BMC Public Health

RESEARCH

Open Access

Outdoor mobility in senior housing residents and community-dwelling older people in different population density areas

Sini Siltanen[1,2*], Essi-Mari Tuomola[2], Markku Kauppinen[2], Kirsi E. Keskinen[2], Taina Rantanen[2] and Mikaela von Bonsdorff[1,2]

Abstract

Background Outdoor mobility supports functioning and active life in old age. There is scarce knowledge about the outdoor mobility of senior housing residents, and it remains unclear whether outdoor mobility is dependent on one's home location.

Aims We investigated outdoor mobility among senior housing residents and community-dwelling older adults in different population-density areas.

Methods We pooled data from two Finnish studies: a senior housing survey ($N=322$) and a population-based cohort study among community-dwelling older adults ($N=1018$). Life-space mobility (higher score indicating greater mobility) and autonomy outdoors (lower score indicating greater autonomy) were used as markers of outdoor mobility. Population density was used as an indicator of service availability and outdoor mobility enabling infrastructure. Data were analyzed with linear regression and moderation analyses.

Results The mean life-space mobility scores were 70.5 (standard deviation, SD 20.0) among community-dwelling older adults and 54.8 (SD 27.6) among senior housing residents. For autonomy outdoors, the scores were 5.3 (SD 3.7) and 7.4 (SD 4.9), respectively. Population density moderated the association of housing type with outdoor mobility. In the highest and lowest population-density areas, senior housing residents had lower life-space mobility and poorer autonomy outdoors than community-dwelling older adults, whereas in the intermediate population-density areas, no such differences were found.

Conclusions The location of a senior house is meaningful and optimal for outdoor mobility when within easy reach but not too near amenities. Poorer outdoor mobility among senior housing residents may reflect their adjustment to a new home environment and life situation, e.g., becoming a widow.

Keywords Communal housing, Life-space mobility, Perceived autonomy, Geographic information system

*Correspondence:
Sini Siltanen
sini.siltanen@folkhalsan.fi
[1]Folkhälsan Research Center, Topeliuksenkatu 20, Helsinki 00250, Finland
[2]Gerontology Research Center, Faculty of Sport and Health Sciences, University of Jyväskylä, PL 35, Jyväskylä 40014, Finland

Introduction

Outdoor mobility, referring to all kinds of trips outside one's home, is a key factor underlying functioning and active life in older age. Leaving the home either by foot or by any type of transportation enables older people to participate in various activities and community life and supports independent living [1–3]. Leaving the home also supports social integration [4] and is associated with greater quality of life [5]. Furthermore, among community-dwelling older adults, going outside one's home increases physical activity [6] and is associated with better health and function [7, 8]. Hence, outdoor mobility is regarded as a central contributor to healthy and active aging and is of high interest for public health actions. It may be assessed from two correlating, but not overlapping perspectives: actual mobility behavior and perceived autonomy for mobility [9]. As a marker of actual mobility behavior, life-space mobility describes the extent of moving in an individual's daily life and incorporates also the frequency of travel and assistance needed for the travel [10]. Perceived autonomy in participation outdoors (from now on 'autonomy outdoors'), in turn, describes one's self-rated possibilities to participate in activities outside the home and incorporates the meanings attached to these activities [11].

Environmental features, both social and physical, can influence outdoor mobility. According to the established ecological theory of aging, to allow optimal mobility, i.e. the ability to go wherever, whenever and however one wants, an individual's competencies need to be in line with the demands and press of the environment [12]. In previous studies among community-dwelling older adults, it has been found that good walkability in the outdoor environment and service availability, assessed based on e.g. population density and street connectivity, increases physical activity and participation in cultural activities [13–15]. On the other hand, longer distances to attractive destinations for outdoor mobility, such as services, parks, or walking trails, seem to prompt older adults for greater activity [16]. Accessibility at home is also important, as thresholds, narrow doorways, and heavy doors may restrict abilities to leave the home and thus decrease participation in activities outside the home [2, 17, 18]. The social environment may also play an important role, as social involvement [19], social networks, and social support [20, 21] have been shown to function as key correlates for greater life-space mobility and autonomy. Overall, it is possible that a home that once facilitated active family life may no longer be optimal at an older age as functional abilities decline, and social networks change. However, it remains unclear whether outdoor mobility varies between older people residing in different housing types.

Senior housing has become a popular housing option in Finland and other Nordic countries in recent years [22]. Briefly, senior houses are a type of non-institutional communal housing, comparable to retirement communities, and include residents mainly over 55 years of age who can live independently. Senior housing typically functions as an "in-between" housing option when living in ordinary private dwellings is no longer feasible but there is yet no need for formal care or assistance (Jolanki 2021). Hence, people move into senior housing due to convenience, not due to a need for functional assistance. Further, senior houses are designed to support independent life and social interaction [23], and thus, they center on providing organized activities and common spaces for their residents. We found in our recent study that senior housing residents have more depressive symptoms and poorer self-rated abilities and overall possibilities to lead an active life compared to community-dwelling older adults [24]. In addition, men residing in senior houses seem to have poorer physical functioning than community-dwelling men, while women in senior houses are often lonelier than community-dwelling women [25]. However, senior housing residents' frequency of activity or will to lead an active life does not differ from that of community-dwelling older adults [24].

There is currently sparse knowledge on the outdoor mobility of senior housing residents. Hence, it remains unclear whether life-space mobility or autonomy outdoors are different among senior housing residents compared to community-dwelling older adults. In principle, senior houses are designed to be located near amenities, recreational spaces, and public transport, and their apartments and other facilities are accessible [22, 26], prompting their residents to an active lifestyle. This may contribute to senior housing residents' autonomy outdoors as well as actual life-space mobility. It is also possible that as most everyday activities can be performed near the home and as functional deficits are common among men residing in senior houses, life-space mobility is generally lower among senior housing residents compared to community-dwelling older adults. It also remains unknown whether the differences in outdoor mobility are more evident in some areas than others, i.e., in areas that have good walkability and service availability versus in more rural areas. These associations warrant investigation to promote active and healthy aging more comprehensively. This study aimed to first, discover the plausible differences in life-space mobility and autonomy outdoors between senior housing residents and community-dwelling older adults, and second, to investigate whether population density area, reflecting service availability and the amount of outdoor mobility enabling infrastructure, moderates the association between housing type and outdoor mobility.

Methods

Study design and data

This study combined data from the BoAktiv senior housing survey [25, 27] and the Active Aging—Resilience and External Support as Modifiers of the Disablement Outcome (AGNES) cohort study [28]. The BoAktiv survey was conducted among over 55-year-old people who were residing independently in Folkhälsan owned private senior houses around coastal regions of Finland and were Finnish- or Swedish-speaking. The data were first collected in 2018 by paper-pencil surveys, which the researchers delivered to the residents either personally in the public area of the senior houses as a part of a data collection event or to their private mailboxes in case a resident was unable to participate in the event. Altogether 465 residents of 12 senior houses were invited to participate and of them, 42% (N=194) consented. In 2020, another data collection round was conducted with three new senior houses included. This time 588 persons were invited and 247 (42%) participated. In the present study, we utilized individual baseline data from the first data collection of each participant, meaning that in case the participant had responded both in 2018 and 2020, only answers from 2018 were utilized from these persons. Additionally, we excluded persons who responded after Mid-March 2020 when COVID-19 pandemic reached Finland. This yielded a baseline sample size of 322 participants. The BoAktiv study participants are herein referred to as "senior housing residents".

The AGNES cohort study was conducted among community-dwelling older adults from three birth cohorts initially aged 75, 80 or 85 years and living independently in Jyväskylä, Central Finland. The baseline data of AGNES was collected in 2018 by face-to-face home interviews. At baseline, 2348 persons were invited to participate and of them, 1021 (43%) consented. The study design and recruitment process of AGNES has been presented more thoroughly elsewhere [28, 29]. In the present study, the AGNES participants are referred to as "community-dwelling older persons".

Measures

Life-space mobility and *autonomy outdoors* were used as markers of outdoor mobility. Life-space mobility was assessed using the University of Alabama at Birmingham Study of Aging Life-Space Assessment (LSA) [10] translated into Finnish [30]. The measure comprises six life-space areas starting from one's bedroom and expanding to the other parts of one's home, yard, neighborhood, town, and eventually, beyond town. Respondents are asked whether they have moved in each area during the previous four weeks, how often and whether they have needed help or assistance in doing so. In this study, we used the validated life-space mobility composite score that takes into account the distance, frequency and level of independence of mobility [10, 31]. The score ranges from 0 to 120, with higher scores indicating greater life-space mobility. In BoAktiv, 316 (94%) and in AGNES, 1017 (99.6%) participants had data on life-space mobility.

Autonomy outdoors was assessed using the "autonomy outdoors" subscale of the Impact on Participation and Autonomy (IPA) questionnaire. The IPA questionnaire is validated and can be used either as a whole or as subscales [32, 33]. The scale assesses perceived possibilities to (1) visit friends and relatives, (2) make trips and travel, (3) spend leisure time, (4) meet other people, and (5) live life as one wants. The response options for these five items range on a Likert scale from "very good" (0) to "very poor" [4]. The item scores are summed, and the total score thus ranges from 0 to 20, with higher scores indicating poorer perceived autonomy. In BoAktiv, 321 (96%) and in AGNES, 995 (97%) participants had data on autonomy outdoors.

Population density area was used to indicate service availability and the amount of outdoor mobility enabling infrastructure [34] at the participant's home location and it was treated as a moderator in the analyses. AGNES participants' home addresses were derived from the population register and geocoded using the Digiroad dataset [35]. All AGNES participants lived in the municipality of Jyväskylä, a medium-sized city with 141 305 inhabitants [36]. The BoAktiv senior houses were manually located on a map based on address information. The Boaktiv senior houses were located in 12 municipalities, which varied from 9400 to 638 000 in their population [36]. For each municipality separately, the range of population density (number of people/km^2, data available in 1 km x 1 km grids) [34] within the municipality's administrative borders [37] was defined in GIS and divided into tertiles (highest, intermediate, lowest). The highest tertile typically indicated the center of each municipality. Each participant was assigned to the population density tertile based on their home location and thus categorized into living in the highest, intermediate, or lowest population density area.

Covariates included variables that correlated with housing type and/or outdoor mobility, i.e., age, sex, depression, self-rated health, educational attainment, living alone, and the length of residence in the current home. Age was calculated based on self-reported birth year (BoAktiv) or drawn from the national population register (AGNES). Sex was categorized as (1) men or (2) women. Depressive symptoms were assessed with the Center for Epidemiologic Studies Depression Scale (CES-D; range 0–60, higher scores indicate more depressive symptoms) [38]. Self-rated health was assessed with one question and six possible responses categorized into three: (1) good or very good, (2) moderate or fair, and

(3) poor or very poor. Educational attainment was based on self-reports and categorized into three: (1) high (high school diploma or university degree), (2) intermediate (middle school, folk high school, vocational school, or secondary school), and (3) low (primary school or less). Living alone was categorized into (1) living alone or (2) living with someone (spouse, family member, or someone else). Length of residence was indicated in years.

Statistical analyses

Mann-Whitney U-test and chi-square test were used to analyze the differences in study participants' background characteristics by housing type. Mann-Whitney U-test was used for continuous variables. In addition, we analyzed the differences in senior housing residents' background characteristics by population density area with Kruskal-Wallis test and chi-square test. To define relevant covariates, the correlations between the main variables and plausible covariates were tested with Pearson's (continuous variables) and Spearman's correlation (categorical variables, data not shown). Thereafter, linear regression analysis was used to investigate the individual associations of housing type and population density area with life-space mobility and autonomy outdoors. Hence, housing type and population density area were analyzed in separate models. Before running the analyses, the assumptions for the absence of multicollinearity, homoscedasticity, and normality were tested and ensured. In the final phase, to assess whether population density area moderates, i.e., influences the strength of the association of housing type with outdoor mobility, we used the PROCESS macro by Andrew Hayes [39]. In these analyses, housing type was set as the independent variable, population density area as a moderator, and life-space mobility and autonomy outdoors as outcomes. All linear regression analyses were first adjusted for age and sex (Model 1), and thereafter additionally for self-rated health, educational attainment, length of residence, living alone, and depressive symptoms one at a time and finally, all together (Models 2 and 3). Life-space mobility and autonomy outdoors were assessed separately. Population density area, educational attainment, and self-rated health were dummy-coded for the regression analyses and the highest or best category was used as a reference category for all these variables. The level of confidence was set at 95% in all analyses.

Moreover, 51 AGNES study participants (5%) were living independently in a senior house. To assess whether this affects the findings, we conducted sensitivity analyses by excluding these persons from the regression analyses. All analyses were performed with SPSS Statistics version 29.

Results

The differences in background characteristics by housing type are presented in Table 1. Senior housing residents were older, had been living in their current home for a shorter period, and had more depressive symptoms and restrictions in life-space mobility and autonomy outdoors than community-dwelling older adults. In addition, a greater proportion of them were women, living alone, and had higher educational attainment compared to community-dwelling older adults. A greater proportion of senior housing residents were also living in an area with higher population density area compared to community-dwelling older adults. The differences in self-rated health did not quite reach statistical significance but suggested that senior housing residents rated their health slightly better than community-dwelling older adults. Lastly, a greater proportion of senior housing residents were widowed compared to community-dwelling older adults (47% vs. 26%, respectively). Moreover, when senior housing residents' background characteristics were analyzed by population density tertile (Supplementary Table), we found that residents in the intermediate population density area were younger, had higher educational attainment, and rated their health better than senior housing residents in the highest and lowest population density areas. In addition, their autonomy outdoors and life-space mobility were greater compared to senior housing residents in the highest and lowest population density areas.

The linear regression analyses showed that housing type was statistically significantly associated with life-space mobility and autonomy outdoors, such that senior housing residents had more restricted life-space mobility and autonomy outdoors compared to community-dwelling older adults (Table 2). These associations remained after all adjustments ($F(10,\ 1218) = 60.16, p < .001$ for life-space mobility and $F(10,\ 1215) = 68.04, p < .001$ for autonomy outdoors). The coefficients were slightly higher for the association between housing type and life-space mobility than for housing type and autonomy outdoors, indicating a stronger effect for the aforementioned. Population density area was not associated with life-space mobility nor autonomy outdoors (Table 2).

In the final phase, we found that population density area moderated the associations of housing type with life-space mobility and autonomy outdoors. With both outcomes, the interaction including the intermediate and highest population density area was statistically significant in the models adjusted for age and sex whereas the interaction including the highest and lowest population density area was not (Table 3). This indicates that the association of housing type with outdoor mobility was similar in the highest and lowest population density areas, but different in the intermediate population density areas (Fig. 1 for life-space mobility and 2 for

Table 1 Background characteristics of the participants according to housing type

	Community-dwelling			Senior housing			
	N	***Mean (SD)***	***Min-max***	***N***	***Mean, SD***	***Min-Max***	***p***[a]
Age, years	1021	78.8 (3.6)	74.6–85.7	303	82.7 (7.5)	62.0-101.0	< 0.001
Depressive symptoms, CES-D	987	8.6 (7.1)	0–43.0	293	14.2 (8.8)	0–42.0	< 0.001
Length of residence, years	1014	22.7 (16.4)	0–84.0	301	4.7 (4.8)	0–24.0	< 0.001
Autonomy outdoors, IPA	995	5.3 (3.7)	0–20.0	308	7.4 (4.9)	0–20.0	< 0.001
Life-space mobility, LSA	1017	70.5 (20.0)	0-120.0	302	55.0 (27.7)	0-120.0	< 0.001
	N	*N (%)*		*N*	*N (%)*		*p*[b]
Sex, women	1021	585 (57)		336	225 (70)		< 0.001
Living alone	1016	419 (41)		332	235 (74)		< 0.001
Married or in a relationship	1017	598 (59)		333	97 (30)		< 0.001
Educational attainment	1006			330			< 0.001
High		268 (27)			190 (60)		
Intermediate		491 (49)			103 (33)		
Low		247 (25)			23 (7)		
Self-rated health	1016			329			0.069
Very good or good		463 (46)			167 (53)		
Moderate or fair		502 (49)			134 (43)		
Poor or very poor		51 (5)			14 (4)		
Population density area	1021			336			< 0.001
Highest		320 (31)			116 (36)		
Intermediate		225 (22)			188 (58)		
Lowest		476 (47)			18 (6)		

Note. CES-D = Center for Epidemiologic Studies Depression Scale, IPA = Impact on Participation and Autonomy outdoors scale, LSA = the University of Alabama at Birmingham Study of Aging Life-Space Assessment

[a] tested with Mann-Whitney U-test

[b] tested with chi square test

Table 2 Standardized coefficients (β) for life-space mobility and autonomy outdoors tested with linear regression analysis

	Life-space mobility			Autonomy outdoors		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Housing type, community-dwelling vs. senior housing	0.146***	0.167***		−0.093***	−0.066*	
Age	−0.337***	−0.265***	−0.302***	0.285***	0.188***	0.202***
Sex, women vs. men	−0.180***	−0.158***	−0.161***	0.089**	0.055*	0.054*
Self-rated health, moderate vs. good		−0.210***	−0.189***		0.237***	0.231***
Self-rated health, poor vs. good		−0.235***	−0.224***		0.264***	0.264***
Educational attainment, intermediate vs. high		−0.109***	−0.074**		0.018	0.010
Educational attainment, low vs. high		−0.119***	−0.080**		−0.004	−0.017
Living alone vs. living with someone		0.037	0.053*		0.028	0.021
Depressive symptoms		−0.091***	−0.121***		0.311***	0.319***
Length of residence		0.030	0.085***		−0.005	−0.027
Population density area, intermediate vs. highest			−0.019			0.045
Population density area, lowest vs. highest			−0.008			−0.020
R^2	0.206	0.336	0.319	0.117	0.363	0.363

Note. *** $p < .001$, ** $p < .01$, * $p < .05$

autonomy outdoors). The moderation effects became non-significant when adjusted for length of residence (Table 3).

Further, we conducted sensitivity analyses by excluding those AGNES participants who lived independently in a senior house ($n = 51$) and found that the results were not impacted at all (data not shown).

Discussion

We found in this study that despite living in an accessible and social environment, senior housing residents demonstrated lower life-space mobility and poorer autonomy outdoors than community-dwelling older adults. However, it was also found that population density, reflecting service availability and the amount of infrastructure that facilitates outdoor mobility, moderated this association.

Table 3 Unstandardized coefficients (B) for life-space mobility and autonomy outdoors with housing type as an independent variable (community-dwelling vs. senior housing) and population density tertiles (highest, intermediate, and lowest) as a moderator

	Life-space mobility		Autonomy outdoors	
	Model 1	Model 2	Model 1	Model 2
Housing type, community-dwelling vs. senior housing	17.12**	12.95*	-3.14**	-1.41
Population density area, intermediate vs. highest	13.95*	8.24	-2.60*	-1.04
Population density area, lowest vs. highest	2.28	−0.470	-1.77	−0.59
Housing type * intermediate vs. highest population density area	-15.20**	-9.06	3.12**	1.60
Housing type * lowest vs. highest population density area	−0.788	1.88	1.49	0.24
R^2	0.222	0.344	0.127	0.369

Note. *** $p<.001$, ** $p<.01$, * $p<.05$. Model 1 adjusted for age and sex; Model 2 adjusted for age, sex, self-rated health, educational attainment, length of residence, living alone, and depressive symptoms

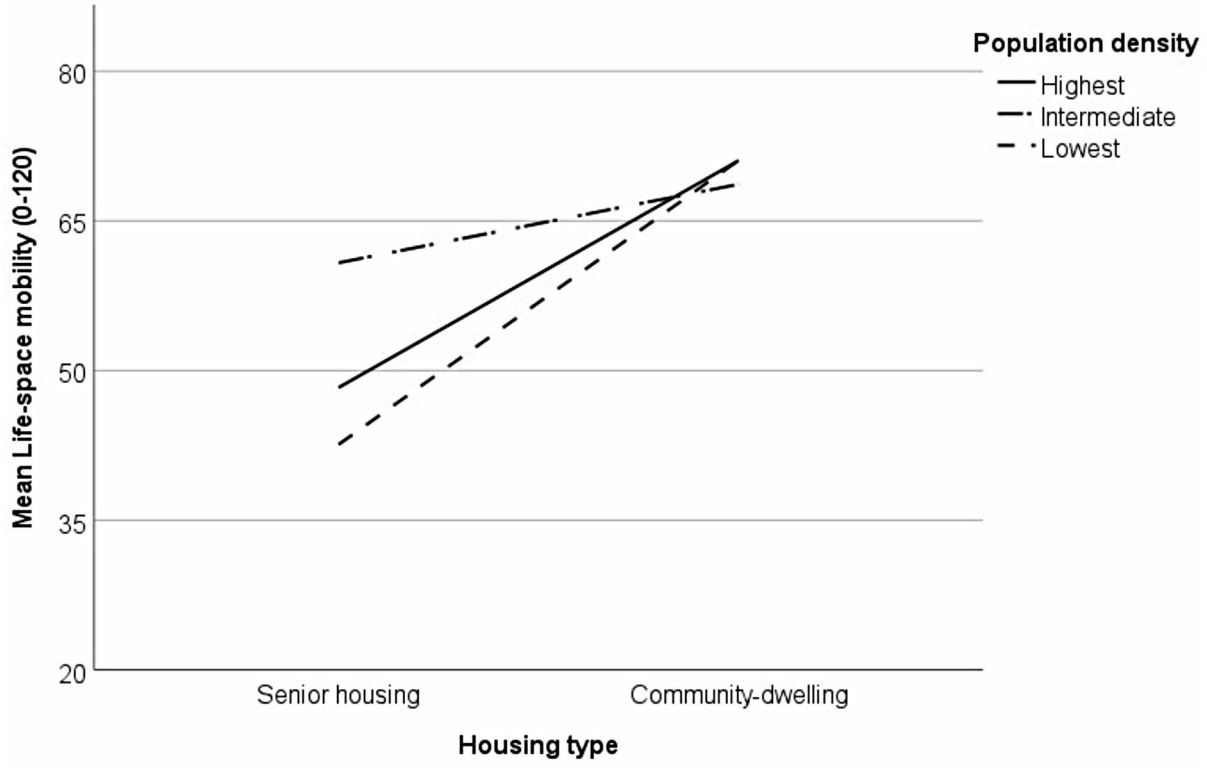

Fig. 1 Illustration of the moderation effect of population density area on the association between housing type and life-space mobility (the higher the score, the better)

While senior housing residents in the highest and lowest population density areas demonstrated poorer outdoor mobility than community-dwelling older adults, in the intermediate population density areas no such difference was found between senior housing residents and community-dwelling older adults. Overall, it seemed that population density area was more meaningful for senior housing residents than for community-dwelling older adults in terms of outdoor mobility. Moreover, the moderation effect of housing type and population density area on life-space mobility became non-significant when controlled for length of residence. There is sparse knowledge on the outdoor mobility of senior housing residents, and thus, this study was among the first ones to show that the physical environment may play a greater role in outdoor mobility among senior housing residents than among community-dwelling older adults.

There are several possible explanations for poorer outdoor mobility among senior housing residents. First, in previous studies among community-dwelling older adults, it has been found that outdoor mobility tends to decline with advancing age [40]. In this study, senior housing residents were older than community-dwelling older adults. Second, it has been shown that poorer physical performance and walking difficulties expose to restrictions in both life-space mobility and autonomy outdoors [9, 41]. Similarly, it has been found that men in senior housing manifest poorer physical function

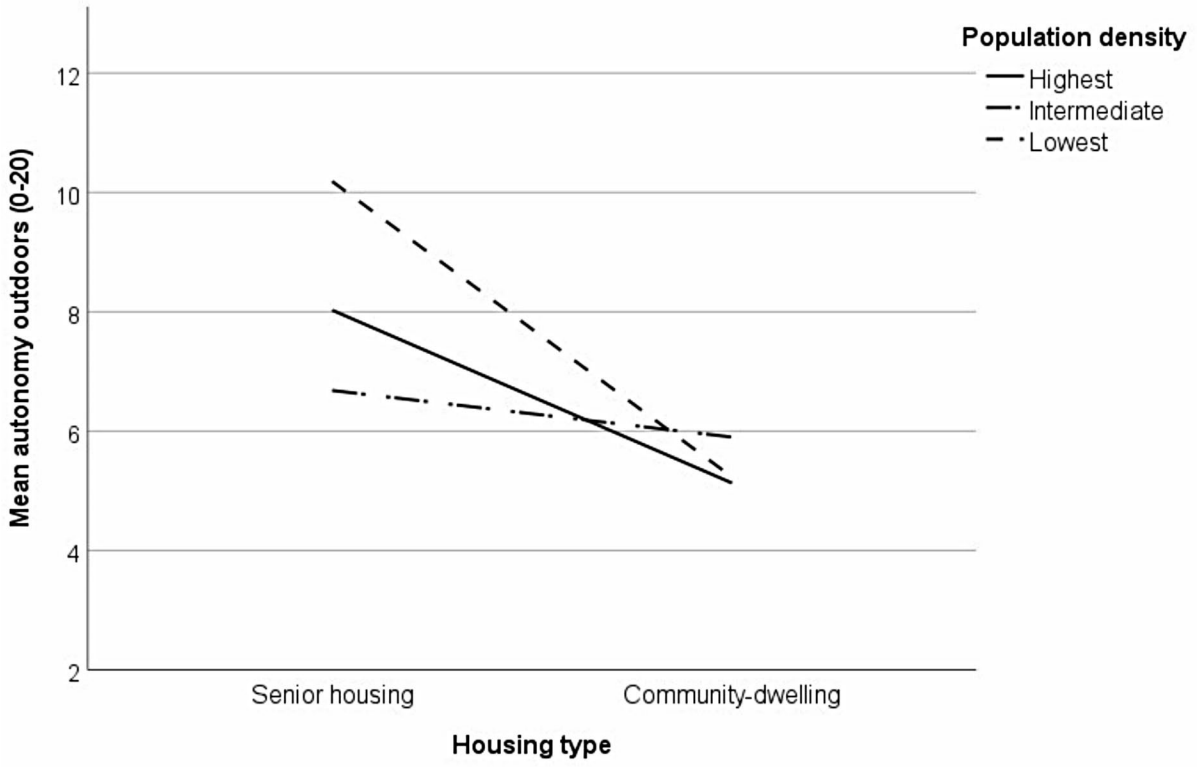

Fig. 2 Illustration of the moderation effect of population density area on the association between housing type and autonomy outdoors (the lower the score, the better)

compared to community-dwelling men [25]. Further, although living in a social environment, most senior housing residents were living alone, and a greater proportion of them were widowed compared to community-dwelling older adults. It has been found that becoming 'alone' in the household´, i.e. the only one left, in old age may decrease outdoor mobility, especially in the face of functional deficits [42]. Another study also found that becoming 'alone' in old age may increase difficulties in finding meaningful activities and keeping up social relations [43]. This may be reflected in decreased life-space mobility and autonomy outdoors. While living alone in an ordinary dwelling has been linked to greater outdoor mobility [44], in the senior housing context it seems to be the opposite. People living alone in ordinary dwellings are typically obliged to run their errands by themselves whereas people living alone in a communal environment may seek help from the community and additionally, have access to certain services and activities already within the house.

The findings may also be explained by the person-environment fit posited in the ecological theory of aging [12]. As we previously reported, people have certain reasons for moving into senior housing, typically related to declining health and function, loneliness, and seeking comfort [24]. Usually, relocation is seen as a way to decrease environmental pressure and maintain autonomy and control over everyday life [45]. However, relocation is also perceived as a straining life event as such [45], and it requires adaptation to a new environment. Perhaps one way to adapt is to decrease life-space mobility – at least for a while. In previous studies, it has been found that moving in an unfamiliar environment increases the need for cognitive processing and may cause sensory overload vs. moving in a familiar environment [46, 47]. This, in turn, may influence autonomy outdoors. Whether this adaptation takes months or years is not known, but in the present study, the median length of residence was 2 years among senior housing residents and 20 years among community-dwelling older adults. However, including the length of residence as a covariate did not explain the association of housing type with outdoor mobility. Finally, we must note that we cannot rule out the possibility that these persons would have even more restricted outdoor mobility if they still lived in their initial dwellings. Hence, we cannot conclude whether the findings of this study reflect the consequences of relocation, the possibilities at the new residence, or rather describe the life situation of the persons who decide to move into senior housing.

Another notable finding was that population density area moderated the association between housing type and outdoor mobility. The difference in life-space mobility and autonomy outdoors was evident in senior housing

residents and community-dwelling older adults living in the highest and lowest population density areas but not among those in the intermediate population density areas. Further, community-dwelling older adults' life-space mobility and autonomy outdoors scores were similar in all population density areas, whereas among senior housing residents, the scores differed quite radically depending on the population density area they were living in. Overall, these findings imply that the most optimal place for senior housing residents to live is in an intermediate population density area and that the physical environment may play a greater role in outdoor mobility among senior housing residents than among community-dwelling residents. It seems that if services and other important outdoor destinations are located very near the home (high population density area, typically centers of municipalities), people do not need to travel far away from the home. This may increase comfort in senior housing residents' everyday lives but negatively influence life-space mobility. On the other hand, if the key destinations are located very far away from the home (low population density area, typically peri-urban and peripheral areas of municipalities), senior housing residents may increase the service use at their residence or just find it difficult to leave the home. Community-dwelling older adults, in turn, may have no choice but to leave the home and run their errands themselves. The distance from home to neighborhood destinations facilitating outdoor mobility has been shown to be meaningful in previous studies as well. Portegijs et al. [16] and Boakye-Dankwa et al. [48] found that in terms of physical activity, the destinations are optimally located when within easy reach but not too close. Based on the findings of this study, the same seems to apply to life-space mobility and autonomy outdoors. However, it should also be noted that the senior housing residents living in the intermediate population density areas were younger and healthier than those living in the highest and lowest population density areas, and hence, perhaps resembled the community-dwelling older adults the most. Finally, it should be noted that when assessing life-space mobility, the moderation effect of population density area became statistically non-significant when controlled for length of residence. However, we believe this might be a false negative finding, as the length of residence is associated with both housing type and life-space mobility and thus may reduce the size of the underlying effect when included in the model. Additionally, when illustrating the fully adjusted moderation effect, the findings seemed similar as in the less adjusted models, i.e., that senior housing residents and community-dwelling older adults in the intermediate population density areas did not have significantly different levels of life-space mobility.

This study has its strengths and weaknesses. Firstly, this study pooled data from two distinct study projects, which enabled comparisons between senior housing residents and community-dwelling older adults. The utilized datasets were rather extensive, including both men and women and people from all social strata. Additionally, the data were collected at similar time points using similar methods, making data harmonization feasible. Finally, the measures were well-established and validated. Overall, this study laid ground for new hypotheses regarding outdoor mobility and active aging in the senior housing context, a growing housing option in the Nordic Countries that has sparsely been studied from this perspective. However, some notes should be made. Senior houses are typically designed to be located near amenities, which is why only a few of the present senior housing residents were included in the lowest population density tertile. Hence, our findings may underestimate the effects of living in low-population-density areas on outdoor mobility among senior housing residents. In addition, it should be noted that the BoAktiv study did not include data on the participants' cognitive function. Thus, we could not consider cognitive function in the present analyses, although it would have been reasonable as we used self-report measures. However, these kinds of activity studies typically draw the most active and healthy people to participate, whereas people with more functional deficits tend to drop out or refuse to participate in the first place [29]. Moreover, to be able to live independently, as the participants in the present study, people cannot have major deficits in their cognition. Thus, we assume that the present study participants' cognition has not significantly influenced the reliability of the findings. Finally, the present study is based on a cross-sectional design, which enables the examination of associations at a certain time point. Longitudinal and causal investigations should be addressed in future studies.

Conclusions

To conclude, senior housing residents in the lowest and highest population density areas had more restricted life-space mobility and autonomy outdoors than community-dwelling older adults. This may reflect their adaptation to a new home environment and life situation, e.g., becoming a widow. However, in the intermediate population density areas, no difference in outdoor mobility was found between senior housing residents and community-dwelling older adults. This implies that the location of the senior house is meaningful for older people and optimal for outdoor mobility when within easy reach but not too near amenities. The findings of this study may help in designing and developing senior housing services that support active and healthy aging and quality of life among older people. Future studies should investigate

whether senior housing residents are satisfied with their dwellings and whether outdoor mobility might be promoted among them.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-20759-4.

Supplementary Material 1

Author contributions

SS formulated the study questions, analyzed and interpreted the data, and drafted the first version of the manuscript. E-MT and KEK conducted the map-based analyses. MK provided the data from AGNES study and contributed to finalizing the pooled dataset. TR and MvB obtained funding for the study. All authors read, commented, and approved the final manuscript.

Funding

This work was supported by Samfundet Folkhälsan; the Jan Magnus Jansson Foundation; the Academy of Finland [grant no. 349336 to M.vB. and 310526 to T.R.]; and the European Research Council [ERC AdvG 693045 to T.R.]. The writing of this article was also supported by the Juho Vainio Foundation [grant to KK]. The funders had no role in the design, methods, results, or their interpretation in the study. In addition, the content of this manuscript does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the manuscript lies entirely with the authors.

Data availability

The data are not openly available due to reasons of sensitivity but are available from the principal investigators of the BoAktiv and AGNES studies (Mikaela von Bonsdorff and Taina Rantanen, respectively) upon reasonable request.

Declarations

Ethics approval and consent to participate

The BoAktiv and AGNES studies followed the guidelines of the Declaration of Helsinki. BoAktiv was approved by the University of Helsinki Ethical Review Board in the Humanities and Social and Behavioral Sciences and AGNES by the Central Finland Health Care District. All participants provided written informed consent before assessments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 30 January 2024 / Accepted: 14 November 2024
Published online: 26 November 2024

References

1. Mollenkopf H. The significance of out-of-home mobility inn modern society. In: Mollenkopf H, Marcellini F, Ruoppila I, Széman Z, Tacken M, editors. Enhancing mobility in late life. Amsterdam: IOS; 2005. pp. 1–9.
2. Rantanen T. Promoting mobility in older people. J Prev Med Pub Health. 2013;46(Suppl 1):S50–4.
3. Satariano WA, Guralnik JM, Jackson RJ, Marottoli RA, Phelan EA, Prohaska TR. Mobility and aging: New Directions for Public Health Action. Am J Public Health. 2012;102(8):1508–15.
4. Mezuk B, Rebok GW. Social Integration and Social Support among older adults following driving Cessation. J Gerontol Ser B. 2008;63(5):S298–303.
5. Rantakokko M, Portegijs E, Viljanen A, Iwarsson S, Rantanen T. Life-space mobility and quality of life in Community-Dwelling Older people. J Am Geriatr Soc. 2013;61(10):1830–2.
6. Portegijs E, Tsai LT, Rantanen T, Rantakokko M. Moving through Life-Space areas and objectively measured physical activity of older people. PLoS ONE. 2015;10(8):e0135308.
7. Shimada H, Ishizaki T, Kato M, Morimoto A, Tamate A, Uchiyama Y, et al. How often and how far do frail elderly people need to go outdoors to maintain functional capacity? Arch Gerontol Geriatr. 2010;50(2):140–6.
8. Simonsick EM, Guralnik JM, Volpato S, Balfour J, Fried LP. Just get out the door! Importance of walking outside the home for maintaining mobility: findings from the women's health and aging study. J Am Geriatr Soc. 2005;53(2):198–203.
9. Portegijs E, Rantakokko M, Mikkola TM, Viljanen A, Rantanen T. Association between physical performance and sense of autonomy in Outdoor activities and Life-Space mobility in Community-Dwelling Older people. J Am Geriatr Soc. 2014;62(4):615–21.
10. Baker PS, Bodner EV, Allman RM. Measuring life-space mobility in Community-Dwelling older adults. J Am Geriatr Soc. 2003;51(11):1610–4.
11. Cardol M, de Haan RJ, van den Bos GA, de Jong BA, de Groot IJ. The development of a handicap assessment questionnaire: the impact on participation and autonomy (IPA). Clin Rehabil. 1999;13(5):411–9.
12. Lawton M, Nahemow L. Ecology and the aging process. In: Lawton M, editor. The psychology of adult development and aging. Washington DC: American Psychological Association; 1973. pp. 619–74.
13. Keskinen KE, Gao Y, Rantakokko M, Rantanen T, Portegijs E. Associations of Environmental features with Outdoor Physical Activity on weekdays and Weekend days: a cross-sectional study among older people. Front Public Health. 2020;8:578275.
14. Portegijs E, Keskinen KE, Tsai LT, Rantanen T, Rantakokko M. Physical limitations, Walkability, Perceived Environmental facilitators and physical activity of older adults in Finland. Int J Environ Res Public Health. 2017;14(3):333.
15. Tuomola EM, Keskinen K, Rantanen T, Portegijs E. P08-16 Neighborhood walkability and older people's participation in leisure activities. Eur J Public Health. 2022;32(Supplement2):ckac095129.
16. Portegijs E, Keskinen KE, Eronen J, Saajanaho M, Rantakokko M, Rantanen T. Older adults' physical activity and the relevance of distances to Neighborhood destinations and barriers to Outdoor mobility. Front Public Health. 2020;8:335.
17. Granbom M, Slaug B, Löfqvist C, Oswald F, Iwarsson S. Community Relocation in very old age: changes in Housing Accessibility. Am J Occup Ther off Publ Am Occup Ther Assoc. 2016;70(2):p70022700201–9.
18. Niva B, Skär L. A pilot study of the activity patterns of five elderly persons after a housing adaptation. Occup Ther Int. 2006;13(1):21–34.
19. Barnes LL, Wilson RS, Bienias JL, Mendes de Leon CF, Kim HJN, Buchman AS, et al. Correlates of Life Space in a Volunteer Cohort of older adults. Exp Aging Res. 2007;33(1):77–93.
20. Hwang HL, Lin HS, Tung YL, Wu HC. Correlates of perceived autonomy among elders in a senior citizen home: a cross-sectional survey. Int J Nurs Stud. 2006;43(4):429–37.
21. Miyashita T, Tadaka E, Arimoto A. Cross-sectional study of individual and environmental factors associated with life-space mobility among community-dwelling independent older people. Environ Health Prev Med. 2021;26:9.
22. Jolanki OH. Senior Housing as a Living Environment That Supports Well-Being in Old Age. Front Public Health [Internet]. 2021 [cited 2023 Apr 25];8. https://www.frontiersin.org/articles/https://doi.org/10.3389/fpubh.2020.589371
23. Lotvonen S, Kyngäs H, Koistinen P, Bloigu R, Elo S. Mental Well-Being of Older people in Finland during the First Year in Senior Housing and its association with physical performance. Int J Environ Res Public Health. 2018;15(7):1331.
24. Siltanen S, Keskinen KE, Lahti AM, Rantanen T, von Bonsdorff M. Active aging in Senior Housing residents and Community-Dwelling older adults: a comparative study in Finland. J Aging Health. 2023;8982643231186627.
25. Lahti AM, Mikkola TM, Salonen M, Wasenius N, Sarvimäki A, Eriksson JG, et al. Mental, Physical and Social Functioning in independently living senior House residents and Community-Dwelling older adults. Int J Environ Res Public Health. 2021;18(23):12299.
26. Tyvimaa T. Social and physical environments in senior communities: the Finnish experience. Int J Hous Mark Anal. 2011;4(3):197–209.
27. Lahti AM, Simonsen N, Seppänen M, Finne M, Sarvimäki A, von Bonsdorff M. Folkhälsans seniorboende och aktivt åldrande – BoAktiv-studien. Gerontologia. 2019;33(2):74–85.
28. Rantanen T, Saajanaho M, Karavirta L, Siltanen S, Rantakokko M, Viljanen A, et al. Active aging – resilience and external support as modifiers of the disablement outcome: AGNES cohort study protocol. BMC Public Health. 2018;18(1):565.

29. Portegijs E, Karavirta L, Saajanaho M, Rantalainen T, Rantanen T. Assessing physical performance and physical activity in large population-based aging studies: home-based assessments or visits to the research center? BMC Public Health. 2019;19(1):1570.
30. Rantanen T, Portegijs E, Viljanen A, Eronen J, Saajanaho M, Tsai LT, et al. Individual and environmental factors underlying life space of older people – study protocol and design of a cohort study on life-space mobility in old age (LISPE). BMC Public Health. 2012;12(1):1018.
31. Allman RM, Sawyer P, Roseman JM. The UAB Study of Aging: background and insights into life-space mobility among older americans in rural and urban settings. Aging Health. 2006;2(3):417–29.
32. Cardol M, de Haan RJ, de Jong BA, van den Bos GA, de Groot IJ. Psychometric properties of the impact on participation and autonomy questionnaire. Arch Phys Med Rehabil. 2001;82(2):210–6.
33. Kersten P, Cardol M, George S, Ward C, Sibley A, White B. Validity of the impact on participation and autonomy questionnaire: a comparison between two countries. Disabil Rehabil. 2007;29(19):1502–9.
34. Statistics Finland. Population Grid Data 2018 (1 km x 1 km) [Internet]. Statistics Finland; [cited 2023 Nov 23]. https://www.stat.fi/org/avoindata/paikkatietoaineistot/vaestoruutuaineisto_1km_en.html
35. Finnish Transport Infrastructure Agency. Digiroad Publication 1/2019 [Internet]. [cited 2023 Nov 23]. https://ava.vaylapilvi.fi/ava/Tie/Digiroad/Aineistojulkaisut
36. Official Statistics of Finland. Population structure 2018 [Internet]. [cited 2023 Nov 23]. https://www.stat.fi/til/vaerak/index_en.html
37. National Land Survey of Finland, Administrative. borders, 2018–2019, 1:10 000 [Internet]. 2018 [cited 2023 Dec 18]. https://etsin.fairdata.fi/dataset/a983614a-833a-4778-839b-08b855116a08
38. Radloff LS, The CES-D, Scale. A self-report Depression Scale for Research in the General Population. Appl Psychol Meas. 1977;1(3):385–401.
39. Hayes AF. Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. Second edition. New York: The Guilford Press; 2018.
40. Rantakokko M, Mänty M, Rantanen T. Mobility decline in Old Age. Exerc Sport Sci Rev. 2013;41(1):19.
41. Leppä H, Karavirta L, Rantalainen T, Rantakokko M, Siltanen S, Portegijs E, et al. Use of walking modifications, perceived walking difficulty and changes in outdoor mobility among community-dwelling older people during COVID-19 restrictions. Aging Clin Exp Res. 2021;33(10):2909–16.
42. Stjernborg V, Emilsson UM, Ståhl A. Changes in outdoor mobility when becoming alone in the household in old age. J Transp Health. 2014;1(1):9–16.
43. Kirkevold M, Moyle W, Wilkinson C, Meyer J, Hauge S. Facing the challenge of adapting to a life 'alone' in old age: the influence of losses. J Adv Nurs. 2013;69(2):394–403.
44. Tsai LT, Rantakokko M, Portegijs E, Viljanen A, Saajanaho M, Eronen J, et al. Environmental mobility barriers and walking for errands among older people who live alone vs. with others. BMC Public Health. 2013;13(1):1054.
45. Löfqvist C, Granbom M, Himmelsbach I, Iwarsson S, Oswald F, Haak M. Voices on Relocation and Aging in Place in very old Age—A complex and ambivalent matter. Gerontologist. 2013;53(6):919–27.
46. Merriman NA, Ondřej J, Roudaia E, O'Sullivan C, Newell FN. Familiar environments enhance object and spatial memory in both younger and older adults. Exp Brain Res. 2016;234(6):1555–74.
47. Phillips J, Walford N, Hockey A, Foreman N, Lewis M. Older people and outdoor environments: pedestrian anxieties and barriers in the use of familiar and unfamiliar spaces. Geoforum. 2013;47:113–24.
48. Boakye-Dankwa E, Barnett A, Pachana NA, Turrell G, Cerin E. Associations between latent classes of Perceived Neighborhood Destination accessibility and walking behaviors in older adults of a low-density and a high-density city. J Aging Phys Act. 2019;27(4):553–64.

Publisher's note