place Standard Living questionnaire and the NEWS. This section is divided among the themes which have a cohesion according to the Cronbach's alpha, explained in Section 3.2. Within each sub-section that follows the question "*What are the preferences of the respondents in their future neighborhood?*" is answered first. Subsequently the main question of this section is answered.

5.4.1 Greenery and Public Space

Greenery is important for almost all respondents, as is shown in Figure 26. Nature and greenery need to be easily accessible, beautiful, and well maintained. The dependent variable "I can enjoy plenty of nature and greenery" is for 3% influenced in its variance by lack of movement, as shown in Table 7.

Pseudo R-Squared	
Cox and Snell	.023
Nagelkerke	.029
McFadden	.014
Link function: Logit.	

Table 7: Pseudo R-Squared, Enjoyment of Plenty of Nature and Greenery

This means that people with lack of movement have less of an interest in nature and greenery in their future neighborhood (Table 8), whereas the presence of greenery is preferred by people who have no lack of movement. Predictably the same leaning is seen with regard to preference for accessible nature and greenery. People with lack of movement have a lower preference for accessible nature in their future neighborhood (see Tables 9 and 10).

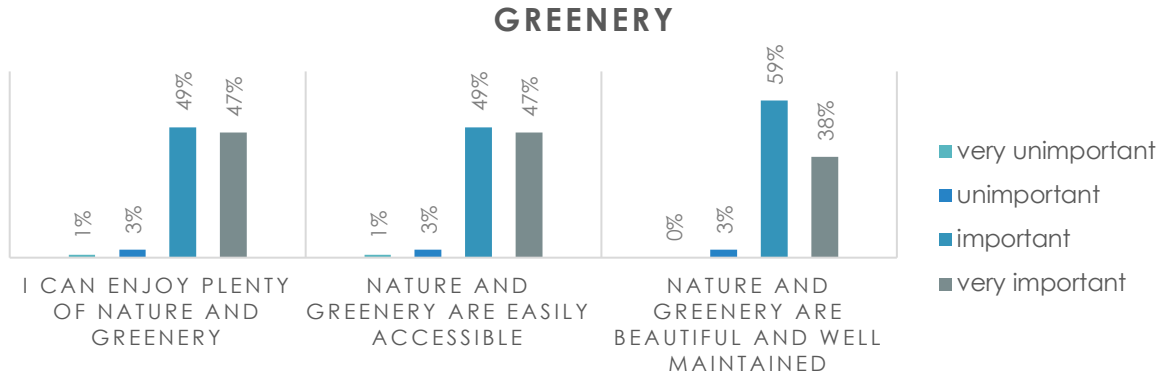


Figure 26: Greenery and Nature

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q16_3 = 1]	-5.013	.592	71.691	1	.000	-6.174	-3.853
	[Q16_3 = 2]	-3.600	.317	128.746	1	.000	-4.222	-2.978
	[Q16_3 = 3]	-.117	.144	.658	1	.417	-.399	.166
Location	[Bewegingsarmoede=1,00]	-.718	.255	7.887	1	.005	-1.218	-.217
	[Bewegingsarmoede=2,00]	-.217	.287	.575	1	.448	-.779	.344
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 8: Parameter Estimates, Enjoyment of Plenty of Nature and Greenery

Pseudo R-Squared	
Cox and Snell	.026
Nagelkerke	.032
McFadden	.016
Link function: Logit.	

Table 9: Pseudo R-Squared, Accessible Nature and Greenery

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q16_4 = 1]	-5.053	.593	72.725	1	.000	-6.214	-3.892
	[Q16_4 = 2]	-3.637	.318	130.873	1	.000	-4.260	-3.014
	[Q16_4 = 3]	-.125	.144	.752	1	.386	-.407	.158
Location	[Bewegingsarmoede=1,00]	-.757	.256	8.731	1	.003	-1.259	-.255
	[Bewegingsarmoede=2,00]	-.350	.287	1.491	1	.222	-.913	.212
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 10: Parameter Estimates, Accessible Nature and Greenery

The preferences for public spaces show (in Figure 27) that an attractively furnished public space is favored by almost all respondents. Well maintained buildings, streets, squares, parks, and facilities and clean city living spaces are also an important factor for all respondents when choosing a new neighborhood. Good facilities for the collection and drop off of waste, which help keep the neighborhood clean, are also considered to be an important consideration when choosing a future neighborhood.

Within the variance for the dependent variable "the living space is attractively furnished" 2% is explained by lack of movement (Tables 11 and 12). Examining this further, people who are just active enough in their daily living have a lower degree of preference for an attractively furnished environment. Conversely, people with a higher MET-score prefer a more attractively furnished environment.

Pseudo R-Squared	
Cox and Snell	.015
Nagelkerke	.019
McFadden	.010
Link function: Logit.	

Table 11: Pseudo R-Squared, Living Space

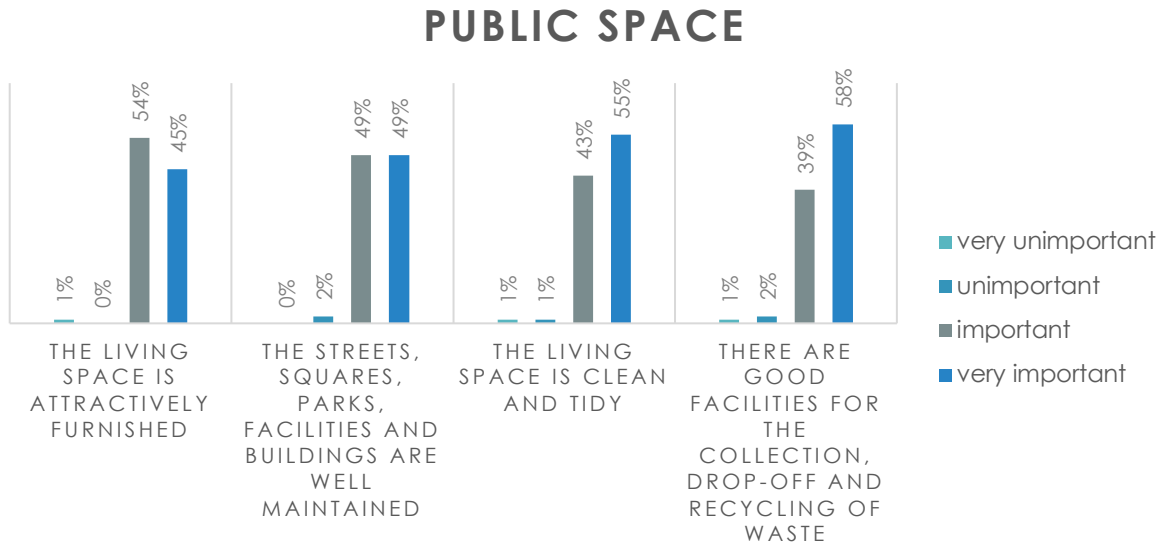


Figure 27: Public Space

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q16_1 = 1]	-4.980	.591	70.960	1	.000	-6.139	-3.822
	[Q16_1 = 3]	.018	.144	.015	1	.903	-.266	.301
Location	[Bewegingsarmoede=1,00]	-.408	.257	2.520	1	.112	-.912	.096
	[Bewegingsarmoede=2,00]	-.591	.298	3.930	1	.047	-1.176	-.007
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 12: Parameter Estimates, Public Space

5.4.2 Public Transport

Respondents' preferences in their future neighborhood regarding public transport, shown in Figure 28, provide insight into the importance of there being a public transport boarding point in the neighborhood. There are only small differences in respondent views regarding the importance of such accessibility by bicycle as opposed to on foot. Indeed, most respondents consider it to be important that public transport is accessible for everyone.

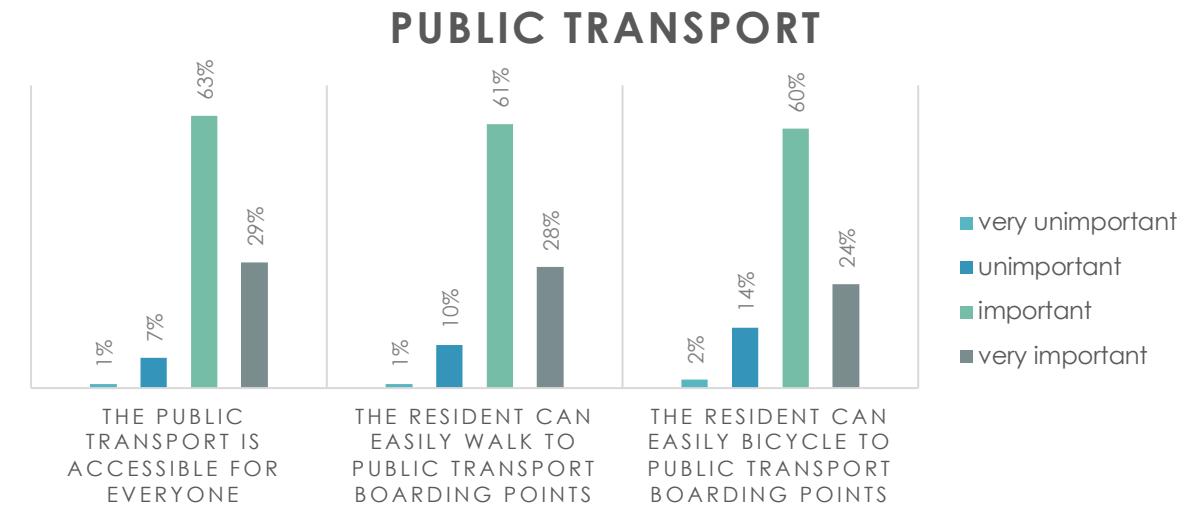


Figure 28: Public Transport

5.4.3 Walking and Bicycling Infrastructure

The preferences for walking and bicycling infrastructure are quite diverse. The presence of enough bicycling and pedestrian lanes is important for almost all respondents, as is the good quality of these paths and lanes. Route signs for pedestrian paths and bicycle lanes is not a necessity for everyone when choosing a new neighborhood. Benches along the paths and two-meter-wide pedestrians' paths are considered important by at least 60% of respondents, while the rest of respondents do not have a preference on this front when choosing a new neighborhood. A neighborhood where respondents can easily find their way is preferred (see Figure 29).

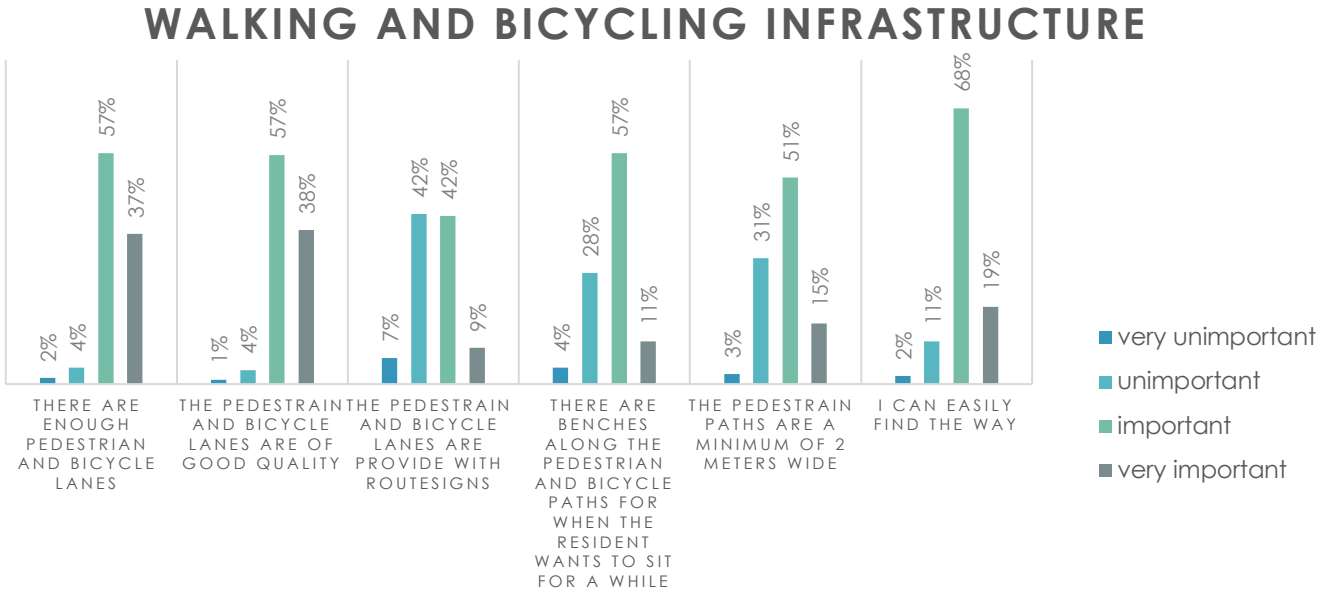


Figure 29: Walking and Bicycling Infrastructure

Taking a closer look at the question of whether having enough pedestrian and bicycle lanes is more important for people with higher MET-scores, an ordinal regression analysis was conducted. The pseudo R-squared let us make the assumption that 7% could be explained due to the variance in the dependent variable (see Table 13). Table 14 shows us that there is a significant negative correlation with this preference and having lack of movement. This means that people with lack of movement typically have less of a preference for there being enough pedestrian and bicycle lanes. A lower score is associated with respondents considering the presence of walking and bicycling lanes to be an unimportant or very unimportant characteristic of their future neighborhood.

Pseudo R-Square	
Cox and Snell	.058
Nagelkerke	.071
McFadden	.035
Link function: Logit.	

Table 13: Pseudo R-Squared, Walking and Bicycling Infrastructure

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q15_1 = 1]	-4.766	.474	100.988	1	.000	-5.696	-3.837
	[Q15_1 = 2]	-3.430	.282	147.496	1	.000	-3.984	-2.877
	[Q15_1 = 3]	.188	.144	1.701	1	.192	-.094	.469
Location	[Bewegingsarmoede=1,00]	-1.211	.277	19.169	1	.000	-1.753	-.669
	[Bewegingsarmoede=2,00]	-.497	.293	2.877	1	.090	-1.071	.077
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 14: Parameter Estimates, walking and bicycling infrastructure

5.4.3 Facilities and Recreation

Respondents prefer to live in a neighborhood with facilities that are close by. They need to be reachable by bike or on foot. Close to 90% of respondents would prefer facilities in their surroundings that support them in living a healthy lifestyle. The presence of such facilities in the neighborhood is considered less important by 12% of respondents.

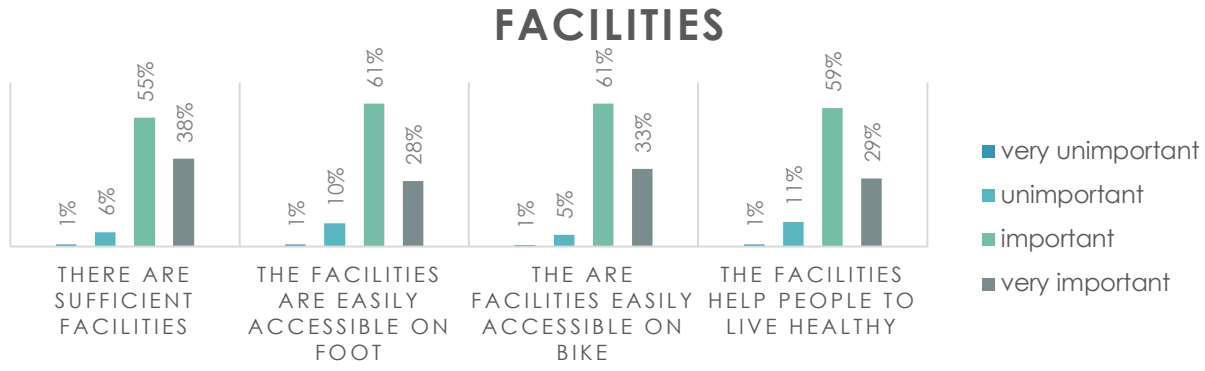


Figure 30: Facilities

Opinions about recreation are more divided. Twenty percent of respondents have no interest in there being facilities that allow for recreation and outdoor play for multiple age groups. Likewise, 28% have no preference in there being enough places where people can meet new people in the neighborhood. However, if there are facilities for recreation and outdoor play in the neighborhood, at least 85% would prefer them to be well maintained. The dependent variable "there are plenty of places and facilities where people can meet" is for 2%

influenced in its variance by the dependent variable "lack of movement" (see Table 15). For people who fit in the category "just active enough", meeting places in their future neighborhood are not important (see Table 16). The respondents in the categories "lack of movement" and "no lack of movement" have more interest in a neighborhood where they can meet others.

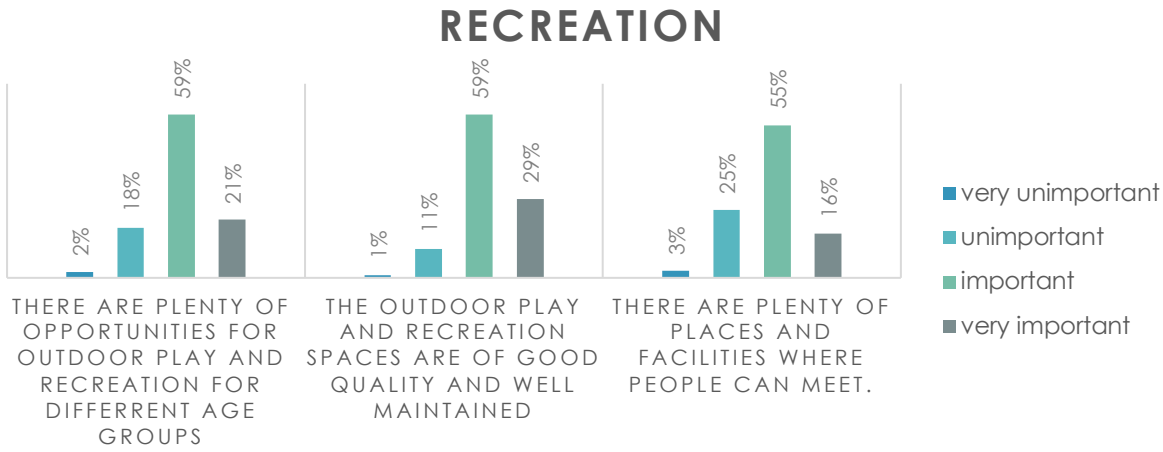


Figure 31: Recreation

Pseudo R-Squared	
Cox and Snell	.018
Nagelkerke	.021
McFadden	.009
Link function: Logit.	

Table 15: Pseudo R-Squared—Recreation

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q20_3 = 1]	-3.956	.377	110.215	1	.000	-4.694	-3.217
	[Q20_3 = 2]	-1.265	.166	58.230	1	.000	-1.590	-.940
	[Q20_3 = 3]	1.462	.173	71.724	1	.000	1.124	1.800
Location	[Bewegingsarmoede=1,00]	-.387	.257	2.272	1	.132	-.890	.116
	[Bewegingsarmoede=2,00]	-.653	.286	5.221	1	.022	-1.213	-.093
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 16: Parameter Estimates, Recreation

5.4.5 Participation in Decision Making

Almost all respondents want to participate in decision making in their future neighborhood. Feeling listened to and knowing where to go with ideas is preferred by most of the respondents. Figure 32 shows these results.

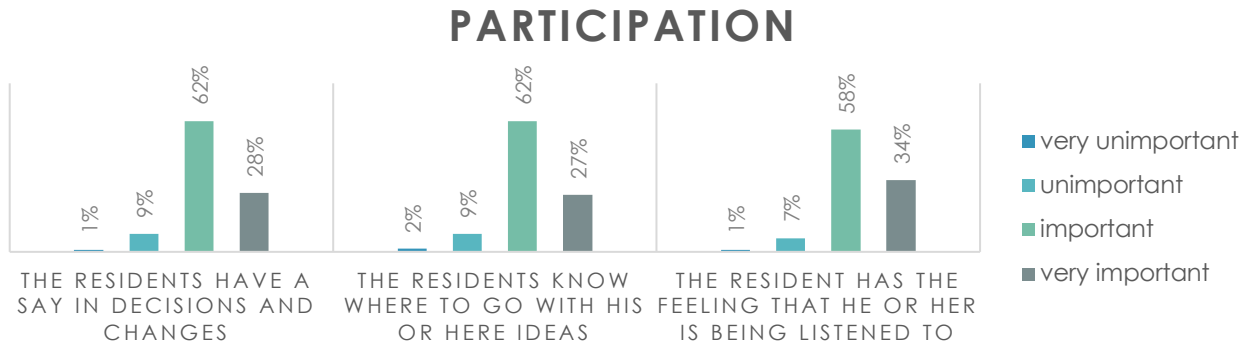


Figure 32: Participation in Decision Making

5.46. Feeling Safe

Respondents would like to live in a neighborhood where they feel safe. Street lighting is very important. Likewise, the possibility of using pedestrian and bicycle lanes all year round is preferred by almost all respondents.

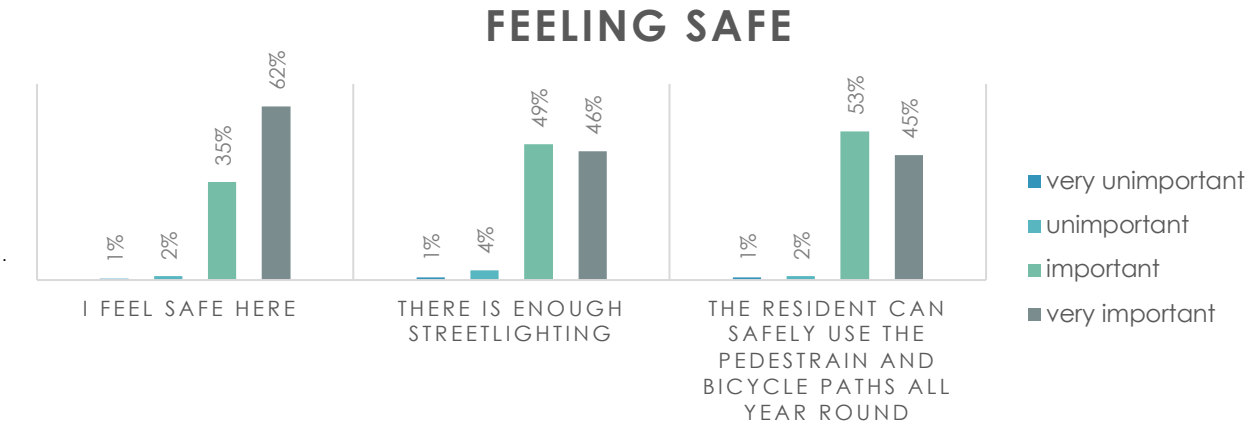


Figure 33: Feeling Safe

5.4.7 Parking facilities and speed measures

Respondents' preferences for parking facilities in their future neighborhoods are shown in Figure 34. For bicycles it is important that the bike can be easily parked and collected if one wants to go for a ride. For vehicle parking opinions are more divided. Most people would like there to be enough parking space in their future neighborhood. Of all respondents, 37% would not want to have clustered parking in the neighborhood, while 24% consider it to be unimportant to have their car parked close to the house. At least 70% would like to have their car close to their home.

Most of the respondents do not want to be bothered by traffic in their new neighborhood. Speed measures are preferred by more than 60% of respondents as a feature of their future neighborhood (see Figure 35).
Elaborating further, the variance for the variable "the resident is not bothered by cars and other traffic" for 3% of respondents is explained by the independent variable "lack of movement" (see Table 17). The estimated parameter for lack of movement is -.806 which means that people with lack of movement have a lower preference for—or care less about—not being bothered by cars and other traffic. Conversely, people who are

more active have more interest in a neighborhood where they are not bothered by cars or other traffic (see Table 18).

Pseudo R-Squared	
Cox and Snell	.028
Nagelkerke	.033
McFadden	.015
Link function: Logit.	

Table 17: Pseudo R-Squared, Speed Measures

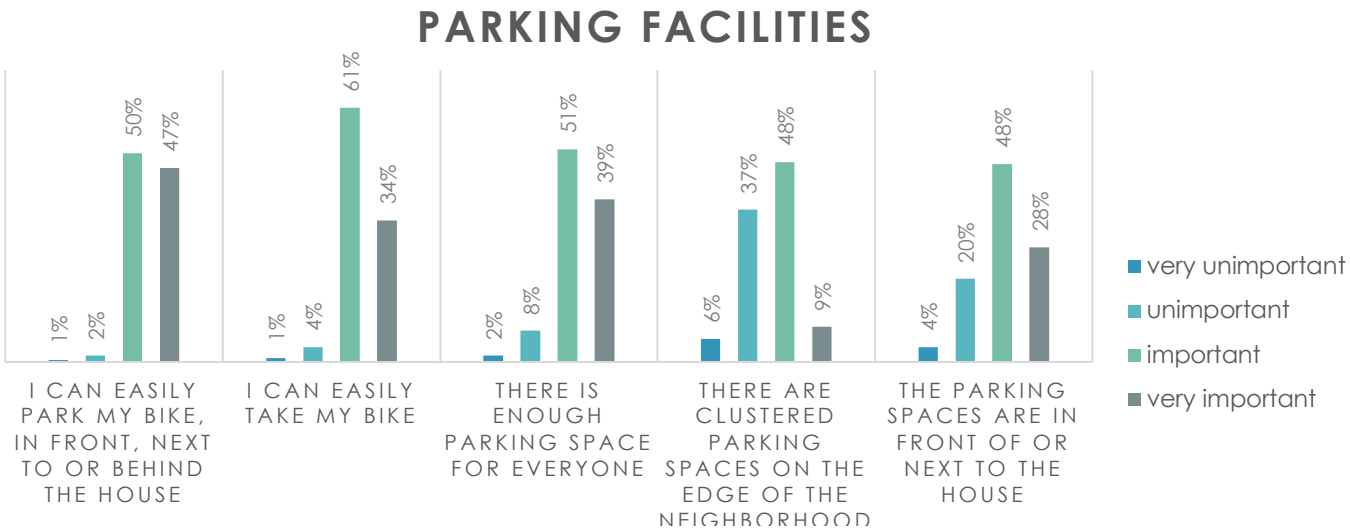


Figure 34: Parking Facilities

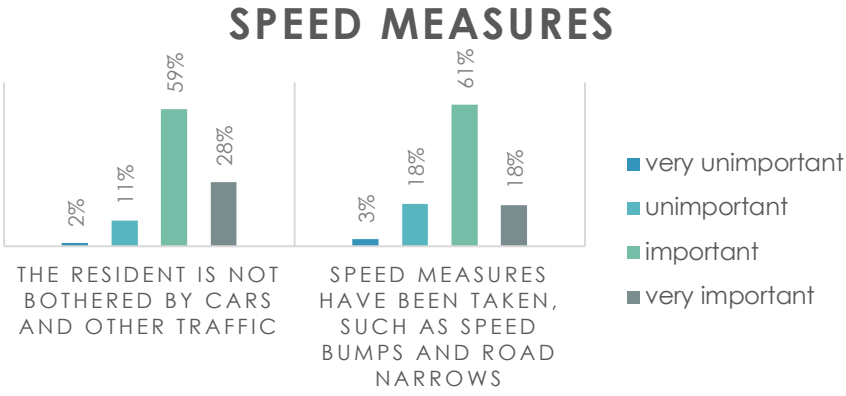


Figure 35: Speed Measures

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q15_2 = 1]	-4.777	.518	84.939	1	.000	-5.793	-3.761
	[Q15_2 = 2]	-2.213	.200	122.344	1	.000	-2.605	-1.821
	[Q15_2 = 3]	.752	.149	25.405	1	.000	.459	1.044
Location	[Bewegingsarmoede=1,00]	-.806	.261	9.567	1	.002	-1.317	-.295
	[Bewegingsarmoede=2,00]	-.323	.290	1.238	1	.266	-.892	.246
	[Bewegingsarmoede=3,00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Table 18: Parameter Estimates, Speed Measures

5.5 Physical Activity and Built Environmental Characteristics

One last sub-question needs to be answered before the main research question will be answered. This section will look at the following question: "*What relationships are there between the physical activity of the respondents and the characteristics of the built environment?"*. To answer this question the correlations between the current neighborhood and respondents' MET-scores are calculated. In Table 19, only the relationships that correlate are shown; the rest of the correlations are shown in Appendix V. These results are from the respondents interested in Waalfront and Nieuwe Kade Kwartier.

The first correlation discovered is a significant positive correlation between easily useable pedestrian and bicycle lanes and MET-scores in sports. This means that respondents had a higher MET-score for sports when they perceived the pedestrian and bicycle lanes to be easy to use. The second correlation connects respondents' enjoyment of plenty of green and nature in their neighborhood with a significantly higher MET-score overall and specifically for Spare Time and Sports. This correlation indicates that people in areas with plenty of green and nature make more use of their environment by venturing out for physical activity outside their homes. Outdoor play and recreation are also positively correlated with MET-scores for spare time, sports, and activity overall. This indicates that respondents who live in a neighborhood with enough opportunities for outdoor play and recreation are more active in their spare time and engage in more sports. Scores for the question "*I'm satisfied with the facilities around my living space"* indicate that people who are more satisfied with their neighborhood engage in more sports. The last significant correlation shows us that the type of neighborhood influences the MET-score for Spare Time, as well as the overall MET-score. Within this analysis no correlation has been found between transport and MET-score.

Respondents interested in Waalfront and Nieuwe Kade Kwartier N=363

Total MET-Score				Spare Time	Transport	Sports	Overall
I can easily make use of pedestrian and bicycle lanes	Pearson Correlation			.042	.044	.168**	.102
	Sig. (2-tailed)			.430	.400	.001	.052
		Std. Error		.046	.045	.048	.046
		95% CI	Lower	-.047	-.046	.072	.014
			Upper	.136	.129	.263	.197
I can enjoy plenty of nature and greenery	Pearson Correlation			.165**	.005	.153**	.179**
	Sig. (2-tailed)			.002	.924	.004	.001
		Std. Error		.053	.056	.053	.055
		95% CI	Lower	.059	-.114	.046	.063
			Upper	.264	.108	.255	.279
There are plenty of opportunities for outdoor play and recreation	Pearson Correlation			.109*	.071	.148**	.155**
	Sig. (2-tailed)			.039	.177	.005	.003
		Std. Error		.049	.048	.052	.046
		95% CI	Lower	.003	-.027	.044	.053
			Upper	.197	.159	.250	.245
I'm satisfied with the facilities around my living space	Pearson Correlation			.035	.048	.166**	.097
	Sig. (2-tailed)			.511	.365	.002	.064
		Std. Error		.045	.045	.053	.049
		95% CI	Lower	-.054	-.047	.054	-.003
			Upper	.126	.133	.264	.194
In what kind of neighborhood do you currently live?	Pearson Correlation			.146**	.058	-.047	.114*
	Sig. (2-tailed)			.005	.272	.368	.030
		Std. Error		.051	.055	.051	.050
		95% CI	Lower	.046	-.046	-.144	0.22
			Upper	.245	.178	.053	.210

Table 19: Significant Correlations, Respondents Interested in Waalfront and Nieuwe Kade Kwartier

Table 20 shows only the significant correlations for the results of respondents living in Waalfront; the rest of the correlations can be found in Appendix VI. A negative correlation exists between engagement in sports and route signs on bicycle and pedestrian lanes, indicating that the more route signs there are in the neighborhood where the respondent lives, the less sports they engage in. Additionally, when respondents can easily find their way through their neighborhood, they tend to have a lower MET-score for sports, as well as a lower MET-score overall. Easily accessible facilities are positively correlated with a higher MET-score for transport, indicating that respondents will use more active transport when facilities are close by. The collection, drop-off, and recycling of waste show a negative correlation with MET-scores for transport, with the Implication that good accessible waste disposal facilities make people less active.

Respondents living in Waalfront N=96

Total MET-score		Spare Time	Transport	Sports	Overall
The pedestrian and bicycle lanes are provided with route signs	Pearson Correlation	.097	.096	-.249*	-.090
	Sig. (2-tailed)	.349	.354	.014	.384
I can easily find the way	Pearson Correlation	-.083	-.032	-.217*	-.204*
	Sig. (2-tailed)	.420	.759	.033	.047
The facilities are easily accessible on foot	Pearson Correlation	.055	.264**	.047	.133
	Sig. (2-tailed)	.597	.009	.647	.197
There are good facilities for the collection, drop-off, and recycling of waste	Pearson Correlation	-.110	-.246*	.073	-.077
	Sig. (2-tailed)	.288	.016	.479	.454

Table 20: Significant Correlations, Respondents Living in Waalfront

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

6. Discussion

This section will elaborate on the findings of this study through a discussion about the results using both new literature not previously mentioned in this paper as well as the literature referenced in the review. This discussion will begin with a more detailed look at the target audience. Subsequently, the lack of movement among respondents will be discussed; this will be followed by a look at respondents' preferences in terms of their future neighborhoods. The discussion will conclude with a final look at the characteristics of the built environment and their influence on the physical activity of the respondents.

6.1 Target Audience

6.1.1 Waalfront, Nijmegen

The target audience that is interested in living in Waalfront, Nijmegen consists mostly of respondents who fall into the "Plan and Run" or "Carefree and Active" categories. The respondents already living in Handelskade and Koningsdaal tend to fall into the "Urban Dynamics" and "Just Average" categories. By contrast, according to research conducted by Klaver (2020b) the main target groups living in Nijmegen fall under the categories of "Young and Hopeful" and "Community and Outspoken". This difference could be due to the location of Waalfront and the audience that is attracted by this location. There are also many students living in Nijmegen who fall into the "Young and Hopeful" target group. The target group "Community and Outspoken" is different in a few respects from the "Urban Dynamics" and "Just Average" target groups. These differences are mainly to be seen in income and education level (WhoozBV, 2019), which indicates that Waalfront tends to be favored by people with higher incomes and levels of educational than the average person living in Nijmegen.

6.1.2 Nieuwe Kade Kwartier, Arnhem

Most people interested in Nieuwe Kade Kwartier, Arnhem fall into the target groups "Just Average", "Carefree and Active", and "Urban Dynamics". Looking at a study by Klaver (2020a) these target groups differ in some respects. "Community and Outspoken", "Just Average", "Young and Hopeful", and "Dreaming and Getting By" are the main target groups living in Arnhem. The main differences between these target groups can be found in the respondents' average incomes and educational levels (WhoozBV, 2019), which indicates that Nieuwe Kade Kwartier tends to be favored by wealthier people.

6.2 Lack of Movement

Within the current study the outcomes show that people lack movement in the way they travel to work. Most of the respondents do not use an active mode of transport. A difference in walking for transport reasons and for leisure purposes is found by Kang, Moudon, Hurvitz, and Saelens (2017). They state that there is a considerable difference in terms of speed, duration, frequency, and location. In the current study there is also a big difference seen in the amount of walking. Most respondents walk in their spare time. This finding agrees with the work of Thompson, Curl, Aspinall, Alves, and Zuin (2014), who discovered in their research that the most frequent outdoor activity was walking. According to the outcomes of the current study only a few respondents walk for transport which is in line with the evidence presented by Kang et al. (2017). The outcome of their research suggested that the mean time people walk for transport reasons as opposed to leisure purposes differs by 12 minutes in favor of leisure purposes.

A total of 40% of the respondents in this study have a lack of movement, meaning that they are not moving enough according to exercise standards. These exercise standards recommend that an adult person be intensely active for at least 150 minutes per week, spread across various days of the week (Backx, 2020). Twice weekly muscle and bone strengthening activities should be engaged in. According to Backx (2020) the Dutch population perceives their own activity level to be higher than it really is; this may be the case for respondents included in this study. But looking at the numbers, 60% of the Dutch population is achieving the previously described exercise norm, meaning that 40% are not, a statement that is completely in line with the results of this study, in which 40% of respondents appear to lack enough movement.

6.3 Preference in Future Neighborhood

6.3.1 Greenery and Public Space

The importance of greenery and nature for respondents when looking at potential future neighborhoods is recognized in this research. Besides this the outcomes also show that people with a lack of movement have less interest in an environment that contains easily accessible nature and greenery. Likewise, Van Cauwenberg et al. (2015) suggest that a nearby park may stimulate adults to walk. They also elaborated that a park of higher quality might influence people to spend more time there, and therefore increase the physical activity people are doing. Greenery and proximity to nature could stimulate residents to go for a stroll. Regarding the literature research in Section 4.2, the findings in this study are in line with Parra et al. (2010), Pearson et al. (2014), Y. Yang et al. (2019), and Zhang, Li, et al. (2014) who all find a positive association between greenery and nature and the behaviors of walking or bicycling.

According to this research public spaces need to be clean and well maintained. Additionally, people with lack of movement have a lower preference for an attractively furnished environment. Research by Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) produced a surprising outcome, showing that more active people perceived the aesthetics in their surroundings as less. Van Dyck, Cardon, Deforche, Giles-Corti, et al. (2011) elaborate this finding as follows, while the person is more actively walking around the neighborhood, they also see more problems accruing in the neighborhoods. This may also be the problem in the current study, but because of the cross-sectional nature of this study more cannot be said about this association.

6.3.2 Public Transport

The on-foot accessibility of public transport is associated with more short walks among the elderly (Hanson et al., 2013). Within the current study, 89% of respondents prefer that their future neighborhood have public transport collection points that are accessible by foot. Making public transportation accessible by foot could increase the daily active travel people engage in. Adams et al. (2016) elaborate on this, stating that the presence of good walking infrastructure in the neighborhood where people work supports walking as a mode of transportation. They also state that the availability of public transport could increase walking to work. The findings of the current study support those of the existing literature in suggesting that easily accessible public transport increases people's engagement in active modes of transportation.

6.3.3 Feeling Safe

Feeling safe is important to respondents when looking at potential future neighborhoods. Likewise, research conducted by Kosoko-Lasaki et al. (2019) observes that feeling unsafe in one's neighborhood negatively influences the amount of time one engages in physical activity. According to Kosoko-Lasaki et al. (2019) social cohesion could have positive health outcomes and promote healthier behavior. Furthermore, social relations could help build a safe environment. Foster et al. (2016) and Trumpeter and Wilson (2014) find that women may walk less if they feel unsafe in the neighborhood in which they live. This study has found no evidence of such a correlation; this is in line with six articles found in the literature review (Adlakha et al., 2017; Jalaludin et al., 2012; Jia & Fu, 2014; Jia et al., 2014; Ou et al., 2016; Van Dyck et al., 2013; Van Dyck et al., 2014).

6.3.4 Recreation and Facilities

Having facilities be nearby is preferred among the respondents of this study. Ease of access to facilities by bike is considered slightly more important than accessibility on foot. The perception of land use mix accessibility was also researched by Kerr et al. (2016), who found a positive association between this characteristic and both walking and cycling for transport reasons. According to their research, a perception of greater land use mix accessibility led to more walking. Moreover, Mertens et al. (2019) found that a higher land use mix diversity increased walking for transport reasons. The preferences of respondents in this study indicate that people would like to have the option to go to facilities on foot or by bike, which could lead to an increase in physical activity.

The presence of outdoor recreation areas is preferred by 80% of respondents, and the availability of facilities and play areas where people can meet is preferred by at least 70% of respondents. An association discovered within this study shows that people who are more active during the week have a higher preference for the

availability of a spot where they can meet other people. As mentioned in the section about feeling safe, healthy behavior is positively influenced by social cohesion. Research by Quinn et al. (2019) revealed a positive correlation between social support and participation in physical activity. This positive correlation was also found by Stella, Trinh-Shevrin, Yen, and Kwon (2016) and Trost, Owen, Bauman, Sallis, and Brown (2002). Therefore it can be said that having more places in a neighborhood where people can meet may influence them to engage in more physical activity.

6.3.5 Infrastructure and Speed Measures

In this study, 66% of respondents prefer that their future neighborhood have sidewalks that are at least 2 meters wide. A study conducted by Hanson et al. (2013) elaborated, showing that for the elderly the presence and characteristics of sidewalks are important. This is consistent with the literature on design principles. Cammelbeeck et al. (2014) and Mahmood et al. (2012) both found that smooth and pleasing environments enhance levels of physical activity. Good quality pedestrian routes are also preferred by the respondents of this study, meaning the findings are in line with the literature.

Recognizing the fact that urban design interventions could cost the developer more money, the cost-effectiveness of investing in sidewalks should be considered. Veerman et al. (2016) examined whether investment in sidewalks would result in higher health-adjusted life years (HALYs). HALYs measure the impacts of mortality and morbidity on a person's well-being. Meaning that a higher HALY is better for the population; the higher the HALY, the healthier the population. According to Veerman et al. (2016) the potential benefits from improvement of sidewalks did not outweigh the costs,; they asserted that there are more effective and less costly ways to promote physical activity.

The respondents in this study highly preferred good quality infrastructure for bicycling. Additionally, 69% would like to have speed measures in their future neighborhood. A study by Mertens et al. (2015) found that almost all adults have preferences for speed limits and an even cycle path. These outcomes are in line with the findings of this study. They also stated that small changes in the neighborhood, such as changing the speed limit from 50km/h to 30km/h could help increase the use of bicycling as a mode of transportation (Mertens et al., 2015). Minor changes like this could have a great impact on the physical activity of adults.

6.4 Physical Activity and Built Environmental Characteristics

A few correlations were found in this study, both positive and negative, between the amount of physical activity respondents engaged in and the built environmental characteristics of their current neighborhood.

In this study a negative correlation was found between physical activity and the presence of pedestrian and bicycle lanes that provide route signs, meaning that respondents were less active when route signs were present in the neighborhood they lived in. This finding is in contrast with the design principle *marked routes for bicycling and walking* by Cammelbeeck et al. (2014), who present it as a way to entice people to walk more. But looking at these results from the perspective of Ajzen (1991) Theory of Planned Behavior, people who do not have the intention to go for a walk could actually be negatively influenced by the route signs. On the other hand, perhaps because of the route signs the routes are shorter, meaning that people need to walk less. Since, this is a cross-sectional study, only guesses can be made.

Likewise, the result for "I can easily find the way", an indicator of the walkability of the neighborhood, is a negative correlation. This negative correlation was not found during the literature review conducted for this study. The negative correlation found in this study could be caused by misperception. Gebel, Bauman, Sugiyama, and Owen (2011) explained how misperception of the walkability of the neighborhood decreases the amount of walking a person does. Therefore, not only does the walkability of the environment need to be good, residents also need to perceive the neighborhood as being easy to walk in. Within this study results suggest that when people can easily find their way and pedestrian and bicycle lanes are provided with route signs, people are less active. The presence of route signs and being able to easily find one's way are components of the

walkability of a neighborhood. Within this study, there is the perception that the walkability of the neighborhood is low, which influences physical activity in a negative way.

On the other hand, positive associations have also been uncovered. Easily accessible facilities, satisfaction with facilities, easy use of pedestrian and bicycle lanes, plentiful greenery and sufficient opportunities for outdoor play and recreation are all components of walkability. The findings of the current research are in line with multiple other studies (Arvidsson et al., 2012; McCormack et al., 2019; Nathan et al., 2014; Towne et al., 2016; Van Dyck, Cardon, Deforche, Giles-Corti, et al., 2011). For example, McCormack et al. (2019) discovered that street patterns have an influence on the amount of walking in the neighborhood. Other research supports the finding that greenery has a positive influence on walking (Y. Yang et al., 2019).

There is thus a need for interdisciplinary collaboration to create neighborhoods and cities that promote active living, as suggested by Adlakha et al. (2017). The current study investigated the relationship between urban design interventions and physical activity levels. The approach of this study was to look at the activity levels of respondents in the current neighborhoods in which they live; the study did not examine the possibility that the move to the new neighborhood (meaning the target location) could affect their activity levels. As a study conducted by Curl, Kearns, Macdonald, Mason, and Ellaway (2018) discovered, the activity levels do not have to be influenced negatively. Their research shows that moving to a new neighborhood could lead to more walking. The increase in walking was especially seen when people already walked a lot in their old neighborhood. Moving to another neighborhood could influence a person's behavior in a healthier direction. As is shown in the results mentioned above, most respondents lack movement in their mode of traveling. Thus moving to a neighborhood with good facilities for walking and bicycling could be the change they need to support the development of healthier habits.

6.5 Limitations of this Research

The present study has a few limitations. First, the study was cross-sectional, and the questionnaires were completed over the months of July and August. The outdoor behavior pattern of the respondents could have been influenced by the summer season. Additionally, COVID-19 entered the Netherlands at the beginning of 2020. The answers given could have been influenced by this factor, so it is possible that a repetition of the questionnaire with the same participants would produce different outcomes.

Second, a survey method was used. People could perceive their behavior to be different—more positive or more negative—than it really is. Furthermore, there could be selection bias due to the target audience who responded to the survey. People without an internet connection living in the locations or interested in the locations could not have joined due to the fact that the survey was distributed online. Regardless of these concerns, the outcomes of this survey are not generalizable to a greater audience as the main respondents belong to a higher social-economic-status (SES) than average. To examine a different SES, a different study should be conducted.

Initially two more locations were added to the research, Den Haag and Breda. The questionnaire came too early for the location in Breda. For the location in Den Haag the questionnaire was sent out, but only 6 respondents filled out the questionnaire. Therefore their results were left out of the study.

A longitudinal study would be more accurate in detecting if the recommended design principles would turn out to effective if implemented. Unfortunately the time restriction for completing a master's thesis mean that a longitudinal study is not possible.

7. Conclusion & Recommendations

7.1 Answers to research questions

During this study multiple questions have been answered. This section will open with the answer to the first question. The characteristics of an active living environment found during the literature review are as follows: residential density; land use mix diversity; street connectivity; land use mix accessibility; aesthetics; infrastructure and safety for bicycling; infrastructure and safety for waking; traffic safety; safety from crime; access to public transport; access to green space; street lightning; walkability.

The target groups interested and living in Waalfront are "Plan and Run", "Carefree and Active", "Urban Dynamics", and "Just Average". The target groups interested in Nieuwe Kade Kwartier, Arnhem are "Just Average" and "Carefree and Active". This is the answer to the second sub-question.

The next question was *"How many respondents have lack of movement and are there differences between the target locations?"* Of the respondents, 40% have lack of movement, and there is no significant difference between the target locations.

As for the final sub-questions, some of the dependent variables were influenced by the independent variable "lack of movement". The dependent variables that were influenced are as follows: nature and greenery; public space; walking and bicycling infrastructure; recreation; and speed measures. The correlations found in this study between physical activity and built environmental characteristics were related to walking and bicycling infrastructure, nature and greenery, recreation, and facilities.

Having answered all of these sub-questions, it becomes tenable to answer the main research question: *"What is the impact of urban design interventions in neighborhoods on the physical activity (focusing on walking and bicycling) of residents?"* Investigating the different angles explained above, urban design interventions could influence the physical activity of residents.

As discussed in Section 4.3, the following design principles are included: parking bicycles in public and built-up space; clustered car parking; frictionless streets, place, and wide sidewalks; green routes for relaxation with enough rest areas, with impact on climate adaptation and heat stress; marked routes for bicycling and walking. Having said this, do these design principles really influence physical activity? Is the null or the alternative hypothesis accepted? Two hypotheses were put forth at the beginning of this research.

The first null hypothesis states as follows: "There is no impact from urban design interventions in neighborhoods on the time residents spent walking and bicycling". This hypothesis is rejected. Consequently, the alternative hypothesis "There is an impact from urban design interventions in neighborhoods on the time residents spent walking and bicycling" is accepted. The second null hypothesis states as follows: There is no relationship between the present physical activity and preferences for an active living environment of the respondents and their choices when selecting a new neighborhood" is also rejected. Which leads to the acceptance of the second alternative hypothesis: "There is a relationship between the present physical activity and preferences for an active living environment of the respondents and their choices when selecting a new neighborhood."

7.2 Recommendations for Practice

Starting off with the design principle *parking bicycles in public and built-up space*—this design principle does not feature in the results discussed in Section 5.5. in the current study this factor has not been shown to influence the activity level of residents. However, looking at the preferences of respondents, they would like to be easily able to park their bikes. Therefore this study still recommends implementing this design principle when building a new neighborhood or when reshaping an already existing neighborhood.

The design principle "frictionless streets, frictionless place, and wide sidewalks" does not show up in the correlations either, meaning that these characteristics have not been shown to influence levels of physical activity in this study. However, looking at the respondents' preferences regarding their future neighborhoods, this design principle is considered to be very important. For this reason, this study does recommend implementing this design principle.

The availability of green routes, with enough rest areas and impact on climate adaptation and heat stress, has been shown to influence the activity level of respondents in this study. As shown above, when a neighborhood contains plenty of greenery and nature, people are more active. Additionally, resting places such as benches along the route are preferred by at least half of respondents. Therefore, this study strongly recommends that this design principle be implemented when creating a new neighborhood.

As mentioned above, urban design interventions cost the developer money. A more in-depth study is needed to evaluate all the possible positive and negative effects of design intervention. The focal point of such a study should be on the cost effectiveness of these different interventions—for instance, a social cost and benefit analysis could be done.

The results of this study show that people who are more active have a preference for neighborhoods that are greener and have more nature, better public spaces and recreation places, better infrastructure, and more traffic speed measures. Knowing these factors, developers can choose to implement these characteristics in the built environment to entice potential buyers to buy properties with these characteristics and create neighborhoods that encourage active living.

7.3 Recommendations for future research

As suggested by B. Giles-Corti et al. (2016), interdisciplinary research is needed. The research conducted in this thesis is a starting point for bringing health and spatial planning together. But more research is needed, particularly strong longitudinal evidence that can broaden the scope of our current understanding.

Differences between urban and rural areas have not yet been mentioned in this study. A study discovered that people living in urban areas are less active and exhibit more sedentary behavior than people living in rural areas (Koyanagi et al., 2018). The respondents of the current study were not asked if they live in rural or urban areas. The difference could influence levels of sedentary behavior and therefore how active a person is. Van Dyck, Cardon, Deforche, and De Bourdeaudhuij (2011) found results that conflict with the results mentioned above. The results of their research show that rural individuals are less active than urban individuals. Their main finding shows that on average urban adults walk 75 minutes per week more. Because of the inconsistency between the two studies mentioned above, more research is needed to understand the differences between urban and rural areas.

Additionally, Gallagher, Clarke, and Gretebeck (2014) detected that walking could be a gender-related outdoor activity. Within their research they found that neighborhood facilities attracted women to go for a walk, while men were influenced by neighborhood density and aesthetics. The data collected for this study could be used to establish if there is a difference between men and women. This study split the data according to location preferences, but it would be interesting to look at the outcomes when split by gender. Perhaps some new and different preferences might be discovered.

Finally, within this study the respondent group falls into the higher social economic status segment. The locations surveyed for this study are those that appeal to the higher SES. But what would the outcomes be if this research were conducted for a social housing corporation, with respondents whose SES is likely to be lower. Would the results be the same? This is an interesting question for further research.

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