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Importance of Lifestyle Activities for Older Adults' Psychosomatic Functions After Driving Cessation: Interpretation by a Mixed-Methods Study

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Abstract

Older adults who cease driving are more likely to experience psychosomatic decline than those who continue driving. This mixed-methods study was intended to examine differences in psychosomatic functions depending on driving status and lifestyle activities, and factors affecting engagement in additional lifestyle activities after driving cessation. The quantitative analysis included individuals aged 60 and above. Driving status, lifestyle activities, and psychosomatic functions were assessed. For qualitative analysis, semi-structured interviews were conducted with the driving-cessation group to determine the factors affecting involvement in various lifestyle activities after driving cessation. Analysis of covariance was used for quantitative data, while text mining and qualitative inductive analysis were used for qualitative data. Older adults who engaged in more lifestyle activities walked faster than those who engaged in fewer lifestyle activities, even after driving cessation. Actively using local and personal resources may increase engagement in lifestyle activities after driving cessation.

Keywords

active life expectancy, qualitative methods, quantitative methods, transportation, living arrangements

What this paper adds

- Older adults engaging in more lifestyle activities could walk faster than those who engage in fewer lifestyle activities even after driving cessation.
- Actively using community and personal resources may increase engagement in lifestyle activities after driving cessation.
- Engaging in more lifestyle activities may play a positive role in psychosomatic functions after driving cessation.

Applications of study findings

- Both government support and self-help are essential to increase lifestyle activities after driving cessation.
- Reducing depressive symptoms after driving cessation requires perspectives other than the enhancement of lifestyle activities.
- It is essential that policymakers acquire a deeper understanding of how to actively use community and personal resources to reduce psychosomatic decline after driving cessation.

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Introduction

Driving can help older adults maintain an active lifestyle (Shah et al., 2012). However, with recent rapid population aging, traffic crashes caused by older drivers have increased, becoming a major social issue (Pitta et al., 2021). In Japan, traffic fatalities among older adults aged 65 years or more account for 56.2% of all road traffic fatalities and are three times that among those under 65 years (Cabinet Office, 2020). This situation has led to efforts to identify groups at high risk for traffic crashes (e.g., mild cognitive impairment) and assist them in continuing to drive safely (Ishii et al., 2021). In addition, policies are being promoted to consider both the voluntary return of driver's licenses and the cessation of driving to avoid the risk of traffic crashes (Cabinet Office, 2017). However, driving discontinuation contributes to the narrowing of living spaces among older drivers (Tsuji et al., 2018), leading to psychosomatic decline. Adverse effects of driving cessation among older adults may include decreased physical function and increased depression, cognitive decline, disability, and mortality (Chihuri et al., 2016). Furthermore, driving cessation is associated with an increased risk of developing nursing care needs (Shimada et al., 2016).

As noted, driving discontinuation leads to psychosomatic decline; however, the maintenance and improvement of psychosomatic functions after discontinuation has remained underexplored. Those maintaining independent mobility through public transportation or bicycle use after driving discontinuation often require less nursing care (Hirai et al., 2020). However, psychosomatic decline after driving cessation may make it more difficult for this group to use other modes of transportation than for continuing drivers (Chihuri et al., 2016). The former group is less likely to use public transport than those who continue to drive (Shimada et al., 2016). Furthermore, policies encouraging older adults to return their driver's licenses have resulted in decreased car crashes but increased bicycle crashes (Inada et al., 2023). Thus, healthy lifestyle support for community-dwelling middle-aged and older adults (CDMOAs) after driving cessation remains in its infancy.

Lifestyle influences health (Friedman, 2020). Lifestyle characteristics are not isolated but are composite with multiple (physical, cognitive, and social) characteristics (Zhou et al., 2021). Even among older adults in car-dependent areas, more outdoor lifestyle involvement (e.g., public transportation and shopping) reduces disability incidence (Katayama et al., 2023). Therefore, even among middle-aged and older adults (MOAs) who have discontinued driving, those who lead more active lifestyles may preserve their psychosomatic functions; however, this relationship and the details of the context in which individuals develop healthier lifestyles after driving cessation are unclear. This study sought to determine (1) whether psychosomatic functions (grip strength, walking speed, muscle mass, and depression) differ depending on CDMOAs' driving status and lifestyle activities and (2) the factors affecting such adults' post–driving cessation engagement in additional lifestyle activities.

Methods

Study Design

We adopted an explanatory sequential mixed-methods approach (Schoonenboom & Johnson, 2017). First, we collected and analyzed quantitative data (observational studies). Next, we collected and analyzed qualitative data (semi-structured interviews) to explain the results derived from the quantitative data. Finally, we interpreted the findings obtained from both data sets. Detailed procedures for the study design are presented in accordance with the guidelines for descriptive sequential design (Supplemental Figure S1; Ivankova et al., 2006).

The study was conducted based on Declaration of Helsinki principles. Information regarding participants' privacy, personal information protection, study content, and withdrawal were fully explained, and written consent was obtained.

Quantitative Strand

Quantitative Participants. Of the 1092 participants (age ≧ 40) in the community cohort study (Tarumizu Study held from June 2019 to March 2022 in Japan), 872 CDMOAs (age ≧ 60) were included in this study. Individuals who were identified as requiring long-term care ($n = 14$) and those who had dementia ($n = 6$) were excluded, as were those who did not indicate their driving status ($n = 1$), had not obtained a driving license ($n = 146$), ceased driving before age 50 ($n = 6$), and were missing key data ($n = 27$); finally, 672 participants (mean age 71.2 ± 6.9 years, 54.5% women) were included in this cross-sectional design study.

Quantitative Survey Items

Driving Status/Lifestyle Activities. Participants' driving statuses included licensed and currently driving, license returned, licensed but not renewed, and licensed and currently not driving. Respondents who answered "licensed and currently driving" were categorized into the driving group, while those who provided any other responses were placed into the driving-cessation group (Shimada et al., 2016).

Twelve lifestyle activities were selected from the Japan Science and Technology Agency Index of Competence (Iwasa et al., 2018) and Kihon Checklist (Arai & Satake, 2015), and selected lifestyle activities were associated with healthy aging (Shimada et al., 2013; Zhao et al., 2023).

The selected lifestyle activities comprised multiple components (physical and daily activities, cognitive activities, and social activities). Previous studies have suggested that "traveling by bus or train" and "touch with soil" (e.g., horticultural activity) are related to physical activities (Gonzalez et al., 2011; Tran et al., 2022; Tsai et al., 2015). The term "touch with soil" was used to encompass activities such as gardening, yard work, and horticultural activities.

Questions regarding physical and daily activities included the following: (1) Do you do light exercise or sports? (2) Do you exercise regularly or play sports? (3) Do you go out by bus or train by yourself? (4) How many days per week do you engage in activities where you touch soil? Questions regarding cognitive activity included the following: (5) How many days a week do you read newspapers? (6) How many days per week do you read books? (7) Do you enjoy art, films, or music? (8) Do you watch educational/cultural programs? Questions regarding social activity included the following: (9) Do you visit your friends? (10) Do you participate in regional festivals or events? (11) Do you participate in neighborhood or residents' associations? (12) Do you engage in charitable or volunteer activities? For items (3) and (7)–(12), respondents answered "yes" or "no" to determine whether they performed the activities in question. For (1), (2), (4), (5), and (6), those who answered that they did the activity at least weekly were considered to be "doing it." Respondents were classified into two groups according to whether they fell above or below a median of nine for 12 lifestyle activities: more lifestyle activities (nine or more) and fewer (less than nine) lifestyle activities (Katayama et al., 2020). Finally, the two driving status groups (driving and driving cessation) and two lifestyle activity status groups (more and fewer) were combined and categorized into four driving status/lifestyle groups: driving with more lifestyle activities, driving with fewer lifestyle activities, driving cessation with more lifestyle activities, and driving cessation with fewer lifestyle activities.

Physical Function/Muscle Mass/Depression Symptoms. Physical function was assessed using maximum grip strength and normal walking speed. Grip strength was measured using a digital grip strength meter (Takei Kiki Kogyo, Grip D.T.K.K. 540) to determine the dominant hand's maximum grip (kg) strength. Normal walking speed was measured using an infrared sensor. Acceleration and deceleration paths were set up 2 meters before and after the 10-meter measurement section, respectively, and the normal walking speed (m/s) was calculated. Muscle mass was calculated using the bioelectrical impedance method as the appendicular skeletal muscle mass index of the extremities (ASMI: kg/m^2). Depressive symptoms were assessed using the 15-point Geriatric Depression Scale-Short Version (GDS-15); the higher the total score, the stronger the tendency toward depressive symptoms (Friedman et al., 2005).

Sociodemographic Variables. We obtained data on age, sex, living-alone status, number of medications per day, and medical history (hypertension, diabetes, and hyperlipidemia). In a face-to-face interview, a licensed physician or nursing practitioner assessed the participants' medical conditions, including their medical history and medications.

Quantitative Statistical Analysis. For comparisons among the four groups based on combined driving status and lifestyle, analysis of variance was used for age and medication, and chi-square tests were used for sex, living-alone status, hypertension, diabetes, and hyperlipidemia. For the associations between the four driving status/lifestyle groups and grip strength (kg), normal walking speed (m/s), ASMI (kg/m2), and GDS-15, analysis of covariance (ANCOVA) was performed with age, sex, medications, and living alone as covariates. The dependent variables of the ANCOVA were grip strength, walking speed, ASMI, and GDS-15, and the independent variables were four driving status/lifestyle groups. As part of the ANCOVA, a post-hoc Bonferroni test was performed. SPSS Statistics version 29 (IBM Corporation) with a significance level of less than 5% was used for statistical analyses. The quantitative survey was conducted in Japanese, and the results were translated into English.

Qualitative Strand

Qualitative Participants. The qualitative study included those who had ceased driving for less than 2 years at the time of the 2021 survey (n = 16). Participants were mailed qualitative follow-up survey invitations in early February 2023. Twelve older adults responded to this invitation, and eight ultimately agreed to participate in a survey conducted in late February 2023. One person with a history of dementia and another who withdrew consent after the survey were excluded; six older adults (mean age 80.8 ± 4.2 years, 100% men) were included in the final analysis.

Qualitative Study (Semi-structured Interviews). Demographic and clinical characteristics—that is, age, sex, dementia (presence or absence), and driving cessation circumstances—were collected during the qualitative study.

Qualitative data were collected through semi-structured interviews. The first author, co-author (T, M), and corresponding author developed an interview guide using the quantitative strand results. The interview guide could be completed in 30 minutes per interview (Supplemental Figure S2). Semi-structured interviews were conducted at either a government facility or participants' residences based on their preferences. The interviewer (first author) was an active clinical practitioner as an occupational therapist with adequate interviewing experience. The interviewer asked questions using the interview guide, and participants could convey their experiences and thoughts. Participants'

responses to the interview guide questions led to spontaneous follow-up questions. The interviews were conducted and analyzed in Japanese, and the results were translated into English. All co-authors reviewed the translated results.

Qualitative Data Analysis. Six semi-structured interviews were audio-recorded, anonymized using an IC recorder, and transcribed verbatim by the first author. KH coder (3.0) was used to quantitatively analyze transcripts (Higuchi, 2016, 2017). Text mining was selected because computerized qualitative data analysis increases the validity and reliability of results (Budding & Cools, 2008). The first author and co-authors (T, M) confirmed the analysis validity while conducting a quantitative text analysis. As a preprocessing step, the interviewer's comments were excluded; proper nouns (e.g., names of people) were converted to common nouns; and a morphological analysis was performed. In the list of morphological analysis–based extracted words, five ("ground golf," "responsible person," "aggressive," "professor," and "can't") were set for forced extraction after the keyword in context concordance (KWIC concordance) was checked to determine whether the decomposed compound word corresponded to the relevant word. A co-occurrence network was created using R built into the KH coder (3.0; settings: minimum number of word occurrences, 3; unknown words and interjections were excluded; and a minimum spanning tree was adopted). Subsequently, a categorization table was created based on the seven subgraphs obtained from the co-occurrence network, indicating strong word co-occurrence relationships (Yama et al., 2022). Category names were derived using the qualitative inductive analysis procedure. For each of the seven subgraphs obtained by the co-occurrence network, the extracted phrases were repeatedly checked for KWIC concordance; each extracted word was coded; and codes with common elements were grouped. Using the grouped codes, subcategories were created, and the main category names were determined (Supplemental Table S1). To strengthen the internal analytical validity, the first author, co-authors (T, M; S, D), and corresponding author repeatedly discussed the coding and category names until contradictions were resolved, a consensus was reached and approved, and the final main category was determined. Research reporting was conducted using established qualitative research reporting guidelines (Supplemental Table S2) (Tong et al., 2007).

Results

Quantitative Strand Results

Participants' Characteristics. Of the 672 quantitative study participants, 630 (93.8%) and 42 (6.2%) were in the driving and driving-cessation groups, respectively (see lifestyle activities' characteristics based on driving status in Supplemental Table S3). Regarding the four driving status/lifestyle groups, 344 (51.2%) and 286 (42.6%) participants were placed into the driving with more and fewer lifestyle activities, respectively, while 20 (3.0%) and 22 (3.2%) were placed into the driving cessation with more and fewer lifestyle activities, respectively.

Table 1 compares the four driving status/lifestyle groups. Significant differences were observed in terms of age ($p < 0.001$), number of medications ($p < 0.001$), living alone ($p < 0.001$), and hypertension ($p = 0.009$). Sex, diabetes, and hyperlipidemia did not differ significantly.

Association Between Driving Status and Lifestyle Activities and Physical Function, Muscle Mass, and Depression. Table 2 shows the ANCOVA results adjusted for covariates and Bonferroni tests. The driving with more lifestyle activities group (1.4 ± 0.2 m/sec) had the fastest walking speed, followed by the driving with fewer lifestyle activities (1.3 ± 0.2 m/sec), driving cessation with more lifestyle activities (1.2 ± 0.2 m/sec), and driving cessation with fewer

Table 1. Participants' Characteristics (Quantitative Strand).

		Driving		Driving cessation		
	All (n = 672)	More lifestyle activities (n = 344)	Fewer lifestyle activities (n = 286)	More lifestyle activities (n = 20)	Fewer lifestyle activities (n = 22)	
						p-value
Age, years; mean ± SD	71.2 ± 6.9	70.1 ± 6.6	70.4 ± 6.6	79.4 ± 4.0	79.0 ± 9.0	<0.001[a]
Women, n (%)	366 (54.5)	198 (57.6)	141 (49.3)	13 (65.0)	14 (63.6)	0.109[b]
Medications, number per day; mean ± SD	2.8 ± 3.0	2.5 ± 2.7	2.9 ± 3.0	4.5 ± 4.0	5.4 ± 4.0	<0.001[a]
Living alone, n (%)	158 (23.5)	81 (23.5)	56 (19.6)	9 (45.0)	12 (54.5)	<0.001[b]
Hypertension, n (%)	301 (44.8)	134 (39.0)	142 (49.7)	13 (65.0)	12 (54.5)	0.009[b]
Diabetes, n (%)	82 (12.2)	37 (10.8)	39 (13.6)	3 (15.0)	3 (13.6)	0.703[b]
Hyperlipidemia, n (%)	175 (26.0)	94 (27.3)	69 (24.1)	5 (25.0)	7 (31.8)	0.745[b]

SD, standard deviation; a, analysis of variance; b, chi-square test.

Table 2. Association Between Driving Status and Lifestyle Activities and Physical Function, Muscle Mass, and Mental Health.

		Driving		Driving cessation		Analysis of covariance			
	All (n = 672)	More[a] lifestyle activities (n = 344)	Fewer[b] lifestyle activities (n = 286)	More[c] lifestyle activities (n = 20)	Fewer[d] lifestyle activities (n = 22)	F-value	p-value	η_p^2	Post-hoc
Grip strength, kg	27.4 ± 7.5	27.7 ± 7.3	27.6 ± 7.7	23.0 ± 7.7	23.6 ± 7.6	2.6	0.051	0.012	
Walking speed, m/s	1.3 ± 0.2	1.4 ± 0.2	1.3 ± 0.2	1.2 ± 0.2	1.0 ± 0.3	14.9	<0.001	0.063	a > b, c > d
ASMI, kg/m^2	6.6 ± 0.9	6.6 ± 0.9	6.7 ± 0.9	6.2 ± 1.0	6.2 ± 1.0	1.2	0.320	0.005	
GDS-15, score	2.8 ± 2.6	2.0 ± 1.9	3.6 ± 3.0	2.8 ± 2.8	4.0 ± 2.4	22.1	<0.001	0.091	a < b, d

Analysis of covariance; grip strength, walking speed, ASMI, and GDS-15 were set as dependent variables; independent variables are four driving status/lifestyle groups. The covariates are age, sex, medication, and living alone. Post-hoc test used: Bonferroni correction.
Note. Continuous variables are presented as means ± SD. SD, standard deviation; ASMI, appendicular skeletal muscle mass index; GDS-15, Geriatric Depression Scale-Short Version.

lifestyle activities (1.0 ± 0.3 m/sec; F = 14.9, $p < 0.001$, ηp^2 = 0.063) groups. Regarding mental function, the driving with more lifestyle activities group had the lowest score, indicating lower depressive tendencies (2.0 ± 1.9 score), followed by driving with fewer lifestyle activities (3.6 ± 3.0 score), and driving cessation with more lifestyle activities (4.0 ± 2.4 score; F = 22.1, $p < 0.001$, ηp^2 = 0.091). No statistically significant differences in grip strength and ASMI were observed for driving status and lifestyle activities in the ANCOVA adjusted for covariates (grip strength: F = 2.6, p = 0.051; ASMI: F = 1.2, p = 0.320).

Qualitative Strand Results

Participants' Characteristics. Table 3 presents the six qualitative study participants' characteristics and their results. The mean age was 80.8 ± 4.2; six participants (100.0%) were men; five participants (83.3%) had ceased driving because they had returned their driver's licenses; one participant (16.7%) had a driver's license but was not driving; and the average number of years since driving cessation was 2.2 ± 1.2. Three participants (50.0%) were interviewed at their homes and three (50.0%) at public facilities.

Co-occurrence Network Diagram. Morphological analysis revealed 304 extracted words. A co-occurrence network was created using R built into the KH coder (3.0) and 49 of these words (Figure 1). The co-occurrence networks were classified into seven clusters, indicating seven strong co-occurrence relationships, and each network was marked with a same-colored subgraph number. The size of each word's circle in the network indicated the number of its occurrences, as obtained by the verbatim transcript's morphological analysis.

Categorization Table Based on Qualitative Inductive Analysis. Qualitative inductive analysis of the seven categories that recognized strong word associations obtained through the co-occurrence network identified the following factors for engaging in various activities after driving discontinuation: (1) an environment promoting autonomous behavior, (2) daily routines with local resources, (3) utilization of local resources with spontaneous actions, (4) social participation through outings based on current and projected activities, (5) recognition of one's community-based role, (6) walking ability required for activities, and (7) opportunities for activities (Table 4).

Discussion

More lifestyle activities were associated with faster post–driving cessation walking speeds among CDMOAs. The continuous driving group that engaged in more lifestyle activities had lower depression scores than those who engaged in fewer lifestyle activities for current driving and driving cessation. Seven categories were important for engaging in various post–driving cessation activities, suggesting that an environment encouraging autonomous behavior and active community participation through local resources and self-resources is important for engaging in such activities.

To explain the association between lifestyle activity engagement and post–driving cessation walking speed, focusing on exercise intensity during lifestyle activities is necessary. Exercise intensity during lifestyle activities is generally light to moderate (Ainsworth et al., 2011). Lifestyle activities require physical function rather than grip strength or ASMI, which are reflected in muscle strength. Therefore, "walking speed," which indicates physical function in older adults, may be associated with increased post–driving cessation lifestyle activities (Mehmet et al., 2020). Disease-

Table 3. Participants' Characteristics (Qualitative Strand) (n = 6).

		Mean ± SD	n (%)
Qualitative strand			
Age, years		80.8 ± 4.2	
Sex	Men		6 (100)
	Women		0 (0)
Driving cessation situation	Cessation of driving owing to return of driver's license		5 (83.3)
	Has a driver's license but has stopped driving		1 (16.7)
Years since ceased driving		2.2 ± 1.2	
Interview location	Participant's home		3 (50.0)
	Public facilities		3 (50.0)
Quantitative strand (supplementary information)			
Living situation	Living alone		2 (33.3)
	Living together		4 (66.7)
Involvement in lifestyle activities	More lifestyle activities		3 (50.0)
	Fewer lifestyle activities		3 (50.0)
Physical and daily activities	Yes		
Do you do light exercise or sports?			5 (83.3)
Do you regularly exercise or play sports?			2 (33.3)
Do you go out by bus or train by yourself?			3 (50.0)
How many days per week do you engage in activities in where you touch soil?			6 (100.0)
Cognitive activities	Yes		
How many days a week do you read newspapers?			6 (100.0)
How many days a week do you read books?			2 (33.3)
Do you enjoy art, films, or music?			6 (100.0)
Do you watch educational/cultural programs?			3 (50.0)
Social activities	Yes		
Do you sometimes visit your friends?			4 (66.7)
Do you participate in regional festivals or events?			4 (66.7)
Do you participate in neighborhood or residents' associations?			3 (50.0)
Do you engage in charitable or volunteer activities?			3 (50.0)

Note. SD, standard deviation.

based intervention studies have suggested an association between lifestyle and walking speed. In community-dwelling older adults with sarcopenia (a condition with reduced skeletal muscle mass, muscle strength, and physical function), a six-month multi-domain (physical, nutritional, and cognitive) lifestyle activity intervention was associated with improved walking speed, particularly compared with muscle strength and ASMI (Lu et al., 2019). Moreover, qualitative findings revealed that the walking ability required for activities was important for involvement in various post–driving cessation lifestyle activities. One specific narrative included the statement "If my legs stop working, I'm done." This may indicate that individuals are acutely aware of the importance of their walking ability for engaging in various post–driving cessation lifestyle activities. Maintaining mobility in living spaces is important for ensuring physical activity (Tsai et al., 2016). Furthermore, the smaller the living space with physical and social activities, the higher the physical frailty prevalence (Doi et al., 2022). In short, walking ability and engagement in post–driving cessation lifestyle activities may share a close bidirectional relationship. This may partially explain why varied involvement in such lifestyle activities is associated with walking speed.

These quantitative results revealed no significant association between depression and lifestyle activities that became more or less frequent after driving cessation. A meta-analysis suggested increased post–driving cessation depression risk among older adults (Chihuri et al., 2016). Lifestyle activities may help protect against depression among older adults (Sarris et al., 2014). Compared to young people, older adults experience greater psychological adjustment difficulties when faced with situations in which they cannot avoid the constant emotional experience of change (Charles, 2010). In short, lifestyle activities' protective effect on psychological aspects may be limited in the unavoidable situation of driving cessation, which significantly changes the living space. Accordingly, deriving a sufficient protective effect against

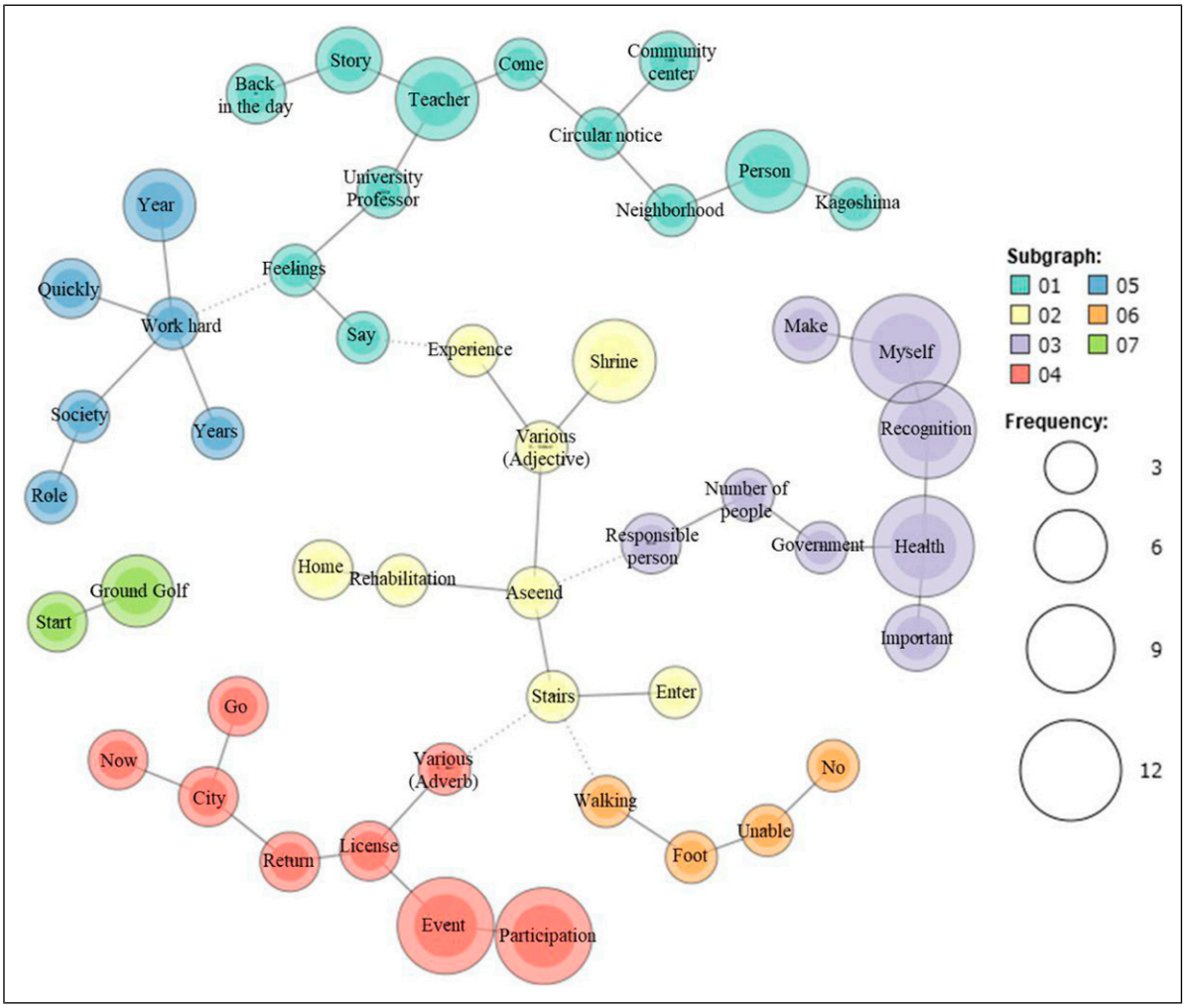

Figure 1. Co-occurrence network diagram on what is important for increasing post–driving cessation life activities.

depression through various lifestyle factors alone may not be possible for older adults who have ceased driving.

The qualitative research findings indicate two key factors for engaging in various lifestyle activities even after driving cessation: an environment promoting autonomous behavior and daily routines with local resources. A specific narrative included the statements "The events at the community center are always very active, and people ask if they can go together because they have never been there before" and "A daily routine is to visit the shrine around 7:30 in the morning." We argue that these statements are commonly related to participants' pre–driving cessation lifestyles and the strength of their connections (social capital) in the community and environment. For example, a systematic review of the impact of social capital interventions (promoting social support and participation) on older adults' health suggests that such interventions may benefit mental functioning (e.g., self-esteem), physical functioning (e.g., walking speed), and the use of health-related resources (Coll-Planas et al., 2017). Reports on environmental characteristics' effects on older adults' walking behavior suggest that neighborhood cohesion is important for promoting walking behavior (Ory et al., 2016). Therefore, coordinating the environment (e.g., providing means of transportation and hobbies) even before driving cessation is important for carrying out various daily activities subsequently.

Government interventions are necessary to achieve active aging (the process of optimizing opportunities for health, participation, and security to enhance quality of life as people age), as advocated by the World Health Organization (World Health Organization, 2002). The qualitative results indicated that utilization of local resources with spontaneous actions and social participation through outings, based on current and projected activities, was an important factor in engaging in various lifestyle activities. A specific narrative included "Information from the community center comes frequently by circular. There is an annoying amount of information about events, and if I find one that I would like to go to, I try to attend it" and "After returning my driver's license, I try to attend city events." These statements suggest that

Table 4. Categories of Important Things to Do to Increase Lifestyle Activities After Cessation of Driving.

No.	Main categories	Subcategories	Specific textual examples (age, driving cessation status, and status of life activities in quantitative strand)
1	An environment that promotes autonomous behavior	Engaging with trusted professionals People and information A place to connect with others Familiar neighborhoods	"The events at the community center are always very active, and people ask if they can go together because they have never been there before." (81 years old, returned driver's license, more lifestyle activities)
		Autonomous action	"If there were more and more events that could be conducted by university professors, I think people would feel like they would like to be taught by this professor." (81 years old, has a driver's license but has stopped driving, more lifestyle activities)
2	Daily routine with local resources	Community resources Physical activity Daily routine Success experience Diverse opportunities	"A daily routine is to visit the shrine around 7:30 in the morning." (88 years old, returned driver's license, more lifestyle activities) "I enjoy the hot springs." (91 years old, returned driver's license, more lifestyle activities) "I climb the stairs of the shrine 2 to 3 times a week for rehabilitation." (78 years old, returned driver's license, more lifestyle activities)
3	Utilization of local resources with spontaneous actions	Autonomous behavior Understanding of current situation Public assistance Human resources Role in the community	"Information from the community center comes frequently by circular. There is an annoying amount of information about events, and if I find one of them that I would like to go to, I try to attend it." (81 years old, returned driver's license, more lifestyle activities) "I think the most important thing is to be healthy and be able to act on your own." (78 years old, returned driver's license, more lifestyle activities)
4	Social participation through outings based on current and projected	Social participation Current and projected Opportunities to get out and about	"After returning my driver's license, I try to attend city events." (81 years old, returned driver's license, more lifestyle activities) "The government is doing a lot for me when I return my license." (89 years old, returned driver's license, more lifestyle activities)
5	Recognition of role in the community	Responsibility Perceived sense of danger Sense of belonging in the community	"When I reach my 80s, I generally plan to retire, and the people in their 70s below me will start to emerge, but now I'm taking on a handful of social roles." (78 years old, returned driver's license, fewer lifestyle activities)
6	Walking ability required for activities	Ability to walk Activity limitations	"If my legs stop working, I'm done. If my legs work, I don't have to ride a bike, it takes longer, but I can walk to get there just fine. There is a lot of fun to be had walking around, meeting people you know and standing around talking to them, starting with going inside a house and having a cup of tea." (78 years old, returned driver's license, fewer lifestyle activities)
7	Opportunities for activities	Places to engage in activities Activities of interest	"I started playing ground golf after I stopped driving." (91 years old, returned driver's license, more lifestyle activities)

government support is necessary to encourage those who have ceased driving to engage in various lifestyle activities. Social support may benefit older adults' cognitive function and physical activity (Kelly et al., 2017; Lindsay Smith et al., 2017). Community-based (salon-based) interventions are practiced worldwide in health promotion plans for older adults (Farrance et al., 2016). For example, salon participants were 6.3% less likely to require long-term care than nonparticipants over a 5-year follow-up period (Hikichi et al., 2015). Therefore, governments and communities should understand older adults' post–driving cessation needs, proactively approach them, and provide them with opportunities for participation in various lifestyle activities.

Moreover, the qualitative results revealed that both recognizing the role of the community and activity opportunities were important for engaging in various post–driving cessation lifestyle activities. A specific narrative included "Now I'm taking on a handful of social roles" and "I started playing ground golf after I stopped driving." Ground golf can be played on a smaller field than golf and is a popular activity among older people in Japan (Ebine et al., 2020). These findings indicate the importance of meaningful activity engagement that helps individuals recognize their roles. Social interaction and

enjoyment are the primary reasons for participating in physical activity across all ages (Allender et al., 2006). "Feeling I am still useful" and "Finding interest through interactions" were considered social activity–related values and pursued by older men in particular (Takashima et al., 2020). Moreover, community-dwelling older adults associated lower satisfaction with and performance in "meaningful activities" that reflect personal values with frailty (Akaida et al., 2023). These considerations suggest that health policies should promote meaningful activity engagement for individuals, so they can experience assuming a social role and enjoyment even after driving cessation. Accordingly, we emphasize the importance of creating an environment where older adults can engage in meaningful activities even after driving cessation and thus enjoy diverse lifestyle activities.

This study's limitations should be considered when interpreting the results. First, they must be interpreted based on local characteristics. Tarumizu city is a small rural area (September 1, 2023: population, 13,324; area, 162.12 square kilometers). Older adults' lifestyle activities may differ between rural and urban areas (Pelletier et al., 2021); rural areas have more barriers to accessing facilities for activity participation and less social support for active lifestyles (Pelletier et al., 2021). In fact, between 1990 and 2015, Japan's public transportation network decreased by 35% and 20% for public buses and local railroads, respectively (Ministry of Land, Infrastructure, Transport and Tourism, 2017). Thus, the results should be interpreted in light of their rural provenance. Second, the population sample's representativeness must be considered for both quantitative and qualitative strands. Participants were not randomly recruited from the community. Given that they participated in a venue-based health assessment survey, they likely had few mobility restrictions, as they could access transportation after driving cessation. Therefore, older adults with significant post–driving cessation mobility limitations may have been excluded. Third, quantitative analysis results require careful interpretation. Given the possible bidirectional relationship between walking speed and diverse lifestyle activity participations, slower walking speeds may hinder participation. As we conducted a cross-sectional study, the causal relationship between walking speed and various lifestyle activities remains unclear. Longitudinal studies could clarify these associations. Finally, the sample size of the qualitative participants in this study was limited to six, which is the minimum sample size required, but it may be insufficient (Fusch & Ness, 2015). However, a sample size of six in a qualitative study suggests the possibility of deriving meaningful themes and useful interpretations (Guest et al., 2006). Additionally, following the inductive research methodology (Gioia et al., 2013), all members of the analysis group (the first author, two co-authors, and the corresponding author) thoroughly discussed the data until they reached a consensus on the data interpretation and derived the category names. Despite the small sample size, the results of the study's qualitative portion suggest that they can be interpreted as a single finding (Guest et al., 2006). Furthermore, the qualitative strand results include men only. Sex differences exist in the characteristics of activities among older adults (Koh et al., 2014). Therefore, the results of this qualitative strand only apply to men.

Conclusions

Engagement in lifestyle activities after driving cessation may be associated with faster walking speed among CDMOAs. Furthermore, the study results indicated that an environment encouraging autonomous behavior and active community participation by using local and self-resources was important for engaging in various activities among MOAs after driving cessation. The study findings suggest that careful assessment of and support for lifestyle activities among MOAs before and after driving cessation may contribute to developing more effective strategies and preventing slow walking speeds after driving cessation.

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Ethical Statement

Ethical Approval

This study was approved by the Kagoshima University Ethics Committee for Epidemiological Research (epidemics 170351 and 220140).

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Supplemental Material

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Phase	Procedure	Product
Quantitative Data Collection	・ Survey by Tarumizu study 2019 or 2021 Cross-sectional analysis (n = 672)	・ Numeric data ・ Categorical variables
Quantitative Data Analysis	・ Data screening	・ Exclusion data
	・ Univariate Analysis of Variance chi-square test	・ Descriptive statistics（Table 1） P-value
	・ multivariate Analysis of covariance Bonferroni method	・ Descriptive statistics (Table 2) F-value, P-value, ηp^2 Post hoc results
	・ Analysis Software: IBM SPSS Statistics 29.0 (IBM Japan, Tokyo, Japan)	
Conncting Quantitative and Qualitative Phases	・ Participants in the quantitative strand who can be determine to have "less than two years from driving cessation" based on their responses in the Tarumizu study 2021 (n = 16)	・ Cases Six participants were included in the analysis
	・ Data screening	
	・ Developing Semi-structured interview guide	・ Developing Semi-structured interview guide（Supplementary Figure S2)
Qualitative Data Collection	・ Face-to-face interviews with 6 participants	・ Text data (Interview transcript) ・ Consent form for qualitative research ・ Information on characteristics of participants in qualitative strands (Table3)
Qualitative Data Analysis	・ Analysis(qualitative text-mining)	・ Co-occurrence network diagram (Figure 1) (Creation of 7 subgraphs)
	・ Qualitative inductive analysis	・ Create tables and categories showing results of inductive analysis (Table 4 and Supplementary Table S1)
	・ Analysis Software: KH coder 3.0	
Integration of the Quantitative and Qualiative Results	・ Interpertation and explanation of quantitative and qualitative results	・ Discussion
		・ Implications
		・ Limitations
		・ Future research

Supplementary Figure S1. Visual Model for Mixed-Methods Sequential Explanatory Design Procedures.

Interview Guide

Approaching (someone)	I would like to ask you about your lifestyle activities after driving cessation.
Question 1	What do you think is important to actively engage in various lifestyle activities after driving cessation?
Question 2	What can you tell us about what you can do for yourself to engage in various life activities after driving cessation, and what are your limitations?
Question 3	What kind of support do you seek from the government or government agencies to carry out various lifestyle activities after driving cessation, and what are the limitations of such support?

Supplementary Figure S2. Semi-structured interview guide.

Supplementary Table S1. Progress in qualitative inductive analyses derived from co-occurrence networks.

No.	Main Categories	No.	Sub-categories	No.	Code	Extracted words represented in the co-occurrence network	Subgraph number
1.	An environment that promotes autonomous behavior	1.1.	Engaging with Trusted Professionals	1.1.1.	Engaging with Professionals	Teacher	01
				1.1.2.	Appreciation for Expertise	University Professor	
				1.1.3.	Connecting with Professionals		
				1.1.4.	Presence of a trusted mentor		
		1.2.	People and Information	1.2.1.	The presence of a sympathizer	Story	
				1.2.2.	Presence of someone who listens		
				1.2.3.	Past experiences	Back in the day	
				1.2.4.	Historical environment		
				1.2.5.	Inspiration of spontaneity	Feelings	
		1.3.	A place to connect with others	1.3.1.	Contribution to others	Say	
				1.3.2.	Contribution to others		
				1.3.3.	Information from outside		
				1.3.4.	Unintended contact with information and people	Come	
				1.3.5.	Passive		
		1.4.	Familiar neighborhoods	1.4.1.	Accidental	Circular notice	
				1.4.2.	Sharing of information		
				1.4.3.	A place to gather	Community center	
				1.4.4.	Place to connect with society		
				1.4.5.	Social connections in the neighborhood	Neighborhood	
		1.5.	Autonomous action	1.5.1.	Informal relationships		
				1.5.2.	Relationships with others		
				1.5.3.	Presence of familiar land	Person	
				1.5.4.	Familiar neighborhood		
				1.5.5.	Understanding of the community		
2.	Daily routine with local resources	2.1.	Community resources	2.1.1.	Common assets of the community	Shrine	02
				2.1.2.	Past successes	Experience	
				2.1.3.	Diverse opportunities	Various (Adjective)	
		2.2.	Physical activity	2.2.1.	Demanding physical activity	Ascend	
				2.2.2.	Sense of responsibility	Rehabilitation	
		2.3.	Daily Routine	2.3.1.	Required Daily Routine		
				2.3.2.	Exercise Habits	Home	
				2.3.3.	Living location		
		2.4.	Success Experience	2.4.1.	Surroundings where exercise is possible	Stairs	
		2.5.	Diverse	2.5.1.	Active behavior/activity	Enter	

			Opportunities				
3.	Utilization of local resources with spontaneous actions	3.1.	Autonomous behavior	3.1.1.	Active and spontaneous behavior and activities	Myself	03
				3.1.2.	Autonomous attitude		
				3.1.3.	Creative activities		
				3.1.4.	Active and spontaneous behavior/activities	Make	
				3.1.5.	Autonomous attitude		
		3.2.	understanding of current situation	3.2.1.	Understanding/recognition of need	Recognition	
				3.2.2.	Understanding/recognition of the current situation		
				3.2.3.	Public environment	Government	
				3.2.4.	Public support		
		3.3.	public assistance	3.3.1	Awareness of the importance of health	Health	
				3.3.2.	Understanding of current situation	Important	
		3.4.	Human resources	3.4.1.	Decrease in community resources	Number of people	
				3.4.2.	Presence of peers		
				3.4.3.	Decrease in human resources		
		3.5.	Role in the community	3.5.1.	Social roles	Responsible person	
				3.5.2.	Existence of leaders		
				3.5.3.	Responsibilities in the community		
4.	Social participation through outings based on current and projected	4.1.	Social Participation	4.1.1.	Voluntary involvement behavior	Participation	04
				4.1.2.	Voluntary community involvement		
				4.1.3.	Opportunities to engage with the community	Event	
				4.1.4.	Public institutions	City	
				4.1.5.	Triggers for behavior change, recognition, understanding	License	
		4.2.	Current and projected	4.2.1.	Anticipation and preparation for the future	Return	
				4.2.2.	Diverse opportunities	Various (Adverb)	
				4.2.3.	Opportunities to go out with others	Go	
		4.3.	Opportunities to get out and about	4.3.1.	Opportunities to go out with close friends	Now	
				4.3.2.	Understanding of current situation		
5.	Recognition of role in the community	5.1.	Responsibility	5.1.1.	Sense of responsibility	Work hard	05
				5.1.2.	Years	Year	
		5.2.	Perceived sense of danger	5.2.1.	Self-awareness	Years	
				5.2.2.	Sense of belonging in the community	Society	
		5.3.	Sense of belonging in the community	5.3.1.	Responsibility in the community	Role	
				5.3.2.	Perceived sense of crisis	Quickly	
6.	Walking ability required for	6.1.	Ability to walk	6.1.1.	Recognition of importance of independent walking	Foot	06
				6.1.2.	Fear of limiting activities	Unable	

	activities	6.2.	Activity limitations	6.2.1.	Limited opportunities for social participation	No	
				6.2.2.	Ability to lead an active life	Walking	
7.	Opportunities for activities	7.1.	Places to engage in activities	7.1.1.	Presence of gathering places	Ground Golf	07
		7.2.	Activities of interest	7.2.1.	Existence of hobbies and activities	Start	
				7.2.2.	Existence of opportunities for exercise		
				7.2.3.	Existence of opportunities for challenge		

Supplementary Table S2. Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist
A checklist of items that should be included in reports of qualitative research

No	Item	Guide questions/description	Author Responses
Domain 1: Research team and reflexivity			
Personal Characteristics			
1	Interviewer/facilitator	Which author/s conducted the interview or focus group?	SA conducted interviews. Oversight was provided by HM. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
2	Credentials	What were the researcher's credentials? *E.g. PhD, MD*	SA: Msc HM: PhD MT: Msc DS: Msc YT: PhD YK: Msc RK: PhD TT: PhD TK: PhD MO: PhD See Title and Author List.
3	Occupation	What was their occupation at the time of the study?	SA was occupational therapist and project researcher. HM was physical therapist and professor. MT was project researcher. DS, YT was physical therapist and assistant professor. YK was physical therapist and project researcher. RK was physical therapist and associate professor. TT was physician. TK was physician and professor. MO was physician and professor. See Author List and Affiliations.
4	Gender	Was the researcher male or female?	SA, HM, DS, YT, YK, RK, TT, TK, MO are male. MT is female.
5	Experience and training	What experience or training did the researcher have?	SA is occupational therapist with prior clinical interviewing experience. MT is project researcher with prior qualitative interviewing experience. SA is trained by HM, who holds an PhD in sports science. HM, DS, YT, YK, RK, TT, TK, and MO are medical professionals with experience in clinical interviews. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
Relationship with participants			
6	Relationship established	Was a relationship established prior to study commencement?	No relationship was established prior to study commencement. See Methods, Qualitative Strand, Qualitative Participants.
7	Participant knowledge of the interviewer	What did the participants know about the researcher? e.*g. personal goals, reasons for doing the*	Participants were informed that SA is occupational therapist and interest in the topic. See Methods, Qualitative Strand Qualitative Participants.

		research	
8	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. *Bias, assumptions, reasons and interests in the research topic*	The interviewer was not involved in driving cessation. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
Domain 2: study design			
Theoretical framework			
9	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? *e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis*	The text mining method and the qualitative inductive analysis. See Methods, Qualitative Strand, Qualitative Data Analysis.
Participant selection			
10	Sampling	How were participants selected? *e.g. purposive, convenience, consecutive, snowball*	Purposive. See Methods, Qualitative Strand Qualitative Participants.
11	Method of approach	How were participants approached? e.*g. face-to-face, telephone, mail, email*	Mail. See Methods, Qualitative Strand Qualitative Participants.
12	Sample size	How many participants were in the study?	six. See Methods, Qualitative Strand Qualitative Participants.
13	Non-participation	How many people refused to participate or dropped out? Reasons?	Sixteen people were emailed about participating in the study, but 4 did not respond and 4 did not consent to participate in the study. One participant had a history of dementia at the time of the survey and was excluded from the analysis, and one participant withdrew consent after the survey. See Methods, Qualitative Strand Qualitative Participants.
Setting			
14	Setting of data collection	Where was the data collected? e.*g. home, clinic, workplace*	Qualitative data were collected at home or in a government facility based on the individual's wishes. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
15	Presence of non-participants	Was anyone else present besides the	No

		participants and researchers?	
16	Description of sample	What are the important characteristics of the sample? *e.g. demographic data, date*	demographic data. See Results; Table 3 and Supplementary Table S2.
Data collection			
17	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	An interview guide was developed by the SA, HM, MT. It was pilot tested with research team and modified for clarity. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
18	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording See Methods, Qualitative Strand, Qualitative Data Analysis.
20	Field notes	Were field notes made during and/or after the interview or focus group?	No
21	Duration	What was the duration of the interviews or focus group?	The average duration was designed to be approximately 30 minutes. See Methods, Qualitative Strand, Qualitative Study (Semi-structured Interviews).
22	Data saturation	Was data saturation discussed?	After 6 interviews. See Methods, Qualitative Strand, Qualitative Data Analysis.
23	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings			
Data analysis			
24	Number of data coders	How many data coders coded the data?	Four researchers coded the data. See Methods, Qualitative Strand, Qualitative Data Analysis.
25	Description of the coding tree	Did authors provide a description of the coding tree?	See Methods, Qualitative Strand, Qualitative Data Analysis.

26	Derivation of themes	Were themes identified in advance or derived from the data?	Themes were derived from the data. See Methods, Qualitative Strand, Qualitative Data Analysis.
27	Software	What software, if applicable, was used to manage the data?	KH coder (3.0) Microsoft Excel See Methods, Qualitative Strand, Qualitative Data Analysis.
28	Participant checking	Did participants provide feedback on the findings?	No
Reporting			
29	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.*g. participant number*	Quotations, identified by age, driving cessation situation, and lifestyle activities status, are provided in the results. See Results, table3 and table 4.
30	Data and findings consistent	Was there consistency between the data presented and the findings?	We held consensus discussions within the research team to ensure consistency between data presented and study findings. See Methods, Qualitative Strand, Qualitative Data Analysis.
31	Clarity of major themes	Were major themes clearly presented in the findings?	Themes presented are related to: 1. An environment that promotes autonomous behavior, 2. Daily routine with local resources, 3. Utilization of local resources with spontaneous actions, 4. Social participation through outings based on current and projected, 5. Recognition of role in the community, 6. Walking ability required for activities, 7. Opportunities for activities. See Results, table 4.
32	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	We included all important themes including majority themes and minority themes. See Results, Figure1 and table 4.

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International Journal for Quality in Health Care. 2007. Volume 19, Number 6: pp. 349 – 357

Supplementary Table S3. Characteristics of participants' lifestyle activities by driving status.

	All (n=672)	Driving (n=630)	Driving cessation (n=42)	P-value
Lifestyle activities				
Involvement in lifestyle activities, More lifestyle activities, n (%)	364 (54.2)	344 (54.6)	20 (47.6)	0.379[a]
Lifestyle activities, number; Median (IQR: Interquartile Range)	9.0 (7.0-10.0)	9.0 (7.0-10.0)	8.0 (6.0-10.0)	0.227[b]
Physical and daily activities, yes; n (%)				
Do you do light exercise or sports?	552 (82.1)	519 (82.4)	33 (78.6)	0.533[a]
Do you regularly exercise or sport?	381 (56.7)	364 (57.8)	17 (40.5)	0.028[a]
Do you go out by bus or train by yourself?	332 (49.4)	304 (48.3)	28 (66.7)	0.021[a]
How many days per week do you engage in activities where you touch soil?	574 (85.4)	536 (85.1)	38 (90.5)	0.337[a]
Cognitive activities, yes; n (%)				
How many days a week do you read newspapers?	537 (79.9)	504 (80.0)	33 (78.6)	0.823[a]
How many days a week do you read books?	337 (50.1)	323 (51.3)	14 (33.3)	0.024[a]
Do you enjoy art, films, or music?	494 (73.5)	466 (74.0)	28 (66.7)	0.299[a]
Do you watch educational/cultural programs?	501 (74.6)	471 (74.8)	30 (71.4)	0.631[a]
Social activities, yes; n (%)				
Do you sometimes visit your friends?	502 (74.7)	472 (74.9)	30 (71.4)	0.614[a]
Do you participate in regional festivals or events?	517 (76.9)	490 (77.8)	27 (64.3)	0.044[a]
Do you participate in a neighborhood association or a residents' association?	465 (69.2)	438 (69.5)	27 (64.3)	0.477[a]
Do you engage in charity or volunteer activities?	461 (68.6)	435 (69.0)	26 (61.9)	0.334[a]

a; chi-square test. b; Mann–Whitney U test.