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Specific effects of balance and gait exercises on physical function among the frail elderly

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Objective: To evaluate the specific effects of balance and gait exercises among frail elderly individuals.
Design: A randomized three-group parallel controlled study.
Setting: Geriatric health services facility in Japan.
Subjects: Thirty-four frail elderly subjects attending the care facility were randomized into a control group, an exercise group with emphasis on balance or an exercise group with emphasis on gait re-education.
Interventions: The two exercise groups received balance or gait exercise for 40 minutes, 2–3 times weekly, for 12 weeks.
Main outcome measures: One Leg Standing Test, Functional Reach Test, Manual Perturbation Test, Functional Balance Scale, Performance-Oriented Mobility Assessment, Timed 'Up and Go' Test and Stair Climbing/Descending Test. These assessments were performed before and after 12-week intervention.
Results: Comparison of the performance before and after intervention demonstrated significant improvement in One Leg Standing Test, Functional Reach Test and Functional Balance Scale in the balance exercise group, and Functional Balance Scale, Timed 'Up and Go' Test and Stair Descending Test showed improvement in the gait exercise group. All test items showed no significant differences in the control groups. Among the three groups, the balance exercise group showed more significant improvement in Functional Balance Scale, and the gait exercise group showed more significant improvement in Performance-Oriented Mobility Assessment than the control group. The balance exercise group showed greater improvement in performance in Functional Reach Test than the gait exercise group.
Conclusions: Balance exercises led to improvements in static balance function, and gait exercises resulted in improvements to dynamic balance and gait functions in the very frail elderly.

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Introduction

A great deal of recent research has focused on postural balance and gait function in the elderly, and the effects of interventions targeting these attributes. However, the findings of such research have been mixed, due to differences in types of exercise, duration, frequency and intensity of interventions, and assessment protocols. Some reports have thus described the benefits of exercise,[1–10] while others have found no such benefits.[11–13] Uniform consensus on the effects of such interventions is therefore yet to be achieved.

An extensive range of programmes has been employed to improve balance and gait function, including high-intensity muscle-strengthening exercises,[4,5] low-intensity muscle-strengthening exercises,[10,11] gait exercises,[2,3] balance exercises,[6,8–10] aerobic exercises,[2] relaxation,[12] mental practice,[1] in-home self-directed exercises,[13] patient education[3] and physical therapy.[7] In many cases, combining exercises has amplified the reported benefits. In particular, balance and gait exercises are frequently combined with other forms of exercise, and the specific effects of individual exercises are not clear. Furthermore, falls triggered by decreased balance or gait function are a major cause of fractures in the elderly, and prevention of such falls warrants immediate attention. Interventions suggested by many researchers for preventing falls have included multiple-exercise modalities and comprehensive interventions.[14–17] However, selective intervention is required because frail elderly individuals with decreased physical fitness are unable to accept severe exercise loads. To that end, details of specific, effective exercises are required.

The present study investigated whether a 12-week programme of exercise intervention could improve physical functions among frail elderly subjects in an institutional setting. A secondary objective was to clarify whether improvement in balance or gait function is affected by the kind of exercise undertaken.

Methods

Subjects

A total of 81 ambulatory individual residents in or attending a geriatric health services facility in Japan were recruited to this study. Of these, 34 were admitted as subjects of the study, after excluding 26 candidates with severely impaired physical functions, most of whom have difficulty in walking without a walker, 13 with severe dementia, and 8 who failed to provide informed consent. The mean age of subjects was 80.8 ± 6.6 years (range 67–91 years). The 34 subjects were randomly assigned to the control, balance exercise or gait exercise group (Figure 1). Table 1 shows the baseline individual characteristics of the subjects. The intervention started after all the participants have given informed consent.

Randomization was performed by random permuted blocks within strata. The strata were classified according to ability to walk outdoors without help. And the research was done non-blind because the authors performed both examination and intervention themselves for all the subjects in a physiotherapy room.

Assessment

The subjects' profiles were assessed by age, sex, body height, body weight and intellectual function (Hasegawa's Dementia Scale).[18] The physical function tests described below were performed before and after the intervention.

Balance tests

Balance was assessed using the following battery of tests: One Leg Standing Test, Functional Reach Test,[19] Manual Perturbation Test,[20] Functional Balance Scale[21] and Performance-Oriented Mobility Assessment of gait and balance.[22]

One Leg Standing Test was performed twice for each leg, with eyes open. Outcomes were measured using a stopwatch for a maximum of 30 seconds. Representative values were selected as the longest of four times. Functional Reach Test involved measurement of the maximum distance that the hand could be extended forward. First, the subject flexed one arm to an angle of 90 degrees, while standing with legs about shoulder-width apart. The maximum distance that the arm could be extended forward was determined using

a tape measure. For the Manual Perturbation Test, the response type when the subject's shoulder was pulled backwards was scored at three levels. We prepared the scoring method with reference to the type of response elicited in the Postural Stress Test.[23] A score of 0 was 'Falling response', corresponding to 0–2 points on the Postural Stress Test. A score of 1 point was 'Step response, with patient maintaining erect stance', corresponding to 3–6 points on the Postural Stress Test. A score of 2 was 'Able to maintain erect stance in position', corresponding to 7–9 points on the Postural Stress Test. Functional Balance Scale and Performance-Oriented Mobility Assessment involved assessment of stability and safety when in static and dynamic positions. Assessment items included standing up, sitting down, maintenance of standing posture, turning movement, transfer and walking. Functional Balance Scale was evaluated in five grades, and

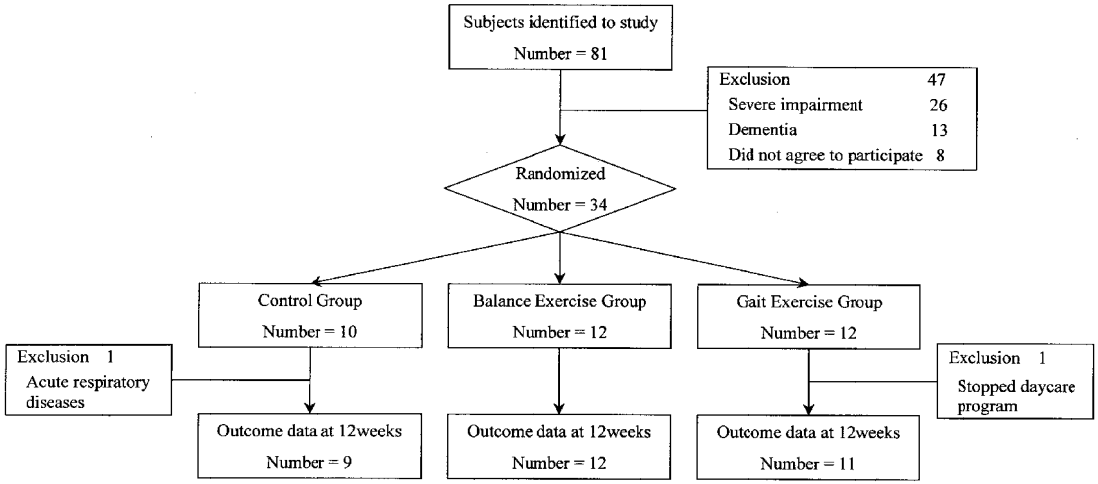

Figure 1 Flow of patients through the study.

Table 1 Baseline characteristics of the subjects

	Control (n = 10)	Balance exercise (n = 12)	Gait exercise (n = 12)	p-value
Age (year)[a]	83.6 (5.7)	79.9 (5.9)	79.3 (7.6)	0.267
Gender (number of women)	7	10	12	0.137
Residence (number)				0.221
Community-dwelling	4	9	8	
Institutionalized	6	3	4	
Height (cm)[a]	144.5 (10.1)	143.8 (8.9)	142.3 (4.0)	0.799
Weight (kg)[a]	52.4 (11.5)	46.8 (9.1)	46.4 (5.2)	0.231
Mental status (Hasegawa's dementia scale)[a]	16.7 (6.3)	21.2 (6.9)	17.0 (8.9)	0.296
Outdoor walking without help (number)	5	7	6	0.897
Use of cane or walker (number)	5	8	8	0.660
Disease (number)				
Stroke	1	3	5	0.243
Osteoarthritis of knee	1	2	1	0.801
Other orthopaedic diseases	3	0	2	0.137
Nothing	5	7	4	0.460

[a]Mean (standard deviation).

Performance-Oriented Mobility Assessment in 2 or 3 grades.

Gait tests

The gait test employed was the Timed 'Up and Go' Test.[24] The applied walking assessment was the Stair Climbing/Descending test.

The Timed 'Up and Go' Test involved stopwatch measurement of the time taken for a return trip to a pole placed 5 m ahead, with the subject starting from a seated position in a chair. The Stair Climbing/Descending test involved stopwatch measurement of the time taken to climb and descend five 15-cm steps. For each test, the subject was asked to walk as quickly as possible.

Intervention

The study was initiated at the same time for all subjects. In the balance exercise and gait exercise groups, exercise interventions were performed for 40 minutes per session 2–3 times weekly, under the guidance of a qualified physiotherapist, for 12 weeks. Interventions in the balance exercise group comprised 30 repeated forward reaching exercises, 10 minutes of centre-of-mass movement using a balance board, 5 minutes of one leg standing, and 5 minutes of tandem standing. Interventions in the gait exercise group comprised 10 minutes of continuous walking, 10 return trips of stair climbing and descending, 5 minutes of tandem walking and 5 minutes of walking sideways. A physiotherapist adjusted the amount of exercise according to the subject's level of physical function, to provide the optimal amount of exercise to each subject.

Subjects in the control, balance exercise and gait exercise groups continued physiotherapy (range of motion and muscle-strengthening exercises) and group exercise (rhythmic movement and stretching exercise in the seated position) programmes that they had been undertaking before intervention.

Statistical analysis

To investigate the specific effects of exercise, we compared the same outcomes between the balance exercise and gait exercise groups. The Wilcoxon signed rank test was used for statistical analyses.

In order to investigate the effects of exercise on physical function in the frail elderly, we compared change ratio of outcomes among the control, balance exercise and gait exercise groups obtained before and after intervention. For comparison a Kruskal–Wallis one-way analysis of variance test was applied. The Mann–Whitney test was used for post-hoc analysis.

Applying SPSS version 10.0 for statistical analyses, we considered differences of two-tailed $p < 0.05$ as statistically significant.

Results

Adherence to exercise

Two of the 34 subjects were unable to complete the study. One individual in the control group was excluded because of a sharp decrease in physical function following acute respiratory disease. The other individual, from the gait exercise group, was unavailable for retesting as he had no longer attended the institution. Subsequent analysis was therefore performed for 32 subjects, with overall adherence to the exercise programme at 94%.

Effects of exercise on balance and gait function (Table 2)

When comparing measurement items before and after intervention in each group, the balance exercise group showed significant functional improvement in One Leg Standing Test, Functional Reach Test and Functional Balance Scale. And Functional Balance Scale, Timed 'Up and Go' Test, and Stair Descending Test showed significant improvement in the gait exercise group. All test items showed no significant differences in the control group.

Comparison of physical performance among the three groups revealed significant differences in Functional Reach Test, Functional Balance Scale and Performance-Oriented Mobility Assessment. When comparing control and balance exercise groups for post-hoc analysis, the latter showed more significant improvement in Functional Balance Scale, and in comparison between gait exercise and control groups, the former showed more significant improvement in Performance-Oriented Mobility Assessment than

Table 2 Comparison of physical performances among control, balance exercise and gait exercise groups

	Control (n = 9)			Balance exercise (n = 12)			Gait exercise (n = 11)			
	Baseline Mean (SD)	Post-intervention Mean (SD)	% change Mean	Baseline Mean (SD)	Post-intervention Mean (SD)	% change Mean	Baseline Mean (SD)	Post-intervention Mean (SD)	% change Mean	p-value‡
OLS (s)	3.1 (3.2)	5.5 (6.0)	+61.8	4.0 (4.1)	8.2 (9.9)*	+123.6	4.3 (5.7)	5.2 (5.2)	+40.7	0.389
FRT (cm)	18.6 (6.4)	18.6 (6.8)	+2.7	18.7 (5.7)	22.7 (4.4)*	+30.3	16.3 (6.4)	15.0 (6.5)	–7.4	0.022¶
MPT (point)	1.7 (0.5)	1.9 (0.3)	+11.1	1.8 (0.5)	1.8 (0.6)	+8.3	1.8 (0.6)	1.6 (0.8)	0.0	0.855
FBS (point)	50.0 (5.8)	50.3 (5.0)	–0.1	48.8 (6.0)	51.1 (5.5)†	+5.0	45.8 (8.9)	48.3 (8.4)†	+5.4	0.036§
POMA (point)	26.8 (2.1)	26.4 (2.6)	–2.6	25.5 (3.9)	25.4 (4.1)	–0.2	24.0 (5.1)	24.9 (5.2)	+4.0	0.140‖
TUG (s)	19.3 (9.2)	17.0 (4.9)	–0.7	24.8 (20.0)	20.4 (11.0)	–8.9	32.6 (30.4)	26.2 (23.0)*	–11.7	0.255
SC (s)	7.6 (5.4)	5.7 (2.1)	–3.8	7.5 (6.7)	5.3 (2.4)	–9.0	8.3 (7.6)	6.2 (3.7)	–14.3	0.785
SD (s)	8.3 (6.0)	6.8 (3.8)	–10.0	7.1 (5.2)	5.3 (2.6)	–14.6	9.4 (7.7)	6.4 (4.0)*	–22.6	0.580

*$p < 0.05$; †$p < 0.01$ results of comparison between baseline and post-intervention in each group.
‡Results of comparison of functional change (% change) among three groups.
§Significant difference ($p < 0.05$) between control and balance exercise groups.
‖Significant difference ($p < 0.05$) between control and gait exercise groups.
¶Significant difference ($p < 0.05$) between balance and gait exercise groups.
OLS, One Leg Standing test; MPT, Manual Perturbation Test; FRT, Functional Reach Test; TUG, Timed 'Up and Go' Test; FBS, Functional Balance Scale; POMA, Performance Oriented Mobility Assessment; SC Stair Climbing; SD, Stair Descending.

the latter. When balance exercise and gait exercise groups were compared, the former had more improved performance in Functional Reach Test.

Discussion

Numerous situations exist in which high-intensity exercise for the frail elderly is not feasible, given concerns such as the risks of exercise and lack of motivation. Therefore, it is very important to determine more effective types of exercise for frail elderly persons.

This study revealed that exercise intervention improves physical function in the institutional setting. The exercises performed in the present research had several advantages: they can be implemented in numerous institutions because they do not involve the use of expensive equipments; level of intensity is relatively low; and the exercise instructions are easy to understand. Most ambulatory elderly individuals were therefore able to perform these exercises, which appear to have resulted in widespread benefit. Demonstrating the effects of the exercise programme, many test values improved significantly after 12 weeks of exercise intervention in the balance exercise and gait exercise groups. Even among the frail elderly individuals who are the focus of maintenance-phase rehabilitation, such as our subjects, it is evident that exercise-induced improvements in function can be achieved. Improvements were noted in test items for balance function (One Leg Standing Test, Functional Reach Test), comprehensive balance function (Functional Balance Scale), gait function (Timed 'Up and Go' Test), and applied gait (Stair Descending Test). As these items include most physical functions needed for activities of daily living, the programme utilized in this study seems to be helpful for living a better life without help. The efficacy of providing exercise intervention was confirmed by the absence of changes in any test item in the control group. And the comparison between groups showed that Functional Balance Scale and Performance-Oriented Mobility Assessment are useful tools for evaluating comprehensive balance function largely improved by exercise intervention. The balance exercise group exhibited better performance in Functional Reach Test than the gait exercise group, and the importance of balance exercise was re-evaluated to improve balance function.

Clinical messages

- Simple exercises that can be performed without the need for equipment led to improved balance and gait functions in frail elderly subjects.
- Specific benefits were observed: balance exercises resulted in improvements to static balance function, and gait exercises led to improvements in dynamic balance and gait functions.

In this study both the balance exercise and gait exercise groups exhibited improvements in the tests relevant to the exercises undertaken. One Leg Standing Test and Functional Reach Test displayed improvements in the balance exercise group, and were included as exercises in the programmes. Hence, improvement in these items may well have been direct manifestations of the effects of exercise. Analysis of mean scores for the Functional Balance Scale subcategories revealed marked improvements in static balance items such as standing with feet together and one legged standing.[25] On the other hand, improvements in Timed 'Up and Go' Test and Stair Descending Test in the gait exercise group appear to have been direct effects corresponding to the nature of the exercise. Analysis of mean scores of the Functional Balance Scale subcategory revealed improvements in scores for picking up objects from the floor, turning 360 degrees, alternate steps to stool, and one-leg standing.[25] In the balance exercise group, comparison of the Functional Balance Scale subcategory, which showed marked improvement, involved dynamic indicators for which a large movement of the centre of mass was needed to accomplish the task.

Among previous researches into the relationship between type of exercise and functional improvement, some studies have reported that gait exercises improved diverse factors including gait and balance functions.[26,27] In contrast, other studies have reported that composite exercises are more useful than balance and gait exercise

only.[28,29] Yet other reports have noted that balance exercises are necessary to achieve improvement of balance functions, and that balance function does not improve with only muscle strengthening and aerobic exercise.[30,31] The balance and gait exercises delivered in the present study resulted in improved balance function in the balance exercise group and improved gait function in the gait exercise group. This suggests that improvement of balance and gait function depends on the exercises undertaken.

This study alone cannot explain the effect of the balance and gait exercises due to the small number of samples and nonblinding. Therefore, our future task is to use a wider range of exercises, and to increase sample size in order to ascertain a better outcome.

In conclusion, exercise intervention was found to be effective for frail elderly subjects. In addition, specific effects corresponding to particular exercises were observed to result in improvements to balance and gait function. When prescribing an exercise programme, thorough evaluation of the individual's balance and gait function is therefore important, to ensure that the content of the exercise programme corresponds to the functional deficits. This will allow effective and efficient improvement of function to be obtained.

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