IMPACT ANALYSIS OF REDUCED FARE PROGRAMME FOR OLDER PEOPLE ON STEP COUNTS PER DAY AND TRAVEL BEHAVIOUR

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ABSTRACT
This study verifies the impact of the reduced fare programme for senior citizens on the step count per day, visited places and the modal share of public transportation. We targeted citizens over 65 years in Toyama City, Japan. The city operates a Special Pass Project, which allows passholders to receive a public transportation discount fare to the city centre from any station or stop in the city. We selected participants randomly and collected global positioning system log data and step counts for one month. Participants were instructed to wear the provided instruments, which we configured in advance. We analysed and compared the results between passholders and non-passholders. Passholders walked more than non-passholders. In addition, passholders visited more places in the city centre. Moreover, the modal share of public transportation between the city centre and home was higher for passholders than for non-passholders. These results confirm that the reduced fare programme supports active lifestyles for senior citizens.
Keywords: older people, reduced fare programme, step counts per day, travel behaviour.

1 INTRODUCTION

It is anticipated that societies of most developed countries will age rapidly in the near future, and Japan is no exception. Governmental healthcare expenditures have been steadily increasing in Japan. Consequently, enhancing older citizens' health is a major challenge to realize a sustainable national public healthcare and nursing system.

Possible political measures to improve the health of older citizens include encouraging them to go out more frequently and to walk more as these may address issues related to physical inactivity. Creating opportunities to leave the house should improve older citizen's motivation to remain active and facilitate participation in social activities. In addition, promotion of travel by foot may contribute to decreased risk factors for a low degree of independence and physical weakness. In a previous study, Aoyagi & Shephard [1] reported that individuals with a '>4,000 steps/day and/or >5 min/day of exercise with intermediate-level intensity' tend to be psychologically healthy. Meanwhile, those who with an '>8,000 steps/day and/or >20 min/day of exercise with intermediate-level intensity' tend to be physically healthy.

Considering such a background, public transportation reduced fare programmes intended for older citizens have been implemented in many Japanese cities. These programmes are expected to encourage activity and increase step counts of older citizens. Such measures are also likely to contribute to the formation of cities that centre on public transportation through the development of public transportation networks and towns connected by these networks. However, the efficacy of such measures has not been fully studied because previous studies did not collect data on step counts or detailed activities throughout the target area.

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This study emphasizes the 'Special Pass Project', which is conducted in Toyama City, Toyama Prefecture, Japan, to revitalize the city centre. Toyama City promotes its Compact City Development through encouraging the utilization of public transportation. In our study, smartphones and smart watches with a dedicated application installed in advance were provided to all subjects. These devices collected the subjects' location data and step counts for one month. The collected data were analysed to identify the impacts of reduced fare programmes on older citizens' daily activities (step counts and visited places) and preferred mode of transportation.

2 REFERENCE REVIEW

Previous Japanese studies have analysed the impacts of reduced fare programmes for older citizens on the places they visited. Ando et al. [2] conducted a questionnaire survey in a suburban area of Akita city, a local city located in the Akita Prefecture, to elucidate the effect of the reduced bus fare programme on the citizens' activities and changes in their quality of life. Minami et al. [3] conducted a questionnaire survey that targeted citizens who lived in suburban areas of a major city and identified differences between subjects who had purchased a train pass and those who had not on the frequency of going out, visited places and frequency of using public transportation. These previous studies assessed the efficacy of political measures subjectively using questionnaires that inquired about the subjects' frequency of going out, visiting places and using public transportation usage. However, a study that analyses the relationship between transportation's fare reduction and citizens' step count has yet to be implemented. In addition, the questionnaires used in these previous studies did not identify the subjects' detailed activities such as the distribution of the visited places or transportation mode measures over a certain time period (e.g. one month).

Some previous studies analysed the relationships among travel behaviour, step count and living functions of older people. Voss et al. [4] used a global positioning system (GPS) and accelerometers to identify the relationships between the usage of public transportation and the level of physical activity. Travel using public transportation was more highly associated with a higher physical activity compared to travel by non-public transportation. In this study, the subjects were older citizens in central Vancouver, Canada.

Yanagihara & Hattori [5] observed the step counts of older people for one month. They sorted out the collected data by the frequency of going out and transportation mode. Then they compared each group.

Tanimoto [6] implemented a questionnaire survey involving older citizens living in a local Japanese city to analyse the influence of going out on the changes in physical function over a year. These studies demonstrate that the relationship between transportation mode and physical activity of older people has been actively investigated.

Some studies have employed location data collected via a GPS system. Examples include a study analysing the travel behaviour in the central area of Kumamoto City, Kumamoto Prefecture, Japan [7], and one examining people's preferred escape routes from a natural disaster [8]. Of these studies, only Voss et al. [4] analysed the behaviour of older citizens.

The unique points of this study are:

- A large number of subjects (1,268 older citizens from all areas of Toyama City), a long survey duration (one month) and use of quantifiable GPS log data and step count data
- Analysis of the impacts of the public transportation fare discount programme for older citizens using actual data with a focus on step counts, visited places and selected transportation modes

3 METHODS

3.1 Target area and project

Toyama City has implemented the Special Pass Project, which allows citizens 65 years of age and older to ride public transportations between any station or stop in the city and the city centre at a discounted fare (100 yen per ride) from 9 am to 5 pm. For example, passholders can use bus at only 100 yen between city centre and Inotani, south area of the city, in spite of the regular fare is 1,160 yen. This project is part of efforts to revitalize the city centre. Users must be registered and obtain the Special Pass card by paying a registration fee of 1,000 yen. The Special Pass is valid until the end of the relevant fiscal year. As of our survey, 22,261 people owned this Pass, which is approximately one-fifth of all older citizens living in the city.

3.2 Investigation

3.2.1 Survey

Candidate subjects were extracted randomly from older citizens (65 years or older) residing in Toyama City. We aimed at achieving a balance between resident area, gender and passholder status. Candidates who agreed to participate were provided with devices for data collection (as discussed later). The subjects were asked to recharge the device(s) while sleeping and to carry his/her devices as much as possible while awake. After the survey period ended, the devices were recovered. The survey duration was from Saturday, 1 October 2016, to Monday, 31 October 2016. A total of 1,268 subjects returned their devices.

3.2.2 Instruments

Survey subjects were provided with both a smartphone (hereinafter referred to as 'Phone') and a smart watch (hereinafter referred to as 'SW') or only an SW. Prior to distributing to subjects, a dedicated application was installed on each device. The Phone was the Blade L3 g01 manufactured by ZTE with an Android 5.0 operating system. The SW was the SmartWatch 3 SWR50 manufactured by Sony and an Android 5.0 operating system. As shown in Fig. 1, SW was placed in a dedicated case with a neck strap.

3.2.3 Data collection

- GPS log data
  Each participant's location data was collected using a GPS system. Data was collected every 5 min when subjects were not walking (e.g. staying home and riding a train, car or bus), and every 10 s when they were walking.
- Step counts
  The total step counts of day were collected at the beginning of every hour. In addition, the step counts were also collected as part of the GPS log data.

3.3 Samples

In some cases, GPS log data was improperly collected. Such cases included when a participant forgot to switch on the device(s), the battery was drained, etc. Thus, 'effective days' were determined based on the number of collected data (step counts and GPS log).

Figure 1: SW device used in this survey.

Figure 2 shows the number of samples grouped by the number of effective days (units are 'person' and 'person-day'). A total of 308 participants had 0 effective days. This may have been due to frequent device failures or technical difficulties, which prevented participants from operating their devices during the survey period.

This study analysed only subjects with seven or more effective days. Hence, the analysis included data from 830 subjects (65.4% of the total of 1,268 participants), 14,881person-days (37.9% of the total of 1,268 × 31 person-days). The total number of GPS log data collected from the analysed subjects during the study was 3,194,860.

Table 1 shows the attributes of the analysed subjects. The subjects were divided into two groups: those with Special Passes (passholders) and those without (non-passholders). There

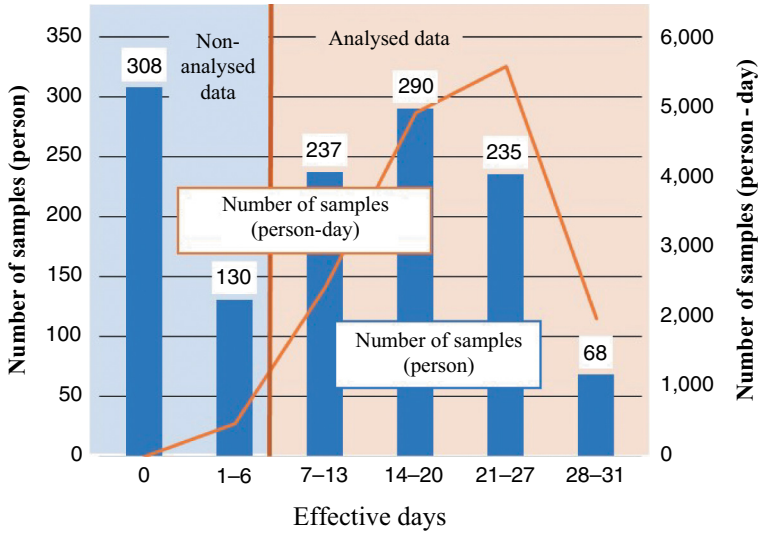

Figure 2: Number of samples by the number of effective days.

Table 1: Subject attributes to be analysed.

		Passholder		Non-passholder	
Number of samples		494		336	
Provided devices	Phone + SW	231	(46.8%)	166	(49.4%)
	Only SW	263	(53.2%)	170	(50.6%)
Gender	Male	336	(68.0%)	236	(70.2%)
	Female	158	(32.0%)	100	(29.8%)
Age	65–69	107	(21.7%)	120	(35.7%)
	70–74	121	(24.5%)	112	(33.3%)
	75–79	141	(28.5%)	55	(16.4%)
	80–84	95	(19.2%)	30	(8.9%)
	85–	30	(6.1%)	19	(5.7%)

were 494 passholders and 336 non-passholders. The device distribution ratio (Phone and SW vs SW only) was the same for both groups. Additionally, both groups were 70% men.

3.4 GPS data processing

The GPS log data was processed to determine the places that subjects visited and the transportation modes used. This study analysed only data with an accuracy level of the confidence interval of 68% for a diameter of 50 m or less. Initially, whether or not the subject was at home was determined. If the subject was away from home, then whether the subject was ambulatory or stationary was determined by referring to Kamada et al. [9]. Finally, if the subject was moving, the mode of transportation was classified as tram, bus, walk or other (car, motorcycle or bicycle) by referring to Matsunaka et al. [10].

The visited places were also determined by using the mean latitude and longitude of serial points where a subject showed a stationary state. Then the number of identified visited places per effective day was summed.

4 RESULTS

4.1 Comparison of the average step count per day between passholders and non-passholders

We compared the step counts per day between passholders and non-passholders. Figure 3 shows the proportion to the whole that belong each group stratified by the average step counts per day in 2,000 step increments.

The band below 2,000 steps had the most subjects in the non-passholder group. The number of subjects decreased as the band's number of step count increased for non-passholders. On the other hand, the band with 2,000–4,000 steps had the most subjects and the band with over 8,000 steps had more subjects than the band with 6,000–8,000 steps for the passholder group. These results suggest that older citizens in the passholders group take more steps than the non-passholder group.

Furthermore, the percentage of subjects with an average step count per day of over 8,000, which is reported to have association with good physical health [1], was compared between

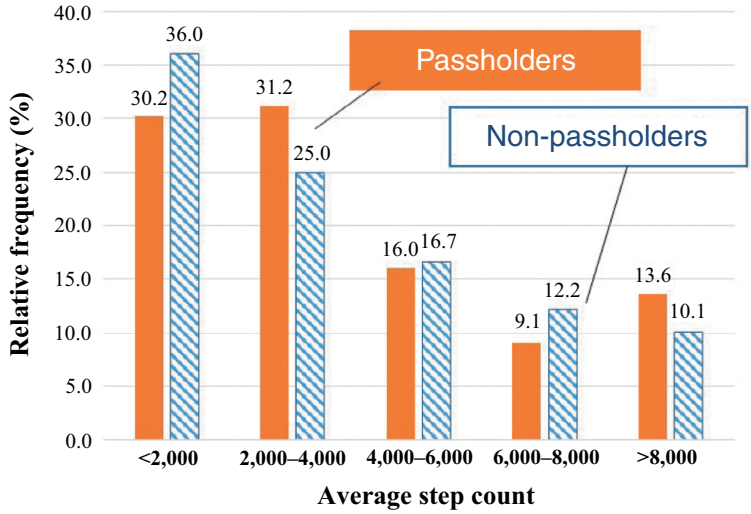

Figure 3: Comparison of the average step counts per day between passholders and non-passholders.

Table 2: Comparison of the percentage of subjects with an average step count per day of over 8,000 between passholders and non-passholders.

Percentage os subjects with 8,000 or more steps	Passholders	13.6%
	Non-passholders	10.1%
Population proportion test	*p*-value	0.065

the two groups using a population proportion test. The passholder group had a larger percentage of subjects with 8,000 or more steps at the 10% significance level; the one-sided *p*-value was 0.065 as shown in Table 2. These results suggest that ownership of the Special Pass provides older citizens more opportunities to participate in activities requiring more step count.

4.2 Comparison of visited places between passholders and non-passholders

Next, we compared the visited places of passholders and non-passholders. The number of visited places per day when a subject went out was 1.41 for passholders and 1.46 for non-passholders. Figures 4 and 5 show the number of visited places per 100 persons per 31 days, which is represented by a 250 × 250 m mesh, for passholders and non-passholders, respectively. In Fig. 5 (non-passholders), meshes with many visited places are observed only in areas around shopping avenues or major stations. However, in Fig. 4 (passholders), meshes with many visited places exist throughout the areas inside the Tram Loop Line. These results show that passholders visit many places in the city centre.

When comparing the facility type, meshes with many visited places tended to have commercial facilities, which are denoted as sky blue points in Figs 4 and 5. However, the number of places visited contained in the meshes in city centre where any public facility (shown as a yellow-green point) exists tended to be larger in Fig. 4 (passholders) than in Fig. 5

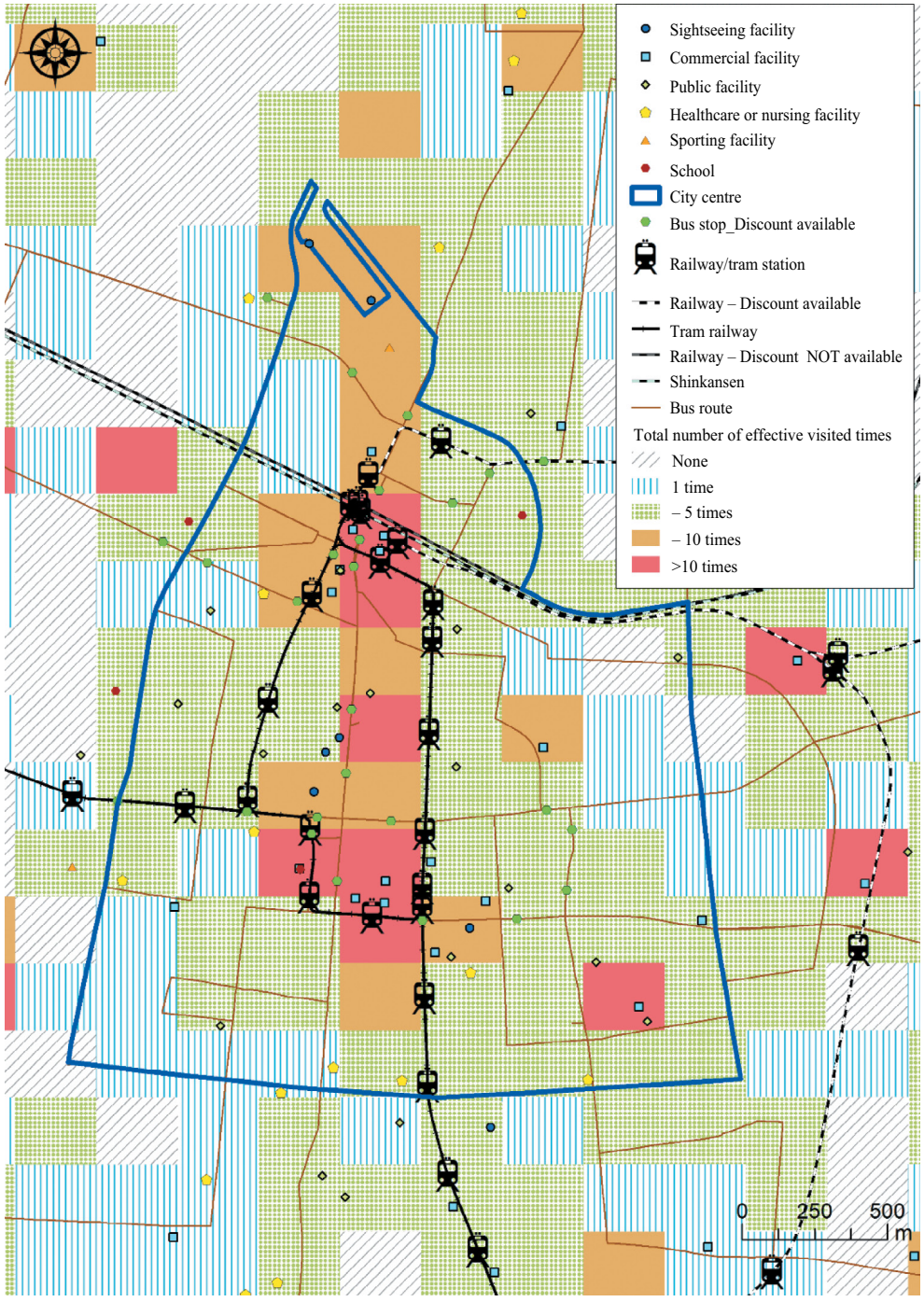

Figure 4: Visited places of passholders (per 100 persons per 31 days).

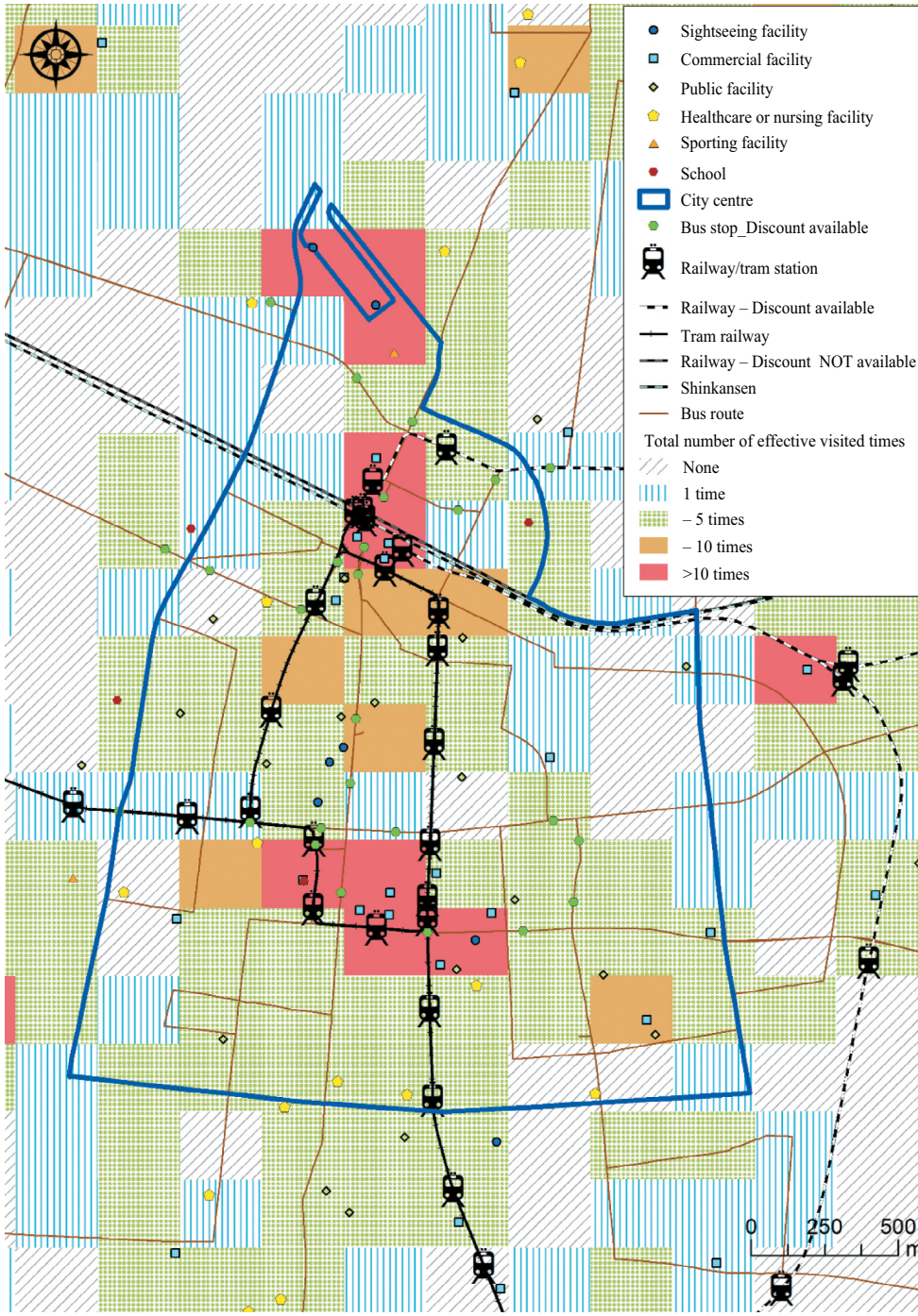

Figure 5: Visited places of non-passholders (per 100 persons per 31 days).

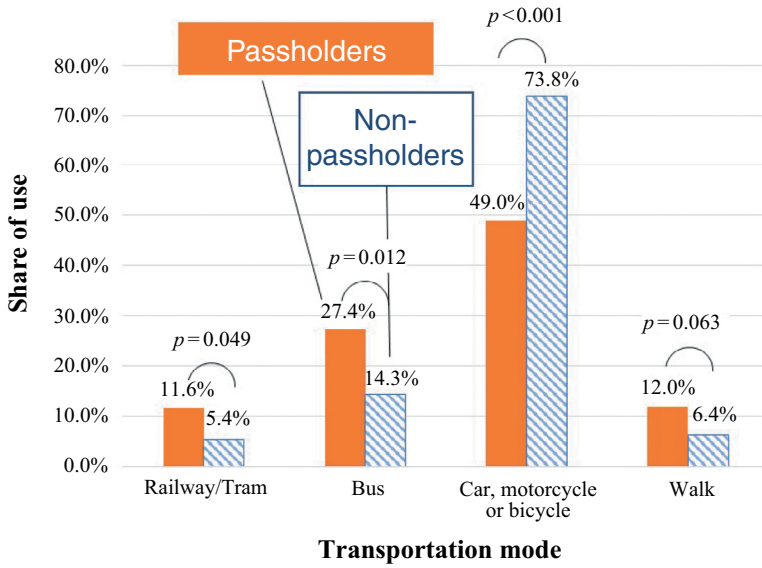

Figure 6: Modal share of public transportation for travel between home and the city centre.

(non-passholders). These results suggest that passholders tend to visit more places in the city centre compared to non-passholders, especially for places along the Tram Loop Line.

4.3 Comparison of the share of public transportation between passholders and non-passholders

In this analysis of the modal share of public transportation in travels between subjects' home and the city centre, subjects were limited to older citizens whose homes were 400 m or more away from the outer edge of the city centre. The analysis involved 118 passholders and 60 non-passholders. We calculated the share of transportation use between home and city centre for each person and compared the average value between passholders and non-passholders by using Welch's *t* test. Figure 6 shows the percentage of the transportation mode between their home and the city centre of passholders and non-passholders. Passholders used public transportation more than non-passholders. Railway/tram and bus usage was higher for passholders compared to non-passholders with a significance level of 5% and the percentage of walk was higher with a significance level of 10%. Moreover, car, motorcycle or bicycle usage was higher for non-passholders with a significance level of 1%.

5 CONCLUSION

This study examined the relationships between the reduced fare programme for older peoples and their step counts per day and visited places using location information and step count data collected over a month period with an emphasis on the Special Pass Project, which is part of Toyama City's efforts to revitalize the city centre.

Initially, we compared the average step counts per day. The percentage of subjects with an average of 8,000 steps per day or more for passholders (13.6%) is larger than that for non-passholders (10.1%). This difference is statistically significant.

Subsequently, we compared the visited places between passholders and non-passholders. It has been suggested that older citizens tend to visit places near commercial facilities. Passholders tend to visit more places in the city centre compared to non-passholders, especially areas along the Tram Loop Line. Furthermore, the modal share of public transportation between home and the city centre is higher for passholders.

These results reveal the following two insights. The percentage of older citizens with an average of 8,000 step counts or more is significantly higher in subjects who participated in the reduced fare programme. GPS log data that recorded subjects' actual activities during the one-month survey period suggest that subjects participating in the reduced fare programme visit more places in the city centre and use more public transportation than subjects who do not participate. Hence, strategic measures that allow older citizens to receive discounted public transportation fares contribute to active living of older citizens.

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