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（要介護高齢者に対する運動介入の効果
～機能訓練に特化した短時間型通所介護の利用効果について～）

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Original Article

The effect of exercise intervention on frail elderly in need of care: half-day program in a senior day-care service facility specializing in functional training

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Abstract. [Purpose] This study investigated the long-term effect of a half-day exercise intervention program on health-related quality of life, life function, and physical function in frail elderly in need of care. The program was conducted at a senior day-care facility specializing in functional training. [Subjects and Methods] Subjects included 41 elderly in need of care who had visited the service facility for at least 1 year. Physical function and life function were evaluated at baseline, 6 months, and 12 months. Quality of life was evaluated with the Short Form-36 at baseline and 12 months. [Results] Improvements in balance, walking speed and endurance, complex performance abilities, self-efficacy during the activities, and the level and sphere of activity were observed at 6 months and maintained up to 12 months. Moreover, improvements in agility, activities of daily living, life function, and quality of life were also observed at 12 months. Improvements in muscle strength, walking ability, self-efficacy over an action, and activities of daily living were related to the improvement in quality of life. [Conclusion] The use of individualized exercise programs developed by physiotherapists led to improvements in activities of daily living and quality of life among elderly in need of care.

Key words: Frail elderly in need of care, Exercise intervention, Health-related QOL

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INTRODUCTION

The ratio of elderly (≥65 years) to non-elderly in Japan was 25.1% in 2013[1)]. The number of elderly in need of care is expected to increase to 5,686,000 in 2015 and 7,020,000 in 2025[2)]. In particular, an increase in the proportion of elderly subjects with disabilities resulting from cerebrovascular disorders or bone and joint diseases is predicted[2)]. Disuse syndrome combined with aging can lead to decreased physical function in the elderly, which in turn leads to frailty[3)]. For example, an elderly subject may experience a decrease in physical function and then become bedridden after a fall. Therefore, countermeasures to prevent falls due to decreased physical function are necessary to prevent frailty. One of these countermeasures could be an exercise intervention program that takes place at senior day-care facilities; this program is paid for by long-term care insurance. Use of day-care facilities is expected to lead to an increase in the level of activity for the elderly due to both increased opportunities for going out and improvements in physical function due to the exercise intervention.

The effects of training intervention in the elderly are well established for muscle power[4–10)], balance function[11–14)], and endurance[15)], but less is known about the effect of this intervention on quality of life (QOL), activities of daily living (ADL), and other activities[7, 14, 16–18)]. Furthermore, most previous studies reported the short-term effectiveness of training

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intervention at 6 months[4–6, 8–11, 13, 16, 19, 20], but few reported on long-term effectiveness at 1 year or longer. In addition, most studies evaluated a uniform exercise program for community-dwelling elderly, though some have also assessed individualized exercise programs developed in response to the level of impairment among the impaired frail elderly[4, 10, 11, 13, 14, 19]. Although the effect of exercise intervention on QOL has been suggested to be related to its effect on physical function or life function, no causal relationship has been established[14, 16–18].

In Japan, senior day-care services are classified into two groups depending on the usage time: half-day programs (3 to 4 hours a day) and full-day programs (6 to 8 hours a day). Recently, some facilities have become specialized in functional training, with programs developed by physiotherapists to maintain or improve the physical function of elderly in need of care. Half-day programs are considered sufficient for an exercise intervention[21].

The purpose of this study was to investigate the long-term effect of a half-day exercise intervention program on health-related QOL, life function, and physical function of the frail elderly in need of care. The program was organized at a senior day-care facility specializing in functional training. We further analyzed the relevance of changes between health-related QOL and life and physical function to identify factors associated with life and physical function that helped maintain and improve QOL.

SUBJECTS AND METHODS

Subjects were 41 elderly in need of care (as certified by municipal governments; 22 females and 19 males, mean age; 72.5 ± 10.1 years) who had visited a senior day-care facility specializing in functional training once or twice a week for at least 1 year. In terms of diagnoses, 15 had cerebrovascular disorders, six had Parkinson's disease, four had backbone compression fracture, three had cervical vertebral diseases, three had lumbar diseases, three had disuse syndrome due to cognitive dysfunction, three had disuse syndrome due to an internal obstacle, two had knee osteoarthritis, one had spino-cerebellar degeneration, and one had a femur neck fracture. As for levels of long-term care required, which is divided into 5 levels of care and 2 levels of support, 10 subjects were certified as support required level 1, 11 as support required level 2, seven as care level 1, seven as care level 2, four as care level 3, and two as care level 4.

After health checks and warm-up exercises, subjects performed an individualized 2-hour self-exercise program designed by physiotherapists based on an evaluation of motor function; all exercises were performed under a physiotherapist's direction. Training machines set at low to intensity were used for muscle function training (rowing, leg press, hip abduction, NuStep® [NuStep Inc., Ann Arbor, MI, USA], etc.). In contrast, balance exercises consisted mostly of suspension exercise therapy[22, 23] set at a moderate level of difficulty. A break was set between each exercise in the individual program based on the state of the subjects. Following a 30-minute break after the individual self-exercise program, the subjects completed a 30-minute group exercise program using slings in the sitting position, mostly for cooling down. Table 1 shows the points of the exercise depending on the clinical diagnoses and nursing care level of each subject. Table 2 shows an example of an exercise program for a patient diagnosed with cervical spondylotic myelopathy.

Physical function and life function were evaluated at baseline, 6 months, and 12 months using the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC)[24], Life-Space Assessment (LSA)[25], Functional Independence Measure (FIM)[26], Fall Efficacy Scale (FES)[27], stick reaction time (RT), grip strength, Functional Reach Test (FRT)[28], one leg standing time (OLS-T), 5 m maximum walking time (5mMWT), 5 m normal walking time (5mWNT), Timed Up & Go Test (TUG)[29], and continuation walking distance (CWD). TMIG-IC, LSA, FIM, and FES were evaluated as life function and the others were evaluated as physical function. Health-related QOL was evaluated using the Short Form-36 v2 (SF-36)[30] at baseline and 12 months. Ethical approval was granted by the Kobe International University Ethics Committee (G2010-005), and written informed consent was obtained from all participants. All studies were conducted at a senior day-care facility. TMIG-IC is a clinical evaluation index of instrumental ADL for elderly people that uses a self-rating questionnaire consisting of five items for instrumental self-maintenance, four items for intellectual motility and four items for social role; total scores range from 0 to 13 points. LSA is a clinical evaluation index for life space determined using a questionnaire on the presence, frequency, and independence level of movement in 5 phases of the life sphere; total scores range from 0 to 120 points and are calculated using an algorithm. FIM is a clinical evaluation index for ADL, evaluating 18 items in 7 areas according to the necessary level of care; total scores range from 18 to 126 points. FES is a clinical evaluation index of confidence of performing without fall, evaluating 10 items in four areas; total scores range from 10 to 40 points. RT is a clinical evaluation index for agility, measuring the length necessary before catching a falling stick. It evaluates reaction time by length, which is short when the response is good. FRT is a clinical evaluation index for dynamic balance, measuring the difference between arm's length and maximal forward reach. OLS-T is a clinical evaluation index for static balance, measuring the time to stand with one leg up to 60 seconds. The 5mWNT and 5mNWT are clinical evaluation indexes for walking ability. TUG is a reliable and valid test for quantifying functional mobility. CWD is a clinical evaluation index for stamina assessed using a questionnaire. SF-36 is a questionnaire assessing general health status. In SF-36, one item is designed to assess perceived change in health status, and each of the remaining 35 items contributes to a score on one of eight subscales: physical functioning (PF), role-physical (RP), bodily pain (BP), general health perception (GH), vitality (VT), social functioning (SF), role-emotional (RE), and mental health (MH).

Changes in physical function and life function were analyzed using Scheffe's multiple comparison test after Friedman's

Table 1. The points of the exercise for establishing the diagnosis and nursing care level for each subject

Clinical diagnosis	Nursing care level (n)	Points of the individualized program
Cerebrovascular disorders	Support-required level 2 (4) Care level 1 (3) Care level 2 (5) Care level 3 (2) Care level 4 (1)	Improvements in the muscle strength of unaffected side and the balance function
Parkinson's disease	Support-required level 1 (1) Support-required level 2 (2) Care level 1 (1) Care level 3 (2)	Adjustment of stooped posture Improvement in the balance function Approach coordinated movement of limbs
Backbone compression fracture	Support-required level 1 (1) Support-required level 2 (3) Care level 1 (1)	Improvements in posture by muscle strengthening of the back and the balance function Exercise to transfer the weight center forward
Cervical vertebrae diseases	Support-required level 1 (1) Care level 2 (1) Care level 4 (1)	Approach upper-limb function and coordinated movement of limbs Improvement in balance function and walking
Lumbar diseases	Support-required level 1 (3)	Improvement in muscle function by muscle strengthening of the trunk and legs Improvement in posture and walking
Disuse syndrome from cognitive dysfunction	Support-required level 2 (1) Care level 1 (2)	Recovery of the motor function decreased due to disuse and inactivity (muscle strength, balance, endurance, walk function)
Disuse syndrome from an internal obstacle	Support-required level 1 (3)	Recovery of the motor function decreased due to disuse and inactivity (muscle strength, balance, endurance, walk function)
Knee osteoarthritis	Support-required level 2 (1) Care level 2 (1)	Improvement in muscle function by muscle strengthening of the lower limb, mainly for knee extension Improvement in the balance function and walking
Spino-cerebellar degeneration	Support-required level 1 (1)	Prevention of the decline of motor function due to inactivity (muscle strengthening, coordination, balance, endurance, walk function)
Femur neck fracture	Support-required level 1 (1)	Exercise which leads to fall prevention (Strengthening of Hip abductor, side step, etc.), Improvement of the balance function, Improvement in walking

Table 2. An example of the exercise program in a patient with cervical spondylotic myelopathy

Health check & self warming up exercise; 30 min		
Individual training; 2 hour	Leg press	Intensity: 35kg, Duration: 5 min, Frequency: 2 set
	Rowing	Intensity: 10.5kg, Duration: 5 min, Frequency: 1 set
	Hip abduction	Intensity: 13.5kg, Duration: 5 min, Frequency: 1 set
	NuStep® recumbent cross trainer	Intensity: 6 level, Target heart rate: 120 bpm, Duration: 10 min, Frequency: 1 set
	Treadmill	Speed: 1.0km/h, Tilting angle: 10-degree, Duration: 10 min, Frequency: 1 set
	Overhead pulley exercise	Duration: 5 min
	Sling exercise	
	One foot standing	Duration: 5 min, Frequency: 1 set
	Step-up exercise	Duration: 5 min, Frequency: 1 set
Break time; 30 min		
Group training; 30 min	Exercise program using a sling in the sitting position mostly for cool-down	

The table shows an example of the half-day program. The executed individual program was an individualized self-exercise program designed by physiotherapists based on an evaluation of the motor function. A training machine was used for muscular exercise and balance training was based on suspension exercise. Muscular exercise was performed at low to intermediate intensity. Balance exercises consisted mostly of a motor task set at a moderate level of difficulty.

test. Subscales of the SF-36 were analyzed using the Wilcoxon signed-rank test. Furthermore, multiple linear regression analysis was conducted using the significant changes on the SF-36 subscales as objective variables and other changes as explanatory variables. Degree of change was used for the analysis of TMIG-IC, LSA, FIM, FSE, and CWD. In contrast, the ratios of change were used for RT, grip strength, FRT, OFS, 5mMWT, 5mNWT, and TUG. A p value<0.05 was considered statistically significant. All statistical analyses were performed using the statistical software EZR[31] (Saitama Medical Center, Jichi Medical University [Saitama, Japan], which is a graphical user interface for R (The R Foundation for Statistical Computing, version 2.13.0 [Vienna, Austria, URL: http://www.R-project.org/]).

RESULTS

TMIG-IC, LSA, FES, FRT, CWD ($p<0.05$), OLS-T, 5mMWT, 5mNWT, and TUG ($p<0.01$) significantly improved at 6 months. TMIG-IC, LSA, FIM, FES, RT, OLS-T ($p<0.05$), FRT, 5mMWT, 5mNWT, TUG, and CWD ($p<0.01$) significantly improved at 12 months (Table 3).

For the subscales of the SF-36, significant improvements at 12 months were observed in PF, RP, BP, GH, and SF (Table 4). Grip strength and 5mMWT were identified as variables influencing a significant change in PF. The multiple correlation coefficient (R) was 0.532 and the coefficient of determination (R^2) of the flexibility adjustment was 0.188 (Table 5). In contrast,

Table 3. Time course of activity and physical function

		Baseline	6 months	12 months
Life function				
Instrumental activities of daily living	TMIG-IC (pt)	7.5 ± 3.5	8.8 ± 3.0 *	8.9 ± 3.1 *
Sphere of activity	LSA (pt)	45.6 ± 20.3	54.3 ± 19.0 *	52.2 ± 19.5 *
Activities of daily living	FIM (pt)	117.9 ± 9.3	118.9 ± 8.6	120.7 ± 6.2 *
Self-efficacy over an action	FES (pt)	26.8 ± 6.9	29.4 ± 6.8 *	28.9 ± 7.5 *
Physical function				
Agility	RT (cm)	27.6 ± 9.3	24.7 ± 8.9	23.6 ± 6.4 *
Muscle strength	Grip strength (kg)	39.7 ± 13.6	40.8 ± 13.2	41.8 ± 13.0
Balance function	FRT (cm)	22.5 ± 5.7	25.8 ± 6.9 *	25.9 ± 6.1 **
	OLS-T (sec)	16.5 ± 20.4	25.2 ± 27.4 **	21.4 ± 22.3 *
Walking ability	5mMWT (sec)	8.6 ± 6.4	7.4 ± 5.4 **	7.2 ± 4.9 **
	5mNWT (sec)	11.1 ± 7.4	9.3 ± 5.9 **	9.1 ± 5.3 **
Functional mobility	TUG (sec)	22.7 ± 16.3	18.4 ± 12.1 **	17.4 ± 11.2 **
Endurance	CWD (pt)	4.5 ± 1.5	5.0 ± 1.3 *	5.1 ± 1.1 **

Average value ± standard deviation.
*Significant difference p<0.05 between baseline and 6 or 12 months later.
**Significant difference p<0.01 between baseline and 6 or 12 months later.
TMIG-IC: Institute of Gerontology Index of Competence, LSA: Life-Space Assessment, FIM: Functional Independence Measure, FES: Fall Efficacy Scale, RT: stick reaction time, grip strength, FRT: Functional Reach Test, OLS-T: one leg standing time, 5mMWT: 5 m maximum walking time, 5mWNT: 5 m normal walking time, TUG: Timed Up & Go Test, CWD: continuation walking distance

Table 4. Change of Short Form-36 subscales at 12 months

	Baseline	12 months
PF: Physical Function (pt)	37.8 ± 22.4	53.1 ± 24.1**
RP: Role Physical (pt)	42.7 ± 35.3	61.6 ± 30.4*
BP: Body Pain (pt)	49.1 ± 26.9	58.8 ± 26.9*
GH: General Health (pt)	43.4 ± 21.0	51.4 ± 23.0**
VT: Vitality (pt)	40.1 ± 24.3	48.4 ± 26.1
SF: Social Functioning (pt)	57.6 ± 32.5	75.3 ± 30.2**
RE: Role Emotional (pt)	54.6 ± 37.5	63.9 ± 35.8
MH: Mental Health (pt)	53.3 ± 25.6	60.1 ± 25.3

Average value ± standard deviation. Wilcoxon signed-rank test.
*Significant difference p<0.05, between baseline and 12 months later.
**Significant difference p<0.01, between baseline and 12 months later.

FIM was shown to influence a significant change in SF (R=0.564; R^2=0.252) (Table 6). Only FES was shown to influence a change in GH (R=0.645; R^2=0.360) (Table 7). No significantly relevant variables were identified for changes in BP or RP.

DISCUSSION

In this study, we revealed that improvements in balance, walking speed and endurance, complex performance abilities, self-efficacy during performance, and an increase in the level and sphere of activity were observed at 6 months and maintained up to 12 months with the use of a half-day exercise program for elderly in need of care at a senior day-care facility specializing in functional training. Moreover, improvements in agility, ADL, and QOL were also observed at 12 months. From these results, the practice of individualized exercise programs designed by physiotherapists was effective at improving physical function, life function, ADL, and QOL for elderly subjects in need of care.

The reasons for the improvements noted in this study were considered as follows: first, the elderly who participated in this study were certified by municipal governments as being in need of care; in other words, they were noted to be staying indoors and prone to secondary hypofunctions accompanying disuse, but were not eligible for medical insurance for rehabilitation services. Therefore, there was scope for improvement in their physical function, which could be achieved by participation in an exercise program.

Second, the exercise programs in this study were individualized according to the necessary tasks, strengths, and difficulty levels of each participant. Although there was no direct comparison between individually programmed exercises and group exercises, a previous study reported that participation in a weekly group exercise program with ancillary home exercises

Table 5. Multiple regression analysis (stepwise method) with Physical Function on the Short-Form 36 as the objective variable

Variable	Partial regression coefficient	Standard error	Standardized partial regression coefficient	Partial regression coefficient 95% confidence interval		VIF
				Lower limit	Upper limit	
Grip strength	0.511	0.202	0.408 *	0.098	0.924	1.092
5mMWT	0.480	0.199	0.394 *	0.074	0.885	1.116
OLS-T	0.371	0.258	0.229	0.155	0.897	1.055
RT	0.133	0.101	0.204	−0.073	0.3394	1.001

ANOVA p<0.01, R=0.532, R^2=0.283. Flexibility adjustment finished R^2=0.188.
*Significant difference p<0.05.
5mMWT: 5 m maximum walking time, OLS-T: one leg standing time, RT: stick reaction time

Table 6. Multiple regression analysis (stepwise method) with Social Functioning on the Short-Form 36 as the objective variable

Variable	Partial regression coefficient	Standard error	Standardized partial regression coefficient	Partial regression coefficient 95% confidence interval		VIF
				Lower limit	Upper limit	
FIM	1.974	0.827	0.371*	0.287	3.662	1.095
5mMWT	−0.517	0.293	−0.278	−1.115	0.081	1.130
OLS-T	0.639	0.374	0.258	0.124	1.402	1.036

ANOVA p<0.01, R=0.564, R^2=0.318. Flexibility adjustment finished R^2=0.252.
*Significant difference p<0.05.
FIM: Functional Independence Measure, 5mMWT: 5 m maximum walking time, OLS-T: one leg standing time

Table 7. Multiple regression analysis (stepwise method) with General Health on the Short-Form 36 as the objective variable

Variable	Partial regression coefficient	Standard error	Standardized partial regression coefficient	Partial regression coefficient 95% confidence interval		VIF
				Lower limit	Upper limit	
FES	1.712	0.422	0.557 **	0.852	2.572	1.000
RT	−0.106	0.064	−0.227	−0.237	0.026	1.014
FRT	0.127	0.084	0.210	−0.043	0.297	1.014

ANOVA p<0.01, R=0.645, R^2=0.416. Flexibility adjustment finished R^2=0.360.
**Significant difference p<0.01.
FES: Fall Efficacy Scale, RT: stick reaction time, grip strength, FRT: Functional Reach Test

could improve balance but not strength, reaction time, walking speed, the physical activity subscale of the SF-36, or fear of falling scales[32] at 6 months. The discrepancy between necessary training and the exercises performed in this study was considered to be less in the individual program than in the group exercise program because the exercise in the former program was designed to match each individual's needs, while that in the latter program was uniform and not every subject could have performed it. As a result, the former is expected to yield better results.

Third, an individualized program composed of both muscle exercises and balance training may increase physical activity and improve physical function and may thus prevent frailty that often occurs among the elderly. The combination of muscle exercises and balance training is essential for improvements in ADL and QOL, as Shimada et al. reported that balance exercises led to improvements in static balance function, and gait exercises resulted in improvements in dynamic balance and gait function in the very frail elderly[13]. Furthermore, the combination of these exercises may increase the subject's confidence regarding performance of an action and expand the number and variety of activities that can be performed. In contrast, the effectiveness of muscle strength enhancement, noted via improvements in physical functional performance such as rise time from chair, TUG, and walking speed for elderly were previously reported by Frontera[4], Fiatarone et al.[5, 6], and in a meta-analysis[7]; however, these improvements disappeared within 6 months after the end of the intervention[5, 6]. Hence, the continuity of an exercise program comprising muscle exercises and balance training may be important to maintain the effectiveness of the program. Regarding the frequency of the exercise, Trappe et al.[33] reported that training at least once a week is necessary for the maintenance of muscle strength. In this study, participants carried out exercises once or twice a week, which was sufficiently frequent for maintenance and improvement of physical function. In addition, although muscle strength training has not been confirmed to lead to an improvement in balance, ADL, or QOL, this study showed for the first time that balance training is useful for improving balance function, as evaluated by the FRT, OLS, and the Berg balance scale[11, 12].

The results of multiple linear regression analyses showed that the improvement in QOL is related to improvements in ADL, walking ability, muscle strength, and self-efficacy in performing an action. QOL might be improved by the improvement in self-efficacy in performing an action[34] led by those in walking ability and ADL[35] led by that of muscle strength after the program. Because improvements in muscle strength, walking ability, self-efficacy over an action, and ADL were related to an improvement in QOL, it is suggested that ADL should be improved and maintained for the improvement in QOL; this can be achieved with a combination of muscle exercise and balance training.

One limitation of this study was that comparisons with a control group that did not undergo any exercise intervention could not be performed. Further investigations are needed to accumulate evidence of higher reliability.

Long-term, individualized exercise interventions designed by physiotherapists for the elderly in need of care are effective in improving ADL and QOL.

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