

Low-frequency group exercise improved the motor functions of community-dwelling elderly people in a rural area when combined with home exercise with self-monitoring

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Abstract.

[Purpose] This study examined whether low-frequency group exercise improved the motor functions of community-dwelling elderly people in a rural area when combined with home exercise with self-monitoring.

[Subjects] The subjects were community-dwelling elderly people in a rural area of Japan.

[Methods] One group (n = 50) performed group exercise combined with home exercise with self-monitoring. Another group (n = 37) performed group exercise only. Low-frequency group exercise (warm-up, exercises for motor functions, and cool-down) was performed in seven 40 to 70-minute sessions over 9 weeks by both groups. Five items of motor functions were assessed before and after the intervention.

[Results] Significant interactions were observed between groups and assessment times for all motor functions. Improvements in motor functions were significantly greater in the group that performed group exercise combined with home exercise with self-monitoring than in the group that performed group exercise only. Post-hoc comparisons revealed significant differences in 3 items of motor functions. No significant improvements were observed in motor functions in the group that performed group exercise only.

[Conclusions] Group exercise combined with home exercise with self-monitoring improved motor functions in the setting of low-frequency group exercise for community-dwelling elderly people in a rural area.

Key words: motor functions, rural area, self-monitoring

INTRODUCTION

Interventions have been implemented to improve motor functions among community-dwelling elderly people, and their effectiveness has been examined in North America since the 1990s. Gillespie et al.¹⁾ reported in their Cochrane systematic review that exercise programs were important factors for decreasing the fall rates of community-dwelling elderly people. Reductions in motor functions (muscle strength and balance) have previously been identified as risk factors of falls²⁾, the risk of which was decreased by an intervention that improved motor functions³⁾. Buchner et al.³⁾ and Hornbrook et al.⁴⁾ demonstrated that high-strength muscle training (6 months, 3 times a week) for the lower limbs was also effective. Most interventions to improve motor functions have consisted of 2–3 sessions per week or more, covered a period of 6 months to one year, and were provided by employed service instructors. However, difficulties have been associated with securing sufficient human resources to provide these services in rural areas, in which depopulation and aging advance together. Even if service providers can be employed, the transportation network of these communities is often insufficient, and travelling to the service center on a regular basis to receive instructions represents a challenge for elderly people. Therefore, motor functions of the elderly need to be improved using low-frequency interventions. This study examined the effectiveness of low-frequency group exercise which was combined with home exercise and self-monitoring, in a rural area.

Self-monitoring assists in the formation and maintenance of healthy behaviors by enabling self-reinforcement through concrete and objective assessments of the self, including observations or using devices that record behaviors and feelings.⁵⁾ Baker⁶⁾ previously reported that self-monitoring was effective as part of an exercise-based weight-loss program for health enhancements. Braveta et al.⁷⁾ also reported that self-monitoring using a pedometer improved physical activity. Based on these findings, self-monitoring is expected to be a useful technique for improving the psychological condition of subjects, especially under conditions in which only minimal interventions are available by the service provider.

Therefore, the main aim of the present study was to examine whether low-frequency group exercise combined with home exercise and self-monitoring improved the motor functions of the community-dwelling elderly people of a rural area.

SUBJECTS AND METHODS

Subjects consisted of community-dwelling elderly people aged 65 years or older who were recruited with the cooperation of the Murakami City Senior Citizens Clubs (2,999 members). The 130 subjects responded to announcements made by the clubs to all members, and the secretariat of the clubs subsequently created a subject list. The subjects were recruited in two different years. The group recruited in 2013 performed low-frequency group exercise and home exercise, combined with self-monitoring for motor functions (GHE-SM group), while the group recruited in 2012 performed low-frequency group exercise alone (GE group). The GE group was recruited in March 2012 and the GHE-SM group was recruited in March 2013, to prevent overlap of subjects in the two groups. At the time of the recruitment, subjects were not informed as to whether they would be using self-monitoring.

One hundred thirty subjects participated in this study. Ten subjects were subsequently excluded due to disabilities associated with ambulation and/or motor functions. In the GHE-SM group, 68 subjects applied and 50 subjects completed the intervention including home exercise, self-monitoring, and assessments: 5 subjects withdrew and the attendance of 13 subjects was poor. In the GE group, 52 subjects applied, 42 subjects completed the exercise, and 37 subjects were analyzed because 5 subjects could not attend the assessment at the endpoint. All subjects were independent in their daily life, and were able to go out from their own houses. Applicants with disabilities and impaired ambulation were excluded, including those who used a cane, had paralysis due to cerebrovascular disorders, and arthralgia due to rheumatoid arthritis (Figure 1).

The low-frequency group exercise was performed in 7 sessions (40–70 min per session; Figure 2) over a

period of 9 weeks and required the subjects to come to the facility. Motor functions were assessed before and after the 9-week intervention period, but not during it. Group exercise was performed by all members who participated on that day, and consisted of a warm-up, exercises for motor functions, and a cool-down. The same physical therapist instructed the exercises throughout the study. The group exercise consisted of ten exercises targeting the trunk and leg muscles, which are necessary for essential movements such as walking or standing up, and were taken from the 19 exercises described previously by Fiatarone et al.⁸⁾ The effectiveness of the ten exercises was previously demonstrated in the Japanese Onishi model.⁹⁾ The intensity of the exercise was set at a moderate strength (perceived as somewhat hard) according to the Rating of Perceived Exertion scale by Borg.¹⁰⁾ Exercise intensity was adjusted using weights. The subjects started with eight different exercises, doing one set for each, and then gradually increased the number of sets by session 3, adding two more exercises by session 4 (Figure 2). In the final two sessions (6 and 7), subjects performed two sets of ten different exercises. The exercise time was gradually increased because the content of the session was different (Figure 2).

The subjects in the GHE-SM group were instructed to perform the group exercise menu at home over a period of nine weeks and record the degree of compliance of the exercise on self-monitoring forms. Self-monitoring forms were partially changed from the manual¹¹⁾ issued by the Ministry of Health, Labour and Welfare of Japan. Subjects were instructed to take records every day. The number of sets and kinds of exercises performed at home were set beforehand and subjects were instructed to record the degree of compliance of the exercise using four levels (Self-monitoring score): "4" performed the entire exercise, "3" performed more than half of the exercise, "2" performed less than half of the exercise, and "1" did not perform any exercise. Self-monitoring records were checked by the same staff before the group exercise. When subjects were unable to perform the home exercise on a given day, subjects noted the reasons why. Instructions on the methods of home exercise were provided individually.

Age and gender were recorded, activities of daily living were assessed using the Tokyo Metropolitan

Institute of Gerontology Index of Competence (TMIG-IC)¹²⁾, and physical activity habits were collected by questionnaire. Motor functions were assessed two times: before the intervention, as a baseline, and within two weeks of the end of the intervention. Trained staff measured motor functions, but were not blinded to the group allocation. In reference to the assessment standard of the manual¹¹⁾ issued by the Ministry of Health, Labour and Welfare, the following assessments of motor functions were performed: knee extension muscle strength (Muscle), standing on one leg with eyes open (Standing), functional reach (FR),¹³⁾ the timed “Up and Go” test (TUG),¹⁴⁾ and 5-m normal walk time (Walking).¹⁵⁾ All five items were measured twice in order to optimize the data. The upper limit of the Standing was set as 120 seconds. Two measurements were performed on the same leg. The assessment of Muscle was performed using an isometric method, as in the preliminary study.¹⁶⁾ Footedness (preferred leg) was determined as the leg used for better ball-kicking. Higher values were used for Muscle, Standing, and FR, and lower values for TUG and Walking.

Statistical analysis was performed using the *t*-test for age, Wilcoxon’s signed-rank test for TMIG-IC, and the Chi-squared test for gender. Pre-intervention assessments were compared between two groups using Student’s *t*-test in order to identify differences at baseline. Differences between the GHE-SM and GE groups were examined by repeated analysis of variance with age and gender as covariates (ANCOVA). The primary analysis was a per protocol analysis. The intention-to-treat (ITT) analysis was conducted using the baseline observation carried forward (BOCF) technique. The Bonferroni method was used for post-hoc tests. All statistical tests were computed using SPSS for Windows Version 22.

The study design conformed to the Helsinki Declaration and was approved by the Ethical Review Board of the Niigata University of Rehabilitation (Approval number 36). Written informed consent was obtained from all subjects before the intervention.

RESULTS

No significant differences were observed in the attributes of the subjects or in the pre-intervention assessment scores of the two groups (Table 1).

Table 2 shows measurement values at the baseline and endpoint of each motor function item. All the different aspects of motor functions showed significant interactions between the groups (GHE-SM vs. GE group) and assessments (before vs. after the intervention). Significantly greater improvements in motor functions were observed in the GHE-SM group than in the GE group [Muscle: $F(1,83) = 6.59, P = 0.01$; Standing: $F(1,83) = 4.32, P = 0.04$; FR: $F(1,83) = 13.50, P < 0.01$, TUG: $F(1,83) = 4.47, P = 0.04$; Walking: $F(1,83) = 5.72, P = 0.02$]. Post-hoc comparisons revealed significant differences between before and after the intervention in FR ($P < 0.01$), TUG ($P = 0.01$), and Walking ($P = 0.02$) in the GHE-SM group, while none of the motor function items showed any significant differences in the GE group. The ITT analysis, using 68 subjects in the GHE-SM group and 52 subjects in the GE group, showed similar results to the per protocol analysis: [Muscle: $F(1,116) = 6.32, P = 0.01$; Standing: $F(1,116) = 4.21, P = 0.04$; FR: $F(1,116) = 12.88, P < 0.01$, TUG: $F(1,116) = 4.58, P = 0.03$; Walking: $F(1,116) = 5.93, P = 0.02$].

DISCUSSION

The present study confirmed that low-frequency group exercise was effective when combined with home exercise with self-monitoring. This result beneficially improved the motor functions of the community-dwelling elderly people of a rural area. The subjects of this study were health conscious and comprised healthy elderly people who were still participating actively in various exercises. The results of this study and their implications are discussed below.

Since no significant differences were observed in age, gender, activities of daily living (TMIG-IC), occurrence of falls, or motor functions at the baseline between the two groups, the observed effects in the GHE-SM group were clear. The reliability of the assessment tool for motor functions conducted before and after the intervention has been demonstrated by previous studies.^{14), 17)-21)} All subjects eagerly performed the

exercise program. However, some data were missing due to cancellations, dropouts, and accidental absences from the exercise class. Regarding the imputation of missing data, the baseline data was considered to not change at the endpoint because no or rare attendance was not expected to affect the motor functions of the active elderly subjects during the 9-week intervention. Thus, the intention-to-treat analysis was conducted using BOCF methods. The ITT analysis also showed that significant improvements were achieved in each motor function item in the GHE-SM group. These results reinforced self-monitoring enhancing the effectiveness of GE.

According to Guralnik et al.²²⁾, functional mobility, which includes walking ability or dynamic balance, is an essential factor that determines the independence of elderly people. Supporting and moving the body is easily evaluated by the TUG test, which is known to be highly reliable and its result is related to muscular strength of the lower limbs, balance, and walking ability.^{14),23),24)} In the present study, TUG also improved significantly in the GHE-SM group. This result indicates there were improvements in functional mobility, which manifested as improved muscular strength, balance, and walking ability.

Although both groups participated in group exercise at the facility at the same time with the same low frequency, significant differences were detected in motor functions in the GHE-SM group at the second assessment. These improvements in motor functions led to increased exercise time in the GHE-SM group, which performed home exercise with self-monitoring in addition to group exercise. Subjects in both groups were originally healthy, and this is one of the reasons why improvements were not observed with once-a-week group exercise alone. Additional home exercise with self-monitoring in the GHE-SM group may have contributed to improvements in physical function.

Improvements in the motor functions of subjects in GHE-SM were markedly smaller than those in previous studies, in which 10-60% improvements were reported in muscular strength using heavy loads and a high-frequency program²⁵⁾⁻²⁷⁾. The subjects exercised at home and recorded it regularly. Their frequency of stumbling decreased, and standing became easier; therefore, the low-frequency intervention resulted in

improvements in activities of daily living. The intervention performed by the GHE-SM group led to the formation of physical activity habits and improvements in activities of daily living. In the present study, home exercise with self-monitoring enabled introspection, self-assessment, and self-reinforcement, which allowed home exercise to become an automatic behavior, thereby increasing the amount of exercise performed. This study may have clinical significance in confirming the preventive effects of group exercise combined with home exercise with self-monitoring even when performed at a low frequency by healthy elderly subjects in rural areas with a limited number of specialists.

There were some limitations of the present study. The motor functions of subjects showed relatively high scores at the baseline assessment, which suggests that the current sample of elderly people was healthier than the average elderly population. This may have contributed to acceptance by our subjects and led them to engage in self-monitoring without strong objections. Due to the selection bias of the present study, the effects of these interventions need to be examined with elderly people who have low exercise awareness as well as with frail elderly people, for whom exercise may assist in preventing an increased need for nursing care in the future. The lack of blinding at the assessment of motor functions is another limitation of the study.

Rural areas facing the double burden of depopulation and aging often have difficulties in securing specialized human resources to ensure the mobility of elderly people. Therefore, the development of a useful strategy in this area is essential. The results of the present study suggest that community-dwelling elderly people in a rural area benefit from low-frequency group exercise combined with home exercise with self-monitoring. Furthermore, these programs may improve motor functions in a relatively short period.

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Table 1. Baseline attributes of participants

Attributes	Per-protocol analysis		Intention to treat analysis	
	GHE-SM (n = 50)	GE (n = 37)	GHE-SM (n = 68)	GE (n = 52)
Age, mean ± SD	76.9±5.3	77.1±5.2	76.7±5.1	76.4±5.2
Gender, n				
Male	23	17	27	18
Female	27	20	41	34
TMIG-IC, mean ± SD	12.7±0.9	12.9±0.4	12.7±0.8	12.8±0.5
Physical activity habits (N/A)	22/28	21/16	42/26	27/25
Baseline of motor functions				
Muscle (kg)	24.9±9.2	24.1±4.8	23.1±8.9	23.4±4.5
Standing (s)	58.7±46.1	61.0±44.1	61.0±46.5	64.5±45.1
FR (cm)	29.2±4.0	33.6±4.0	28.9±4.2	33.2±4.1
TUG (s)	7.5±1.2	7.3±1.2	7.5±1.2	7.3±1.2
Walking (s)	3.5±0.6	3.3±0.5	3.4±0.6	3.3±0.4

Statistical analyses: age by the *t*-test; TMIG-IC by Wilcoxon's signed-rank test; gender and physical activity habits by the Chi-squared test; baseline motor functions by Student's *t*-test.

No significant differences were observed in the attributes of the participants or in the pre-intervention assessment scores between the two groups.

Abbreviations: n.s., not significant; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence; N/A, not available/available; s, second; FR, Functional Reach; TUG, timed Up-and-Go; Muscle, muscle strength; Standing, standing on one leg with eyes open; Walking, 5-min walking test

Table 2. Effects of the interventions on the motor functions of both groups

Classification	Mean ± Standard Deviation					
	GHE-SM			GE		
	Before	After	The amount of change	Before	After	The amount of change
Per-protocol analysis	(n = 50)			(n = 37)		
Muscle (kg)**	24.9±9.2	26.5±9.6	1.6±5.6	24.1±4.8	22.9±5.6	-1.2±3.8
Standing (s)*	58.7±46.1	64.3±46.2	5.6±20.3	61.0±44.1	56.6±46.2	-4.4±24.5
FR (cm)**	29.2±4.0	31.8±4.7	2.6±3.9**	33.6±4.0	33.2±4.9	-0.4±3.6
TUG (s)*	7.5±1.2	7.1±1.0	-0.4±0.9*	7.3±1.2	7.3±1.5	0.1±0.9
Walking (s)*	3.5±0.6	3.3±0.4	-0.2±0.6*	3.3±0.45	3.3±0.4	0.0±0.3
Intention to treat analysis	(n = 68)			(n = 52)		
Muscle (kg)*	23.1±8.9	24.3±9.4	1.2±4.8	23.4±4.5	22.6±5.0	-0.8±3.3
Standing (s)*	61.0±46.5	65.1±46.4	4.1±17.5	64.5±45.1	61.4±46.8	-3.1±20.7
FR (cm)**	28.9±4.2	30.8±4.9	1.9±3.5**	33.2±4.1	32.9±4.7	-0.3±3.1
TUG (s)*	7.5±1.2	7.2±1.1	-0.3±0.8*	7.3±1.2	7.4±1.4	0.0±0.8
Walking (s)*	3.4±0.6	3.3±0.5	-0.2±0.5*	3.3±0.4	3.4±0.4	0.0±0.2

Interactions indicate whether differences occurred between groups and assessments: *P < 0.05, **P < 0.01.

The Bonferroni method was used for post-hoc pairwise comparisons: *P<0.05, **P<0.01.

The maximum was measured for the following motor functions: Muscle, Standing, and FR, and 120 seconds was the upper limit for Standing. The minimum time to achieve the task was measured for TUG and Walking.

Abbreviations: FR, Functional Reach; TUG, timed Up-and-Go; Muscle, muscle strength; Standing, standing on one leg with eyes open; Walking, 5-min walking test; GHE-SM, the GH-SM group; GE, the GE group

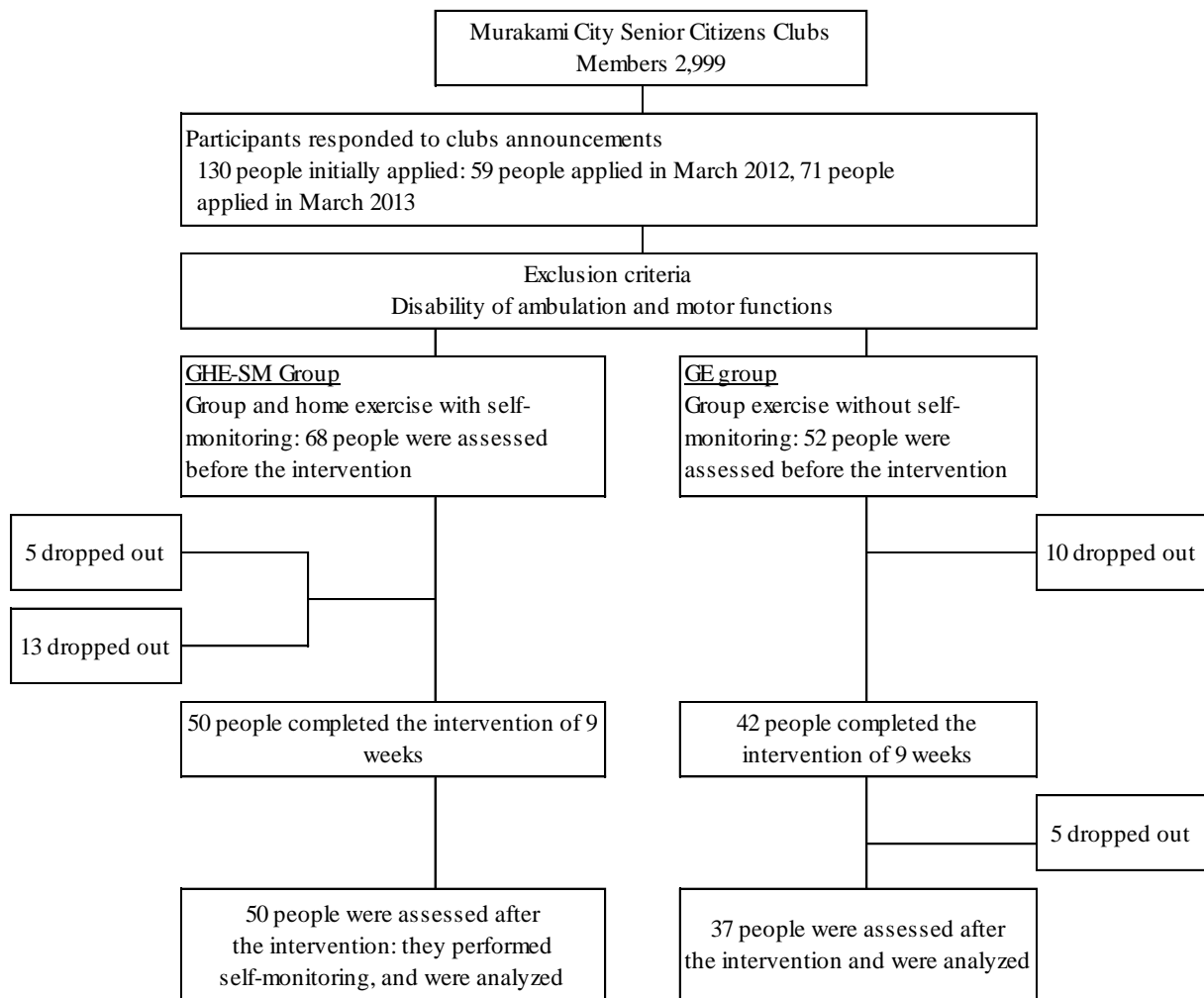


Figure 1. Selection of participants

One hundred thirty people participated in this study. Ten people were subsequently excluded due to disabilities associated with ambulation and/or motor functions. In the GHE-SM group, 68 subjects applied and 50 subjects completed the intervention including home exercise, self-monitoring, and assessments: 5 subjects withdrew and the attendance of 13 subjects was poor. In the GE group, 52 subjects applied, 42 subjects completed the exercise, and 37 subjects were analyzed because 5 subjects could not attend the assessment at the endpoint.

Exercise No.	Exercise program	Session & Sets			
		1-2	3	4-5	6-7
Exercise 1	Flexion and extension of the knee in the sitting position	1*	2	1	2
Exercise 2	Flexion and extension of the shoulder and elbow in the sitting position	1	2	1	2
Exercise 3	Flexion and extension of the ankle in the standing position	1	2	1	2
Exercise 4	Abduction and adduction of the hip in the standing position	1	2	1	2
Exercise 5	Flexion and extension of the knee in the standing position	1	2	1	2
Exercise 6	Abduction and adduction of the shoulder in the sitting position	1	2	1	2
Exercise 7	Extension of the hip in the standing position	1	2	1	2
Exercise 8	Flexion and extension of the hip and knee in the standing position	1	2	1	2
Exercise 9	Squatting	/		1	2
Exercise 10	Sit-up in the sitting position			1	2
Total time (minutes) in each session		40	50	50	70

Figure 2. Group exercise programs

*number of sets performed in each session.

Group exercise programs consisted of a warm-up (10 min), exercises for motor functions (20-40 min), and a cool-down (10 min).