REPRODUCIBILITY OF GROUP EVACUATION BEHAVIOR OF THE ELDERLY BY SUBJECTS WEARING ELDERLY SIMULATOR

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ABSTRACT

Because a rapid aging of society is being realized, evacuation planning that considers the inclusion of aged people is becoming very important. For the introduction of the design guide for evacuation from barrier-free buildings, experiments have been widely conducted using an ordinary person wearing an "elderly simulator", which is called "Instant Senior", mostly for safety reasons. However, the reproducibility of the evacuation behavior of elderly people has not yet been established, therefore the behavior of groups with ordinary people along with Instant Seniors are compared with those of ordinary people with Actual Seniors in order to study the suitability of using Instant Seniors instead of Actual Seniors. From the results, we concluded that Instant Seniors are appropriate as subjects for modeling the walking behavior of a group evacuation, from the point that they become obstacles to ordinary people as Actual Seniors actually do. Attention to the method of using Instant Seniors to improve reproducibility is also discussed.

KEYWORDS: Fire safety, Group evacuation, Instant Senior, Elderly, Walking behavior

INTRODUCTION

In buildings that are used by the general public, elderly people and normal people may occupy them together while escaping during an emergency. The presence of elderly people interferes with escape effort actions of both normal people and elderly people. This is a problem that we should examine immediately because of the rapid aging of society is realized and it is known that many elderly people get out into the world because barrier-free is progressing. The best way to substantially grasp group-walking behavior that includes both normal people and elderly people is through experiments with actual senior citizens as subjects. While elderly people with deteriorating physical strength have a deep impact on group evacuation, there is fear that actual elderly people lack physical strength, which causes accidents during experiments. Therefore, this study examines the possibility and propriety of an experiment using normal people subjects. They are attached with a senior citizen simulated experience tool (they are referred to as "Instant Seniors") as a means to model the walking behavior of a mixed group of elderly and normal people. Because there are presently few examples of escape experiments of groups, which include both elderly and normal people, this was undertaken due to the following reasons:

① There is little danger of an accident using Instant Seniors as subjects during experiments compared with using actual senior citizens.
② It is easy to explain about experiments and to receive comments about experiments from the subjects.
③ It is easy to find enough subjects when it is necessary, and to reproduce experiments.

Instant Seniors are used in experiments to model action characteristics of senior citizens and to obtain basic data for the design plan of institutions[1]. When this technique is applied to understanding escape action characteristics of senior citizens, attention should be paid to how to reproduce escape actions of an actual senior citizen, and it is necessary to plan development of experimental plan techniques to raise propriety, if necessary. Therefore, in this study, the same experiments were conducted in relation

to group walking behavior of Instant Seniors and actual senior citizens as subjects. This study shows the propriety of using Instant Seniors instead of actual senior citizens as subjects for modeling group walking behavior with the group that is consist of normal people with Instant Seniors or actual senior citizens (both of these subjects together as follows are called "Instant and Actual seniors").

Outline of Instant Senior Tools

In this study, a marketed senior citizen simulated experience tool called "Instant Senior [note 1]" was used for the reasons below. The details of the equipment are shown in Table 1 and Pic. 1.

(1) Because they are easy to put on over clothes, the subjects can easily use them for experiments in ordinary buildings or outdoors.
(2) The tools that are worn are all separate items, so that the influence from each item on the experiment results can be judged.
(3) It is possible to do an experiment with a lot of subjects, even with third-party people, because it is relatively inexpensive and the tools are available worldwide.

Pic. 1. Outline of instant senior

In addition, the state of the subjects is classified in Table 2 according to whether or not they are equipped with Instant Senior and whether they are fully or partly equipped.

TABLE 1. Details of instant senior [note 1]

Kind of equipment		The method and parts worn and functions
Audio-Visual	Ear plugs	Both ears; Hearing ability diminishes
	Goggles	Both eyes; Vision diminishes and simulate having cataract
Other parts	Wrist weights	Dominant hand; Raising arms becomes difficult
	Rubber gloves and tape	2 gloves on each hand, index and middle fingers bound together with tape, and ring finger and small finger bound together; Finger tops become insensitive
	Ankle weights	Different weights on each ankle to create a sense of imbalance
	Supporters	The joints of dominant arm and leg; The joints become difficult to bend
	Cane	Supports the body of normal person and slows their walking speed

TABLE 2. The classification of the subjects depends on the instant-senior equipment

Normal	Unequipped
Instant Seniors (full)	All the Instant Senior equipment is worn
Instant Seniors (without audio-visual)	Only weights, supporters and cane are used

Definition of Terms

The terms used in this article are defined as follows:
(1) An Actual Senior: An actual elderly person that is used to contrast with an Instant Senior.
(2) Instant Senior: A normal person who wears the Instant Senior equipment
(3) Walking time: The time that subjects walk in an experimental course (20 m).
(4) Solo walking time: The time that subjects walk alone in an experimental course (20 m).

(5) Group walking time: The time that subjects walk in an experimental course (20 m) with the group.
(6) Walking time of the whole group: The time when the first person of a group starts until the last person of a group reaches a goal.
(7) Walking speed: A value determined by dividing walking distance (20 m) by walking time.
(8) Starting point passing time: The time when the first person of a group passes the starting point until the last person of a group passes the starting point.
(9) Goal point passing time: The time when the first person of a group passes the goal until the last person of a group passes the goal.

MATERIALS AND METHODS

Methods and Conditions of Experiments

Subjects
The details of the subjects are shown in Table 3. Because these experiments were carried out as a part of an experimental course of a university department, the subjects were students from 19 years old to 25 years old. They were students at Waseda University, and they were divided into three groups according to numerical order at the time of the experiments. All of the subjects were in good health and they had no defects that would create obstacles to the experiments. The Actual Senior subjects living at the residence "Silver Peer [note 2]", in the university neighborhood were recruited under the requirement that they could walk a distance of 20 m several times, by themselves. The use of any measure of support for walking, except for wheelchairs, was allowed during the experiments. The oldest subject was 83 years old; the average age was 73 years old. All of the subjects were in good health, they could all walk by themselves, but three people used canes in everyday life, and 2 used canes in these experiments. All the members lived in the same apartment and they knew each other. In addition, in order to reproduce the group walking behavior for emergencies in normal buildings, the same instructions were given to all subjects before the experiment was started. They were instructed to:

(1) Walk at the same speed as walking ordinary.
(2) Not speak to anybody during the experimental walk.
(3) Not take anything except what was necessary to assist walking.

In addition, Instant Seniors were instructed to have weights on their canes while they were walking. If they had not been instructed to do so, they might not have done it, as they are not accustomed to using canes. Putting pressure on the canes affected the subjects, because it was harder to adjust their walking speed to around them. This was predicted to make it similar to an Actual Seniors walking behavior.

TABLE 3. Subjects details

Kind of experiment		The number of subjects [note 3]	Age	Notes
Instant Senior experiments	Group 1	Men 20, Women 4	19~25	Sutudents
	Group 2	Men 18, Women 6		
	Group 3	Men 20, Women 4		
Actual senior experiments		Actual senior citizens; Men 3, Women 17	64~83	The residents of "Silver Peer"
		Ordinary; Men 21, Women 3	19~25	Students
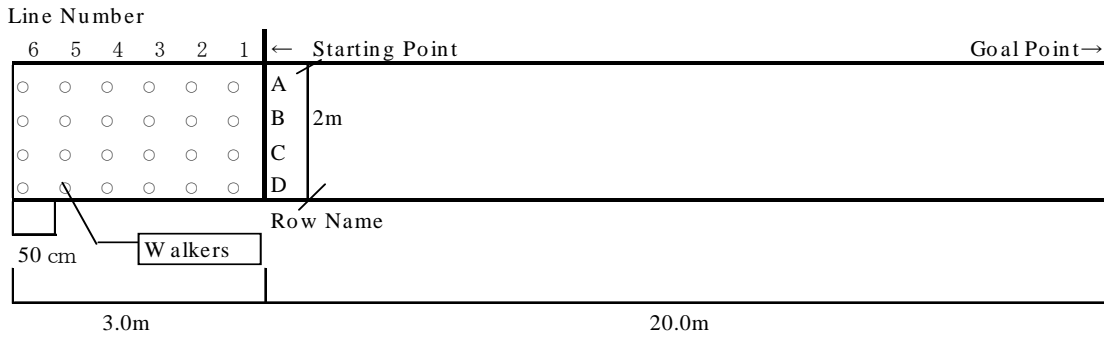
FIGURE 1. The walking route of group walking experiments
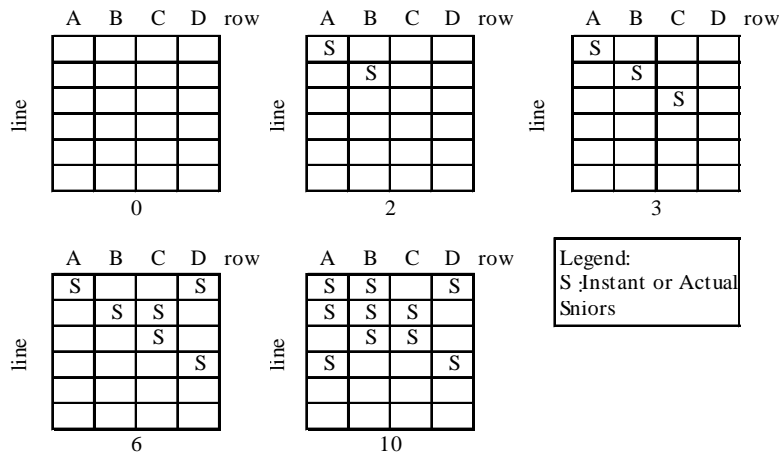
FIGURE 2-1. Placement of walkers (random placement)
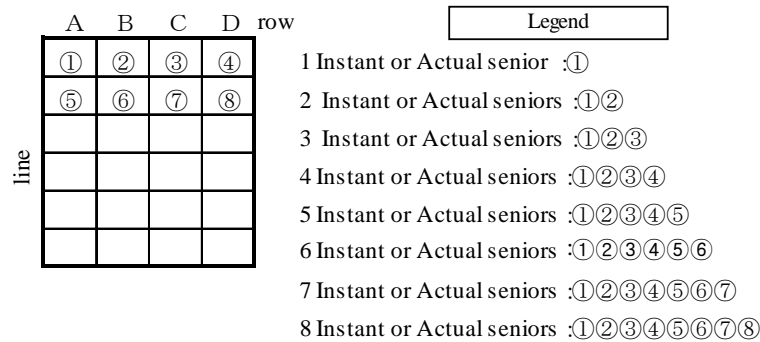
FIGURE 2-2. Placement of walkers (regular increase)

The test site

The experiments with Instant Senior subjects (hereafter referred to as "Instant Senior experiment") were carried out in the Waseda University outdoor court and the experiments with Actual Senior subjects (hereafter referred to as "Actual Senior experiments") were held in the open space of the housing complex where subjects lived. The boundaries were established by using red cones connected by horizontal bars for Actual Senior experiments. For Instant Senior experiments, one side of the walking route had red cones with bars, but the other side was a wall [note 4]. The walking distance (20 m) was decided based on the Building Standard Law and the general walking distance of ordinary building corridors, which lead to escape stairs. The initial value of density in group walking

4

experiments was set at 4 people/square meter. A little higher density value compared with people who can walk smoothly was adopted for group walking experiments. Because it was considered that the existing impact that Instant and Actual seniors had on group walking was observed obviously. Walking time of the whole group decreases as the density of people increases[2] in general, but in this experiment the length of the group was longer right after the group started, then as the walking speed of the group increased, it was observed that the group spread out [note 5]. And in this article, the rows of the groups were named A row, B row, C row and D row, as shown Fig. 1. The subjects whom the groups were made up of were expressed by combining the row name and the line number. The first person in A row was "A1".

The steps of experiments
A stopwatch was used to measure the walking time of the subjects. At first, the solo walking time and then the group walking time was measured for both Instant Senior experiments and Actual Senior experiments. The total time required for each experiment was 3 hours, a 15-minutes break was taken after 1.5 hours of each experiment. All measurement was done only once for each walking condition in order to prevent the subjects become from getting accustomed to the Instant Senior equipment, due to repeating the same experiments.

The measurement method of walking time
a) Solo walking experiments: In the case of Instant Senior experiments, two subjects were paired and the role of walker and measurer were alternated. For Actual Senior experiments, the measuring staff measured walking time.
b) Group walking experiments: The Instant Senior subjects measured their walking time by themselves, and the measuring staff measured the Actual Senior subject's walking time. The subjects began walking on a starting signal. Each line was instructed not to press the stopwatch until they reached the starting point. The measuring staff measured the Walking time of the whole group, the Starting point passing time and the Goal point passing time for both the Instant Senior experiments and Actual Senior experiments. The experiments were filmed from above.

The placement method of walkers
Referring to the results of past experiments [3] the impact of Instant Seniors on a group was found to be strong when Instant Seniors were posted in the first line, more Instant and Actual seniors were placed in the front of the group.

a) Random Placement: Instant and Actual seniors were placed randomly in the group, assuming the situation in a building in a real situation, and not being Instant and Actual seniors concentrated in parts (shown in Fig.2-1, hereafter referred to as "Random Placement").
b) Regular Increase in the number of subjects: The number of Instant and Actual seniors was increased one-by-one, regularly (shown in Fig.2-2, hereafter referred to as "Regular Increase"). In total there were 8 subjects who were posted to produce the greatest impact that Instant and Actual seniors give to group walks.

The method of choosing the subjects
For the group walking experiments, Instant Senior subjects were chosen by two methods as shown in Table 4. Because a strong impact to the group walking behavior is expected when the original walking speed is slow, so the Instant Senior subjects were priority selected among the subjects whose solo walking speed became slower when they wore Instant Senior equipment (full), compared with ordinary walking speed. Taking into account that elderly people are liable to feel distressed, all of the Actual Senior subjects were alternated. They repeated the set of walking twice and resting.

a) The method of alternating: All Instant Senior subjects rotated after every walking pattern, and do not repeat walking patterns. In this case fatigue (which has an impact on experiment results) of the subjects is avoided, but if the walking speeds had been irregular, there was the possibility that the analysis of the impact by the Instant Seniors would not be scientific.

b) The rigid method: Instant Seniors are posted in the order of the solo walking speed difference between when they are normal subjects and when they wear Instant Senior equipments (full equipment) is big. Even when walking patterns change, the same subjects are used. In this case, it is predicted that the walking speed will not be irregular, but fatigue of the subjects' impact the results of the experiments.

TABLE 4. Walking condition of group walking experiments

			Method of choosing the subjects
Instant Senior Experiments	Group 1	Random placement	The ridge method
		Regular increase	The ridge method
	Group 2	Random placement	The ridge method
		Regular increase	The ridge method
	Group 3	Random placement	The method of alternating
		Regular increase	The ridge method
Actual Senior experiments			The method of alternating (every 2 walks)

TABLE 5. The walking speed of instant seniors (solo walking) (m/s)

	Group 1	Group 2	Group 3
Instant Seniors (full)	0.80～1.72、average 0.99	0.29～1.16、average 0.64	0.34～1.27、average 0.87
Instant Seniors (without audio-visuall)	0.97～1.68、average 1.11	0.46～1.60、average 0.83	0.53～1.41、average 1.01
Unequipped	1.15～2.07、average 1.36	1.03～1.46、average 1.28	1.04～1.63、average 1.34
Actual Seniors	0.57～1.65 average 1.23		

**TABLE 6.** The walking speed of instant seniors (group walking) (m/s)

|		Group 1	Group 2	Group 3
Instant Seniors	The first line	0.86～1.11、average 0.99	0.71～0.99、average 0.79	0.71～1.95、average 0.77
	The whole group	0.86～1.11、average 0.99	0.61～0.99、average 0.78	0.69～1.02、average 0.78
Actual seniors		0.70～1.73、average 1.24		

RESULTS AND DISCUSSIONS

Solo Walking Experiments

The solo walking speed of every Instant Senior is the fastest when they are unequipped, the slowest is when they are wearing the Instant Senior full equipment (as in Fig. 3) [note 6]. For almost all subjects, the difference of walking speeds between Instant Seniors (full) and Instant Seniors (without audio-visual equipment) is smaller than the difference between Instant Seniors (without audio-visual equipment) and when they are unequipped. This shows that when the subjects attached the equipment to the limbs and when using a cane, there is a greater impact on the walking behavior than when using audio-visual equipment. The average walking speed according to groups is shown in Table 5. Although the experiment conditions were common for all groups, the subjects of Group 1 were faster than Group 2 and 3 without regard to wearing Instant Senior equipment or not. In addition, the fastest walking speed of all unequipped person was 2.07 m/s; the slowest was 1.03 m/s; the average of all members when they were unequipped was 1.36 m/s. In the case of Instant Seniors (full equipment), the fastest was 1.72 m/s and the slowest was 0.29 m/s. There is a great difference according to individual ability. On the other hand, for an Actual Senior, the fastest was 1.65m/s; the slowest was 0.57 m/s; the average was 1.23 m/s. There is less difference in the walking speed compared with the Instant Seniors. The

interrelationship of the age and the solo walking speed is shown in Fig. 4. There is much dispersion at the same age, the correlation coefficient between the walking speed and age is -0.14. It shows that the walking speed becomes a bit slower as people age. In addition, the walking speeds of Actual Senior subjects who used canes in the experiments were slower than the other subjects of the same age. In this their leg strength was low, so they used canes to assist them in walking.
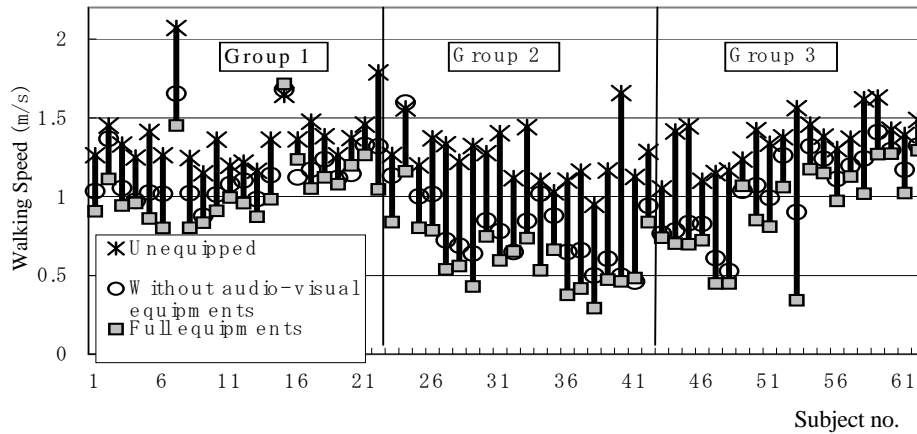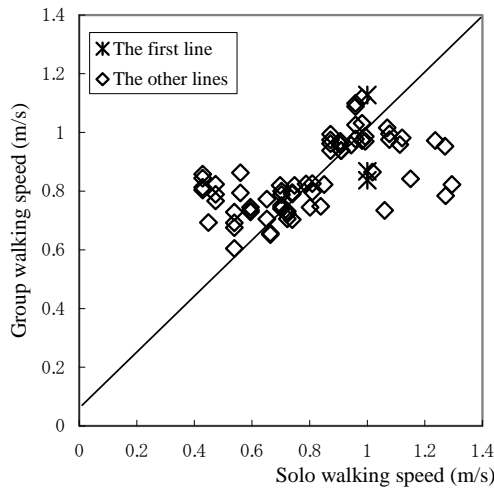

FIGURE 3. Walking speed difference (solo walking)
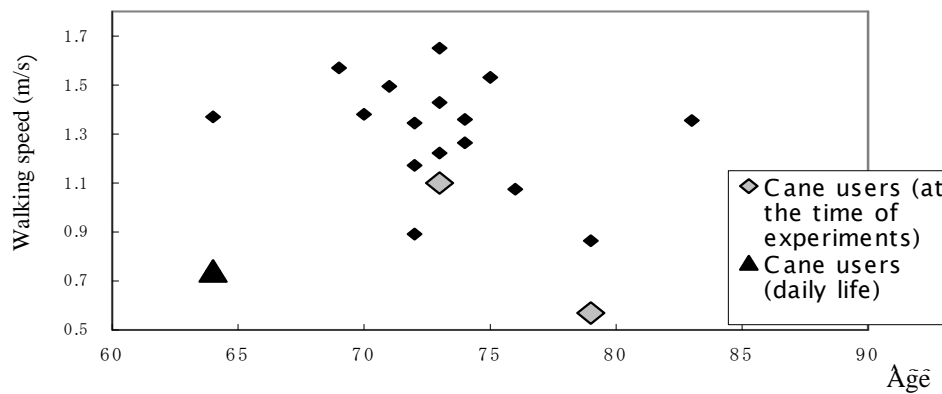
FIGURE 4. The interrelationship of age and solo walking speeds (actual seniors)
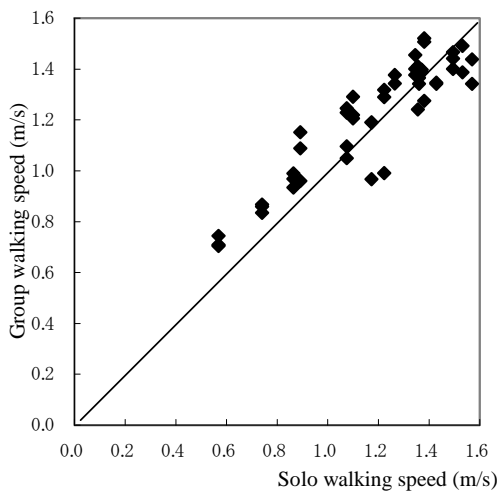
**FIGURE 5.** The difference between the solo walking speed and the group walking speed (actual seniors)

7

FIGURE 6. The difference between the solo walking speed and the group walking speed (instant seniors)

Group Walking Experiments

A comparison of solo walking speed and group walking speed

The walking speed of solo walking and group walking by Actual Seniors shows a high correlation (Fig. 5). Although the group walking speed was faster than the solo walking speed for 70% of Actual Seniors, the difference was small: The average ratio of increase is 6.2%, whereas the highest increase in group walking speed was seen in subjects who were the slowest solo walkers. This fact suggests that some subjects adjust their walking speed to the group, but almost all other subjects could not adjust their walking speed. On the other hand, in the case of Instant Seniors, the group waking speed was faster than the solo walking speed in 87% of subjects as shown in Fig. 6. The ratio of the subjects whose group walking speed was faster than solo walking speed was 82.5% in Group 1, 94.7% in Group 2 and 70.2% in Group 3. The range of the solo walking speed was from 0.29m/s to 1.72m/s (Table 5), while group walking speed was from 0.61 m/s to 1.11 m/s of Instant Senior subjects[note7], as shown in Table 6, the difference between the walking speeds among the subjects becomes small in group walks. The average rising ratio of walking speed of the subjects whose group walking speed was faster than solo walking speed is an 36.7% for Group 2, 7.7% for Group 1 and 15.3% for Group 3. Because the group walking speed of Instant Seniors tends to become equal, the slower the solo walking speed, the higher the ratio of the increase in the walking speed. In Group 2, there are many Instant Seniors whose solo walking speed was slow, so that the rising ratio of walking speed is high. Therefore, Instant Seniors adjust their walking speed in group walks, this is different from Actual Seniors, the slower the solo walking speed, the more noticeable the tendency.
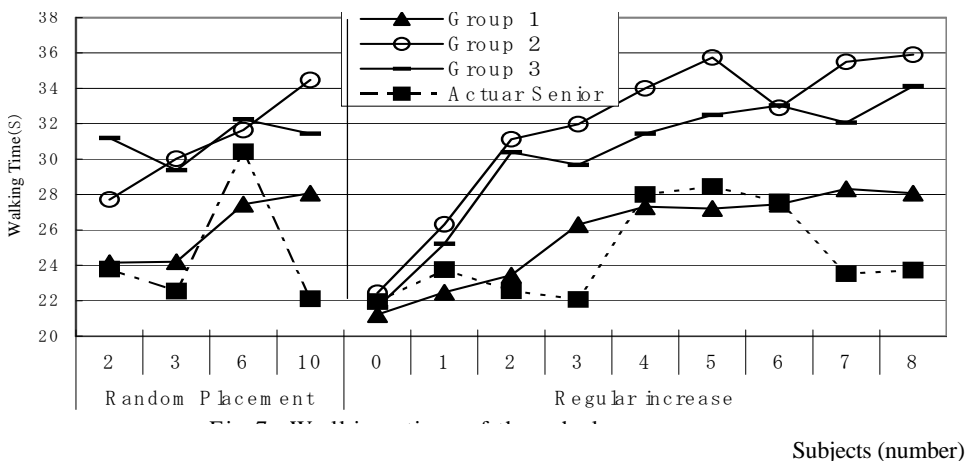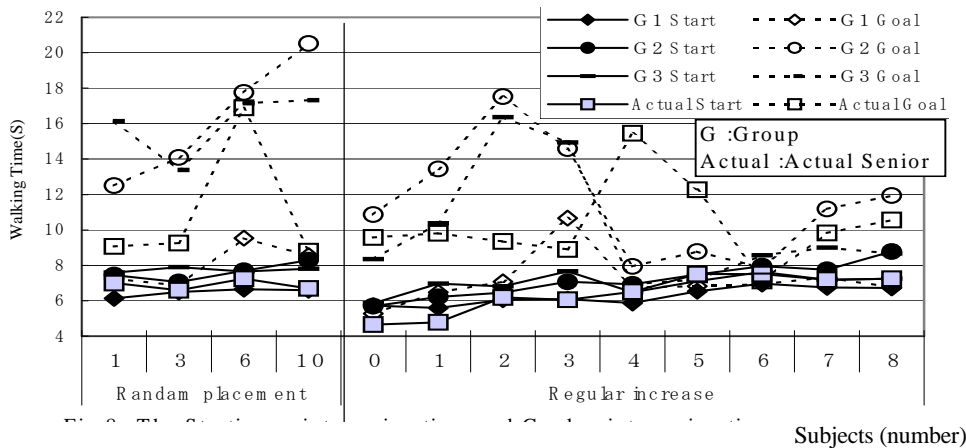

FIGURE 7. Walking time of the whole group

8

The relationship between the number of Instant Seniors and the group walking behavior

When Instant Seniors are incorporated into a group, the Walk time of the whole group becomes longer overall as the number of Instant Seniors increases, as shown in Fig. 7. In Group 1, both the Walk time of the whole group and the difference between the Starting point passing time and the Goal point passing time are short (Figs. 7 and 8), while in Group 2, both the Walk time of the whole group and the Goal point passing time are the longest, without regard to the increase in the number of Instant Seniors. This is because that in Group 2, there are many Instant Senior subjects whose group walking speeds are rather slow, as shown in Table 6. Whereas in both Group 1 and Group 2, the Walk time of the whole group are longer according to the increase in the number of Instant Seniors, in Group 3, in the case of Random Placement, there is a slight change in the Walk time of the whole group as the number of Instant Seniors increases. This is because the method of choosing the Instant Senior subjects is the rigid method as in Group 1 and Group 2 for Random Placement, this is a means that Instant Seniors were posted in such an order that the solo walking speed was slow. On the other hand, in Group 3, in the case of Random Placement, the method of choosing the Instant Senior subjects was the method of alternating and Instant Senior subjects were posted randomly, with no consideration of their solo walking speed. So the increase in the number of Instant Seniors was unrelated to the Walk time of the whole group. This result indicates that the rigid method is suited to grasp the impact that the number and position of Instant Seniors has on group walking behavior in these walking frequencies. For the Regular Increase, only in Group 2 and 3, in which the Instant Seniors solo walking speed was slow, up to when the number of Instant Seniors was increased to 3, according to the increase in the number of Instant Seniors, the spaces where normal subjects in the back of the group pass were narrow (Pic. 2). But in all groups, the Walk time of the whole group changed little after increasing the number of Instant Seniors to 4 or more. In these cases, the whole first line was made up of Instant Seniors. This indicates that because Instant Seniors who were posted in the first line made a "wall", the normal subjects who were posted after the second line could not pass the first line of Instant Seniors (Pic. 3). Thus, the Walk time of the whole group depended on the walking time of anterior Instant Seniors. These situations confirm that in the case of 4 or more Instant Seniors being posted, for Regular Increases, the difference between the Starting point passing time and Goal point passing time is smaller, as shown in Fig. 8.

FIGURE 8. The starting point passing time and goal point passing time

The walking behavior of Actual Seniors in group walks

In Actual senior experiments, the Walk time of the whole group and the Goal point passing time were remarkably long in the walking pattern of 6 Actual Seniors being posted by Random Placement and when 4 to 6 Actual Seniors were posted by Regular Increase as shown in Figs. 7 and 8. There is no relationship between the increase in the number of Actual Seniors and Walk time of the whole group. This is because the Actual Seniors who had different walking speeds were posted in every walking pattern, because the method of alternating was adopted. The walking behavior of 6 Actual Seniors were incorporated into Random Placement, as shown in Pic. 4, Actual Seniors whose walking speed was slow were concentrated in the middle of the group, and the normal ones were stacked up behind them. On the

other hand, the Walk time of the whole group was shortest in the walking pattern of 3 and 10 Actual Seniors being posted by Random Placement and 3 or fewer Actual Seniors were posted by the Regular Increase. In these cases, the Walk time of the whole group was the same level as the walking pattern when all of the subjects were normal. It is considered that the Actual Seniors whose solo walking speed was the same as the normal subjects (from 1.07 m/s to 1.53 m/s) were posted, and the group walking behavior shows the same situation when all of the subjects were normal. The Walk time of the whole group was the longest in the walking pattern of 5 Actual Seniors posted by Regular Increase, as shown in Pic. 5, it indicates that the normal people were stacked up behind 2 Actual Seniors whose walking speed was slower. Therefore, it is considered that because Actual Senior subjects had to be chosen by the method of alternating, the walking speed of them varies so much in group walks, the data of group walking speed is also more varied than in the case of Instant Senior subjects who were used.

Pic. 2. The situation of 2 instant seniors being incorporated (group 2/white point shows instant seniors)
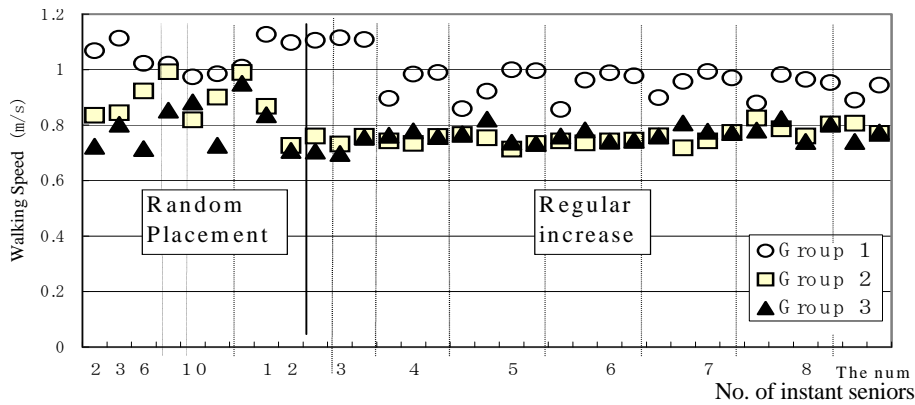

Pic. 3. The situation of 4 instant seniors being incorporated (group 2/white point shows instant seniors)
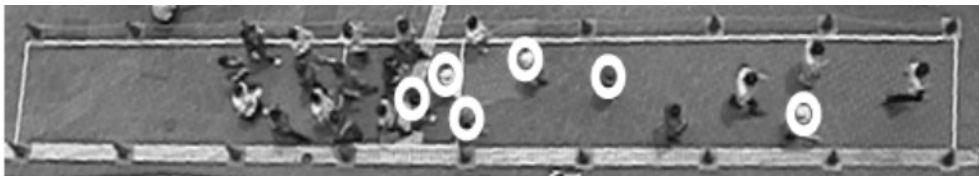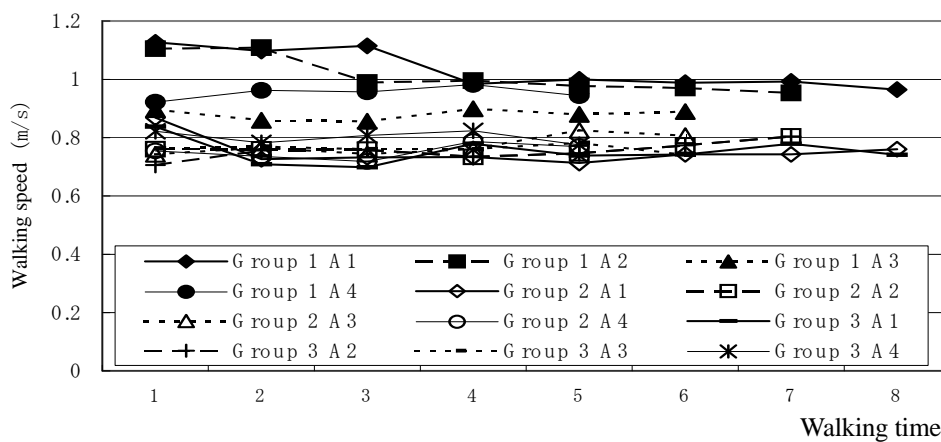

Pic. 4. The situation of 6 actual seniors being incorporated (white point shows actual seniors)

Pic. 5. The situation of 5 actual seniors being incorporated (white point shows actual seniors)

FIGURE 9. The walking behaviour of instant seniors who were posted in the first line

FIGURE 10. Relationship between walking time and walking speed for instant seniors posted in the first line

<u>Walking behavior of Instant Seniors who were posted in the first line of the group</u>
No walkers disturbed the walking behavior of the first line subjects, so the walking speeds of the first line subjects for each experiment are shown in Fig. 9. In the case of Group 2 and Group 3, which include Instant Seniors whose solo walking speeds were slow, the walking speeds of Instant Seniors were constant in all cases of Regular Increase, while the walking speeds were more varied in the case of Random Placement with the same number of Instant Seniors. It is considered that although Instant Seniors are side-by-side in the walking pattern of Regular Increase, Instant Seniors walk alongside normal subjects in the walking pattern of Random Placement. Then Instant Seniors adjusted to the walking speed alongside normal people in some cases of Random Placement, it was a common tendency among Group 2 and Group 3, without regard to the method of choosing the subjects. On the other hand, in the case of Group 1, which included Instant Seniors whose solo walking speed was faster, there was little difference between Regular Increase and Random Placement. Therefore, Instant Seniors adjusted their walking speed, depending on their solo walking speed; the slower the solo walking speed, the more they adjusted their walking speed to the normal subjects. In addition, the walking speed of some first line subjects became slower according to the increase in walking times by the walking pattern of the Regular Increase and the rigid method (Fig. 10). These phenomena relate to the fatigue of the subjects. But after walking 5 times, the difference of the walking speed of every subject was small. It is almost constant, the range being from 0.7 m/s to 1.0 m/s. These values difference are depending on the subjects, because there are different physical abilities among the subjects, but the variability of the walking speed among the subjects is small compared with the case of solo walking. Because solo walking experiments are done first and then the group walking experiments are conducted, there are possibilities that the

11

subjects were accustomed to using Instant Senior equipment, so their walking speed became faster.

CONCLUSION

To grasp the group walking behavior of Actual Seniors by using Instant Senior, the following things should be studied:

1. The Limit of Using Actual Seniors as Subjects

The results of experiments show that using Actual Seniors as subjects is very difficult due to the following reasons:

(1) The selection of the subjects and analysis of experiment results must be conducted with much caution because there is a lot of personal difference among the walking speed of the subjects who are of similar age.
(2) The method of choosing the subjects has to be to adopt the method of alternating, in order to prevent fatigue of Actual Seniors. The walking speed of Actual Seniors is quite variable, thus the identification of the reasons for the different experiments among different subjects is not easy if systematic experiments using Actual Seniors as subjects is done.

2. A Study of Reproducibility of the Group Evacuation Behavior by using Instant Seniors

The solo walking speed of both the Actual Seniors and Instant Seniors varies due to the difference in personal ability. Although in the case of the Actual senior experiments, the group walking speed range was from 0.7 to 1.7 m/s, and these walking speeds were almost the same as their solo walking speed, the group walking speed of Instant Seniors was from 0.7 to 1.1 m/s; there is little variation. Therefore, attention should be paid as follows: When Instant Seniors are used to grasp group walking behaviors, when both normal people and Actual Seniors are included;

(1) Instant Seniors are not suitable for the experiments which purpose is to compare the solo walking speed with the group walking speed for the Actual Seniors.
(2) Instant Seniors are substitutes for Actual Seniors. The reason is that although the walking speed of all Instant Seniors tends to be equal, their walking speeds correspond to the walking speed of some Actual Seniors under 75 years old whose solo walking speed was slowest, and all Actual Seniors 75 and over.
(3) By using Instant Seniors, the group walking speed cannot be predicted on the basis of the solo walking speed for each subject.

The Precepts of Group Walk Behavior Experiments of Actual Seniors, by Using Instant Seniors

According to 1. and 2. (above), the measurement of Instant Senior group walking behavior is useful for grasping group walking behaviors that include Actual Seniors. But the contents and purpose are limited, so it is necessary to pay close attention to the following points;

Direction of using Instant Seniors
The results of the experiments indicated that binding the limbs and using a cane has more impact than the decline of audio-visual ability when walking on a plane surface. Therefore, fastening the supporter and attaching the weights should be the right method. Also, the cane must be used properly.

Necessity of skill for the choice of subjects, and using Instant Senior tools
(1) The variability of the data is great when the method of alternating was chosen. So the ridge method should be chosen to fully grasp the impact that the Instant Seniors have on the group walking behavior.

(2) The walking speed of Instant Seniors after second times experimental walk became slower than their first walk which means the subjects wearing the Instant Senior equipment for the first time. But the walking speeds of Instant Seniors became almost uniform after the fifth walk. Therefore 5 preliminary walks are good in order to obtain stable data.

Placement of Instant Seniors in the group

The walking speeds of the Instant Seniors became faster when they attempted to adjust their walking speed in order to match those of the normal subjects next to them, while the Actual Seniors couldn't adjust their walking speeds to neighboring people in the group. Therefore, Instant Seniors should be side-by-side in the group as in the Regular Increase, to fully grasp the impact that the Instant Seniors have on group walking behavior. In addition, the walking speed of Instant Seniors tends to be uniform, and it was noticeable when the Regular Increase method was adopted. But Instant Seniors became a "wall" to the walkers behind them, and had a great impact in this case; it greatly affected the evaluation results.

ACKKNOWLEDGEMENT

NOTATION LIST

Note 1) A senior citizen simulated experience program that the Ontario provincial government of Canada developed. Their purpose was to create a decline in physical ability with aging. In Japan, only "Well-Aging Association (WAJ) http://www.wellaging.ne.jp/" may conduct it.

Note 2) An apartment buildings supported by the Tokyo Metropolitan Government that is for exclusive use of senior citizens who need financial assistance for housing. In order to live there, the government requires people to be at least 65 years old and they must be able to care for themselves.

Note 3) The number of the subjects (24) is equal to the number of walkers in the Instant Senior experiments because the subjects alternate the roles of normal people and the Instant Seniors. On the other hand, in the Actual Senior experiments, a total of 20 subjects are used; they walked twice and then rested. This pattern was repeated in order to prevent fatigue of the subjects

Note 4) Because of location of the test site and necessity of filming from above, the walking route did not have walls on both sides as in ordinary building corridors. Not having the walls on both sides may have affected the walking area actually used by the walkers; this would affect group walking densities.

Note 5) The approach route should be before the beginning of the measuring point in order to prevent this situation, and measuring should not begin until after walking behavior is suitable.

Note 6) Some of the normal subjects overlapped in different groups in the group walking experiments, so the number of the subjects in Table 3 does not match Fig. 3.

Note 7) The fastest walking speed was 1.72 m/s, in Group 1 and Group 2, but these subjects didn't take part in the group walking experiments, because these experiments were conducted using the Ridge method. Fig. 6 shows the comparison between solo walking speed and group walking speed by Instant Seniors; the fastest walking speed was under 1.4 m/s.

REFFERENCES

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