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Nature as a facilitator for physical activity: Defining relationships between the objective and perceived environment and physical activity among community-dwelling older people

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ABSTRACT

The aim was to study the correspondence between the objective and perceived environment and to assess their associations with physical activity (PA) in older people. 848 community-dwelling older people aged 75–90 were interviewed on their difficulties in walking 500 m, perceiving nature as a facilitator for outdoor mobility, and PA. The presence of water and landscape diversity were objectively assessed inside 500 m and 1000 m circular buffers around participants' homes. Using logistic regression, participant data were analyzed together with the objectively assessed environmental features. Our results indicate that higher habitat diversity within natural areas correlates with higher PA among older people without walking difficulties and the presence of water correlates with higher PA among those with walking difficulties.

1. Introduction

Regular physical activity (PA), especially outdoors, positively affects health throughout the lifecourse (Pasanen et al., 2014; Gladwell et al., 2013). Even moderately active compared to sedentary behavior decreases the relative risk of mortality (Löllgen et al., 2009). Walking outdoors, for example, improves the physical capability of older people, including those reporting difficulties in walking (Simonsick et al., 2005). Environmental factors play an important role in enabling or preventing outdoor mobility among older people (Eronen et al., 2014; Rantakokko et al., 2012). A higher number of facilitators in the environment of older people increases their likelihood of engaging in physical activity (Eronen et al., 2014) whereas perceived barriers in the environment predicts a decline in walking capability (Rantakokko et al., 2012). Places perceived as positive by older people are mostly located close to home (Laatikainen et al., 2017) and this is also where older people's PA mostly occurs (Chaudhury et al., 2016). Going out of home increases the PA in older people (Portegijs et al., 2015). With the growing number of older people in the population, understanding the environmental factors that facilitate their PA is increasingly important from the perspective of both the individual and society.

With age, the physiological and sensory capacities of people decline (Viljanen et al., 2012). Typically, perceiving difficulties in walking longer distances is the first sign of mobility decline (Rantanen, 2012). Lower body function and walking difficulties thus merit consideration as they affect the way environmental factors are perceived (Sakari et al., 2017; Moura et al., 2017), how the perceived environment is related to PA (Levasseur et al., 2015; Haselwandter et al., 2015; Gallagher et al., 2012; Satariano et al., 2010), and how the objective features of the neighborhood are related to PA (Satariano et al., 2010; King et al., 2011; Gong et al., 2014). Clearly distinguishable patterns in land use and structures in the landscape can simplify extracting information from the environment (Kaplan and Kaplan, 1989). Similarly, according to the widely known person-environment fit (P-E fit) theory based on the ecological model of ageing by Lawton and Nahemow (1973), objective environmental features, personal capabilities, and perceptions of the environment are factors that largely determine older persons' prospects for engaging in a specific activity in the environment, such as walking. Based on recent review articles, the relationship between built and natural environmental features and PA (Harris et al., 2013) has been widely investigated, but only a few studies have simultaneously addressed the perceived and objective neighborhood environment and mobility limitations as factors underlying PA among older people (Levasseur et al., 2015; Haselwandter et al., 2015; Rosso et al., 2011).

Nature and green spaces (Levasseur et al., 2015; Rosso et al., 2011) and aesthetics (Levasseur et al., 2015; Rosso et al., 2011; Yen et al., 2014) can be considered important environmental facilitators for

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outdoor mobility among older people. The concept of landscape aesthetics often seems to overlap with nature: An environment perceived as aesthetic is commonly described with reference to the presence of trees, gardens, or vegetation in the landscape (Yen et al., 2014; McCormack and Shiell, 2011) and naturalness (Frank et al., 2013), all of which are aspects of nature. Drawing on the geospatial environmental data in the Geographic information system (GIS), perceived neighborhood features of these kinds have been operationalized into objectively assessed features of the natural environment, expressed in numerical values. Using GIS, high diversity and structural richness have been identified as key features of attractive landscapes (Schirpke et al., 2013; Tveit et al., 2006). Additionally, it has been suggested that when operationalizing green or natural environments as GIS measures, quality instead of proximity measures should be used (Ekkel and de Vries, 2017). On the question of spatial scale, large natural areas are suggested to offer a deeper experience of perceiving nature compared to small-sized areas (Ekkel and de Vries, 2017). Perceptions of nature and/or landscape aesthetics often correspond with the presence of water (Tveit et al., 2006; Dramstad et al., 2006; Dorwart, 2015) and with the measures of landscape diversity, such as patch density (Frank et al., 2013), number of land types (Frank et al., 2013), and the Shannon's Diversity Index (SHDI) (Frank et al., 2013; Dramstad et al., 2006). The presence of large natural areas with attractive features (Giles-Corti et al., 2005) as well as habitat diversity (de Jong et al., 2012), have also been proposed as potential correlates of PA. Among older persons with mobility limitations, however, the perceived and objective environmental determinants of PA continue to remain obscure (Levasseur et al., 2015; Satariano et al., 2010; Rosso et al., 2011). Also, studying perceived environmental features as connected with performing outdoor mobility would elaborate further knowledge on the facilitating effect of environmental determinants of outdoor mobility. Previous studies have shown that use and presence of environmental resources have different relationships with PA (Carlson et al., 2016). Few studies have focused on factors specifically motivating people to outdoor mobility.

The purpose of this study was to further knowledge about how well objectively assessed features of the natural environment correspond to perceiving nature as a facilitator for outdoor mobility among community-dwelling older people and whether objective environmental features vs. perceiving environmental facilitator for outdoor mobility correlate with PA. Our framework was based on the P-E fit theory (Lawton and Nahemow, 1973), and we considered difficulties in walking as the principal dimension of functional capacity in older people (Fig. 1).

Our study had three aims: (1) to find out how objectively assessed features of the natural environment are related to perceiving nature as an environmental facilitator for outdoor mobility; (2) to investigate the associations between objectively assessed features of the natural environment and PA; and (3) to examine whether perceiving nature as an environmental facilitator for outdoor mobility is related to a higher level of PA.

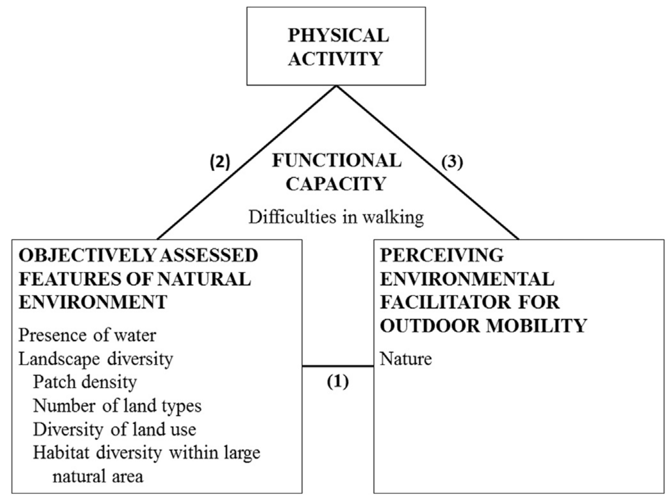

Fig. 1. The study framework was based on the person-environment fit theory and describes the associations between (1) objectively assessed features of the natural environment and perceiving environmental facilitator for outdoor mobility, (2) between objectively assessed features of the natural environment and physical activity, and (3) between perceiving environmental facilitator for outdoor mobility and physical activity, all three of which are affected by the functional capacity of the person.

2. Method

2.1. Study design

This cross-sectional study is part of the project "Geographic characteristics, outdoor mobility and physical activity in old age" (GEOage). In the study, participant data, including self-reports of perceived environmental factors, functional capacity, and PA, were linked to a set of objectively assessed features of the natural environments of the participants. Data reported by older people, collected as part of the baseline assessments of the "Life-space mobility in old age" (LISPE) cohort study, were used and have previously been described in detail (Rantanen et al., 2012). Participants were community-dwelling older people aged 75–90 years living in the municipalities of Jyväskylä and Muurame in Central Finland, where high numbers of lakes and hills are the predominant topographic features of the area. A random, non-spatial sample of 2550 people was drawn from the national population register and informed about the study by letter. A total of 848 people who were willing to participate, lived independently and were able to communicate were interviewed in their homes in 2012. All participants signed a written informed consent before interview.

Participants' homes were then located on a map by geocoding their addresses using the Digiroad 2013 dataset (dataset, 2013a) in ArcMap 10.3 software. Manual geocoding was required for 16 participants, who were not automatically located. Objectively assessed features of the natural environment were defined in GIS based on geospatial data on land use and topography within circular neighborhood buffers of 500 m and 1000 m radius around the participants' homes. The 500 m distance has been proposed by the European Commission Expert Group on the Urban Environment to serve as a common indicator for a walkable distance to public open areas. The distance of 500 m is expected to correspond to a 15-min walk for older people (European Commission, 2001). A 1000 m distance was also used since environmental features located further away may also be relevant facilitators for PA (Villanueva et al., 2014), especially among those without difficulties in walking. The LISPE project and the GEOage project have been approved by the Ethical Committee of the University of Jyväskylä, Finland.

2.2. Participant measures

2.2.1. Difficulties in walking

Difficulties in walking were assessed by asking "Are you able to walk 500 m?" The response options were (a) able without difficulty, (b) able with some difficulty, (c) able with a great deal of difficulty, (d) unable without the help of another person, and (e) unable to manage even with help. For the analysis, the responses were dichotomized into no difficulties (a) and difficulties (b-e). Self-reported difficulties in walking 500 m has been shown to be a valid measure to capture mobility limitations (Mänty et al., 2007).

2.2.2. Perceiving nature as a facilitator for outdoor mobility

Perceiving nature as a facilitator for outdoor mobility was obtained from one item of a checklist on environmental facilitators for outdoor mobility (PENFOM) (Rantakokko et al., 2015). The PENFOM checklist comprises 16 environmental facilitators for outdoor mobility of which the participants selected those that they perceived in their neighborhood as motivating them for outdoor mobility. We analyzed the responses for perceiving (yes) or not perceiving (no) nature in the neighborhood as a facilitator for outdoor mobility.

2.2.3. Physical activity

Physical activity was self-reported by participants using the question “Thinking of the past half year, which of the following best describes your physical activity?” The response options were (a) mostly resting, hardly any activity, (b) mostly sitting, with PA confined to activities of daily living (grooming, dressing), (c) light PA, such as light housework or light gardening or going for a walk two or three times a week, (d) moderate PA about 3 h a week, (e) moderate PA at least 4 h a week or heavier PA up to 4 h a week, (f) engaging in active sports several times a week or heavy gardening or leisure-time activities, at least 3 h a week, and (g) participating in competitive sports. For the analysis PA was dichotomized into light PA only (a-c) and at least moderate PA (d-g). The question on self-reported PA and its categorization have been shown to be valid in assessing the PA level of older people (Portegijs et al., 2016).

2.3. Objectively assessed features of the natural environment

Objectively assessed features of the natural environment, indicating the presence and diversity of natural areas (presence of water, patch density, number of land types, diversity of land use, and habitat diversity within large natural areas), were obtained from the open-source GIS resources Topographic Database 2013 (dataset, 2013b) and Corine Land Cover (CLC) year 2012 raster data (dataset, 2014), enhanced by the Finnish Environment Institute to a resolution of 20 m × 20 m and classified into 48 classes at the most detailed level. For the analyses, we reclassified the CLC data into 13 land types. The reclassified data includes three land types of the built environment and ten land types of the natural environment indicating presumed differences in the height, density, and color of the land cover in order to emphasize the natural environment in the values of the landscape diversity measures (Appendix 1, Supplementary Table 1).

2.3.1. Presence of water

Presence of water within the neighborhoods of the participants was defined by locating bodies of water on the map based on geospatial data from the Topographic Database 2013 (dataset, 2013b) and then spatially joining the neighborhood buffers with the water bodies. Lakes at least 1000 m^2 in area and rivers with a minimum width of 5 m were counted as bodies of water. The presence of water within the 500 m or 1000 m buffer was recorded as either no (no presence of water) or yes (presence of water) based on the result of the spatial analysis.

2.3.2. Patch density

Patch density is a measure of landscape diversity, and refers to richness in the spatial configuration. Patches are defined as areas consisting of one land type only. In calculating patch density, patches located either partially or wholly inside the study area, even when of the same land type, are included (Riitters et al., 1995). Patch density was obtained by dividing the number of patches inside the buffer by the size of the buffer (circular areas with a radius of 500 m or 1000 m). Patches were identified based on all the 13 categories of land types, thus including all three land types of the built environment (Residential and service; Industry, transport and construction; Sport and leisure facilities) and all ten land types of the natural environment (Cultivated fields; Fruit trees and berry plantations; Pastures; Uncultivated agricultural areas; Forests; Shrub and/or herbaceous vegetation; Open spaces with little/no vegetation; Wetlands; Swamps; and Water bodies), (Appendix 1) in the reclassified CLC data (dataset, 2014). Patch density ranged from 25.5 to 228.0 patches/km^2 in the 500 m buffers and 25.5–166.0 patches/km^2 in the 1000 m buffers.

2.3.3. Number of land types

Number of land types indicates land type richness as one measure of landscape diversity. It is defined as the total number of different land types completely or partially located within the study area, with each land type included in the calculations only once (Magurran, 1988). Land type was calculated based on all the 13 categories (Appendix 1) of the reclassified CLC data (dataset, 2014) inside the buffer, including thus both built and natural environments. The values of the land types ranged from 3 to 10 in the 500 m buffers and 5–11 in the 1000 m buffers.

2.3.4. Diversity of land use

Diversity of land use measures landscape diversity as the proportional abundance of land types taking into account land use heterogeneity and evenness, and may be calculated with the normalized Shannon's Diversity Index (SHDI) (Magurran, 1988). The minimum value 0 means that only one land type is present and hence there is no diversity. The maximum value 1 requires the presence of all the possible land types in even proportions in the study area. Area sizes of land types were defined inside the buffer based on all the 13 categories (Appendix 1) of the reclassified CLC data (dataset, 2014) including thus both built and natural environments, and the normalized SHDI value calculated using Eq. (1): (Magurran, 1988)

$$\text{Normalized SHDI} = -\frac{\sum_{i=0}^{S} p_i * \ln p_i}{\ln S} \tag{1}$$

p_i equals the proportion of a given land type area of the total buffer area, and is calculated as the sum of the areas of the same land type within the buffer area divided by the total buffer area.

S equals the number of all the 13 possible land types.

The values for the diversity of land use were in the range 0.16–0.77 in the 500 m neighborhood buffer and 0.16–0.73 in the 1000 m buffer.

2.3.5. Habitat diversity within large natural area

Habitat diversity within large natural area was defined as the highest normalized SHDI value of a large natural area among the values of all the large natural areas extending inside the buffer. To calculate the values of the habitat diversity within large natural area, we first localized large natural areas within the municipalities of Jyväskylä and Muurame. By a large natural area we understood an area of a minimum of 10 ha in size and consisting only of natural environment land types, excluding water. Habitat diversity , which can also be understood as landscape diversity or heterogeneity and to build up biodiversity at ecosystem level for one part (Wiens, 1995), was defined separately for each of these large natural areas. Data on land type is commonly used (Zebisch et al., 2004; Schindler et al., 2008; La Rosa et al., 2013; Martínez et al., 2010; Hietala-Koivu et al., 2004) and the SHDI is a commonly used measure for heterogeneity (La Rosa et al., 2013; Martínez et al., 2010; Hietala-Koivu et al., 2004; Wrbka et al., 1999). Similarly as in the studies of Zebisch et al. (2004), Wrbka et al. (1999), and Frank et al. (2013), we excluded land types that could no longer be perceived as environments providing perception of nature from the calculations, that is, the built environment land types of the reclassified CLC data (dataset, 2014). We also excluded water bodies. Normalized SHDI values were calculated for each large natural area using Eq. (1) based on the remaining nine natural environment land types, that is: [(Cultivated fields; Fruit trees and berry plantations; Pastures; Uncultivated agricultural areas; Forests; Shrub and/or herbaceous vegetation; Open spaces with little/no vegetation; Wetlands; Swamps); see Appendix 1] drawn from the reclassified CLC data (dataset, 2014). If multiple large natural areas were extending inside the buffer, the highest SHDI value of these areas was selected for the analyses. The value 0, the lowest value in the distribution of this variable, was assigned to 50 participants as no large natural area extended to within a 500 m radius of their home. Scores describing the habitat diversity within large natural area ranged from 0 to 0.71 in the 500 m buffer and 0.13–0.71 in the 1000 m buffer.

2.4. Covariates

Age, sex, number of chronic conditions, years of education, time in current home and type of residential area, were considered as confounders in the analyses. Age and sex were obtained from the national population register data. Number of chronic conditions was calculated as the sum of 22 physician-diagnosed chronic conditions and an additional open-ended question (Rantanen et al., 2012). Participants were also asked how many years of education they had received. Owing to the small number of missing responses (n=8), no imputation was made for missing values in years of education. Time in current home was calculated based on the latest change of address, information on which was derived from the national register. For the 30 people with no record of their last change of address, the mean value of the study population was used.

Type of residential area of the home address was defined for each participant using the GIS. Based on the Urban form dataset (dataset, 2013c), in which data are presented in grids of 250 m × 250 m cells, the participant's home location was first classified as in either a densely populated area (more than 200 inhabitants), village (more than 39 inhabitants), small village (20–39 inhabitants), or sparsely populated rural area (at least one inhabitant in a km^2). For those living in densely populated areas, a further categorization was conducted based on the Residential areas dataset (dataset, 2013d). It also provides data in grids of 250 m × 250 m cells, specifying densely populated areas as high-rise or low-rise, based on the distribution of different housing types, or as sparsely built areas with detached houses (areal density below 0.02), or as urban non-residential areas (the gross floor area of other than residential buildings is dominant). Finally, for each participant his or her residential area was classified into one of the following categories: High-rise urban area (high-rise), Low-rise urban area (low-rise), Sparsely built urban area (sparsely built areas with detached houses and urban non-residential areas), and Rural area (villages, small villages, and sparsely populated rural areas).

2.5. Analyses

The participants were divided into two groups based on reported walking difficulties: without (n = 631) or with (n = 217) difficulties in walking. Characteristics of participants and values of the objectively assessed features of the natural environment in the 500 m and 1000 m neighborhoods were compared between participants without and with walking difficulties using the Mann-Whitney *U*-test in the analysis of variance. As Moran's Index calculated for responses in perceiving nature as a facilitator for outdoor mobility and physical activity indicated no spatial autocorrelation of variables (Appendix 2, Supplementary Table 1), traditional statistical methods were selected for the further analyses.

The landscape diversity measures (patch density, number of land types, diversity in land use, and habitat diversity within large natural areas) were categorized into tertiles. Participants with the imputed value of 0 for habitat diversity within large natural area within the 500 m neighborhood were added into the lowest tertile in that variable. In the stratified analyses for participants with and without walking difficulties, relationships between objectively assessed features of the natural environment, perceiving nature as an environmental facilitator for outdoor mobility, and PA (Fig. 1) were studied using logistic regression. For study aim 1, the objectively assessed features of the natural environment were included separately as independent variables in the models estimating perceiving nature as an environmental facilitator for outdoor mobility. For study aim 2, the objectively assessed features of the natural environment were included separately as independent variables in the models estimating the odds for reporting at least moderate PA. For study aim 3, perceiving nature as a facilitator for outdoor mobility was included in the models estimating the odds for reporting at least moderate PA.

All the tests were first adjusted for age and sex (Model 1), after which number of chronic conditions, years of education, time in current home, and residential area type were added into the models (Model 2). Objectively assessed features of the natural environment and spatial autocorrelation were defined using ArcMap 10.3 software. IBM SPSS Statistics 22 was used for statistical testing. The statistical significance level was set to 0.05.

3. Results

The mean age of the participants was 81 years and 62% of them were women. Difficulties in walking 500 m were reported by 26% (n = 217) of the participants. These individuals were older, they were also more often female, had more chronic conditions, fewer years of education, and they were less physically active compared to participants without difficulties in walking. Perceiving nature as a facilitator for outdoor mobility was statistically significantly more common among those without difficulties in walking (Table 1). The objectively assessed features of the natural environment within a 500 m or 1000 m radius of the participants' homes did not differ between those without vs. those with walking difficulties. As almost all participants had a water area within their 1000 m neighborhood buffer, the presence of water within the 1000 m neighborhood was excluded from further analyses.

3.1. Associations between objectively assessed features and perceiving environmental facilitator for outdoor mobility

In the stratified logistic regression analyses, the presence of water areas within 500 m similarly increased the odds of perceiving nature as a facilitator for outdoor mobility among both those with and those without walking difficulties (Table 2). For those without difficulties in walking, higher habitat diversity within large natural area within the 500 m radius increased the odds of perceiving nature as a facilitator for outdoor mobility compared to having a large natural area with only lower habitat diversity or no large natural area at all. In addition, for this group, higher numbers of land types and higher diversity of land use within both the 500 m and the 1000 m radiuses, compared to lower values in these variables, roughly tripled the odds for perceiving nature as a facilitator for outdoor mobility. For those with difficulties in walking, a higher number of land types within the 500 m neighborhood was only significantly associated with higher odds for perceiving nature as a facilitator for outdoor mobility in the fully adjusted model when compared to those having a lower number of land types in their neighborhood.

3.2. Associations between objectively assessed environmental features and physical activity

For participants without difficulties in walking, the odds for reporting at least moderate PA (Table 3) were almost doubled for those having a large natural area with higher habitat diversity within the 1000 m radius compared to those having a large natural area with only lower habitat diversity or no large natural area at all. For those with difficulties in walking, the odds for reporting at least moderate PA was fourfold higher if water was present compared to those with no water area. For those with difficulties in walking and living in an area of the middle tertile of the number of land types, the odds were more than twofold higher compared to those with a lower number of land types within the 500 m neighborhood. Additionally, for those with difficulties

Table 1
Characteristics of participants and the environment in which they live, according to the absence/presence of difficulties in walking 500 m.

	Without difficulties (n = 631) Mean ± SD	With difficulties (n = 271) Mean ± SD	p-value[a]
Age (yr)	80.0 ± 4.1	82.4 ± 4.1	< 0.001
Number of chronic conditions (n)	3.9 ± 2.3	5.7 ± 2.4	< 0.001
Years of education (yr)	9.9 ± 4.3	8.6 ± 3.6	< 0.001
Time in current home (yr)	23.2 ± 14.5	22.3 ± 15.0	0.468
Patch density 500 m (patches/km^2)	129 ± 38	130 ± 41	0.834
Patch density 1000 m (patches/km^2)	107 ± 26	108 ± 28	0.818
Number of land types 500 m (n)	6.2 ± 1.2	6.2 ± 1.1	0.946
Number of land types 1000 m (n)	7.7 ± 1.3	7.7 ± 1.4	0.447
Diversity of land use 500 m (SHDI)	0.51 ± 0.08	0.51 ± 0.09	0.406
Diversity of land use 1000 m (SHDI)	0.57 ± 0.07	0.57 ± 0.07	0.625
Habitat diversity within large natural area 500 m (SHDI)	0.35 ± 0.15	0.35 ± 0.16	0.748
Habitat diversity within large natural area 1000 m (SHDI)	0.44 ± 0.13	0.42 ± 0.13	0.123
	%	%	p-value[b]
Women	58	73	< 0.001
At least moderate PA 3 h/week	78	22	< 0.001
Perceiving nature as a facilitator for outdoor mobility	77	60	< 0.001
Residential area type			0.174
High-rise urban area	52	52	
Low-rise urban area	40	40	
Sparsely built urban area	5	3	
Rural area	3	6	
Presence of water in 500 m	77	79	0.574
Presence of water 1000 m	99	98	0.486

[a] Mann-Whitney *U*-test.
[b] Chi-Square test.

in walking and living in an area of the middle tertile for habitat diversity within large natural area within the 500 m radius and, in the fully adjusted model only, within the 1000 m radius, the odds for at least moderate PA were about one-third of the odds for participants who had a large natural area with only lower habitat diversity or no large natural area at all in their neighborhood.

3.3. Associations between perceiving environmental facilitator for outdoor mobility and physical activity

Among participants without difficulties in walking, perceiving nature as a facilitator for outdoor mobility showed no association with PA level (Table 3). Among those with difficulties in walking, perceiving nature as a facilitator for outdoor mobility resulted in two- to threefold higher odds for reporting at least moderate PA compared to those not perceiving nature as a facilitator for outdoor mobility.

4. Discussion

Older people with walking difficulties who lived within 500 m of a water area were more likely to report nature as a facilitator for outdoor mobility and were also more physically active than those who lived further away from a water area. Higher landscape diversity correlated with perceiving nature as a facilitator for outdoor mobility and reporting higher PA, but inconsistently across measures. Among those without difficulties in walking, living in neighborhoods with a higher number of land types, higher diversity of land use, and higher habitat diversity within large natural area increased the odds for perceiving nature as a facilitator for outdoor mobility compared to those living in areas with lower values in these landscape diversity measures. Among participants with difficulties in walking, only a higher number of land types increased the odds for higher PA whereas higher habitat diversity within large natural area decreased the odds for higher PA. In sum, as the direction in the associations with PA were largely the same for the presence of water and a higher number of land types regardless of difficulties in walking, our study indicates that these measures may be considered as correlates for PA in older people.

Perceiving nature as a facilitator for outdoor mobility appears to be more important for PA among older people with difficulties in walking than among those without difficulties in walking. This can be explained with reference to the P-E fit theory (Lawton and Nahemow, 1973): while mobility limitations introduce imbalance into the P-E fit, perceiving the environment as a facilitator for outdoor mobility restores the balance and encourages mobility in the outdoor environment. Further, among older people with difficulties in walking, positive associations between objectively assessed features of the natural environment and PA appeared only in the 500 m neighborhood, whereas among those without difficulties in walking these associations were also found for the 1000 m neighborhood. Thus, differences in physical capabilities also seem to relate to the size of the neighborhood area in which facilitators for PA take effect; however, our study does not allow direct conclusions to be drawn on the associations between mobility limitations and the sizes of activity spaces among older people.

Our results are in line with those of the earlier studies reporting a positive correlation between perceived attractiveness of the landscape and the presence of waterways (Tveit et al., 2006; Dramstad et al., 2006; Dorwart, 2015). Some evidence of the same positive link between the presence of water and public health exists, although the relationship has not been widely studied (Ekkel and de Vries, 2017). In our study, the importance of the presence of water may also reflect the great abundance of water areas in the region of Finland where the participants lived and that more densely populated areas with a well-maintained road network are commonly located close to lake shores. Water fronts are familiar environments for older people in Finland and often provide opportunities for walking on flat terrain, which may contribute to increasing their PA. Flat terrain may be especially attractive to older people with difficulties in walking.

Diversity is one of the most important dimensions for arousing a sensation of nature (Grahn and Stigsdotter, 2010) and may be a marker of high-quality in green space (Ekkel and de Vries, 2017). For participants without difficulties in walking, higher habitat diversity within large natural area was associated with perceiving nature as a facilitator for outdoor walking within the 500 m radius and with higher PA within the 1000 m radius. These results are in line with earlier studies, which have

Table 2
Odd ratios (95% CI) for perceiving nature as a facilitator for outdoor mobility.

	Without difficulties in walking (n = 631)				With difficulties in walking (n = 217)			
	Model 1		Model 2		Model 1		Model 2	
Objectively assessed features of the natural environment in the 500 m neighborhood								
Presence of water								
no	1.00		1.00		1.00		1.00	
yes	**2.43**	**(1.61–3.68)**	**2.57**	**(1.66–3.98)**	**2.00**	**(1.02–3.90)**	**2.57**	**(1.25–5.28)**
Patch density								
low	1.00		1.00		1.00		1.00	
middle	1.53	(0.97–2.40)	1.51	(0.95–2.41)	0.74	(0.36–1.49)	0.82	(0.40–1.72)
high	1.23	(0.78–1.93)	1.22	(0.76–1.96)	0.81	(0.42–1.55)	0.97	(0.49–1.91)
Land types								
low	1.00		1.00		1.00		1.00	
middle	1.46	(0.95–2.26)	1.37	(0.87–2.16)	1.68	(0.85–3.29)	1.81	(0.90–3.64)
high	**3.40**	**(2.04–5.68)**	**3.34**	**(1.99–5.60)**	1.88	(0.92–3.83)	**2.15**	**(1.01–4.60)**
Diversity of land use								
low	1.00		1.00		1.00		1.00	
middle	1.47	(0.96–2.27)	1.44	(0.93–2.24)	1.24	(0.64–2.41)	1.44	(0.73–2.88)
high	**3.45**	**(2.07–5.72)**	**3.35**	**(2.01–5.60)**	1.66	(0.84–3.28)	1.99	(0.96–4.11)
Habitat diversity within large natural area								
low	1.00		1.00		1.00		1.00	
middle	1.19	(0.77–1.85)	1.40	(0.86–2.27)	1.04	(0.54–2.01)	0.72	(0.34–1.55)
high	**1.72**	**(1.08–2.76)**	**1.82**	**(1.11–2.96)**	1.63	(0.82–3.24)	1.61	(0.78–3.30)
Objectively assessed features of the natural environment in the 1000 m neighborhood								
Patch density								
low	1.00		1.00		1.00		1.00	
middle	0.70	(0.44–1.11)	0.63	(0.39–1.02)	0.58	(0.29–1.17)	0.64	(0.31–1.31)
high	0.80	(0.50–1.29)	0.73	(0.44–1.21)	0.56	(0.29–1.10)	0.67	(0.33–1.38)
Land types								
low	1.00		1.00		1.00		1.00	
middle	1.26	(0.80–1.97)	1.24	(0.78–1.95)	1.58	(0.78–3.20)	1.53	(0.74–3.13)
high	**3.17**	**(1.80–5.57)**	**3.13**	**(1.76–5.55)**	1.60	(0.75–3.45)	1.50	(0.67–3.37)
Diversity of land use								
low	1.00		1.00		1.00		1.00	
middle	1.16	(0.75–1.79)	1.15	(0.74–1.79)	0.58	(0.29–1.13)	0.65	(0.32–1.32)
high	**2.63**	**(1.60–4.31)**	**2.53**	**(1.53–4.20)**	0.87	(0.43–1.76)	1.08	(0.52–2.28)
Habitat diversity within large natural area								
low	1.00		1.00		1.00		1.00	
middle	1.22	(0.77–1.92)	1.18	(0.74–1.89)	0.64	(0.33–1.23)	0.67	(0.33–1.37)
high	1.22	(0.77–1.92)	1.20	(0.75–1.92)	1.36	(0.67–2.75)	1.60	(0.76–3.35)

Values in bold; $p < 0.05$.
Model 1: Logistic regression analysis, adjusted for age, sex.
Model 2: Logistic regression, analysis, adjusted for age, sex, number of chronic conditions, years of education, time at current address, type of residential area.

reported positive associations between PA and qualitative features or attributes of green areas, such as the presence of attractive features (Giles-Corti et al., 2005; de Jong et al., 2012; Paquet et al., 2013; Sugiyama et al., 2012), high quality green areas, or a green area sufficiently large in size (Giles-Corti et al., 2005; Paquet et al., 2013).

Among participants with difficulties in walking, higher habitat diversity within large natural area increased the likelihood of low PA, which is in line with the studies by Gong et al. (2014) and Colléony et al. (2017). Higher variety in vegetation was related with lower PA among older men with poor lower extremity function (Gong et al., 2014). Forests were mentioned as the most frequently visited natural place, but with increasing age forests were mentioned less often (Colléony et al., 2017). Kaplan and Kaplan's attention restoration theory (Kaplan and Kaplan, 1989) posits that difficulties in processing information from the environment may lead to a negative perception of the environment, which in turn induces difficulties in performing a task, such as walking. The surface of a forest area may be uneven and hinder the maintenance of balance among older people. Challenging terrain may induce fear of moving outdoors (Rantakokko et al., 2009) and sensations arousing from nature, e.g. feelings of being isolated by nature, are deeper when being in a large natural area compared to small areas (Ekkel and de Vries, 2017). In addition, diverse forests may trigger numerous visual cues that require the person to divide their attention. Processing information from multiple sources simultaneously is more difficult for older people. These challenges presented by nearby environments with high habitat diversity may explain the lower PA among the present participants with difficulties in walking.

Interestingly, a higher number of land types proximal to home increased the odds for higher PA among those with difficulties in walking. First, the features that are captured in the number of land types may burden the information processing system less than the information processing requirements stemming from high habitat diversity within large natural areas. This difference may be meaningful for older people whose walking ability has declined. Route networks and characteristics may also be different in neighborhoods with a higher number of land types compared to areas that harbor large natural areas with higher habitat diversity. Roads typically separate areas of different land types, e.g. residential and industrial areas and forests. This may result in higher route density in neighborhoods with a higher number of both built and natural environment land types compared to diverse large natural areas consisting only of natural land types. In diverse large natural areas the maintenance and condition of routes as well as the availability of amenities may be lacking, when compared to areas including also built environments. A denser route network offers more possibilities for route selection enabling better adjustment of route length and e.g. avoidance of steep hills, which often hinder outdoor mobility among older people with difficulties in walking (Rantakokko et al., 2015).

Table 3
Odd ratios (95% CI) for reporting at least moderate PA in the association between objectively assessed features of the natural environment and perceiving nature as the environmental facilitator for outdoor mobility.

	Without difficulties in walking (n = 631)				With difficulties in walking (n = 217)			
	Model 1		Model 2		Model 1		Model 2	
Objectively assessed features of the natural environment in the 500 m neighborhood								
Presence of water								
no	1.00		1.00		1.00		1.00	
yes	0.98	(0.62–1.56)	0.97	(0.59–1.59)	**4.12**	**(1.35–12.64)**	**4.01**	**(1.26–12.80)**
Patch density								
low	1.00		1.00		1.00		1.00	
middle	0.87	(0.54–1.39)	0.76	(0.46–1.26)	0.67	(0.28–1.62)	0.60	(0.24–1.47)
high	0.79	(0.49–1.28)	0.77	(0.46–1.29)	0.77	(0.35–1.67)	0.61	(0.27–1.36)
Land types								
low	1.00		1.00		1.00		1.00	
middle	0.99	(0.62–1.59)	1.00	(0.61–1.64)	**2.48**	**(1.04–5.93)**	**2.68**	**(1.08–6.65)**
high	1.33	(0.81–2.18)	1.42	(0.85–2.36)	1.45	(0.57–3.69)	1.56	(0.57–4.29)
Diversity of land use								
low	1.00		1.00		1.00		1.00	
middle	0.83	(0.51–1.35)	0.80	(0.48–1.33)	1.09	(0.49–2.41)	0.87	(0.38–1.96)
high	0.77	(0.48–1.25)	0.75	(0.46–1.24)	0.86	(0.37–1.98)	0.72	(0.30–1.74)
Habitat diversity within large natural area								
low	1.00		1.00		1.00		1.00	
middle	0.88	(0.56–1.39)	0.83	(0.50–1.38)	**0.27**	**(0.11–0.68)**	**0.30**	**(0.11–0.84)**
high	1.34	(0.82–2.19)	1.40	(0.84–2.34)	0.63	(0.28–1.39)	0.63	(0.27–1.46)
Objectively assessed features of the natural environment in the 1000 m neighborhood								
Patch density								
low	1.00		1.00		1.00		1.00	
middle	1.24	(0.77–2.02)	1.24	(0.75–2.07)	0.89	(0.38–2.08)	0.69	(0.29–1.66)
high	0.89	(0.56–1.43)	0.95	(0.57–1.58)	1.06	(0.48–2.34)	0.78	(0.34–1.79)
Land types								
low	1.00		1.00		1.00		1.00	
middle	1.42	(0.88–2.30)	1.43	(0.87–2.37)	0.99	(0.41–2.36)	1.09	(0.45–2.63)
high	1.42	(0.84–2.42)	1.45	(0.83–2.53)	0.66	(0.25–1.75)	0.73	(0.26–2.03)
Diversity of land use								
low	1.00		1.00		1.00		1.00	
middle	1.00	(0.62–1.59)	0.92	(0.56–1.50)	1.17	(0.51–2.69)	0.90	(0.38–2.12)
high	1.14	(0.71–1.84)	1.05	(0.64–1.73)	1.35	(0.59–3.11)	1.04	(0.44–2.47)
Habitat diversity within large natural area								
low	1.00		1.00		1.00		1.00	
middle	1.07	(0.68–1.69)	1.02	(0.63–1.65)	0.47	(0.19–1.13)	**0.31**	**(0.12–0.82)**
high	**1.70**	**(1.04–2.78)**	**1.82**	**(1.08–3.04)**	1.27	(0.58–2.78)	1.08	(0.47–2.44)
Perceiving environmental facilitator for outdoor mobility								
Nature								
no	1.00		1.00		1.00		1.00	
yes	1.31	(0.84–2.03)	1.34	(0.85–2.11)	**2.25**	**(1.05–4.84)**	**3.05**	**(1.35–6.86)**

Values in bold; $p < 0.05$.
Model 1: Logistic regression analysis, adjusted for age, sex.
Model 2: Logistic regression, analysis, adjusted for age, sex, number of chronic conditions, years of education, time at current address, type of residential area.

In our study, patch density was the only landscape measure to indicate richness in the spatial configuration of the landscape. It appeared also to be the only landscape measure not having association with perceiving nature as a facilitator for outdoor mobility or with reporting a higher level of PA. All the other measures of landscape diversity indicate heterogeneity in landscape and they were associated with perceiving nature as a facilitator for outdoor mobility or with PA in our study. To obtain a high score for the number of land types, diversity of land use, and habitat diversity within large natural areas, it is necessary to have a high variety of land types within the area of interest, but the number of separate patches is irrelevant (Magurran, 1988). Thus, heterogeneity may be a more important correlate of perceiving nature as a facilitator for PA, or of PA, than richness in the spatial configuration.

A limitation of this study is that PA was self-reported. In asking the respondents on their PA level, no differentiation was made between outdoor and indoor PA. We nevertheless consider this as a reliable method of obtaining data, as the question of reporting PA has been shown to be valid for assessing PA among older people (Portegijs et al., 2016) and previous studies have shown that among older people most of PA occurs out of home (Portegijs et al., 2015). We acknowledge that several common facilitators of built and social environments for older adults' PA, e.g. proximity to services and facilities (Levasseur et al., 2015; Rosso et al., 2011; Yen et al., 2014), higher street connectivity (Levasseur et al., 2015; Rosso et al., 2011; Yen et al., 2014), quality and amenities of public spaces (Levasseur et al., 2015), safety (Levasseur et al., 2015; Rosso et al., 2011; Yen et al., 2014), social cohesion and network support (Levasseur et al., 2015), and dog ownership (Dall et al., 2017) were not studied here but they may have contributed to the PA level of respondents. Concentrating on the facilitating features of nature for PA, we have not included environmental barriers for older adults' outdoor mobility such as hills (Rantakokko et al., 2015) to our study although they also may have had an effect on the PA of the respondents. Also the perceptions of nature may vary greatly among people. We acknowledge that the objective environmental features studied here and perceiving nature as a facilitator for outdoor mobility may not be perfectly matched. The features the respondents perceived may have differed from those captured with our measures of objectively assessed features of natural environment. In addition, the participants may have considered a different spatial area when answering the question on outdoor mobility facilitators compared to the buffer area used to obtain the objective environmental measure values (spatial incongruence). We also chose to use circular buffers as the basis for objectively assessed features of the natural environment instead of street network buffers (Villanueva et al., 2014; Sallis et al., 2016; Schipperijn et al., 2013; Kerr et al., 2014), which have become increasingly common in research on the relationships between the environment and PA. We have two reasons for our decision to use circular buffers. First, perceiving nature as a facilitator for outdoor mobility may arise from exposure to the local environment such as the landscape, which then requires a large spatial scale. Second, studying environments using circular buffers yields knowledge that is applicable in planning neighborhoods at the local level, whereas studying areas along road networks would have produced information specific to those areas. A final limitation is that this study is based on cross-sectional analyses, thus limiting the generalizability of the results.

The strengths of our study lie in our large population-based sample, which enabled us to conduct stratified analysis for people based on their functional capability. A further strength is the absence of differences in the objectively assessed natural environments between those with vs. without walking difficulties. Further, as mean residency in the current home was high, we are convinced that lack of familiarity with the neighborhood had no effect on the result. We had few missing data. Additionally, we used a variety of objective GIS-based measures to describe the natural environment. Of these, we find that the presence of water and habitat diversity within large natural areas are able to provide a more site-specific scale for the objectively assessed features of the natural environment. This supports the suggestion that multiple GIS -measures defined using different spatial scales may better capture features significant for health behaviors (Pliakas et al., 2017). Further strengths of this study that add to its societal importance are the applicability of the GIS -measures used for land-use planning purposes and that the measures are easy to derive from open data sources.

5. Conclusion

Based on our findings, the associations between objectively assessed features of the natural environment and PA in older people are highly dependent on functional capabilities. As facilitators for PA, the presence of water was especially important for older people with difficulties in walking and higher habitat diversity within large natural areas for those without difficulties in walking. There is a need to study the mechanisms underlying PA behavior, such as the attention directed to scenery and functional capabilities in greater detail. Further studies on how environmental characteristics affect the associations between environmental facilitators and PA are also warranted. For practical applications, the presence of water and number of land types are measures that are simple and easy to derive from open data sources and to apply when planning environments that encourage older people to be physically active regardless of their physical capabilities.

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Author contributions

K.K., M.R., T.R. and E.P conceived and designed the study; M.R., T.R. and E.P contributed to the participant data collection; K.K. contributed to the spatial data collection and analyses; K.K. conducted the statistical analyses; K.K. wrote the paper; M.R., K.S., T.R. and E.P critically revised the paper.

Conflicts of interest

The authors declare no conflict of interest. The funding sponsors had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.healthplace.2017.12.003.

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