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An Epidemiological Evaluation of a Fall Prevention Program in H Town, Shimane Prefecture

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We investigated effects of a fall prevention program on blood pressure and physical strength and balance in the elderly living in H Town, Shimane Prefecture. The program consisting of 12 sessions was held from September to November, 2005. After completing the program, there were significant changes in several parameters measured, i.e., a decrease in diastolic blood pressure, rise in handgrip strength, elongation of the duration for keeping balance on one foot with eyes open, increase in maximum stride length, and shortening of 10 m full-speed walking (n=25; average age ± SD, 72.9 ± 6.0). No such changes were shown in the control group (participants in salon meetings; n=26; average age ± SD, 73.2 ± 9.5). The results suggest that the fall prevention program improved blood pressure and physical strength and balance in the elderly in H Town.

Key words: Shimane Prefecture, fall prevention program, physical strength and balance test, blood pressure, epidemiological study

INTRODUCTION

A survey regarding falls was conducted on the elderly in 5 regions in Japan by Niino *et al.* (1). They reported that the proportion of elderly (age of 65 and above) who experienced one or more falls in a year was 12.7-20.8%. Laurence *et al.* (2) reported that decline of muscle strength, history of falls, abnormal gait, balance dysfunction, visual impairment, and cognitive impairment were important risk factors for falls. Fracture is one of the main causes for individuals to require nursing care. It has been reported that 80-90% of fractures are caused by falls (3, 4), and that the frequency of falls is more than twice as high among individuals under nursing care than among independent individuals (2, 5). Thus, implementation of fall prevention measures is important to prevent the number of individuals requiring nursing care from increasing. According to the nursing care insurance administrative survey (6), 1,968 municipalities among the 3,213 municipalities in Japan (61.3%) have implemented fall and fracture prevention projects as of April 1st, 2003.

H Town is located in the east of Shimane Prefecture. As of October 1st, 2003, the population was 13,817 (6,693 males and 7,124 females), and those aged 65 and older numbered 2,656 (19.2%; 1,110 males and 1,556 females) (7). The medical care services available in the Town included 10 physicians, 1 belonging to hospital, and 9 belonging to general clinics. Since the public transportation system was well-designed, it was easy for the H Town residents to visit main hospitals in neighboring municipalities. In H Town, a preventive care program has been held once a week at a preventive care facility. The city has also been training volunteers specializing in preventive care. A salon meeting for the elderly has been organized and held by such volunteers once a month.

In 2005, the city implemented a fall prevention program, which aimed to improve lower extremity muscle strength and balance, as a part of the preventive care project with a subsidy from the "*koureisha marugoto anshin seikatsu sapouto jigyou*" of Shimane Prefecture. Herein, we evaluated the program epidemiologically by measuring physical strength levels and blood pressure of the program participants. Consent for participation was obtained from all participants in the present study.

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MATERIALS AND METHODS

Fall prevention program

H Town recruited participants in a fall prevention program among the community residents in August 2005. Recruitment criteria were age of 60 or older, history of fall within the previous year, and recent increase in the frequency of falls. This study was approved by the Ethical Committee of Shimane University School of Medicine, and the written informed consent was obtained from all donors. All applicants were accepted as program participants. The program was held for 1-2 hours once a week in the period from September 14 to November 30, 2005, a total of 12 sessions. The program contents included public health lectures, nutrition guidance, and practical training exercises to improve lower extremity muscle strength and balance (Table 1). Blood pressure and physical strength levels were measured concurrently. For participants who could not exercise sufficiently due to their disabilities, support was provided or the exercise was modified to match the physical strength level. These program participants were classified as the intervention group.

Salon meetings for the elderly

Activities for promoting interactions among the elderly, named "*hono-bono salon*" and "*iki-iki kyoshitsu*" have been held once a week in the town. B Area in the town has also been holding its original meeting for the elderly in order to promote their interaction. In the salon meetings and program, in addition to conversation, stretching exercises have been performed irregularly for health maintenance. Participants in the elderly salon meeting were classified as the control

Table 1. Outline of the fall prevention program

Session	Date (2005)	Number of participants	Contents	Measurement items	Personnel in charge
1	Sept. 14	36	Opening ceremony Lecture	Blood pressure Physical strength and balance	Physiotherapist public health nurse
2	Sept. 21	29	Lecture		Physician public health nurse
3	Sept. 28	33	Practical training exercises		Physiotherapist public health nurse
4	Oct. 5	28	Lecture		Physician public health nurse
5	Oct. 12	30	Practical training exercises		Physiotherapist public health nurse
6	Oct. 19	24	Practical training exercises		Public health nurse
7	Oct. 26	25	Practical training exercises		Physiotherapist public health nurse
8	Nov. 2	23	Lecture		Nutritionist public health nurse
9	Nov. 9	22	Practical training exercises		Physiotherapist public health nurse
10	Nov. 16	21	Practical training exercises	Blood pressure Physical strength and balance	Public health nurse
11	Nov. 24	23	Individual guidance	Blood pressure Physical strength and balance	Physiotherapist public health nurse
12	Nov. 30	26	Closing ceremony		Physiotherapist public health nurse

group.

Blood pressure measurement

Blood pressure was measured twice, and the average value was adopted for analysis. For the intervention group, two measurements were performed at the beginning and the end of the fall prevention program. For the control group, two measurements were performed in October and December.

Physical strength and balance test

The physical strength and balance test was conducted twice at the beginning of the fall prevention program in September and the end of the program in November for the intervention group, and in October and December for the control group. The actual measuring procedures for each item were as follows.

Handgrip strength: Handgrip strength was measured once for each hand using a hand dynamometer, and the average value was adopted for analysis. Single-leg balance with eyes open: Subjects stood still on one foot with the eyes open, and tried to keep their balance without putting the other foot on the ground, and the duration before the other foot touched the ground was measured. Measurements were performed once for each leg, and the average value on each measure was adopted for analysis. The maximum time of measurement was 60 seconds. Maximum stride length: Subjects stood still before striding one foot as far forward as possible, then moved the other foot up to join the first, and then stood still again. The distance between the position of the tips of the toes before and after the stride was measured. Ten meter full-speed walking: Subjects stood still before walking as fast as possible through a point 10 m away without stopping. The time from the start to the point when the tip of the toe passed the 10 m point was measured.

Statistical analysis

The difference in average age between the intervention and control groups was calculated using a Stud ent's t-test. Blood pressure and physical strength and balance test measurements were compared between before and after the fall prevention program by the intervention and control groups. Differences in average values were evaluated using a paired t-test.

RESULTS

Forty-six individuals (5 men and 41 women) applied for the fall prevention program; 39 (4 men and 35 women) participated in at least one session. Participants in each session are shown in Table 1. Among these, 25 participants (2 men and 23 women) underwent blood pressure measurements and physical strength and balance test measurements both at the beginning and the end of the program. These 25 participants were classified as the intervention group. A total of 26 participants (11 men and 15 women) attending the salon meetings for the elderly were classified as the control group.

Average age and standard deviation (SD) in the intervention and control groups are shown in Table 2. No significant difference in age was observed between the intervention and control groups.

Blood pressure and physical strength and balance measurements before commencing and after completing the fall prevention program are shown in Table 3. Diastolic blood pressure in the intervention group was significantly lowered by 5 mmHg ($P<0.01$) at the end of the program compared to that at the beginning. That in women alone was also significantly lowered by 5 mmHg ($P<0.01$). No significant change was observed in systolic blood pressure in the intervention

Table 2. Gender and age distributions of subjects

	Gender	Number of participants	Average age	SD*	range (year)
Fall prevention program (intervention group)	Men and women	25	72.9	6.0	61-82
	Men	2	71.0	1.4	70-72
	Women	23	73.1	6.3	61-82
Salon meetings for the elderly (control group)	Men and women	26	73.2	9.5	60-94
	Men	11	71.4	8.0	60-85
	Women	15	74.5	10.6	62-94

*SD: standard deviation

group; the same was true for women alone. Maximum stride length in the intervention group was significantly increased by 4.6 cm (P<0.01) at the end of the program compared to that at the beginning. That in women alone was also increased by 5.3 cm (P<0.01). Handgrip strength in the intervention group was significantly increased by 1.8 kg (P<0.01). That in women alone was also significantly increased by 1.8 kg (P<0.01). Single-leg balance with eyes open in the intervention group was significantly improved by 2.3 seconds (P<0.01). That in women alone was also improved by 10.5 seconds (P<0.01). No significant change was observed in 10 m full-speed walking in the intervention group; the same was true for women alone. Blood pressure and physical strength measurements in the control group are shown in Table 4. No significant changes were observed in systolic blood pressure, diastolic blood pressure, maximum stride length, handgrip strength, single-leg balance, or 10m full-speed walking before and after the program.

DISCUSSION

Improvements were observed in diastolic blood pressure, maximum stride length, handgrip strength and single-leg balance with eyes open among the participants in the fall prevention program. In contrast, such improvements were not observed in the control group.

Consensus has not been reached on the definition of a fall, and various definitions have been used according to subjects and survey methods. A large-scale study was conducted by Tinetti *et al.* (8) based on the definition, "a subject's unintentionary coming to rest on the ground or at some lower level, not as a result of a major intrinsic event (e.g., stroke or syncope) or overwhelming hazard " which indicates falls sustained during activities of daily living (ADL). The result showed that the percentage of falls in the elderly at the age of 75 and above in US in a year was 32%. Delbaere *et al.* suggested that fear of falls is a risk factor for falling. Fear of falls, which reduces

Table 3. Test results of the participants in the fall prevention program

		Beginning of the program (September 2005)			End of the program (November 2005)			
		Number of participants	Average value	SD*	Number of participants	Average value	SD*	P-values
Systolic blood pressure	Men and women	22	139	17.1	22	135	13.3	n.s.
(mmHg)	Men	2	164	11.3	2	155	4.2	n.s
	Women	20	137	15.6	20	134	12.3	n.s
Diastolic blood pressure	Men and women	22	79	7.6	22	74	5.9	<0.01
(mmHg)	Men	2	90	—	2	76	5.7	n.s
	Women	20	78	7.1	20	73	6.1	<0.01
Maximum stride length	Men and women	25	72.7	13.1	25	77.3	14.9	<0.01
(cm)	Men	2	89.3	5.3	2	86.3	1.1	n.s.
	Women	23	71.3	12.6	23	76.6	15.3	<0.01
Handgrip strength	Men and women	25	21.0	5.1	25	22.8	5.6	<0.01
(kg)	Men	2	33.8	3.2	2	37.3	1.1	n.s.
	Women	23	19.8	3.5	23	21.6	3.6	<0.01
Single-leg balance with	Men and women	25	18.5	17.5	25	29.2	18.7	<0.01
eyes open	Men	2	11.4	7.0	2	23.3	26.3	n.s.
(seconds)	Women	23	19.2	18.1	23	29.7	18.7	<0.01
10 m full-speed walking	Men and women	25	7.3	2.0	25	7.2	1.6	n.s.
(seconds)	Men	2	6.8	0.7	2	7.4	1.6	n.s.
	Women	23	7.4	2.1	23	7.1	1.7	n.s.

*SD: standard deviation

Table 4. Test results of the participants in the elderly salon meeting

		October 2005			December 2005			
		Number of participants	Average value	SD*	Number of participants	Average value	SD*	P-values
Systolic blood pressure	Men and women	26	142	10.9	26	141	13.9	n.s.
(mmHg)	Men	11	144	11.3	11	143	10.4	n.s.
	Women	15	140	10.6	15	140	16.2	n.s.
Diastolic blood pressure	Men and women	26	80	10.8	26	82	9.3	n.s.
(mmHg)	Men	11	79	10.4	11	83	8.5	n.s.
	Women	15	81	11.4	15	81	10.1	n.s.
Maximum stride length	Men and women	26	70.8	13.9	26	71.6	17.0	n.s.
(cm)	Men	11	75.3	9.7	11	79.5	14.1	n.s.
	Women	15	67.4	15.8	15	65.9	17.1	n.s.
Handgrip strength	Men and women	26	25.7	9.5	26	25.5	9.8	n.s.
(kg)	Men	11	31.9	9.7	11	32.3	9.0	n.s.
	Women	15	21.1	6.5	15	20.6	7.1	n.s.
Single-leg balance with	Men and women	24	28.5	23.6	24	29.8	24.4	n.s.
eyes open	Men	10	40.0	20.0	10	37.6	23.2	n.s.
(seconds)	Women	14	20.3	23.2	14	24.3	24.5	n.s.
10m full-speed walking	Men and women	26	8.2	3.2	26	8.4	3.3	n.s.
(seconds)	Men	11	8.0	4.2	11	8.1	4.2	n.s.
	Women	15	8.3	2.5	15	8.6	2.7	n.s.

*SD: standard deviation

physical activity level, leads to a decline in lower extremity muscle strength and trunk balance. As a result, the risk of falling increases (9). As individuals with a history of falls tend to experience greater fear, the influence on daily living becomes significant; thus, it is necessary to prevent fear of falls from developing further at an early stage (10, 11). Since a history of falls increases fear of falling, individuals may refrain from going outside and performing ADL, this can result in reduced muscle strength, further increasing the risk of falls (4, 5, 9, 11, 12). Hence, a vicious circle can occur. When the level of ADL is decreased due to fears of falls, or by fracture caused by falls, the requirement for nursing care in daily living is increased (5). The annual nursing care expenses in 2005 were 5,996.8 billion yen, of which 2,998.4 billion yen was charged to the public expenses. As the elderly population grows, nursing care expenses will certainly increase in the future. Thus, establishing measures to keep the increase to a minimum is an important task in the current situation.

Currently, various indices are adopted for the evaluation of physical strength for prediction of falls. Handgrip strength, as used in the present study, is useful as an index to estimate lower extremity muscle strength (13-16). Maximum stride length and single-leg balance with eyes open are indices for the lower extremity muscle strength and balance. Improved lower extremity muscle strength and balance due to increase of kicking strength of the supporting leg in addition to a prolonged swinging phase due to increased muscle strength obtained in the program can lead to an increase of stride length (17). It was assumed that such improvements could contribute to fall prevention. 10m full-speed walking is an indicator of agility and systemic function. However, no improvement in these parameters was observed among the program participants. It has been reported that exercise lowers blood pressure (18). Although exercise in the fall prevention program was light, it is assumed that it was nonetheless effective for lowering blood pressure in the elderly. Prevention of falls can

be achieved by continuing training voluntarily after the test values were improved in the fall prevention program and by maintaining the awareness of fall prevention (17, 19-21).

In conclusion, the present fall prevention program appears effective for improving balance, muscle strength, and decreasing blood pressure, and seems useful as a fall prevention measure.

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