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Original Article

Title:

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Abstract

Aim: The present study clarifies the effects of participation in a preventative health classroom program (exercise program) for 1-year on the physical functions of pre-frail elderly individuals in comparison to healthy elderly individuals.

Methods: Participants in the study included 28 elderly pre-frail female participants and 28 elderly healthy female participants. Participants engaged in the exercise program for 1-year. There was no significant age or physical differences between both groups. Before and after the exercise program, the following physical function tests were performed: grip strength, one-legged balance with eyes open, 5-meter walking time and a timed up & go (TUG).

Results: The pre-frail elderly group tested significantly lower in the one-legged balance with eyes open test and the TUG test compared with the healthy elderly group. The 5-meter walking time test improved significantly in both groups, but the TUG improved only in the pre-frail elderly group. Conversely, the grip strength and one-legged balance with eyes open tests remained unchanged.

Conclusion: Improvements in the TUG and 5-meter walking time tests were found in the pre-frail elderly group following the 1-year exercise program. Their results in the TUG test may be greater than those among the healthy elderly individuals.

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Keywords: longitudinal study, physical function, pre-frail elderly, preventative exercise, timed up & go.

Introduction

Recently, Japan has been witnessing a rapid increase in the elderly population. The number of certifications for long-term care positions in the nursing-care insurance system was approximately 2 million in 2000, and more than 5.2 million in 2012.[1] It is feared that they may exceed the number of young old (65—74 years old) after 2020 as the percentage further increases.[2] In addition, in April 2006, the Japanese long-term care insurance system was revised from institutional measures under government (municipal) leadership to oriented care prevention. Further, new initiatives such as preventive care benefits and community support projects began. Community support projects were introduced to prevent pre-frail elderly individuals from being certified as requiring support and nursing care by improving their functional mobility while

attending specific day care programs. Presently, various preventive nursing care projects have been established.[3] This project offers many services and programs, particularly regarding movement and functional mobility improvement.[4] Preventing the pre-frail elderly from moving to a long-term state of care will help improve their quality of life (QOL) and reduce reliance on public funding.[3] As part of the community support project, it is necessary to identify pre-frail elderly individuals who are likely to move to a state of need for long-term care support early, and to effectively support them.[3] Candidates in the pre-frail elderly group were selected by a municipal head on the basis of a doctor's recommendation after checking laboratory results and a basic life-function evaluation "checklist" (see Appendix1) among individuals over 65 years of age. After obtaining their informed consent, the pre-frail elderly group was given a care prevention plan to improve movement and physical function, nutritional guidance, and oral function.[3] Improving movement and physical functions is important. Seven local governments in Tokyo have carried out strength training and balance exercises on 276 community-dwelling pre-frail elderly individuals (mean age 75.3 years) twice weekly for 3 months. Arai et al reports that all tests with the exception of one-legged balance with eyes closed were significantly improved.[5] Furthermore, elderly individuals with lower physical functions at the program's onset can expect larger improvements; their trainability can be enhanced through prescribed exercises.[5] In addition, Takimoto et al examined the effect of an exercise program that focused on muscle training twice

weekly for three months on 95 people (mean age 77.8 years) who participated in an exercise classroom for the past 4 years. They reported significant improvements in all tests with the exception of the trunk flexion test. Further, an improvement in knee extension strength and balance ability contributed to improved walking ability.[6] Stewart et al. and Fiatarone et al. also reported that a moderate exercise intervention as aforementioned can improve physical functions of elderly individuals over 75 years of age and among pre-frail elderly people. Moderate exercise intervention contributes to the delay in age-associated declines in physical functions.[7,8] However, comparative studies on healthy elderly and pre-frail elderly individuals in terms of the effect of maintaining and improving physical functions by an exercise program have been minimal. In the field of exercise prescription, ensuring that the control group (healthy elderly group) maintains activity is difficult. However, it is important to evaluate the characteristics of physical functions and effects of exercise among pre-frail elderly individuals by comparing with the characteristics of those considered healthy to effectively support themselves by exercise care prevention. In short, useful findings will be obtained regarding whether a decline in physical functions makes a healthy, elderly individual into a pre-frail elderly individual or whether physical functions should be improved in the population to prevent disability. The present study was hypothesized on the basis of previous studies Stewart et al. and Fiatarone et al. as follows: through care prevention exercises for one year, pre-frail elderly individuals can suppress the decline

in physical functions similar to healthy elderly individuals.[7,8] The present study clarifies the effects of participation in a preventative health program (exercise program) classroom for one year on the physical functions of pre-frail elderly people.

Methods

Participants

This study included 28 pre-frail elderly female participants (pre-frail group: 78.2, SD = 6.4) and 28 elderly healthy female participants (control group: 75.3, SD = 5.3) who consistently participated in the exercise program for care prevention for a 1-year period (Table 1). All subjects resided of Kyoto city, Japan. Physical function measurements were conducted at the beginning and end of the exercise program in both groups. No significant differences were observed in the mean values of age and physique between the control and the pre-frail elderly groups. All participants were healthy and could participate in the study's physical function tests. The purpose of this study, measurement contents, and safety procedures as well as their right to refuse the survey and tests and that participation was on a voluntary basis, was explained to all participants. After receiving written informed consent from all participants, the following survey and tests were carried out.

This study was approved by the Ethics Committee on Human Experimentation of the Faculty of Human Science, Kanazawa University (2012-27).

*** Table 1 near here ***

Exercise program

The single exercise program lasting 1 h was as follows: 10 minutes warm-up (body stretching and hand and finger exercises in a sitting position), 40 minutes main exercise (strength exercise by its own weight load, balance exercise, and rhythmic movement), and 10 minutes cooling down. Both groups performed this exercise program once a week for 1 year during a 2.5 year period from April 2007 to December 2010.

Pre-frail elderly group selection criteria

In the Japanese Nursing Care Insurance System (1997), support and nursing care are defined as cases that correspond to any state that requires watch and support in daily life or constant nursing care based on the nursing-care standards of the Ministry of Health, Labour and Welfare.[3] Pre-frail elderly individuals are those who display a high probability of fitting into the above-mentioned support and nursing care.[3] Fried et al. defined frail individuals as having ≥3 items and pre-frail individuals as those having one or two of the following five items: unintentional weight loss, exhaustion, decrease in

grip strength, decrease in walking speed, and low physical activity.[9] Individuals in need of support and nursing in the present study were those with certified long-term care in Japan.[3] However, the pre-frail individuals in this study were those who could not receive the above certification.[3] All pre-frail elderly individuals in this study had the corresponding pre-frail characteristics set by Fried et al. (28.6% with the abovementioned two items and 71.4% with the abovementioned one item).[9] On the basis of the long-term care insurance standard,[3] pre-frail elderly individuals were selected by the following procedure into the newly installed community support project. The candidates were selected using a basic life-function evaluation checklist for the first insured individuals over the age of 65 except for those individuals who require state needed support and nursing care. The basic life-function evaluation checklist includes 25 “yes” or “no” items on motor function, nutritional status, oral function, living conditions, and mental status. This checklist is used to screen pre-frail and healthy elderly individuals in Japan. The pre-frail elderly group includes individuals with any of the following corresponding items: more than 10 of the 20 items excluding those related to mental status, more than three items among those related to motor function, all of the two items related to nutritional status, and more than the two items among those related to oral function. In addition, the healthy elderly group included individuals without the corresponding abovementioned criteria and showed a decline in vital functions. Mental services, such as a visiting nurse, were provided to both the pre-frail and healthy elderly

individuals who were identified to withdraw indoors and have a decline in cognitive functions and mental status. None of the participants in the present study withdrew indoors or showed a decline in cognitive functions and mental status.

Physical function measurement

The following four physical function tests were performed to understand physical functions of the pre-frail elderly group and the effect of classroom exercise care prevention in the community support project: grip strength, one-legged balance with eyes open, 5-meter walking time, and TUG.[3] These four tests have been used as the index to evaluate the effects of preventive care projects.

It is desirable for elderly individuals to undergo tests that may reflect a decrease in their physical functions with age in view of their safety and physical and mental burden.[10] These tests have been used generally due to their high degree of safety.[3]

Grip strength of the right and left hands was measured once while standing using a Smedley hand dynamometer (TKK5401, Takei Scientific Instruments, Niigata , Japan). The mean of the strength of both hands was analyzed. The one-legged balance with eyes open test was measured on the basis of the Implementation Guidance of the Ministry of Education, Culture, Sports, Science and Technology.[3,11] For the 5-meter walking time test, when participants walked 11 meters, the time taken to walk from the 3-meter point to the 8-meter point was measured.[3] The TUG test was measured as the time taken to walk to a cone at a distance of 3 meters starting from a sitting position on a chair, to

return to the original seated position.[3,12]

Measurement procedure

The survey and measurements were carried out after sufficiently explaining the content to each participant in advance. We asked them not to participate in the physical function tests if they felt it would be too difficult for them. In addition, we emphasized that survey participation was voluntary. After confirming that there were no particular problems after measuring physique and blood pressure (systolic and diastolic), following the 10 min warm-up that focused on stretching exercises, the physical function tests were performed.

Statistical analysis

Statistical analysis was carried out by using SPSS 11.5J for Windows (SPSS Japan Inc, Tokyo, Japan). A two-way ANOVA with repeated measures on period was used to examine mean differences for the physical function tests. When significant interaction and main effects were found, a multiple-comparison test was conducted using Tukey's Honestly Significant Difference (HSD) method for pair-wise comparisons. The change rate after 1 year of physical function tests was calculated by dividing a measured value after 1 year by one measured before beginning the exercise. A mean change rate between groups was examined by an unpaired t-test. An alpha level of 0.05 was

significant for all tests.

Results

Table 2 shows the means, standard deviations, and the results of two-way ANOVA with repeated measures, and a pair-wise comparison test. A significant interaction was found in TUG test ($F = 4.43$, $p < 0.05$) and with post-hoc analysis, the pre-frail group was significantly larger than the control group in both periods ($F = 8.23$, $p < 0.05$) and showed a significant decrease at the end of the exercise program ($F = 10.42$, $p < 0.05$). The grip strength test showed no significant differences between both groups ($F = 2.86$, $p > 0.05$) and between periods ($F = 1.30$, $p > 0.05$). The one-legged balance with eyes open test showed a significant main effect in group factor ($F = 8.91$, $p < 0.05$), the pre-frail group showed a lower mean than the control group. The 5-meter walking time test showed a significant main effect in period factor ($F = 21.62$, $p < 0.05$). The means of both groups were significantly shorter at the end of the exercise program than at the beginning.

*** Table 2 near here ***

Table 3 shows the means of change-rates after 1 year, standard deviations, and the results of the t-test for each test. The TUG test mean was significantly lower in the pre-frail elderly group than in the control group ($t = 2.01$, $p < 0.05$). Differences between both groups for grip strength ($t = 0.25$, $p > 0.05$), 5-meter walking time ($t = 1.30$, $p > 0.05$), and one-legged balance with eyes open tests ($t = 0.53$, $p > 0.05$) were insignificant.

*** Table 3 near here ***

Discussion

The present study clarifies the effects of participation in the exercise program for 1-year on physical functions of pre-frail elderly individuals from a comparison with a healthy elderly group. Generally, physical functions of elderly individuals decrease with age. [13—15] In particular, the decrease in leg strength, balance ability, and flexibility is common.[16] Balance ability markedly decreases in individuals over 75 years of age.[17] Leg strength and walking function are important to gauge the extent of nursing care requirements. It was reported that a decrease in muscle mass, mobility, and balance ability is related to weakness in elderly individuals.[18,19]

Grip strength is a simples and safe test of muscle strength. Furthermore, it is highly

related with back and leg strength.[20] Al-Snih et al. reported that grip strength test is an independent predictive factor for activities of daily living (ADL) disability, and is effective for risk assessment of ADL.[21] In short, although grip strength relates to upper limb strength, it is an index that reflects the strength of the entire body.[21] Also, the usefulness and significance of grip strength measurement is reported.[21] Additionally, according to Guralnik et al. and Visser et al. mobility limitation is an index reflecting the difficulty of basic daily movements such as walking, stair-climbing, and standing from a seated position; a decrease of leg strength contributes strongly to limiting mobility.[22,23] According to Seino et al. mobility limitation can be evaluated by grip strength, but their relationship is less in females than in males.[24] They reported that grip strength does not reflect a decrease in basic mobility and leg strength in females as compared with males.[24] Kinugasa et al. reported that among elderly people over 70 years of age who participated in "Tokyo's skillful examinations," participants with a lower score on the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence (assuming a low strength) had low scores across the tests (knee extension strength, flexibility of trunk flexion, functional reach, usual walking, maximum walking, and 400 m walking) except for grip strength.[25] No difference was recorded between the pre-frail elderly group and the control group for grip strength in the present study. Because arms and hands are frequently used in daily activities such as eating and toilet movements, it is inferred that grip strength does not decrease significantly.

Bohannon et al. reported that the holding time of one-legged balance with eyes open test decreased after 60 years of age and decreased further markedly in the elderly group older than 70 years of age.[26] Lord et al. reported that when community-dwelling elderly individuals aged 60–85 performed strength and balance exercises twice weekly for 1 h over a 1-year period, their postural sway during static standing improved significantly.[27] Kadoya and Maruyama. also reported that leg strength and balance ability of the elderly (Mean age 72.4 years) participating in classroom muscle strength reinforcement continuously for more than 3 years showed significant improvements.[28] Murata et al. reported that if the elderly can hold a one-legged balance with eyes open for 30 seconds, they can prevent falls.[29] The present results however report a significant difference in the one-legged balance with eyes open test; the control group could stand for more than 30 seconds; however, the pre-frail elderly group balance time could stand for less than 20 seconds. The one-legged balance with eyes open test may be an effective estimate if the risk of falls in elderly individuals. In addition, the effect of participation in the exercise program for 1 year was not found in the one-legged balance with eyes open test. For this reason, the following is considered: the exercise program used in this study emphasized safety, and therefore the exercise intensity was low. This point requires further investigation.

Walking ability declines after the age of 75 and 60 in men and women, respectively.[30] It was reported that the onset of functional decrease is earlier in women

than in men.[30] Walking ability is an estimate of instrumental activity of daily living (IADL), death risk, and nursing home admission[22,31,32]; it is used to evaluate the effects of care prevention exercise programs. The present result showed that the 5-meter walking time test significantly improved after 1year in both groups.

The TUG test is different from the 5-meter walking time test; it contains not only the walking movement but also movements such as rising from a chair, walking conversion, and seating behavior.[12] Therefore, it is a complex movement for elderly individuals.[12] This test reflects walking ability, leg strength, balance ability (balance), and ADL of the elderly; high test reliability and validity have been reported. [12,33,34] The present results showed that the pre-frail elderly group tested low on the TUG test before and after the exercise program. However, it improved after 1 year only in the pre-frail elderly group. The pre-frail elderly group showed a significant improvement in change-rates compared with the control group. Hess et al. reported that when community-dwelling elderly individuals aged over 75 years carried out leg strength exercises for 10 weeks,

the Berg's balance scale and the TUG test improved significantly.[35] Takimoto et al. measured physical fitness before and after the exercise program to examine the effect of exercise in the participation of an exercise classroom twice weekly for 3 months.[6] They reported an improvement in the maximum knee extension strength, one-legged balance with eyes open, TUG, and 10 m walking time. [6] This is because elderly participants with lower total physical fitness score before the exercise program showed significant

improvement, the exercise effect is found in those with low physical fitness. The result of change-rates of TUG in the present study was similar to the report by Takimoto *et al*.

From the aforementioned data, pre-frail elderly individuals experienced improvements in their walking and mobility abilities, but not in balance ability, by participating in the preventive exercise program for 1 year. It is important for pre-frail elderly individuals to improve their balance ability to prevent falls. Hence, it is necessary to examine the existing exercise programs and improve them. The exercise program intensity is a major factor that determines the effect of optimal exercise guidance as an intervention. In cases where it is difficult to increase the exercise intensity, it may be important to design an exercise program that considers exercise frequency and duration to increase the effects of exercise.

The present study comprised 28 pre-frail and 28 healthy elderly female participants in the regional exercise program for care prevention for a 1-year period. Because of the difficulty of having the same participants for 1 year, it is necessary to adequately examine the effect of the aforementioned program by using as many participants as possible. In addition, the study only assessed female participants with only four items assessing physical function tests. Therefore, novel insight may be obtained by examining the effects of the above exercise program using male pre-frail elderly and many physical function tests.

In conclusion, pre-frail elderly participants scored poorly in one-legged balance

with eyes open and TUG tests compared with the control group. Pre-frail elderly individuals can enhance their performance in the TUG and 5-minute walking tests by participating in exercise programs for 1 year and obtain greater exercise effect in the TUG test than the healthy elderly group.

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Disclosure statement

The authors declare no conflict of interest.

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Table 1. Physical characteristics of participants

	Healthy elderly[a] Mean ± SD		Pre-frail elderly[b] Mean ± SD		t-value	p-value	Effect size
Age (years)	75.3	5.3	78.2	6.4	1.86	0.07	0.50
Height (cm)	152.3	4.1	150.0	5.5	1.78	0.08	0.47
Weight (kg)	50.9	5.6	48.7	7.2	1.28	0.21	0.34
BMI	21.8	2.5	21.7	3.1	1.53	0.95	0.41

note) [a]: n = 28, [b]: n = 28, SD: standard deviation

Table 2. Mean, standard deviation of physical function tests by group and period, results of two-way ANOVA, and multiple comparisons

	Healthy elderly		Pre-frail elderly			Two-way ANOVA				Multiple comparison	
	Mean± SD		Mean± SD		Factor	df	F value	p value	η^2	Healthy/Pre-frail	period
Grip strength (kg)					Group	1	2.86	0.09	0.05		
Beginning	19.2	4.6	17.3	4.6	Error	54	40.26				
End	19.2	4.6	17.1	4.4	Period	1	1.30	0.58	0.01		
					interaction	1	0.34	0.56	0.01		
					Error	54	1.50				
One-legged balance with eyes open(sec)					Group	1	8.91	0.01*	0.14	Healthy＞Pre-frail	
Beginning	31.3	23.0	15.2	13.6	Error	54	702.36				
End	33.6	22.8	19.8	19.3	Period	1	3.29	0.07	0.06		
					Interaction	1	0.38	0.53	0.01		
					Error	54	101.06				
five-meter walking time (sec)					Group	1	3.42	0.07	0.06		Beginning＞End
Beginning	4.4	0.7	4.8	1.2	Error	54	1.47				
End	3.9	0.7	4.3	1.0	Period	1	21.62	0.01*	0.29		
					Interaction	1	0.26	0.60	0.01		
					Error	54	0.33				
Timed up & go(sec)					Group	1	8.23	0.01*	0.13	Healthy＜Pre-frail	Pre-frail:
Beginning	7.2	1.6	8.9	2.5	Error	54	6.12				Beginning＞End
End	7.0	1.6	8.0	1.7	Period	1	10.42	0.01*	0.16		Healthy: ns
					Interaction	1	4.43	0.04*	0.08		
					Error	54	0.77				

note）M: Mean, SD: standard deviation, df: degree of freedom, η^2: effect size, *: $p<0.05$

Healthy＞Pre-frail: The healthy elderly shows significantly larger results than pre-frail elderly.

Healthy＜Pre-frail: The healthy elderly shows significantly smaller results than the pre-frail elderly.

Beginning＞End: The beginning of the exercise program shows significantly greater results than the end of the exercise program.

ns: not significant

Table3. Means and standard deviations of the change-rate of physical function tests in the healthy and pre-frail groups

	Healthy elderly[a] Mean±SD		Pre-frail elderly[b] Mean±SD		t-value	p-value	Effect size
Grip strength	1.01	0.88	1.00	0.12	0.25	0.80	0.07
One-legged balance with eyes open	1.30	0.90	1.50	1.10	0.53	0.59	0.14
five-meter walking time	0.88	0.14	0.94	0.20	1.30	0.20	0.35
Timed up & go	0.99	0.17	0.91	0.12	2.01	0.04*	0.54

note) [a]: n = 28, [b]: n = 28, SD: standard deviation, *: $p < 0.05$
The beginning of the exercise program is equal to 1.00.

Appendix1

Ministry of Health, Labour and Welfare, 2012

Basic health check list for those over 65 years in age

Date
Name
Year & date of birth

	No.	Questionnaire	Circle either
1. Daily life	1	"Do you normally travel by bus or train by yourself?"	0 "Yes" 1 "No"
	2	"Do you go out to buy daily necessities by yourself?"	0 "Yes" 1 "No"
	3	"Do you manage your own deposits and savings at the bank?"	0 "Yes" 1 "No"
	4	"Do you often go out to visit friends?"	0 "Yes" 1 "No"
	5	"Do you consult with your family or friends about their problems?"	0 "Yes" 1 "No"
2. Locomotory	6	"Are you able to climb stairs without holding rail or wall?"	0 "Yes" 1 "No"
	7	"Are you able to get off the chair without support?"	0 "Yes" 1 "No"
	8	"Are you able to continuously walk for 15 minutes?"	0 "Yes" 1 "No"
	9	"Have you fallen in the past year?"	1 "Yes" 0 "No"
	10	"Do you worry about falling?"	1 "Yes" 0 "No"
3. Nutrition	11	"Have you lost more than 2–3 kg in the past 6 months?"	1 "Yes" 0 "No"
	12	"Height" __ cm "Weight" __ kg (BMI) ____ (Less than 18.5 of BMI fall under "yes".) ※"BMI" = "weight" (kg) ÷ "height"(m)× "height"(m)	1 "Yes" 0 "No"
4. Oral condition	13	"Compared with six months ago, is it difficult to eat hard foods?"	1 "Yes" 0 "No"
	14	"Do you choke when you drink tea or soup?"	1 "Yes" 0 "No"
	15	"Is there something that is bothering you for your mouth to be dry?"	1 "Yes" 0 "No"
5. Seclusion	16	"Do you go out more than once in a week?"	0 "Yes" 1 "No"
	17	"Compared with last year, do you not go out as often?"	1 "Yes" 0 "No"
6. Forgetfulness	18	"Do people around you complain that you repeat the same thing and have become forgetful?"	1 "Yes" 0 "No"
	19	"Do you make phone calls by yourself?"	0 "Yes" 1 "No"
	20	"Do you find yourself not knowing today's date?"	1 "Yes" 0 "No"
7. Metal problem	21	"In the last two weeks, I have not felt satisfied by my daily life's routine."	1 "Yes" 0 "No"
	22	"In the last two weeks, I have been unable to enjoy the things I once enjoyed."	1 "Yes" 0 "No"
	23	"In the last two weeks, I have been unwilling to do the things I once was more than willing to do."	1 "Yes" 0 "No"
	24	"In the last two weeks, I have thought of myself as being useless to others."	1 "Yes" 0 "No"
	25	"In the last two weeks, I have felt exhausted for no possible reason. "	1 "Yes" 0 "No"