The relationship of car driving and bicycle riding on physical activity and social participation in Japanese rural areas

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1. Introduction

Physical activity is closely associated with health (Chalé-Rush et al., 2010; Kyu et al., 2016; Landi et al., 2007; Sabia et al., 2017; Tsunoda et al., 2013). For example, a large sample study that included data on more than 130 thousand participants from 17 countries reported that higher physical activity was independently associated with lower risk of mortality and incidence of cardiovascular disease even after controlling some potential confounding factors (Lear et al., 2017). Social participation also brings health benefits. For instance, some longitudinal studies have confirmed that social participation reduces the risk of adverse health outcomes such as cognitive decline (Tomioka et al., 2016), incidence of functional disability (Kanamori et al., 2014), and all-cause mortality (Väänänen et al., 2009). These evidences imply that engaging in physical activity and social participation plays a key role in maintaining health in old age.

People are deemed as having a limited transport mobility when they cannot use some kind of transportation without help (Curvers et al., 2017; Peel et al., 2005). It is associated with restriction of daily living area, which in turn leads to a decrease in physical activity (Tsai et al., 2015) and social participation (Curvers et al., 2017). Although these findings suggest that transportation is directly/indirectly related to physical activity and social participation, these associations (i.e., transportation mode, and physical activity and social participation) are depended on research areas (Currie et al. 2009). This is because various factors that include the number of public facilities, accessibility to those facilities, and supplied transportation are different in research areas. Accumulation of findings that are obtained from various areas is needed and is useful when practitioners consider improving transportation system.

In japan, a major transportation mode for older adults is driving a car. This

feature is emphasized in rural areas because people living those areas feel poor convenience of public transport (The Japanese Cabinet Office, 2016; The Japanese Ministry of Land, Infrastructure and Transport, 2015). As a previous mail survey in urban area reported that 63% of Japanese older adults frequently ride a bicycle (Sakurai et al., 2015), a large number of them who use a bicycle is one of the characteristics of them. Therefore, this study focused on car driving and bicycling among Japanese older adults aged 65 or older living in rural area. Rural areas have a few recreational facilities compared to urban areas, which means rural areas have a relatively large area where those facilities are not around. The association of each transportation mode on physical activity and social participation under the conditions that were described above remain unclear. Specifically, this study aimed to examine the association of each transportation mode (car driving and bicycle riding) on physical activity and social participation in older adults. Car driving enables individuals to travel long distances and go to specific place for doing social activities, and bicycle riding involves physical activity; hence, our hypothesis was that while driving is associated with social participation, bicycling is correlated with a higher level of physical activity.

2. Methods

2.1 Study design and data collection

This cross-sectional study used data obtained from the 2017 Kasama Health Checkup for Longevity survey, a community-based cohort study (Okura et al., 2017). This survey has been conducted annually since 2009, on participants selected using the following eligibility criteria: 1) aged 65 years or older, 2) not using long-term care insurance, and 3) living in Kasama city (population: 75,794 (older adults were 30.0%),

population density: 315.3/km^2), Japan. Kasama city has 9.3% of building area, 63.0% of forest and farmland (Soma et al., 2017), and a few community centers (0.13 n/km^2), sports/recreational facilities (0.11 n/km^2), and parks (0.08 n/km^2) (Statistics of Kasama city, 2016). The cohort study includes some items to obtain basic information and to evaluate physical and cognitive functions, physical activity, and psychosocial factors such as depression mood, social network. A total of 1652 older adults (follow-up and new participants were 852 and 800, respectively) were called for participation in the survey, then 400 participants (follow-up and new participants were 299 and 101, respectively) took part in the 2017 survey. New participants aged 65 to 85 years were selected randomly from the Basic Resident Register. Participants were required to visit a local community center in where the survey was conducted. We excluded 26 participants who did not complete survey. Finally, the data of 374 participants (93.5%) were included in the analysis. This study was approved by the Ethics Committee of the University of Tsukuba (Ref No., Tai 26–31). The participants were explained the study concepts, and we obtained their written informed consent.

2.2 Transportation

To examine the transportation mode, we used a self-report questionnaire comprising the following questions: “How often do you usually drive a car per week?” and “How often do you usually ride a bicycle per week?” The present study defined “driving a car” as when participants drove a car at least once a week. As for bicycle riding, participants were categorized as bicyclists and non-bicyclists.

2.3 Outcome variables

The main outcome measures in this study were physical activity and social participation. To assess physical activity, the Japanese version of the Physical Activity Scale for the Elderly (PASE) was used (Hagiwara et al., 2008). The PASE includes 12 items, 5 on leisure time activity, 6 on household activity, and 1 on work-related activity, which provide scores for each physical activity domain based on contents, frequency, and activity duration in the past week. The leisure time activity score, household activity score, work-related activity score, and total score were used for the analysis.

Additionally, participants were asked about participation in the following social activity groups: sports group, hobby group, community association, and volunteer group. Considering culture, these groups were selected based on previous research conducted in Japan (Kanamori et al., 2014; Tomioka et al., 2017). A sports group includes organized groups for sports or exercise. A hobby group includes various activities such as flower arrangement, handcraft, and karaoke. A community association is a small group that consists of neighbors. Representative activities of a community association include safety patrol and cleaning activity in and around the living area. Volunteer group activities include, for example, visiting older adults living alone and providing support for individuals with disabilities. For each social activity, participants were labeled as "participation" if they reported participating at least once per month.

2.4 Covariates

According to previous studies (Ding et al., 2014; Kamada et al., 2009), the following covariates were selected for the analysis: age, sex, body mass index (BMI), years of education (< 12 or ≥ 12), living arrangement (alone or not), economic status (poor or normal/good), smoking status (current or past/never), and alcohol consumption

(drinker or non-drinker). Clinical history in terms of the number of diseases including stroke, hypertension, hyperlipidemia, diabetes, kidney disease, and heart disease (yes or no) was categorized as 0, 1, 2, and ≥ 3. For psychiatric factors, self-reported cognitive impairment (yes or no) and depressive mood were included. The 15-item Geriatric Depression Scale was used to assess depressive mood with a cut-off point of 5/6 (Sheikh and Yesavage, 1986).

2.5 Statistical analysis

Mean and standard deviation were calculated for all demographic data. Two kinds of groupings, namely, drivers/non-drivers and bicyclists/non-bicyclists, were used in this study. An analysis of covariance (ANCOVA) was performed to compare each PASE score in each grouping. All ANCOVA analyses were adjusted for age, sex, BMI, years of education, living arrangements, economic status, smoking status, alcohol consumption, comorbidities, self-reported cognitive impairment, and depressive mood. The other transportation mode was also added as a covariate. Specifically, bicycle riding was entered when the ANCOVA was used for drivers vs. non-drivers, and vice versa.

A multivariate Poisson regression analysis was used to examine the association between car driving, bicycle riding, and social participation. We calculated prevalence ratio (PR) and 95% confidence interval (CI). The following three models were adopted: a crude model; Model 1 with age, sex, BMI, years of education, living arrangements, economic status, smoking status, alcohol consumption, and comorbidities added as covariates; and Model 2, the full adjusted model that included covariates from Model 1 plus psychiatric factors (i.e., self-reported cognitive impairment and depressive mood).

A supplementary analysis was performed to examine the interaction between car

driving and bicycle riding. A two-way ANCOVA was used for each PASE score, and a model including the interaction term tested the impact on social participation.

Significance level was set at 0.05 for all analyses, and they were computed using SPSS version 25.0.

3. Results

Table 1 presents the descriptive data of the participants. The mean age was 74.4 ± 5.3 years, and the sample comprised 216 women (57.8%). Further, 301 (80.5%) were drivers, while 106 were bicyclists (28.3%). The number of participants who drove a car as well as rode a bicycle was 66 (17.6%). The total PASE score was 122.3 ± 51.4, and the highest score among the subscales was for household activity. More than half of the participants (n = 195; 52.1%) joined a sports group. Participation in a hobby group, community association, and volunteer activity was reported by 145 (38.8%), 65 (17.4%), and 80 (21.4%) participants, respectively.

There were no significant differences between drivers and non-drivers in terms of each PASE score (Table 2). Bicyclists were significantly more likely to have high leisure time activity ($p = .009$), household activity ($p = .001$), and total ($p < .001$) scores as compared to non-bicyclists, but the two groups did not differ significantly with reference to the work-related activity score (Table 3). A two-way ANCOVA showed that there was no significant effect of the interaction term car driving × bicycle riding on each PASE score.

The results of the multivariate Poisson regression analysis have been presented in Table 4. Bicyclists showed a higher PR for participation in a community association and volunteer activity in all three models ($p < 0.05$). In Model 2, the full adjusted model,

drivers were observed to be significantly more likely to participate in a sports group (PR = 1.31, 95% CI: 1.00–1.72) and a hobby group (PR = 1.50, 95% CI: 1.03–2.19). Further, there was a significant association between bicycle riding and participation in a community association (PR = 1.75, 95% CI: 1.11–2.77) and a volunteer group (PR = 1.62, 95% CI: 1.08–2.43). The interaction term car driving × bicycle riding did not show any significant association with any form of social participation.

4. Discussion

To examine the association of transportation, former studies used a rough categorization based on whether people used a motor vehicle, including a car, motorbike, and taxi, or not (Shaw et al., 2017), or they classified individuals as those with or without a limited transport mobility (Curvers et al., 2017; Peel et al., 2005). Instead of these categorizations, the present study focused on the individual association of car driving and bicycle riding on physical activity and social participation. Our results revealed that while car driving was not associated with physical activity, riding a bicycle was associated positively. Additionally, this study showed that car driving and bicycle riding had different association on social participation; that is, car driving promoted participation in sports and hobby groups that are based in specific place which there would not be neighborhood, and bicycle riding promoted participation in community associations and volunteer groups that are mainly done in neighborhood.

A previous study suggested that there was no significant difference between drivers and non-drivers in objectively measured moderate to vigorous physical activity and total physical activity (Ding et al., 2014). Our results supported this finding and additionally suggested that there were no significant differences in the effect of type of

physical activity. As our hypothesis predicted, as compared to non-bicyclists, bicyclists showed higher scores on each dimension of the PASE, except for work-related activity. It has been reported that older adults can derive health benefits from bicycling (Woodcock et al., 2014), and bicycle riding is associated with maintenance of instrumental activities of daily living and higher levels of physical activity (Sakurai et al., 2016; Tsunoda et al., 2015). As observed in these previous studies, the present results showed the positive association of bicycling on physical activity. However, although the present study analyzed each domain of physical activity, it cannot address the mechanism through which bicycling contributes to an increase in leisure time activity and household activity. Although life-space areas are associated with objectively measured physical activity (Tsai et al., 2015), Barnes and colleagues (2007) reported that going out of one's neighborhood is not associated with increase in physical activity measured by self-reported questionnaire. This study that used a self-reported questionnaire to evaluate physical activity supported the findings of Barnes and colleagues, and one possibility is that older adults engage in physical activity within neighborhood areas, which they can travel to by riding a bicycle.

The World Health Organization (2002) has proposed that social participation is one of the components of active life, which is essential for achieving successful aging (Rowe and Kahn, 1997). A study conducted in the Netherlands found that individuals aged 55 years or over, who can use transportation without help, were 2.08 times more likely to participate in social activity as compared with those who needed help with the same (Curvers et al., 2017). Car driving is representative of such transportation modes, and is positively associated with social participation (Pristavec, 2016). There is no doubt that car driving contributes to participation in social activity, but the degree of its effect

193 would differ based on the type of social activity. In fact, in the present study, car driving
194 was associated only with participation in sports and hobby groups. The research field for
195 this study was a rural area with few locations for such group activities. Further, people in
196 rural areas are forced to depend on car driving to travel to specific locations (Johnson,
197 1998). Our results, therefore, are interpreted as a feature of rural areas. Carpool system
198 for non-drivers living these areas may need to promote participation in sports and hobby
199 groups because using a car as a passenger is preferred (Davey, 2007; Kostyniuk and Shope,
200 2003). Bicycle riding is incorporated into daily life (Woodcock et al., 2014) and is a
201 common transportation mode among Japanese older adults (Sakurai et al., 2015).
202 Although little was known about the association between bicycle riding and social
203 participation, the present study showed that bicycle riding was positively associated with
204 participation in community associations and volunteer groups even after adjusting for
205 confounding factors. Older adults often engage in social group activities around their
206 place of residence, which suggests that such places would be within bicyclists' reachable
207 range. Therefore, it is possible that some older adults rode a bicycle to participate in these
208 social group activities.

209 In Japan, approximately 69.9% and 30.3% of the older adults aged 65 to 74 years
210 and those aged 75 years or over have a driver's license, respectively (The Japanese
211 National Police Agency, 2017). Additionally, 63% of the Japanese older adults living in
212 urban areas regularly ride a bicycle (Sakurai et al., 2015). The present study's participants
213 were more likely to drive a car (80.5%) and were less likely to ride a bicycle (28.3%).
214 Transportation in rural areas is characterized by poor accessibility to public transport, and
215 most people living in such areas drive a car (Johnson, 1998). Generally, older men tend
216 to keep a driving license. The trend was found in this study (men: 91.8%, women: 72.2%)

and may be associated with some results in our study albeit adjusted for sex. Built-environments and social factors are associated with our results. It found that research field for this study was small building area and 84.0% of the participants had normal/good economic status. However, environment factors such as cycling infrastructure and traffic safety were not examined in this study. Some environment factors are determinant for selection of transportation mode. Therefore, our results can be generalized to rural areas, especially where most older adults drive a car. There is a high probability that different results could be obtained from other areas that have large building area with large numbers of community centers and recreational facilities.

There are some limitations in this study. First, this cross-sectional study is assumed to include participants who used to drive a car and ride a bicycle, and it reveals significant associations at a specific point in time. Future research is needed to investigate the impact of cessation of car driving and bicycle riding on physical activity and social participation. Further, some older adults receive support for transportation from their family or friends (Arcury et al., 2005) and use public transport. However, this study could not examine the use of any other transportation mode. Additionally, though the number of drivers who rarely usually use own car only (Kostyniuk and Shope, 2003) was relatively large in the present study, our results may be affected by another transportation mode. This study includes sampling bias because our survey requested participants to visit the place in where research was conducted. This means that people who are health conscious are more likely to participate in our survey. As a matter of fact, participants of this study showed slightly higher PASE score and participation rate of social activity compared to previous studies (Kanamori et al., 2014; Hagiwara et al., 2008). A final limitation is the possibility of misunderstanding the meaning of community associations.

This term is ambiguous (Kanamori et al., 2014) because there is some overlap between it and the activities of a volunteer group. In fact, participation in these activities showed similar trends in this study. Therefore, clearer definitions of each social activity need to be included to address this limitation in future studies.

5. Conclusions

This study focused on the use of specific transportation modes, driving a car and riding a bicycle, in Japanese older adults living in a rural area. Most of our participants drove a car and approximately one-fourth of them rode a bicycle. It was found that car driving and bicycle riding have different association on physical activity and social participation. Future research needs to examine the longitudinal effects of each transportation mode on health behavior and negative event such as incidence of functional disability and mortality. Based on the current and previous results (Johnson, 1998; Sahlqvist et al., 2013; Shaw et al., 2017), although older adults living in rural areas mainly drive a car for transportation, it is important and practical to promote active modes of transport such as walking and bicycling to increase physical activity and social participation among the elderly. Additionally, driving a car and promoting carpool system are important to go to just specific location for doing sports and hobby activities.

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Table 1. Participants' characteristics (n = 374)

		Mean ± SD
Age	(years)	74.4 ± 5.3
Women	n (%)	216 (57.8)
Body mass index	(kg/m^2)	22.9 ± 3.0
Years of education	n (%)	
<12		95 (25.4)
12≤		279 (74.6)
Geriatric depression scale	n (%)	
<6		290 (77.5)
6≤		84 (22.5)
Self-reported cognitive impairment	n (%)	
Yes		127 (34.0)
No		247 (66.0)
The number of comorbidities	n (%)	
0		138 (36.9)
1		144 (38.5)
2		71 (19.0)
3≤		21 (5.6)
Living arrangements (living alone)	n (%)	45 (12.0)
Economic status (poor)	n (%)	60 (16.0)
Smoking status (current/past)	n (%)	132 (35.3)
Alcohol consumption (drinker)	n (%)	144 (38.5)
Driver	n (%)	304 (81.3)
Driving frequency	(d/w)	5.6 ± 1.9
Bicyclist	n (%)	106 (28.3)
Bicycling frequency†	(d/w)	3.8 ± 2.2
Time of bicycle riding†	(m/d)	26.1 ± 30.8
Physical Activity Scale for the Elderly		
Leisure time activity score	(point)	25.1 ± 23.4
Household activity score	(point)	85.2 ± 32.2
Work-related activity score	(point)	12.1 ± 30.4
Total score	(point)	122.3 ± 51.4
Type and number of social participation	n (%)	
Sports group		195 (52.1)
Hobby group		145 (38.8)
Community association		65 (17.4)
Volunteer group		80 (21.4)

SD: standard deviation

†: n = 106

Table 2. Comparison of PASE score by car driving

		Drivers (n = 301)		Non-drivers (n = 73)		p value for ANCOVA
		Mean	SE	Mean	SE	
Leisure time activity score	(point)	24.5	± 1.4	27.6	± 3.1	.381
Household activity score	(point)	85.9	± 1.9	82.2	± 4.2	.451
Work-related activity score	(point)	11.4	± 1.8	15.1	± 4.1	.432
Total score	(point)	121.7	± 3.0	124.9	± 6.7	.684

Mean, standard error (SE) and p value were adjusted for age, sex, BMI, years of education, living arrangements, economic status, smoking status, alcohol consumption, comorbidities, self-reported cognitive impairment, depressive mood, and bicycle riding.

Table 3. Comparison of PASE score by bicycle riding

		Bicyclists (n = 106)		Non-bicyclists (n = 268)		p value for ANCOVA
		Mean	SE	Mean	SE	
Leisure time activity score	(point)	30.3	± 2.3	23.0	± 1.4	.009
Household activity score	(point)	94.0	± 3.2	81.7	± 1.9	.001
Work-related activity score	(point)	13.9	± 3.1	11.4	± 1.9	.505
Total score	(point)	138.1	± 5.0	116.1	± 3.1	< .001

Mean, standard error (SE) and p value were adjusted for age, sex, BMI, years of education, living arrangements, economic status, smoking status, alcohol consumption, comorbidities, self-reported cognitive impairment, depressive mood, and car driving.

Table 4. Adjusted prevalence ratios (95% confidence interval) for social participation

	Crude		Model 1		Model 2	
	PR	95% CI	PR	95% CI	PR	95% CI
Sports group						
Drivers	1.07	(0.83–1.38)	1.31	(1.00–1.71)	1.31*	(1.00–1.72)
Non-drivers	1.00		1.00		1.00	
Bicyclists	1.10	(0.89–1.35)	1.16	(0.94–1.43)	1.15	(0.94–1.42)
Non-bicyclists	1.00		1.00		1.00	
Hobby group						
Drivers	1.22	(0.86–1.75)	1.53*	(1.05–2.23)	1.50*	(1.03–2.19)
Non-drivers	1.00		1.00		1.00	
Bicyclists	1.03	(0.78–1.36)	1.09	(0.83–1.44)	1.09	(0.83–1.43)
Non-bicyclists	1.00		1.00		1.00	
Community association						
Drivers	0.97	(0.56–1.68)	1.13	(0.60–2.12)	1.14	(0.61–2.14)
Non-drivers	1.00		1.00		1.00	
Bicyclists	1.69*	(1.08–2.62)	1.74*	(1.10–2.73)	1.75*	(1.11–2.77)
Non-bicyclists	1.00		1.00		1.00	
Volunteer group						
Drivers	1.25	(0.73–2.14)	1.50	(0.83–2.72)	1.50	(0.83–2.72)
Non-drivers	1.00		1.00		1.00	
Bicyclists	1.52*	(1.02–2.25)	1.62*	(1.08–2.44)	1.62*	(1.08–2.43)
Non-bicyclists	1.00		1.00		1.00	

* $p < 0.05$, PR: prevalence ratio, CI: confidence interval
Model 1 is adjusted for age, sex, BMI, years of education, living arrangements, economic status, smoking status, alcohol consumption, and comorbidities.
Model 2 is adjusted for the covariates in Model 1 plus self-reported cognitive impairment, and depression mood.