sustainability

MDPI

Article

The Healthy and Sustainable City—Influences of the Built Environment on Active Travel

Kerstin Kopal * and Dirk Wittowsky

Department of Structural Engineering, Institute of Mobility and Urban Planning, University of Duisburg Essen, 40219 Essen, Germany; dirk.wittowsky@uni-due.de
* Correspondence: kerstin.kopal@uni-due.de

Abstract: The city's built environment and functionality play a crucial role in shaping individual mobility patterns, impacting the overall health and quality of life of its population. Understanding these influences is an important research topic, making it a central focus of this paper. This study aims to identify the factors responsible for promoting healthy mobility behavior. To address this comprehensively, a multidisciplinary empirical survey was developed based on the "Triad"—a model consisting of the built environment, mobility(-behavior), and public health. In addition to the evaluation of socio-demographic factors and activity radius mapping, statistical analyses like multiple linear regression were used. These statistical analyses allow the assessment of the impact of various independent variables on the promotion of healthy mobility behavior within urban settings. The multiple regression shows that the satisfaction with the accessibility of public transport and the sense of safety as a cyclist contribute to explaining the variation of healthy mobility. Furthermore, the satisfaction with walking in the neighborhood and the inhalation of exhaust fumes while walking also seem to have an impact. The results show the link between the Triad and make it clear that mobility planning and urban planning must take a more integrated approach to promote health and simultaneously protect the climate.

Keywords: mobility; transportation; built environment; urban planning; mobility behavior; sustainability; public health; active travel; urban mobility

check for updates

Citation: Kopal, K.; Wittowsky, D. The Healthy and Sustainable City—Influences of the Built Environment on Active Travel. *Sustainability* **2023**, *15*, 14655. https://doi.org/10.3390/su151914655

Academic Editor: Giovanni Leonardi

Received: 29 July 2023
Revised: 1 October 2023
Accepted: 5 October 2023
Published: 9 October 2023

1. Introduction

The current urban expansion is leading to various impacts on climate change and mobility behavior [1]. It is predicted that by 2050, 70% of the world's population will live in cities [2]. This means that three out of four people will live in an urban setting. This poses several challenges for future urban planning. Changes in urban development and in transportation systems have the potential to improve or harm our health. On the one hand, a transportation system provides access to employment opportunities, education, services, recreation, and social participation. On the other hand, a transportation system continues to have negative impacts on the environment, health, and well-being. However, mobility provides a sustainable and easy opportunity for physical activity, especially through walking and cycling. The focus of this paper is therefore on sustainable and healthy forms of mobility that reduce land use as well as pollutant emissions [3]. The built environment and mobility system have a significant impact on people's mobility behavior and activity patterns and in turn on the health and quality of life of the entire population [4]. In addition to that, in recent decades, policymakers and municipalities have accepted negative impacts on people and the built environment through predominantly car-oriented structures. Transport infrastructures—and depending on this, the shares of the different modes of transport (modal split)—influence the extent of positive and negative impacts for society and the individual to a large extent [5].

The transportation sector is still responsible for the largest share of pollutant emissions, with motorized private transport and air traffic leading the way [6]. Furthermore, climate change and health are closely linked, and both are negatively impacted by pollutant emissions. This can be seen at various levels. On the one hand, a car-oriented lifestyle contributes to immobility, and on the other hand, pollutant emissions are harmful to the respiratory system [7,8]. People breathe in about 10,000 L of air per day. According to WHO, air pollution is one of the biggest negative factors affecting health. Pollutants from vehicles can trigger or increase respiratory illnesses, cardiovascular problems, and even heart attacks—8.8 million people die prematurely each year as a result of poor air quality. In addition, the natural exchange of air within high-density areas does not often exist due to impervious surfaces, and the risk of urban heat islands increases [9,10]. However, in the last 20 years, little has changed regarding the modal split in Germany. The habitual behavior patterns have hardly been broken in the direction of active mobility [11]. Despite this, electric cars are becoming more popular as part of the mobility turn [12]. This may improve local air quality in cities, using renewable energy, but it does not solve problems like PM10 or the disposal of batteries. Electric cars continue to take up space in cities for activity and sustainable transportation, and there is a risk that the car industry will experience a renewed surge in popularity by supposedly solving the pollution caused by internal combustion engines [13,14].

In the future, measures need to be increasingly assessed based on health targets. The switch to climate-friendly means of transport and the strengthening of local mobility is supported by various consortia like the Working Group of Pedestrian and Bicycle Friendly Cities, Communities and Districts in North Rhine-Westphalia or the WHO European Healthy Cities Network [15]. The World Health Organization has persistently promoted an integrated approach to transport and urban planning to simultaneously take account of social, health, and sustainability aspects and to constructively address conflicting goals. The Pan-European Programme for Transport, Environment, and Health (THE PEP) is particularly committed to this goal. Active travel provides a sustainable and easy way to engage in physical activity, especially walking and cycling. It is therefore an important contributor to empowerment and economic development [16]. Many determinants have the potential to improve or impair health. As these determinants lead to certain behaviors related to our travel patterns, the built environment should be health-promoting, which would also enhance the quality of life in our cities. Therefore, urban and transport planners, as well as public health professionals, need to work together to create a healthy and sustainable built environment for everyone [17].

2. State of Research

The synergies between health and mobility planning as well as urban planning are relevant at this point given that mobility behavior and daily physical activity are also influenced by the built environment in the neighborhood [18,19]. Inadequate or completely missing infrastructures can often be observed, which makes accessible and comfortable use with active forms of travel difficult [20]. The direct connection between cities, mobility, and health can be derived based on these synergies and linkages. This paper focuses on the Triad consisting of the built environment (urban planning) with its transport systems and public spaces, mobility (mobility planning) and behavior as well as subjective perceptions, and public health (health sciences) with regard to environmental and human pollution as well as the physical activity (walking or cycling) of the population, as seen in Figure 1.

2.1. The Built Environment in Health Sciences

The built environment covers a wide spectrum in the health sciences due to the Spatial Turn, i.e., the increased consideration of spatial contexts in health sciences, and the paradigm shift from the individual to the environment [21,22]. From a health science perspective, the built environment can be well seen in Barton and Grant's Health Map. The Health Map represents a human ecology model of a settlement and describes the determinants of health and well-being in people's living environments. Various aspects of social and economic life and the immediate environment are represented in the model. It also shows, that the built environment influences health (see Figure 2) [23].

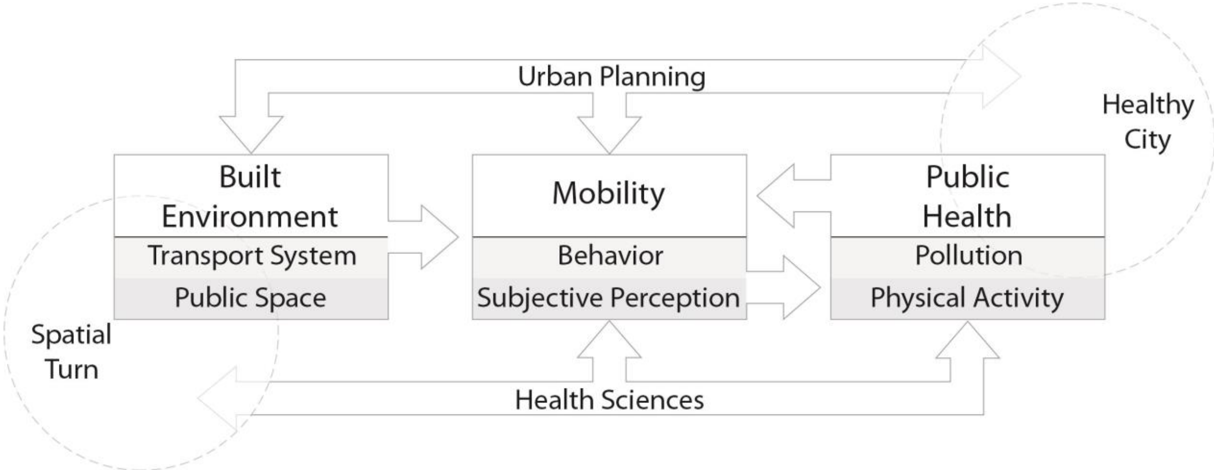


Figure 1. Triad with disciplinary approaches.

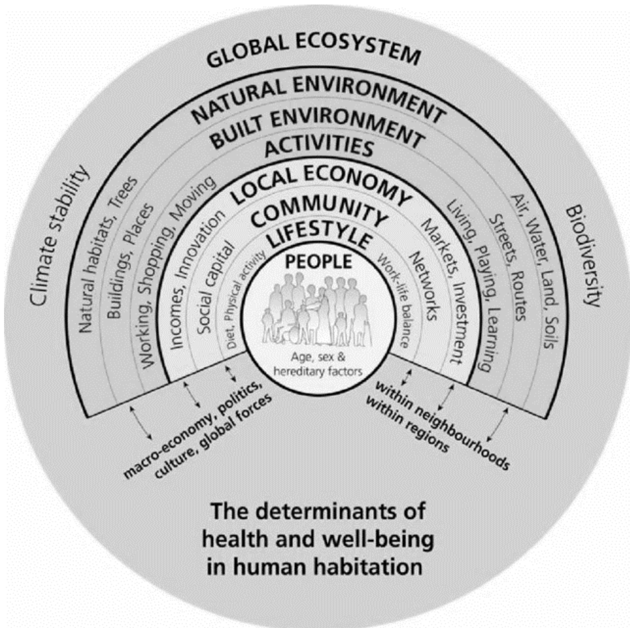


Figure 2. Health map [23].

The link to urban planning is clear at this point. In simple terms, the built environment consists of settlement structures and infrastructural linkages. Spatial planning is intended to guide the development of these structures, which is why the discipline of health sciences has also been intensively engaged with mobility and urban planning, since the Spatial Turn [21]. The WHO's Ottawa Charter for Health Promotion referred to the systematic recording of the health consequences of the environment as early as 1986. Urban development is also specifically mentioned here, among others, in connection with ensuring a positive influence on public health. Furthermore, according to the Charter, urban planning is also to be placed at the center of public attention to achieve and promote a common commitment to health promotion. The Ottawa Charter was the first to name action strategies and fields of action for an overall health-promoting policy [24]. Today, this approach is an integral part of health sciences, and it is known as the Health in All Policies approach. Thus, public health is to be further integrated into all policy areas and inclusion is to be promoted [25].

2.2. Physical Activity, Mobility, and Public Health

Physical inactivity is an important cause of many non-communicable diseases such as type 2 diabetes or cardiovascular diseases, which lead to significant healthcare costs [26]. It is increasingly recognized that physical activity should be promoted not only as a sporting activity but as an integrated movement in everyday life for all groups of the population [27]. This is where the link between the Triad's research of mobility and public health comes in. There is increased research and practice, especially in mobility planning, on moving from car-oriented to sustainable and active transportation. Bicycling and walking are forms of physical activity that are feasible for many segments of the population if the built environment provides the appropriate conditions [14]. Therefore, approaches from the health sciences have also been taken up in research on mobility and transportation. The concept of walkability emerged in the late 1990s, as part of transportation research in the United States, from the assumption that the built environment exerts an influence on physical activity and, thus, also on mobility [28]. Walkability is to be understood as a holistic and interdisciplinary construct that aims at an environment-promoting physical activity [29]. The magnitude of the positive health and environmental effects of active mobility has long been underestimated. In 2012, Wanner et al. first summarized evidence that active transportation is associated with more physical activity as well as lower body weight [30]. This observation was confirmed in a longitudinal analysis [31]. The often-cited fear that air pollution would negate the positive effects of active mobility has been refuted [32].

2.3. Mobility Behavior in the Context of the Triad

Traffic is caused for mobility needs and is the sum of a daily multitude of satisfying needs. The mode of transportation is defined by individual decisions [33]; therefore, special attention is paid to the research field of mobility behavior as in the Triad. Different research designs are given, due to numerous disciplines, which investigate different behavioral characteristics [34]. In a 2015 publication on a built environment and travel behavior, Heinen, Steiner, et al. found that numerous studies show that people in neighborhoods with a high density and a high mix of uses walk more and drive less than people in neighborhoods with a low density and a low mix of uses. In addition, however, some studies support the assumption that people who live in attractive neighborhoods are more likely to walk and that proximity to parks increases physical activity [35]. However, evidence that these characteristics have an impact on travel behavior is scant. Another aspect that influences the relationship between the built environment and travel behavior is residential self-selection. This approach assumes that individual transportation preferences influence residential choice and transportation mode. This implies that the relationship between the built environment and transport behavior could also be due to transport mode preferences [36].

3. Theoretical Framing

This paper focuses on the following research question: What are the discriminant factors that are responsible for healthy mobility behavior in the field of tension between neighborhood, structural environment, as well as individual attitudes and norms? Therefore, a multidisciplinary empirical study was conducted to build up a corresponding data base that allows statistical and GIS-related analyses of mobility behavior, the built environment, and its infrastructures, as well as health-related aspects. With this database, dependencies and effect sizes can be estimated, and complex impact mechanisms can be analyzed. In addition, with the help of indicators and environmental variables, recommendations for action can be derived for a city that promotes healthy and active mobility behaviors.

A conceptual framework was developed based on the current state of research on the Triad (Figure 1). For this purpose, a model that builds up on the Triad and bundles different variables was set up. Measurable variables can be used to determine the interrelationships and influences within the Triad. The following figure provides an overview of the variables and latent constructs of the framework.

Embedding of the Study in Existing Research

The existing literature and studies tend to focus on two of the three areas (built environment, mobility, and public health) or often on walkability with the missing element of public-health-related issues. For example, the NEWS-G (Neighbourhood Environment Walkability Scale) questionnaire (see Chapter 4) focuses on the built environment with some mobility aspects [37]. Due to the lack of health assessments in mobility behavior research, we integrated these in our model framework (see Figure 3). Another good example with a different research topic is Pfertner et al. who developed an "Open-Source Modelling Methodology for Multimodal and Intermodal Accessibility Analysis of Workplace Locations." Their research focuses on daily mobility behavior, transport choice, and accessibility. Although it also concentrates on sustainable mobility options, it lacks a reference to public health in the urban system [38]. The literature on statistical models in transportation planning shows that most regression models focus on the built environment or mobility. Liao et al. examine mobility behavior and walkability. The focus is on just two factors of the Triad. Although public health is addressed, no health-related items were included in the regression analysis [39]. However, when approaching the Triad from a public health perspective, there are also a few studies, such as Cobbold et al. 2022, which focus on multimodal behavior and use items of physical activity and quality of life in their analyses [40].

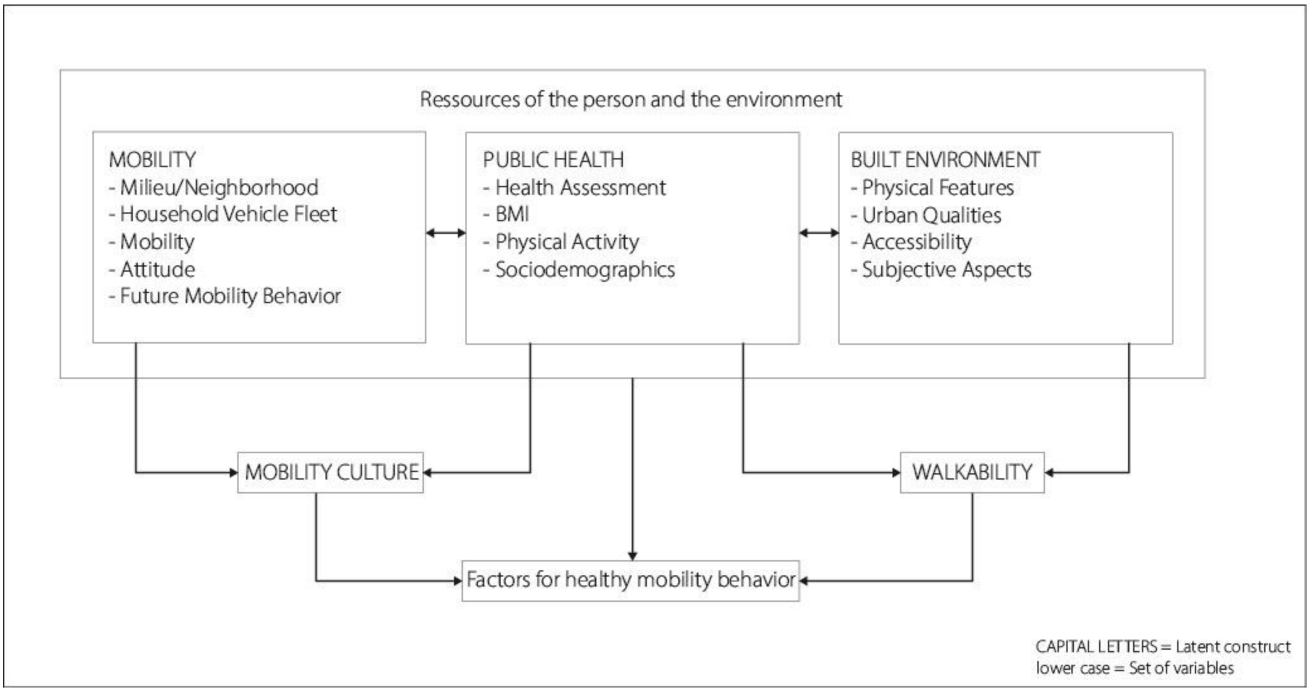


Figure 3. Conceptual model framework for healthy mobility behavior.

However, there is no study that comprehensively analyzes the influences on healthy mobility behavior in terms of the theoretical framework of the Triad described above. For this purpose, a corresponding empirical study was built up and items developed. To fill this research gap, an empirical study was conducted, and relevant items were identified. The research of this paper seeks to advance and consolidate the link between the fields within the Triad with qualitative and quantitative analyses.

4. Empirical Analysis

The multidisciplinary empirical survey was developed based on the model of factors for healthy mobility behavior (see Figure 3). The variables concerning the built environment are based on the NEWS-G questionnaire, which is a worldwide standardized tool for assessing walkability [37]. The NEWS-G provides several variables that also contribute to the research design (see Appendix A). To measure mobility behavior, we relied on standardized German transportation surveys such as “Mobility in Germany” and the “German Mobility Panel” [11,41]. These surveys contain comprehensive data on transport demand in Germany and data about the vehicle fleet, attitudes, and mobility. In addition, socio-demographic data were surveyed, as well as weight and height to calculate BMI. Questions on general health self-assessment were also included.

The online survey was conducted by a market research institute, and participants were selected from an access panel weighted by age, gender, and geographic location. The sample consists of 500 people living in Essen, Germany, and respondents were 18 years of age or older. The survey was conducted in July 2021. The questionnaire consisted of a total of 57 questions on the following areas:

- Sociodemographic standards
- Health status
- Household vehicle fleet
- Physical activity
- Quality of the environment
- Mobility behavior and activity radius
- Attitude and mobility culture
- Future visions.

The study area is the city of Essen located in the Ruhr area, which is the most densely populated region in Germany [42]. Essen currently has a population of 595,598, and the city consists of 50 districts [43]. Today, the Ruhr area is mainly affected by structural change (from an industrial area to a modern metropolitan economy) and is a city with a high car density [44]. During industrialization and urbanization, car-oriented urban planning dominated. Healthy and sustainable urban and mobility planning is becoming increasingly important as the effects are still being felt today.

4.1. Overview of the Sample

To ensure the reliability of the research, the data set was checked for redundant responses as a plausibility check. In the descriptive analyses, outliers were identified and removed. In addition, the data set was compared with statistical data from the city of Essen to check the validity of the sample with respect to the population. Where the reference values of the sample (e.g., gender, age, and number of trips) differed from the statistics, the data set weights were applied.

The sample consisted of 61% women and 39% men with an age range of 18–79 years. The largest proportion was employed (67%), 29% were unemployed, and the remaining 4% were students (including school as well as university students). Health status as shown in Table 1 is composed of three subjective health items (see Appendix A). Health status was reported as good by most respondents (44.6%), followed by very good with 36.2%, and average with 15.4%. It was reported that 3.4% answered as poor, and 0.4% of respondents indicated their health as very poor. The calculated BMI also reflects this picture; according to the BMI, 2.4% are underweight, 33.4% of people have a healthy weight, and 25.6% fall into the pre-obesity category. It was reported that 17.8% of the sample fall in the category of obesity grades, 1–3.84% of the sample have a driver’s license, and households have an average of 1.1 cars and 1.4 functioning bicycles. The sample takes an average of 3.8 trips per day; furthermore, the average daily activity per foot per person is 5882 steps.

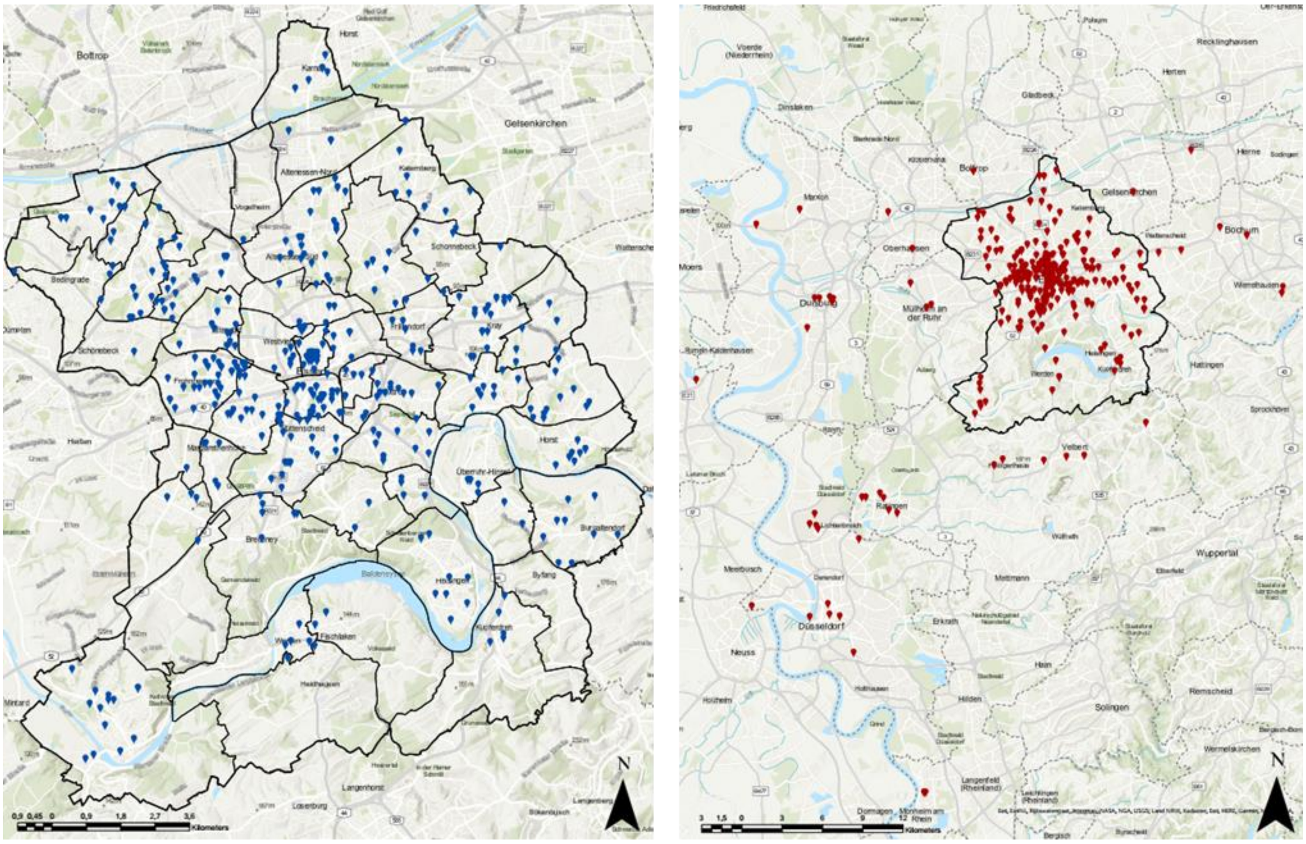
Table 1. Sociodemographic and mobility characteristics of participants.

Sociodemographic Characteristics	n
Gender	
Female	303 (60.6)
Male	197 (39.4)
Other	0 (0)
Age	
18–29	114 (22.8)
30–39	118 (23.6)
40–49	99 (19.8)
50–59	90 (18.0)
60–69	69 (13.8)
70–79	10 (2.0)
Educational level **	
Without degree	5 (1.0)
High school diploma	365 (73)
University degree	129 (25.8)
Employment	
Unemployed	144 (28.8)
Student	21 (4.0)
Employed	335 (67.0)
Health status	
Very poor	2 (.4)
Poor	17 (3.4)
Average	77 (15.4)
Good	223 (44.6)
Very good	181 (36.2)
BMI	
Underweight	12 (2.4)
Healthy weight	167 (33.4)
Pre-obesity	128 (25.6)
Obesity class 1	61 (12.2)
Obesity class 2	16 (3.2)
Obesity class 3	12 (2.4)
Driver's license	
Yes	422 (84.4)
No	78 (15.6)
Mobility Characteristics	M
Household vehicle fleet	
Cars	1.1
Bikes	1.4
E-Bikes/pedelecs	0.2
Motorcycle/mopeds	0.2
E-Scooter	0.1
Other	0.1
Daily activity by foot	
Steps	5881.9
Minutes	95.4
Kilometers	5.6
Trips per day	3.8

Note: Unless stated data reported as n (%) and mean (M). ** Translation based on the U.S. education system.

4.2. Activity Radius of the Sample

Activity radius mapping serves as a key measurement tool for assessing and localizing the influence of the built environment. The data on residence and workplace (as shown in Figure 4) provide a starting point for activity patterns and mobility options. Furthermore, the approach of residential self-selection can be applied to residential locations. The distribution of residential locations could provide reasons why residential locations were chosen and whether there is a preference for a certain mobility behavior. Participants placed pins on maps and marked their place of residence, place of work, and three preferred recreational areas.



(**a**) (**b**)

Figure 4. (**a**) Place of residence and (**b**) place of work; n = 329.

A decline from north to south can be seen in the pattern of residential areas (see Figure 4). The south of Essen is more rural and contains forests as well as some agricultural land. In addition, the large local recreational areas of Baldeneysee and the urban forest are located in the south. The majority of the sample lives in the district of Frohnhausen (located to the west), followed by Rüttenscheid (located south of the city center), Altenessen-Süd (located north of the city center), and Südviertel (southern part of the city center). Regarding both places of residence and places of work (see Figure 4), it can be seen that the data are concentrated in the northern and central parts of Essen. About 14% of the sample does not work in Essen but in the surrounding cities of the Rhine-Ruhr region.

4.3. Statistical Modeling

First, it is necessary to provide an overview of the latent constructs relevant to answering the research question. This is followed by the presentation of the correlation between those latent constructs, which thereupon follows the multiple linear regression model that provides information about the factors for healthy mobility behavior and therefore leads to the answer to the research question of this article.

Table 2 gives an overview of the latent constructs included for the statistical modeling and presents their reliability by showing Cronbach's alpha to assess the internal consistency of the latent constructs. See Appendix A for a detailed listing of the latent construct items.

Table 2. Cronbach's alpha of latent constructs.

Latent Construct	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N. of Items
Walkability			
Subjective walkability	0.808	0.819	18
Objective walkability	0.765	0.784	14
Accessibility	0.628	0.644	7
State of health	0.873	0.874	3
Attitude toward			
Car	0.722	0.720	3
Bicycle	0.839	0.837	5
Public transport	0.799	0.797	7
Walking	0.745	0.759	5
Healthy mobility	0.633	0.668	13

Note: See Appendix A for all items.

The internal consistency of the latent constructs, with respect to Cronbach's alpha, reaches from acceptable to very good from 0.628 to 0.873. Table 1 displays the latent construct walkability, which consists of the three different latent constructs, namely subjective walkability, objective walkability, and accessibility. The latent construct of walkability consists of a total of 39 and is split into the following latent constructs: the subjective walkability consists of 18 variables and has the highest internal consistency with Cronbach's alpha = 0.808 within the latent construct of walkability; it is therefore used for regression modeling. Furthermore, Table 1 also shows the internal consistency of the latent construct's state of health and the attitude toward different means of transport. The last latent construct in Table 1 is healthy mobility. It consists of the state of health, daily physical activity, mobility behavior, and the attitude toward different means of transport. The latent construct of healthy mobility consists of a total of 13 items and has an acceptable internal consistency with Cronbach's alpha = 0.633 [45]. The latent construct of healthy mobility consists of the items that determine healthy and active mobility behavior (see Appendix A).

The significant correlations between the latent constructs are shown in Table 3. This suggests that subjective walkability may influence healthy mobility. The correlation between the attitudes toward car use and the other modes of transport (cycling, public transport, and walking) is worth mentioning because these are significant negative correlations. This implies that the better the attitude toward driving a car, the worse the attitude is toward the other active forms of travel. Interestingly, the attitude toward public transport is the worst ($r = -0.625$, $p = 0.01$, and $n = 499$) when correlated with the attitude toward the car. Furthermore, the state of health has significant positive correlations with all other latent constructs but the attitude toward the car. The strong positive correlation between walkability and subjective walkability, objective walkability, and accessibility was to be expected since walkability consists of those three latent constructs. Also, there is a significant positive correlation between the status of health and walkability, $r = 0.367$ and $p < 0.01$. This also suggests that the built environment may have an impact on healthy mobility behavior. Since the latent construct of healthy mobility consists of the state of health, daily physical activity, mobility behavior, and the attitude toward different means of transport, it was also to be expected to have good (negative) significant correlations between those variables. Also worth mentioning is the correlation between the latent construct of healthy mobility and walkability, $r = 0.353$ and $p < 0.01$. This is another indicator of the built environment's connection to mobility (behavior) and public health. The aspects of subjective walkability, in particular, that have an impact on healthy mobility behavior will be shown in the following multiple linear regressions.

Table 3. Means, standard deviations, and correlations between the latent constructs.

	n	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
1 Walkability	499	3.77	0.37	--									
2 Subjective walkability	499	3.66	0.51	0.756 **									
3 Objective walkability	499	3.84	0.51	0.791 **	0.589 **								
4 Accessibility	499	3.81	0.56	0.586 **	0.060	0.130 **							
5 State of health	499	3.82	0.82	0.367 **	0.376 **	0.242 **	0.170 **						
Attitude toward													
6 Car	499	3.27	1.10	−0.008	0.043	0.000	−0.056	0.074					
7 Bicycle	499	2.82	1.09	0.231 **	0.211 **	0.203 **	0.084	0.328 **	−0.164 **				
8 Public transport	499	2.89	0.90	0.186 **	0.137 **	0.120 **	0.138 **	0.133 **	−0.625 **	0.349 **			
9 Walking	499	3.55	0.84	0.289 **	0.282 **	0.250 **	0.091 *	0.265 **	−0.378 **	0.469 **	0.394 **		
10 Healthy mobility	499	3.11	0.51	0.353 **	0.331 **	0.250 **	0.175 **	0.616 **	−0.313 **	0.668 **	0.579 **	0.584 **	--

Note: Displayed are statistics of cases with the listwise exclusion of missing values; ** = $p < 0.01$ and * = $p < 0.05$.

Table 4 shows a multiple linear basic regression model of the latent healthy mobility construct. The multiple linear regression model resulted in an adjusted R-squared value of 0.256, indicating that approximately 26% of the variance in healthy mobility can be explained by the independent variables. The F-statistic for the model is 33.326 ($p < 0.001$). The unstandardized coefficients show that less variance in healthy mobility can be explained by the independent variables in this model. The factors in the model are pointed out in the expected sign. Road safety and access to public transport have the greatest impact on healthy mobility. Poor air quality has the only negative effect on the model.

Table 4. Multiple linear basic regression model of healthy mobility on the significant variables of Table 5.

	Coefficients					
	B	Std. Error	t	*p*	CI (95%)	
Intercept	1.839	0.147	12.493	<0.001	1.550	2.129
1 Satisfaction walking	0.125	0.028	2.811	0.005	0.024	0.136
2 Satisfaction accessibility of public transport	0.206	0.027	4.663	<0.001	0.074	0.181
3 Exhaust fumes while walking	−0.173	0.019	−4.009	<0.001	−0.111	−0.038
4 Exceeding posted limits while driving	0.067	0.020	1.529	0.127	−0.009	0.069
5 Sense of safety as a cyclist in traffic	0.359	0.018	8.722	<0.001	0.125	0.197

Note: $R^2 = 0.264$; Adj. $R^2 = 0.256$.

The regression model in Table 5 is extended by relevant variables to identify further aspects regarding the influences on healthy mobility. The regression model for predicting healthy mobility is based on 18 different variables of subjective walkability. Multiple linear regression was used to estimate the effects of the independent variables of the latent construct of subjective walkability on the latent construct of healthy mobility. The multiple linear regression model resulted in an adjusted R-squared value of 0.273, indicating that approximately 27% of the variance in healthy mobility can be explained by the independent variables. The effect size of the model according to Cohen is large with a value of 0.61 [46]. The F-statistic for the model is 10.697 ($p < 0.001$), indicating that the overall model is statistically significant. Furthermore, the regression analysis assumes linearity. The standard errors for the coefficients can be read from Table 4. Thus, the following are the independent variables: satisfaction with walking (2), satisfaction with accessibility of public transport (6), exhaust fumes while walking (9), exceeding of posted limits while driving (11), and sense of safety as a cyclist in traffic (13). They contribute to the explanation of the variation of healthy mobility because their *p*-value shows significance, with alpha level <0.05 (bolt in Table 4).

Table 5. Multiple linear regression model of healthy mobility on the variables of the latent construct subjective walkability.

	Coefficients					
	B	**Std. Error**	**t**	***p***	**CI (95%)**	
Intercept	1.713	0.183	9.353	<0.001	1.353	2.073
1 Satisfaction cycling	0.004	0.028	0.151	0.880	−0.050	0.058
2 Satisfaction walking	0.070	0.033	2.095	0.037	0.004	0.135
3 Satisfaction congestion and speed of traffic	−0.011	0.029	−0.364	0.716	−0.068	0.047
4 Satisfaction traffic noise	0.012	0.027	0.441	0.659	−0.042	0.066
5 Satisfaction neighborhood as a place to live well	0.030	0.032	0.931	0.352	−0.033	0.093
6 Satisfaction accessibility of public transport	0.110	0.030	3.675	<0.001	0.051	0.169
7 Satisfaction accessibility of shopping facilities	0.020	0.034	0.583	0.560	−0.047	0.087
8 Traffic makes it difficult or unpleasant to walk	−0.038	0.025	−1.536	0.125	−0.088	0.011
9 Exhaust fumes while walking	−0.062	0.024	−2.572	0.010	−0.110	−0.015
10 Crosswalks and pedestrian signals	−0.007	0.018	−0.376	0.707	−0.043	0.029
11 Exceeding posted limits while driving	0.048	0.021	2.239	0.026	0.006	0.090
12 Sense of safety as a pedestrian in traffic	0.038	0.035	1.103	0.270	−0.030	0.107
13 Sense of safety as a cyclist in traffic	0.097	0.027	3.610	<0.001	0.044	0.150
14 Sense of safety while walking in the dark alone	0.031	0.027	1.152	0.250	−0.022	0.083
15 Sense of safety while cycling in the dark alone	0.048	0.025	1.893	0.059	−0.002	0.097
16 Interesting things to look at while walking	0.017	0.025	0.666	0.506	−0.033	0.066
17 Attractive natural sights	−0.011	0.023	−0.492	0.623	−0.057	0.034
18 Attractive buildings/homes	−0.030	0.028	−1.070	0.285	−0.086	0.025

Note: R^2 = 0.302; Adj. R^2 = 0.273.

The regression equation for predicting healthy mobility based on the different variables of the subjective walkability is as follows:

$$Y = 1.713 + 0.004x\_1 + 0.07x\_2 - 0.011x\_3 + 0.012x\_4 + 0.03x\_5 + 0.11x\_6 + 0.02x\_7 - 0.038x\_8 - 0.062x\_9 - 0.007x\_10 + 0.048x\_11 + 0.038x\_12 + 0.097x\_13 + 0.031x\_14 + 0.048x\_15 + 0.017x\_16 - 0.011x\_17 - 0.03x\_18$$

The unstandardized coefficient for satisfaction walking (B_2 = 0.070) indicates that for each unit, as the coefficient increases, healthy mobility improves by 0.070. For satisfaction accessibility of public transport (B_6 = 0.110), the regression model predicts that healthy mobility increases even by 0.110 per unit. It also seems reasonable that the unstandardized coefficient for exhaust fumes, while walking (B_9 = −0.062), indicates that for each unit when the coefficient increases, healthy mobility decreases by −0.062. This is also the case with the unstandardized coefficient for the sense of safety as a cyclist in traffic (B_13 = 0.097); it indicates that for each unit, when the coefficient increases, healthy mobility improves by even 0.097. However, one coefficient does not seem to be explainable: the unstandardized coefficient for exceeding posted limits, while driving (B_11 = 0.048), shows that healthy mobility increases by 0.48 per unit. This would mean that the more the posted limit is exceeded, the more healthier mobility in this neighborhood would increase.

5. Conclusions

In future urban planning processes, it will be important to build modern infrastructures for healthy mobility. However, it is not just objective walkability that will play an important role but also subjective walkability indicators. The analyses give a first indication of possible effects on healthy mobility. The model for the factors for healthy mobility behavior (see Figure 3) clearly shows the link within the Triad. It is possible to combine the multidisciplinary research of the Triad with the different approaches of different disciplines. Building on the model, the empirical study offers the possibility to estimate the effects of the discriminant factors for healthy mobility behavior in the field of tension between neighborhoods, building structures, as well as attitudes and norms. This could be demonstrated using the latent constructs and significant correlations within the Triad as well as two comparing multiple linear regression models of healthy mobility on the variables of the latent construct of subjective walkability. The regression model in Table 5 provides the first concrete approaches as to which individual factors are responsible for healthy mobility behavior. Subjective walkability as a subset of walkability is important to estimate the effects influencing healthy mobility behavior. The model fit shows that the statistical models might be able to explain the variance of the factors for healthy mobility behavior. Further analysis using a structural equation model combines factor analysis, regression analysis, and path analysis for the full set of walkability, mobility behavior, and health-related aspects. Nevertheless, the multiple regression model shows that factors like satisfaction of walkability, accessibility of public transport, cycling-safety, and the reduction in air pollution improve the healthy mobility behavior.

Furthermore, indicators or environmental variables for a movement and health-promoting municipality are to be derived, which integrate the topics of mobility and urban design to promote health and protect the climate at the same time. These indicators can be translated into (infrastructural) measures such as wide sidewalks with sufficient urban furniture, awnings, but also greenery. In addition, reduction in the posted limits for drivers and mobility management can contribute to a safer and healthier environment for all road users. Mobility planning and urban planning must take a more integrated approach to focus on the design of urban public spaces. A movement-friendly and health-promoting impact of the built environment must be contextualized with walkability and mobility behaviors, as well as attitudes and mobility culture. The widely desired transport and mobility transition can therefore be promoted primarily with infrastructural and behavioral measures in neighborhoods to integrate individual movement promotion in everyday life.

Author Contributions: Conceptualization, K.K.; Methodology, K.K.; Validation, D.W.; Writing—original draft, K.K.; Writing—review & editing, K.K. and D.W.; Supervision, D.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data may be viewed upon request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Items of the latent constructs as shown in Tables 2–4.

List of items of subjective walkability
How satisfied are you with the possibility to ride a bike in your neighborhood?
How satisfied are you with the possibility to walk in your neighborhood?
How satisfied are you with the congestion and speed of traffic in your neighborhood?
How satisfied are you with the traffic noise in your neighborhood?
How satisfied are you with your neighborhood as a place to live well and feel comfortable?
How satisfied are you with the accessibility to public transport in your neighborhood?
How satisfied are you with the accessibility to shopping facilities in your neighborhood?
There is so much traffic along the street I live on that it makes it difficult or unpleasant to walk in my neighborhood.
When walking in my neighborhood there are a lot of exhaust fumes.
There are crosswalks and pedestrian signals to help walkers cross busy streets in my neighborhood.
Most drivers exceed the posted limits while driving, in my neighborhood.
How safe do you feel as a pedestrian (or wheelchair user) when participating in road traffic (regarding the risk of an accident)?
How safe do you feel as a cyclist when participating in road traffic (regarding the risk of an accident)?
How safe do you feel from assault and harassment when walking in the dark without an escort?
How safe do you feel from assault and harassment when riding a bicycle in the dark without an escort?
There are many interesting things to look at while walking in my neighborhood.
There are many attractive natural sights in my neighborhood.
There are attractive buildings/homes in my neighborhood.

List of items of objective walkability
The streets in my neighborhood do not have many cul-de-sacs. There are walkways in my neighborhood that connect cul-de-sacs to streets, trails, or other cul-de-sacs. The distance between intersections in my neighborhood is usually short. There are many four-way intersections in my neighborhood. There are many alternative routes for getting from place to place in my neighborhood. There are sidewalks on most of the streets in my neighborhood. The sidewalks in my neighborhood are well-maintained. There are bicycle or pedestrian trails in or near my neighborhood that are easy to get to. There is at least one park (or other recreational facilities such as green spaces, water, and forest) in my neighborhood. There is at least one playground in my neighborhood. There are spaces for sports activities in my neighborhood. There are trees along the streets in my neighborhood. Trees give shade to the sidewalks in my neighborhood. My neighborhood is generally free from litter.
List of items of accessibility
How many minutes does it take to walk to your nearest transit stop (bus, train)? Approximately how long does it take to walk (in minutes) from your home to the nearest small shop like a bakery etc., regardless of whether you use them yourself? Approximately how long does it take to walk (in minutes) from your home to the nearest grocery store, regardless of whether you use them yourself? Approximately how long does it take to walk (in minutes) from your home to the nearest fast-food restaurant, regardless of whether you use them yourself? Approximately how long does it take to walk (in minutes) from your home to the nearest café or restaurant, regardless of whether you use them yourself? Approximately how long does it take to walk (in minutes) from your home to the nearest local recreation area, regardless of whether you use them yourself?
List of items of state of health
How would you describe your health in general? How would you describe your current motivation? How did you feel in the last few weeks?
List of items of attitude towards means of transport
Car: I need to own a car. Driving a car is fun, and it is a passion for me. I can organize my everyday life very well without a car. Bicycle: If I want to, it's easy for me to make my everyday trips by bike or walk instead of driving. I like to ride my bike. I can reach many important destinations by bicycle as well. I don't mind biking even when the weather is bad. I cycle because I enjoy the exercise. Public transport: For me, it is difficult to make my everyday trips by bus and train instead of by car. I appreciate traveling by bus and train because there is usually something interesting to observe. If I want, it is easy for me to use bus and train instead of my car. If I take the bus and train, I would feel very limited in my personal space. Individuals who make many of their trips by bus and train impress me. I can relax well when riding the bus or train. When traveling by bus or train, my privacy is restricted unpleasantly. Walking: If I want to, it's easy for me to make my everyday trips by bike or walking instead of driving. I like to walk.

I feel good walking.
I walk even in bad weather.
Most of the time it is too exhausting for me to walk.
List of items of healthy mobility
How would you describe your health in general?
How would you describe your current motivation?
How did you feel in the last few weeks?
How often do you use the car (as a driver)?
How often do you use the bicycle/pedelec?
How often do you use public transport?
How often do you walk?
How many steps do you walk per day?
How many trips do you make on a normal day?
Attitude towards car
Attitude towards bicycle
Attitude towards public transport
Attitude towards walking

References

1. Dewan, A.M.; Kabir, M.H.; Nahar, K.; Rahman, M.Z. Urbanisation and environmental degradation in Dhaka Metropolitan Area of Bangladesh. *Int. J. Environ. Sustain. Dev.* **2012**, *11*, 118. [CrossRef]
2. UN-Habitat. *Planning Sustainable Cities: Global Report on Human Settlements 2009*, 1st ed.; Earthscan: London, UK, 2009; ISBN 978-92-113-2003-9.
3. Stevenson, M.; Gleeson, B. Complex Urban Systems: Compact Cities, Transport and Health. In *Integrating Human Health into Urban and Transport Planning: A Framework*; Nieuwenhuijsen, M.J., Khreis, H., Eds.; Springer: Cham, Switzerland, 2019; pp. 271–285. ISBN 978-3-319-74982-2.
4. Giles-Corti, B.; Vernez-Moudon, A.; Reis, R.; Turrell, G.; Dannenberg, A.L.; Badland, H.; Foster, S.; Lowe, M.; Sallis, J.F.; Stevenson, M.; et al. City planning and population health: A global challenge. *Lancet* **2016**, *388*, 2912–2924. [CrossRef] [PubMed]
5. Nieuwenhuijsen, M.; Khreis, H. Urban and Transport Planning, Environment and Health. In *Integrating Human Health into Urban and Transport Planning: A Framework*; Nieuwenhuijsen, M.J., Khreis, H., Eds.; Springer: Cham, Switzerland, 2019; pp. 3–16. ISBN 978-3-319-74982-2.
6. Forehead, H.; Huynh, N. Review of modelling air pollution from traffic at street-level—The state of the science. *Environ. Pollut.* **2018**, *241*, 775–786. [CrossRef] [PubMed]
7. Schulz, H.; Karrasch, S.; Bölke, G.; Cyrys, J.; Hornberg, C.; Pickford, R.; Schneider, A.; Witt, C.; Hoffmann, B. Atmen: Luftschadstoffe und Gesundheit—Teil I. *Pneumologie* **2019**, *73*, 288–305. [CrossRef]
8. Conrad, K.; Oswald, F.; Penger, S.; Reyer, M.; Schlicht, W.; Siedentop, S.; Wittowsky, D. Urbane Mobilität und gesundes Altern: Personen- und Umweltmerkmale einer generationengerechten Stadtgestaltung. Zur Arbeit der Forschungsgruppe autonomMOBIL. In *Stadt der Zukunft Gesund und Nachhaltig: Brückenbau Zwischen Disziplinen und Sektoren*; Fehr, R., Hornberg, C., Eds.; Oekom: Munich, Germany, 2018; pp. 291–319. ISBN 978-3-96238-074-8.
9. European Environment Agency. *Europe's Air Quality Status 2022*; European Environment Agency: Copenhagen, Denmark, 2022; ISBN 1977-8449.
10. Zhong, C.; Guo, H.; Swan, I.; Gao, P.; Yao, Q.; Li, H. Evaluating trends, profits, and risks of global cities in recent urban expansion for advancing sustainable development. *Habitat Int.* **2023**, *138*, 102869. [CrossRef]
11. infas; DLR; IVT; Infas 360. Mobilität in Deutschland: MiD Ergebnibericht. Available online: https://www.mobilitaet-in-deutschland.de/archive/pdf/MiD2017_Ergebnisbericht.pdf (accessed on 26 July 2023).
12. Sheller, M. From spatial turn to mobilities turn. *Curr. Sociol.* **2017**, *65*, 623–639. [CrossRef]
13. Nieuwenhuijsen, M.; Khreis, H. *Integrating Human Health into Urban and Transport Planning: A Framework*; Nieuwenhuijsen, M.J., Khreis, H., Eds.; Springer: Cham, Switzerland, 2019; ISBN 978-3-319-74982-2.
14. Glazener, A.; Khreis, H. Transforming Our Cities: Best Practices Towards Clean Air and Active Transportation. *Curr. Environ. Health Rep.* **2019**, *6*, 22–37. [CrossRef]
15. Kahlmeier, S.; Wittowsky, D.; Fehr, R. Mobilität und StadtGesundheit; Manuskript-ID GESU-2023-03-1824-SN.R1; Bielefeld, Germany. 2021. Available online: http://stadt-und-gesundheit.de/wp-content/uploads/2021/03/Mobilitaet_Lit_2020_03_16.pdf (accessed on 4 October 2023).
16. Arseni, O.; Racioppi, F. Making THE (Transport, Health and Environment) Link: Transport, Health and Environment Pan-European Programme and the Sustainable Development Goals. Available online: https://apps.who.int/iris/handle/10665/342213 (accessed on 26 July 2023).
17. Kopal, K.; Wittowsky, D. Stadtgesundheit als Baustein der Mobilitätswende—Wie beeinflusst die gebaute Umwelt ein nachhaltiges und bewegungsförderndes Verhalten. In *Towards the New Normal in Mobility: Technische und Betriebswirtschaftliche Aspekte*,

1st ed.; Proff, H., Ed.; Springer Fachmedien Wiesbaden GmbH; Springer Gabler: Wiesbaden, Germany, 2023; pp. 321–335. ISBN 978-3-658-39437-0.
18. Giles-Corti, B.; Gunn, L.; Hooper, P.; Boulange, C.; Diomedi, B.Z.; Pettit, C.; Foster, S. Built Environment and Physical Activity. In *Integrating Human Health into Urban and Transport Planning: A Framework*; Nieuwenhuijsen, M.J., Khreis, H., Eds.; Springer: Cham, Switzerland, 2019; pp. 347–381. ISBN 978-3-319-74982-2.
19. Xiao, Y.; Miao, S.; Zhang, Y.; Xie, B.; Wu, W. Exploring the associations between neighborhood greenness and level of physical activity of older adults in shanghai. *J. Transp. Health* **2022**, *24*, 101312. [CrossRef]
20. Handy, S.L.; Boarnet, M.G.; Ewing, R.; Killingsworth, R.E. How the Built Environment Affects Physical Activity: Views from Urban Planning. *Am. J. Prev. Med.* **2002**, *23*, 64–73. [CrossRef]
21. Andrews, G.J.; Hall, E.; Evans, B.; Colls, R. Moving beyond walkability: On the potential of health geography. *Soc. Sci. Med.* **2012**, *75*, 1925–1932. [CrossRef]
22. Macintyre, S.; Ellaway, A.; Cummins, S. Place effects on health: How can we conceptualise, operationalise and measure them? *Soc. Sci. Med.* **2002**, *55*, 125–139. [CrossRef] [PubMed]
23. Barton, H.; Grant, M. A health map for the local human habitat. *J. R. Soc. Promot. Health* **2006**, *126*, 252–253. [CrossRef] [PubMed]
24. World Health Organization. Regional Office for Europe. Ottawa Charter for Health Promotion. Available online: https://apps.who.int/iris/handle/10665/349652 (accessed on 26 July 2023).
25. Schlicht, W.; Bucksch, J.; Kohlmann, C.-W.; Renner, B.; Steinacker, J.; Walling, F. Die „gesunde Kommune" im Lichte, großer Wenden"—Ein sozialökologisch fundiertes Ziel kommunaler Gesundheitsförderung (KoGeFö). *Präv Gesundheitsf* **2022**, *17*, 266–274. [CrossRef]
26. WHO. Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World. Available online: http://apps.who.int/iris/bitstream/handle/10665/272722/9789241514187-eng.pdf (accessed on 9 October 2018).
27. Lau, J.H.; Nair, A.; Abdin, E.; Kumarasan, R.; Wang, P.; Devi, F.; Sum, C.F.; Lee, E.S.; Müller-Riemenschneider, F.; Subramaniam, M. Prevalence and patterns of physical activity, sedentary behaviour, and their association with health-related quality of life within a multi-ethnic Asian population. *BMC Public. Health* **2021**, *21*, 1939. [CrossRef] [PubMed]
28. Kerr, J. Definition und Dimensionen der Walkability. In *Walkability: Das Handbuch zur Bewegungsförderung in der Kommune*, 1st ed.; Bucksch, J., Schneider, S., Eds.; Verlag Hans Huber: Bern, Switzerland, 2014; pp. 131–142. ISBN 978-3-456-85351-2.
29. Kerr, J. *Walkability: Das Handbuch zur Bewegungsförderung in der Kommune*, 1st ed.; Bucksch, J., Ed.; Huber: Bern, Switzerland, 2014; ISBN 978-3-456-85351-2.
30. Wanner, M.; Götschi, T.; Martin-Diener, E.; Kahlmeier, S.; Martin, B.W. Active transport, physical activity, and body weight in adults: A systematic review. *Am. J. Prev. Med.* **2012**, *42*, 493–502. [CrossRef]
31. Dons, E.; Rojas-Rueda, D.; Anaya-Boig, E.; Avila-Palencia, I.; Brand, C.; Cole-Hunter, T.; de Nazelle, A.; Eriksson, U.; Gaupp-Berghausen, M.; Gerike, R.; et al. Transport mode choice and body mass index: Cross-sectional and longitudinal evidence from a European-wide study. *Environ. Int.* **2018**, *119*, 109–116. [CrossRef]
32. Tainio, M.; de Nazelle, A.J.; Götschi, T.; Kahlmeier, S.; Rojas-Rueda, D.; Nieuwenhuijsen, M.J.; de Sá, T.H.; Kelly, P.; Woodcock, J. Can air pollution negate the health benefits of cycling and walking? *Prev. Med.* **2016**, *87*, 233–236. [CrossRef]
33. Steierwald, G.; Künne, H.D.; Vogt, W. *Stadtverkehrsplanung: Grundlagen, Methoden, Ziele*, 2nd ed.; neu bearbeitete und erweiterte Auflage; Springer: Berlin/Heidelberg, Germany, 2005; ISBN 3-540-40588-7.
34. Ohnmacht, T.; Sauter, D. Gebaute Umwelt und körperliche Aktivität: Ein Literaturbericht. Available online: https://repository.difu.de/jspui/bitstream/difu/175616/1/DN0007.pdf (accessed on 4 May 2020).
35. Pyrialakou, V.D.; Gkritza, K.; Fricker, J.D. Accessibility, mobility, and realized travel behavior: Assessing transport disadvantage from a policy perspective. *J. Transp. Geogr.* **2016**, *51*, 252–269. [CrossRef]
36. Heinen, E.; Steiner, R.L.; Geurs, K.T. Special issue: Built environment and travel behaviour. *Eur. J. Transp. Infrastruct. Res.* **2015**, *15*, 3051. [CrossRef]
37. Almeida, D.P.; Alberto, K.C.; Mendes, L.L. Neighborhood environment walkability scale: A scoping review. *J. Transp. Health* **2021**, *23*, 101261. [CrossRef]
38. Pfertner, M.; Büttner, B.; Wulfhorst, G. An Open-Source Modelling Methodology for Multimodal and Intermodal Accessibility Analysis of Workplace Locations. *Sustainability* **2023**, *15*, 1947. [CrossRef]
39. Liao, B.; EW van den Berg, P.; van Wesemael, P.J.; AArentze, T. How Does Walkability Change Behavior? A Comparison between Different Age Groups in the Netherlands. *Int. J. Environ. Res. Public. Health* **2020**, *17*, 540. [CrossRef] [PubMed]
40. Cobbold, A.; Standen, C.; Shepherd, L.; Greaves, S.; Crane, M. Multimodal trips, quality of life and wellbeing: An exploratory analysis. *J. Transp. Health* **2022**, *24*, 101330. [CrossRef]
41. Vallée, J.; Ecke, L.; Chlond, B.; Vortisch, P. *Deutsches Mobilitätspanel (MOP)—Wissenschaftliche Begleitung und Auswertungen Bericht 2021/2022: Alltagsmobilität und Fahrleistung*; Karlsruher Institut für Technologie (KIT): Karlsruhe, Germany, 2022.
42. Referat Bildung und Soziales; Team Regionale Statistik und Umfragen. Metropole Ruhr: Die Region in Zahlen. Available online: https://www.rvr.ruhr/fileadmin/user_upload/01_RVR_Home/03_Daten_Digitales/Regionalstatistik/03_Publikationen/2021-08_Metropole_Ruhr_Die_Region_in_Zahlen.pdf (accessed on 28 September 2023).
43. Stadt Essen. Bevölkerung: Bevölkerungsstand. Bevölkerung am Ort der Hauptwohnung am 30.06.2023. Available online: https://www.essen.de/dasistessen/essen_in_zahlen/bevoelkerung.de.html (accessed on 28 September 2023).

44. Dahlbeck, E.; Gärtner, S.; Best, B.; Kurwan, J.; Wehnert, T.; Beutel, J. Analysis of the Historical Structural Change in the German Hard Coal Mining Ruhr Area. Available online: https://epub.wupperinst.org/frontdoor/deliver/index/docId/7945/file/7945_Structural_Change_Ruhr_Area.pdf (accessed on 4 October 2023).
45. Streiner, D.L. Starting at the beginning: An introduction to coefficient alpha and internal consistency. *J. Pers. Assess.* **2003**, *80*, 99–103. [CrossRef] [PubMed]
46. Cohen, J. A power primer. *Psychol. Bull.* **1992**, *112*, 155–159. [CrossRef]