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Original Article

The effects of low-load resistance training on activity of daily living of elderly individuals requiring daily life assistance

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Abstract

We focused on low-load resistance training (hereinafter simply called "low-load training") as a means of rehabilitation for elderly patients with disuse syndrome. The efficacy of low-load training was compared with that of a conventional group exercise program, and its efficacy was evaluated in relation to the frequency and period of training. In addition, we analyzed the relationship of the efficacy of low-load training to the pre-training baseline level of the ability of exercise in individual patients, and explored the factors affecting improvements in ADL and QOL following the implementation of this kind of training. The subjects of this study were selected from among 467 elderly patients who required daily life assistance and participated in one of three rehabilitation programs (once weekly 6-month group exercise program, once weekly 6-month low-load training program, and twice weekly 3-month low-load training program). Of these 467 patients, 153 were selected for analysis in the present study. That is, 51 patients were assigned to each of the three groups described below, with care taken to make the distribution of age, male-to-female ratio and ADL level as uniform as possible among the three groups. The three groups were: (1) a group participating in a once weekly group exercise program for 6 months, involving antigravitational exercise, (2) a group participating in a once weekly low-load training program for 6 months and (3) a group participating in a twice weekly low-load training program for 3 months. In the latter two groups, exercise with a low load (equivalent to a Borg scale level of 11, an easy exercise level) was performed on 6 kinds of training machines. The efficacy of each program was evaluated on the basis of an exercise performance test and assessments of ADL and QOL. Improvement in gait and the ability to adjust body position was more marked following the once weekly 6-month low-load training than following the once weekly 6-month group exercise program. When the efficacy of low-load training was analyzed by the frequency and period of training, improvement in muscle strength and balance maintenance was more marked following the twice weekly 3-month program than following the once weekly 6-month program. Improvement in ADL among the patients in the twice weekly 3-month low-load training program was found to be affected by three factors: ability to adjust body position, physical flexibility and age. Improvement in QOL among the same patients was affected by two factors: endurance for movement and ability to adjust body position. It was also suggested that even in cases where the baseline ability to adjust body position is low, this ability is quite likely to improve following implementation of this kind of low-load training.

Key words

Low-load resistance training, Elderly individuals requiring daily life assistance, Activity of daily living, 6 kinds of training machines

Department of rehabilitation science, Graduate school of medicine

Introduction

In January 2004, the Study Group on Rehabilitation of the Elderly published a report titled "Desirable Directions for Rehabilitation of the Elderly", in response to a request from the Health and Welfare Bureau for the Elderly, the Ministry of Health, Labour and Welfare[1]. The report dealt with three model groups of elderly individuals (post-stroke patients, patients with disuse syndrome and patients with dementia) who are targets of rehabilitation. It also stated that it is essential to seek appropriate approaches to rehabilitation, based on a thorough understanding of the conditions prevailing in the lives and health of elderly individuals. Past rehabilitation programs have tended to focus on providing care tailored to the features of each particular disease. They did not incorporate concrete means of dealing with the reduced activity level associated with disuse syndrome, which becomes apparent in those of advanced age. There are only a small number of reports, in Japan or elsewhere, written on rehabilitation programs focusing on disuse syndrome. To the author's knowledge, no published reports have dealt with evaluating of the effects of rehabilitation programs in terms of improving the activity levels of these elderly people or the effect rehabilitation programs have on activity of daily living (ADL).

In view of the trend toward an aging population, it has become more and more necessary to develop effective and efficient rehabilitation programs. In 2005, after Japanese governmental initiative, the Committee for the Promotion and Evaluation of Home Care and the Prevention of Disabilities began to implement the Local Community Model Project on Home Care and the Prevention of Disabilities, drawing findings and skills from various related fields[2]. Of all the training programs shown to provide significant improvements in activity levels, 84% involved some devices or machines. The authors therefore reviewed previous studies of training programs for the elderly that made use of devices or machines. Arai et al.[3] reported that training programs using devices/machines reinforced the muscle strength of elderly people requiring daily life assistance and were thus useful for elevating overall physical strength, energy metabolism and so on. Vincent et al.[4] and Hruda et al.[5] also reported on the usefulness of this kind of training for reinforcing the muscle strength of the elderly, and its usefulness in terms of elevating exercise capabilities. Rooks et al.[6] and Buchner et al.[7] reported the usefulness of this kind of training in terms of improving the maintenance of balance. On the other hand, negative views on the effectiveness of this kind of training have been presented by some investigators, including reports by Lord et al.[8] and Singh et al.[9], who found that no improvement in the speed of gait was seen following this kind of training, and a report by Barrett et al.[10] that no improvement in subjective health level was noted. Thus, varying findings have been obtained by different investigators about the efficacy of this kind of training, and no valid method for this kind of training has been established.

Takeuchi[11] proposed a low-load resistance training program (hereinafter called "low-load training") that made use of devices. He undertook studies of this kind of program, and is a pioneer in this field. However, no papers endorsing the efficacy of Takeuchi's method have been published to date. Takeuchi reported that the method he proposed facilitates muscle coordination and improves energy efficiency during activities, leading to improvement in the overall ability to be active and better ADL (activity of daily living) and QOL (quality of life)[11]. In the present study, the author focused on low-load training as a means of rehabilitating elderly patients with disuse syndrome. This study involves the following three forms of analysis, using statistical methods: (1) comparing the efficacy of low-load training with that of a conventional group exercise program, (2) evaluating the efficacy of low-load training in relationship to frequency and period of training, and (2) assessing the effects of low-load training on ADL and QOL.

Subjects

The study involved a preliminary pool of 467 elderly patients requiring daily life assistance. Some of them participated in one of the rehabilitation programs provided within the framework of the Toyama City Functional Rehabilitation Programs, and others attended one of two elderly health promotion facilities or one of two homes for the aged in Toyama City. All subjects were free of cerebrovascular disease, Parkinsonism and severe dementia. Three different rehabilitation programs were provided, and each elderly patient participated in only one of the three programs. Of the 467 patients, 156 attended a once weekly 6-month group exercise program, 89 received once weekly 6-month low-load training and 222 received twice weekly 3-month low-load training. The present study was designed to compare the outcomes of these three programs by analyzing data from a subset of 153 patients drawn from the pool of 467 patients. These subjects were divided into three groups on the basis of the three exercise programs they attended, but each group had a similar age distribution, male-to-female ratio and ADL score distribution. That is, 51 patients were assigned to each of the three groups differing from each other in terms of the rehabilitation program (153 patients in total) in such a manner that each patient assigned to one group was identical to one patient assigned to the second group and one patient assigned to the third group in terms of age category (65-59, 70-74, 75-79, 80-84 or over 85), sex (male/female) and the ADL score as rated by the Barthel index (BI level 60-69, 70-79, 80-89 or over 90). All over the measurement period, the subject who participated in everyday life and different activity removed it from a person of object. Thus, the 153 patients assigned to the three groups were composed of 51 trios identical in the categories of age, sex and BI level. The three rehabilitation programs could thus be analyzed on the basis of data from the three statistically identical groups in terms of age distribution, male-to-female ratio and BI level distribution (see Table 1).

Differences in the efficacies of the three rehabilitation programs (whose features will be described in detail below) were analyzed statistically. Prior to the study, individual patients were told about the design of the study and their consent to be involved in the study was obtained in writing. The author additionally received a permit from the Toyama City Government to collect the data for this study. To protect privacy, the data was kept anonymous (Table 1).

Methods

1. Three rehabilitation programs

(1) Once weekly 6-month group exercise program

This program involves group exercises practiced once weekly for 6 months, emphasizing antigravitational exercises. The exercises are practiced while the participant is sitting in a chair or standing. During the standing exercises, the subject stands straight, with the legs apart at a distance equal to the width of the shoulders, and stands straight, holding onto a support (table, etc.) with both hands, to practice: (1) squatting (slowly

Table 1. Background variables common for the three groups

Sex (No. of subjects)	males	28
	females	23
Age (years)	65-69	9
	70-74	19
	75-79	12
	80-84	6
	Over 85	5
Baseline BI score	60-69	6
	70-79	9
	80-89	12
	90-99	24

51 subjects each for the once weekly 6-month group exercise, once weekly 6-month low-load training and twice weekly 3-month low-load training.

bending the knees as though sitting on a chair), (2) hip extension and flexion (raising one leg backwards, without bending the knee, (3) hip abduction (raising one leg horizontally, without bending the knee), and (4) standing on tiptoes (raising both heels as if stretching to reach high). The exercises practiced while sitting in a chair were: (5) knee extension (raising one leg slowly, while keeping the knee straight, (6) trunk flexion and extension (bending the trunk forwards with both arms stretched forwards and then raising both arms to bring the trunk upright, looking up toward the ceiling, (7) exercising both arms (swinging the arms forward and backward with the elbows bent, and stretching the arms horizontally with the elbows kept extended). All of these exercises were practiced without any load other than the patient's own body weight.

(2) Once weekly 6-month low-load training

This program involves low-load resistance training carried out once weekly for 6 months. In defining load levels, Satake et al.[12] reported that the intensity of exercise equivalent to 30-40% of full muscular strength can be viewed as low-load training, corresponding to a subjective exercise level of "easy" or "very easy". Based on this report, the load level was adjusted for each subject during each round of training so that it was approximately Level 11 (easy) according to the Borg scale (a scale of subjective exercise levels). Training machines manufactured by Proxomed (Germany), shown in Fig. 1, were used in this study. All exercises were practiced while sitting in a chair. The exercises consisted of: (1) horizontal hip and knee flexion and extension with the planta fixed (Horizontal Leg Press), (2) leg extension/flexion, (3) hip abduction/adduction, (4) trunk-extension/flexion, (5) shoulder and elbow flexion and extension (Rowing MF), (Chest Press). Of these exercises, trunk-extension/flexion requires the subject to maintain his/her body position without the help of any back support, and is thus expected to improve the ability to hold an erect posture.

(3) Twice weekly 3-month low-load training

This program involves training with identical load levels and methods to those of the once weekly 6-month low-load training. It differed from the latter in terms of frequency (twice weekly instead of once weekly) and period (3 months instead of 6 months).

In all three of these rehabilitation programs, vital signs (blood pressure, heart rate, etc.) and subjective sensations of fatigue were checked for each subject before and after training, to ensure safety. One set of training was composed of 10 sessions of exercise, and a maximum of 3 sets were practiced in one day. A rest period of 2 minutes or longer was interposed between different exercises or sets. One program lasted for about 90 minutes.

2. Tests and methods

The following tests were administered to each subject at the beginning and end of the program.

(1) Exercise function tests

1) Grip strength

A digital grip meter was used. Measurements were taken with the subject in a standing position. The way the grip meter was held by the fingers (the defined grip width) was adjusted so that the second joint of the index finger would be bent at approximately a right angle. Grip strength was

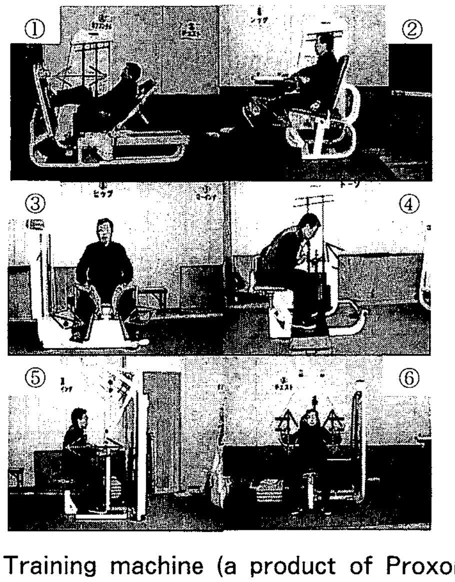

Fig.1. Training machine (a product of Proxomed)

Dimension (Width × Length × Height):
① Horizontal Leg Press 2040 × 1055 × 1665mm
② Leg Extension/Flexion 1090 × 1020 × 1665mm
③ Hip Abduction/Adduction 1315 × 1190 × 1665mm
④ Trunk Extension/Flexion 1360 × 1125 × 1665mm
⑤ Rowing MF 1245 × 715 × 1995mm
⑥ Chest Press 1310 × 1350 × 1985mm

calculated to the first decimal place and expressed in units of kg[13].

2) Ability to stand on one leg with the eyes open (one leg stand)

When the examiner gave a signal, the subject started to stand on one leg. The examiner measured with a stopwatch the duration of time the subject could stand on one leg. This time was calculated to the first decimal place and expressed in seconds[14].

3) Functional reach test (FRT)

This test was administered according to the method of Duncan et al.[15]. The subject stood with one side near a wall, with legs spread to the width of the shoulders. The subject reached straight ahead with one arm at shoulder height and bent the shoulder joint by 90 degrees. From this initial position, the subject stretched both arms as far forward as possible, keeping both arms parallel with each other. After performing this action, the subject returned to the initial position. The examiner measured the distance moved horizontally of the middle finger tip during this exercise in units of cm (calculated to the first decimal place), as shown in Fig. 2.

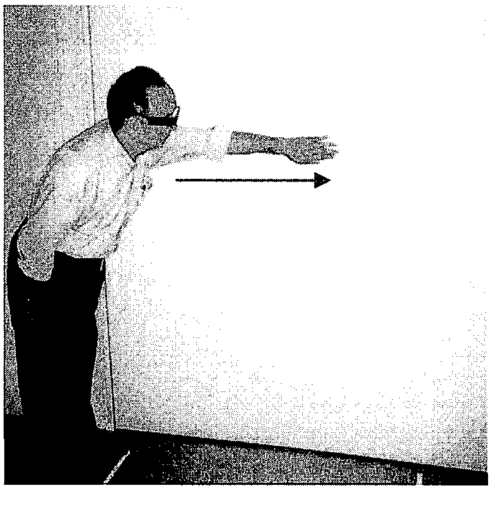

Fig. 2. Functional reach test (FRT)

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4) Trunk-flexion in the sitting position

While sitting on a chair, the subject stretched one knee to an angle of 0 degrees, kept the ankle on this same side at an angle of 0 degrees and placed his/her heel in contact with the floor. Then, the subject bent his/her trunk forward and stretched both arms toward the toes. The distance between the tips of the toes and the middle fingers was measured. If the middle finger did not reach the tip of the toes, the distance was given with the label "minus". If the middle finger stretched beyond the tip of the toes, the distance was given with the label "plus". The distance ("minus" or "plus") was recorded in units of cm (calculated to the first decimal place)[13].

5) Minimum time needed to walk 10 meters (10 m walk)

This test was conducted according to the method of Morohashi et al.[16]. The subject walked a 16 m long course (the 10 m main course plus 3 m more both before and after the main course). The examiner counted the time it took for the subject to pass through the 10 m main course, using a stopwatch. The examiner's instructions to the subject were: "Please walk as fast as you can." The time was recorded in units of seconds (calculated to the first decimal place).

6) Time "Up and Go" Test (TUG)

This test was carried out according to the method of Podsialo et al.[17]. The subject first sat on a chair. When the examiner gave a signal, the subject stood up from the chair and walked to an object 3 m in front of the chair, returned to the chair and sat down again. The examiner's instruction to each subject was: "Please walk as fast as you can." The examiner counted the time from the signal to start the action to the end of the action, using a stopwatch. The time was recorded in units of seconds (calculated to the first decimal place) (Fig. 3).

Each of the tests 1) through 6) was performed twice. The better of the two measurements was the one chosen.

7) Distance walked in 6 minutes

This test was conducted according to the method of Morice et al.[18]. The subject walked on a

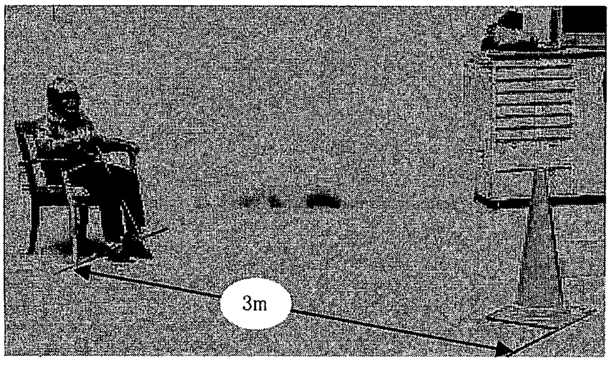

Fig.3. Time "Up and Go" Test (TUG)

The subject first sat on a chair. When the examiner gave a signal, the subject stood up from the chair and walked to an object 3 m in front of the chair, returned to the chair and sat down again. The examiner's instruction to each subject was: "Please walk as fast as you can." The examiner counted the time from the signal to start the action to the end of the action, using a stopwatch.

course for 6 minutes. The distance walked during the period from the signal to start walking to the end of exercise (i.e., after 6 minutes) was measured in units of m (calculated to the first decimal place). This test was only performed once per subject.

(2) Evaluation of activities of daily living (ADL)

The subject's BI was rated at the start and end of the program.

(3) Evaluation of quality of life (QOL)

The subject's QOL was evaluated at the start and end of the program, using a Japanese version of the EuroQOL (EQ-5D)[19-20].

3. Study design

(1) Study 1

The once weekly 6-month group exercise program was compared with the once weekly 6-month low-load training on the basis of checking for significant differences in parameters of exercise function (grip, one leg stand, FRT, trunk-flexion, 10m walk, TUG and BI) between measurements at the start and end of each program.

(2) Study 2

A comparison between two low-load training programs with varying frequencies and periods (the once weekly 6-month low-load training and the twice weekly 3-month low-load training) was conducted by checking for significant differences in parameters of exercise function (grip, one leg stand, FRT, trunk-flexion, TUG and BI) following the program (comparison between the measurement at the start and the measurement at the end of the program)

(3) Study 3

The effects of twice weekly 3-month low-load training on the ADL and QOL of individual patients were evaluated on the basis of the results of exercise function tests. The influence of each exercise function tested on ADL and QOL was assessed, and the relationship of background variables of patients to ADL and QOL was also analyzed.

4. Data analysis

Paired t-test was used for comparison of each parameter of exercise function, total BI score and EQ-5D utility score between the measurement before training and the measurement after training. Mann-Whitney test was employed for such a comparison of BI and each EQ-5D score. Pearson product moment correlation coefficient was used for analysis of the relationship between the baseline level of each parameter of exercise function and the magnitude of change in each parameter after training (the difference between the baseline and final levels). Multiple regression analysis was employed for evaluation of the relationship of changes in ADL or QOL to parameters of exercise function and background variables (age and sex). The total BI score and EQ-5D utility score served as dependent variables, while the change in each parameter of exercise function, sex (coded with dummy variables) and age served as independent variables. Data were processed and analyzed on the computer program SPSS11.5.

Results

1. Study 1 (Table 2 and 3)

Following the once weekly 6-month group exercise program, exacerbation was noted in trunk-flexion ($p<0.05$) and TUG ($p<0.05$) among the parameters of exercise function. Following the once weekly 6-month low-load training, exacerbation

Table 2. Changes in exercise function following training in each group

n = 51

	Group exercise			Once weekly 6-month training			Twice weekly 3-month training		
	Baseline	Final	p	Baseline	Final	p	Baseline	Final	p
Grip (kg)	21.7 (6.3)	21.6 (6.6)	ns	23.1 (7.0)	23.4 (6.9)	ns	22.2 (7.5)	23.4 (7.5)	*
One leg stand (sec)	8.7 (5.4)	8.6 (5.6)	ns	9.2 (3.8)	9.9 (4.6)	ns	12.3 (5.2)	14.3 (5.6)	ns
FRT (cm)	24.9 (6.2)	24.9 (6.8)	ns	25.6 (6.2)	26.8 (6.3)	ns	24.5 (7.6)	27.4 (7.6)	**
Trunk-flexion (cm)	11.8 (6.8)	8.8 (5.9)	*	7.6 (4.9)	11.4 (4.3)	**	10.3 (4.2)	12.3 (4.8)	**
10m walk (sec)	12.1 (3.7)	12.2 (4.1)	ns	12.6 (3.6)	11.6 (3.3)	**			
TUG (sec)	12.0 (4.4)	12.7 (4.6)	*	13.4 (2.9)	12.0 (3.2)	**	12.1 (3.2)	10.1 (2.8)	**
Distance walked in 6 minutes (m)							225.5 (70.7)	257.7 (79.0)	**

Mean (SD). ns = not significant. *p<.05 **p<.01
One leg stand: Duration of one leg standing with eyes open, FRT : Functional Reach Test, torso-flexion : in sitting, 10m walk : maximum time needed for 10 m walk,
TUG : Time "Up and Go" Test

Table 3. Changes in ADL (Total BI score) after training in each group

n = 51

	Group exercise			Once weekly 6-month training			Twice weekly 3-month training		
	Baseline	Final	p	Baseline	Final	p	Baseline	Final	p
Meal	9.0 (2.0)	8.8 (2.1)	ns	8.1 (2.4)	8.2 (2.4)	ns	9.1 (1.9)	9.2 (1.8)	ns
Vehicle	12.2 (3.0)	11.8 (3.0)	ns	12.9 (3.0)	12.5 (3.2)	ns	10.8 (2.3)	12.5 (2.5)	**
Grooming	4.6 (1.4)	4.7 (1.2)	ns	3.9 (2.1)	4.0 (2.0)	ns	3.6 (2.3)	4.2 (1.8)	*
Toilet	9.3 (1.7)	9.1 (1.9)	ns	9.4 (1.6)	9.6 (1.4)	ns	9.4 (1.9)	9.6 (1.7)	ns
Bathing	4.0 (2.0)	4.1 (1.9)	ns	3.2 (2.4)	3.6 (2.3)	ns	3.3 (2.4)	4.1 (1.9)	*
Gait	12.2 (3.0)	12.1 (2.7)	ns	12.1 (2.7)	13.1 (2.4)	**	13.4 (2.5)	14.3 (2.0)	**
Stairs	5.6 (2.4)	5.8 (2.7)	ns	5.8 (2.7)	7.4 (2.9)	**	5.2 (2.7)	7.7 (2.9)	**
Dressing	8.9 (2.1)	8.8 (2.1)	ns	9.4 (1.6)	9.5 (1.5)	ns	9.3 (1.7)	9.7 (1.2)	ns
Defecation	9.1 (1.9)	9.0 (2.0)	ns	9.4 (1.6)	9.5 (1.5)	ns	9.8 (1.0)	10.0 (0.0)	ns
Total score	83.8 (10.5)	83.0 (10.8)	ns	83.2 (10.2)	86.3 (9.1)	**	83.1 (10.3)	90.9 (8.2)	**

Mean (SD). ns = not significant. *p<.05 **p<.01

was not noted in any parameter, and significant improvement was observed in trunk-flexion ($p<0.01$), 10 m walk ($p<0.01$) and TUG ($p<0.01$) among the parameters of exercise function as well as in gait ($p<0.01$), going upstairs and downstairs ($p<0.01$) and total BI score ($p<0.01$) among the parameters of BI.

2. Study 2 (Table 2 and 3)

Following the twice weekly 3-month low-load training, significant improvement was observed not only in trunk-flexion ($p<0.01$), TUG ($p<0.01$), gait ($p<0.01$), going upstairs and downstairs ($p<0.01$) and total BI score ($p<0.01$) on which improvement had been seen following the once weekly 6-month low-load training in Study 1 but also in the following parameters: grip ($P<0.05$) and FRT ($p<0.01$) among the parameters of exercise function and getting on vehicles ($p<0.01$), grooming ($p<0.05$) and bathing ($p<0.05$) among the parameters of BI.

3. Study 3

Following the twice weekly 3-month low-load training, all 5 parameters of EQ-5D (a scale of QOL) and the EQ-5D utility score improved significantly. Among the parameters of BI (a scale of ADL), significant improvement was noted after this training in the six parameters mentioned above, i.e., getting on vehicles ($p<0.01$), grooming ($p<0.05$), bathing ($p<0.05$), gait ($p<0.01$), going upstairs and downstairs ($p<0.01$) and total BI sore ($p<0.01$). Among the parameters of exercise function, significant improvement was seen in 5 parameters, i.e., grip ($p<0.05$), FRT ($p<0.01$), trunk-flexion ($p<0.01$), TUG ($p<0.01$) and distance walked in 6 minutes ($p<0.01$), as shown in Tables 2 through 4. A negative correlation between the baseline level and the change after training was noted for FRT ($r=-0.51$, $p<0.01$) and TUG ($r=-0.49$, $p<0.01$), while no correlation was noted for any other parameter of exercise function (Table 5).

Table 4. Changes in QOL after twice weekly 3-month low-load training n=51

EQ- 5 D	Baseline		Final		p
	Mean	SD	Mean	SD	
Mobility	2.2	0.6	1.7	0.7	**
Self-care	2.2	0.7	1.9	0.7	**
Usual activities	2.4	0.6	2.0	0.6	**
Pain	2.4	0.6	2.3	0.6	*
Anxiety	2.5	0.6	2.2	0.7	**
QOL utility score	0.34	0.18	0.46	0.19	**

Mean (SD). ns = not significant. *p<.05 **p<.01

Table 5. Baseline levels and changes in parameters of exercise function after twice weekly 3-month low-load training n = 51

	Grip		One leg stand		FRT		Torso-flexion		TUG		Walk in 6 min	
	r	p	r	p	r	p	r	p	r	p	r	p
Grip	−0.26	ns	−0.15	ns	0.12	ns	0.05	ns	0.13	ns	0.03	ns
One leg stand	−0.21	ns	−0.26	ns	−0.06	ns	0.14	ns	0.24	ns	0.11	ns
FRT	0.03	ns	0.14	ns	−0.51	**	0.09	ns	0.18	ns	0.18	ns
Trunk-flexion	−0.09	ns	0.04	ns	−0.09	ns	−0.39	**	0.07	ns	−0.12	ns
TUG	−0.01	ns	−0.13	ns	0.06	ns	0.5	ns	−0.49	**	−0.15	ns
Walk in 6 min	−0.14	ns	−0.02	ns	0.04	ns	0.05	ns	0.34	**	0.06	ns

ns = not significant. *p<.05 **p<.01

Significant correlation was noted between the change in total BI score and the change in TUG (standardization coefficient $\beta = -3.928$, $p<0.01$), between the change in total BI score and the change in trunk-flexion ($\beta = 0.542$, $p<0.01$) and the change in total BI score and age ($\beta = -2.243$, $p<0.01$). Furthermore, a significant correlation was noted between change in total BI score and the total of change in TUG, change in trunk-flexion and age (multiple correlation coefficient $R = 0.680$, determination coefficient $R^2 = 0.463$, $p<0.01$), as shown in Table 6.

A significant correlation was observed between the change in EQ-5D utility score and the change in distance walked in 6 minutes ($\beta = 0.602$, $p<0.01$) and between the change in EQ-5D utility score and the change in TUG ($\beta = -0.242$, $p<0.05$). The relation between change in EQ-5D utility score and the total of change in distance walked in 6 minutes and change in TUG was also significant (multiple correlation coefficient R= 0.658, determination coefficient $R^2 = 0.433$, $p<0.01$), as shown in Table 7.

Discussion

In the past, group exercise programs for elderly people requiring daily life assistance were often provided within the framework of functional rehabilitation programs under the Senile Health

Table 6. Relationship of changes in ADL to changes in parameters measured and background variables

	Partial correlation coefficient	Standardization coefficient	p
Intercept	4.421		
Change in TUG	−3.928	−0.530	.001
Changes in trunk-flexion	0.542	0.263	.027
Age	−2.243	−0.228	.047

Multiple regression (R = 0.680, R2 = 0.463, P<.01)
Y = 4.421 − 3.928 × (change in TUG) + 0.542 × (change in trunk−flexion) − 2.243 × (age: 4 categories)
Change in ADL = Y, Significant at P<0.01

Table 7. Relationship of changes in QOL to changes in parameters measured and background variables

	Partial correlation coefficient	Standardization coefficient	p
Intercept	−0.075		
Change in distance walked in 6 minutes	0.004	0.602	.001
Change in TUG	−0.039	−0.242	.031

Multiple regression (R = 0.658, R2 = 0.433, P<.01)
Y = 0.004 × (change in distance walked in 6 minutes) − 0.039 × (change in TUG) − 0.075
Change in QOL = Y, Significant at P<0.01

Act. This kind of training was used extensively and played a significant role in facilitating resumption of functions by elderly people through habitual exercise. However, when providing this kind of training, the efficacy of the program (including the appropriateness of the guidance for participants and the measurements performed on the participants) was not adequately evaluated on the basis of changes in the exercise function of individual participants. Takeuchi[7] served as a pioneer in introducing a low-load training program to elderly people requiring daily life assistance and made efforts to make this program adopted widely. To date, however, no study endorsing the validity of this program or analyzing its efficacy in relation to the frequency and period of training or evaluating its effects on ADL and QOL has been reported. The author has been providing a once weekly 6-month low-load training to elderly people, laying emphasis on people who tend to remain indoors (the subjects emphasized by the program proposed by the Ministry of Health, Labour and Welfare)[21]. Although the Japan Health Promotion & Fitness Foundation recommended twice or three time weekly exercise as a means of improving the physical strength of people, the author previously reported that practicing exercise four weeks or more per week can cause accumulation of fatigue and hamper the individuals to form a habit of exercise[22]. Under such circumstances, the author recently developed a new training program (twice weekly 3-month low-load training) and evaluated the efficacy of this program as well as two other programs (once weekly 6-month group exercise and once weekly 6-month low-load training) (Study 1). Furthermore, the efficacy of low-load training was evaluated at varying frequencies and periods of training (once weekly 6-month training and twice weekly 3-month training) (Study 2). Because the twice weekly 3-month low-load training program was found to be more effective than the once weekly 6-month low-load training program, the author then evaluated the effects of the twice weekly 3-month low-load program on ADL and QOL, using BI and EQ-5D[19·20] (Study 3). In all of these three studies (Study 1, 2 and 3), the four parameters reported by Miyahara et al.[23] as useful in efficacy evaluation (grip strength, one leg stand, trunk-flexion and 10 mg walk) as well as 3 parameters of performance test (FRT, TUG and distance walked in 6 minutes) were adopted as parameters of exercise function. The test data were processed and analyzed statistically to evaluate the efficacy of the programs.

1. Re: Study 1

In Study 1, the once weekly 6-month group exercise program, which is primarily based on antigravitational exercises and has been provided within the framework of the Senile Health Act, was compared with the once weekly 6-month low-load training, by means of exercise function tests. Following the group exercise program, some subjects showed improvements in exercise function in a sporadic manner, but no parameter of exercise function improved significantly when all subjects assigned to this group were analyzed together. Following the low-load training program, three parameters (trunk-flexion, 10 m walk and TUG) improved significantly. This result in the low-load training group probably reflects the effectiveness of low-load training using machines. The use of training machines seems to have the following advantages: (1) the range, direction and frequency of articular motions can be set at a level optimal for training of the target muscle, thus allowing constant rate exercise; and (2) it is easy for the subject to keep his/her body position optimal for a given articular motion. During group exercise, compensatory motions (departing from normal motions) or inadequate motions are sometimes seen, and it is difficult to practice exercise in right direction or range. Ohata et al.[24] reported that repeated quantitative learning of task motions can suppress instability of voluntary motions and plays an important role in learning how to control body position in an appropriate manner, resulting in improved physical coordination during exercise.

2. Re: Study 2

In Study 2, the efficacy of low-load training at varying frequencies and periods of training was evaluated. In both the once weekly 6-month training group and the twice weekly 3-month training group, trunk-flexion and TUG improved significantly, and no parameter exacerbated. In the twice weekly 3-month training group, parameters of muscle strength and balancing capability (grip strength and FRT) also improved significantly. The greater number of parameters showing significant improvement in the twice weekly 3-month training group is probably because the efficacy of the previous sessions of the training was carried forwards to the next session in this group although the efficacy of previous sessions did not continue until the next session in the once weekly 6-month training group. Because no parameter exacerbated in the once weekly 6-month training group, this training program can also be viewed as having shown long-lasting efficacy. However, considering that the twice weekly 3-month training program allowed significant improvement in grip strength in addition to balancing capability and that subjects are easier to become aware of improvement following this short-term (3-month) training, we may say that the twice weekly 3-month training program is more suitable as a means of guiding people to continue training for the goal of improving the exercise function. Feigenbaum et al.[25] reported that improvement was greater following twice weekly training than following once weekly training, similar to the findings from the present study, and that the improvement after twice weekly training did not differ from that after three times weekly training. If their finding is combined with the findings from the present study, we may say that twice weekly training is more advisable in terms of cost-benefit relationship.

3. Re: Study 3

In Study 3, the effects of twice weekly 3-month low-load training on ADL and QOL were evaluated. Following twice weekly 3-month training, significant improvement was seen not only in trunk-flexion and TUG (parameters of exercise function) and gait and going upstairs and downstairs (parameters of BI), like after once weekly 6-month low-load training, but also in some additional parameters (grip strength and FRT among parameters of exercise function and getting on vehicles, grooming and bathing among parameters of BI). The improvement seen in these additional parameters after twice weekly 3-month training is attributable to improved muscle strength and balancing capability. Grip strength is often used as a parameter since this is thought to represent the systemic muscle strength. Shinkai[26] listed grip strength as one parameter of the physical strength of elderly people. Therefore, the improvement in grip strength seems to reflect improvement in muscle strength. We may say that the subjects of this study, who had probably show reduced activity level before the study, were able to activate their muscles through practicing the low-load training program. We may also say that the balancing capability was improved by simultaneous use of multiple muscles involved in the control of body position (e.g., the muscles used during, trunk-extension/flexion and shoulder flexion/extension).

Regarding load resistance training programs, Arai et al.[3] reported that the endurable training machine load level and the magnitude of improvement in the one-leg standing capability (with eyes open or closed) were higher among individuals who had a higher physical strength at the start of the training. In the present study, however, a negative correlation between the baseline level and the magnitude of change after training was noted for FRT and TUG.. This result suggests that even subjects with low baseline levels have high potentials of improvement. This issue, however, needs to be further studied.

Now, factors affecting the ADL are to be discussed. The magnitude of change in ADL had significant correlation with TUG (standardization coefficient $\beta = -0.53$, $p < 0.01$), trunk-flexion ($\beta = 0.263$, $p < 0.05$) and age ($\beta = -0.228$, $p < 0.05$). TUG pertains to the capability of instantaneously selecting one motion and continuing it, i.e., a capability to deal with a given situation quickly. Prolongation of the time needed for TUG can lead to disturbances in activities such as getting on vehicles, walking, going upstairs and downstairs, making outdoor activities, and so on[27]. The results of the present study endorsed the usefulness of TUG as an indictor of the range of ADL.

During trunk-flexion, flexibility of muscles improves the coordination of muscles involved in articular motions. This function seems to affect the range of motions possible under various situations or environments and to affect the magnitude of change in ADL. According to Miyashita[22], reduction in flexibility can reduces the degree of physical independence and elevates the risk for falling.

The influence of age on ADL has been shown in many reports, and the present study endorsed such previous findings.

Now, factors affecting the QOL are to be discussed. The magnitude of change in QOL correlated significantly with the distance walked in 6 minutes ($\beta=0.602$, $p<0.01$) and TUG ($\beta=-0.242$, $p<0.05$). If an individual has sustainable physical strength, he/she can feel joyful or high-spirited before feeling fatigued, and fatigue is unlikely to persist long, thus making it possible for the individual to undertake activity to become joyful again. This will lead to a subjective sensation of health or the sense of worth living.

Following the twice weekly 3-month low-load training, improvement was seen in four aspects of exercise function (gait, body position control, muscle strength and flexibility), and favorable effects on ADL (primarily the capability to move) were noted, leading to improved QOL. Among factors affecting ADL, body position control, flexibility and age seem to be particularly important. Among factors effecting QOL, sustainability of the capability to move and the capability of controlling body position are important. The results from the present study suggest that these important factors are highly likely to improve following training with this program.

In the present study, improvement in ADL and QOL following this training program was confirmed by analysis of exercise function. However, the daily lives of elderly people cannot be completely understood from the viewpoint of physical function alone. In the future, approaches involving a combination of emotional, cultural, social and environmental supports will be desirable. In any event, the findings from this study will provide hints when discussing the issues faced by the current society with a progressively aging population.

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References

1) Study Group on Rehabilitation for the Elderly: Desirable direction of rehabilitation for the elderly. Ministry of Health, Labour and Welfare. 2004.

2) Committee for Promotion and Evaluation of Daily Life Assistance and Prevention: Report from the local community model programs on daily life assistance and prevention of disabilities. Ministry of Health, Labour and Welfare. 2005.

3) Arai T, Obuchi S,Shiba Y,et al.: Effects of exercise programs (high-load resistance train-ing,etc.) in improving the physical function of feeble elderly people and physical and other factors affecting such effects. Journal of Japanese Physical Therapy Association. 2003; 30: 377-385.

4) Vincent KR, Braith RW, Feldman RA,et al.: Resistance exercise and physical performance in adults aged 60 to 83. J Am Geriatr Soc. 2002; 50(6): 1100-7.

5) Hruda KV, Hicks AL, McCartney N: Training for muscle power in older adults: effects on functional abilities.Can J Appl Physiol. 2003; 28(2): 178-89.

6) Rooks DS, Kiel DP, Parsons C, et al.: Self-paced resistance training and walking exercise in community-dwelling older adults: effects on neuromotor performance. J Gerontol. 1997; 52A: M161-168.

7) Bushner DM, Cress ME, de Lateur BJ, et al.: The effect of strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. J Gerontol. 1997; 52A: M218-M224.

8) Lord SR,Castell S.:Physical activity program for older persons:effect on balance,strength, neuromuscular control,and reaction time. Arch Phys Med Rehabil. 1994; 75(6): 648-52.

9) Singh NA,Clements KM,Fiatarone MA.:A randomized controlled trial of progressive resistance training in depressed elders.J Gerontol A Biol Sci Med Sci. 1997; 52(1): M27-35

10) Barrett CJ, Smerdely P.: A comparison of community-based resistance exercise and flexi-bility exercise for

seniors. Aust J Physiother. 2002; 48(3): 215-219.

11) Takeuchi T: Power rehabilitation (edt. Study Group on Daily Life Assistance, Prevention of Disabilities, Support to Independence Power Rehabilitation), First Edition, 7-19, Ishiyaku Shuppan, 2002.

12) Satake K: How to proceed muscle training for the elderly (edt. Kawahatsu K, et al.), Text-book for improving the functions of rehabilitation machines, First Edition, 42-43, Chuo Hoki Shuppan, 2006.

13) Okamochi T: Assessments during power rehabilitation. Journal of Physical Therapy. 2002; 19: 997-1005,.

14) Japanese Society of Equilibirum Neurology : Practice with equilibrium function test, 121-133,Nanzando,1992.

15) Duncan PW, Studenski S, Chandler J,et al.: Functional reach :a new clinical measure of bal-ance. J Gerontol. 1990; 45: M192-197.

16) Morohashi I: Maximum speed of walk (edt. Uhciyama Y, et al.), Introduction to indicators of clinical evaluation, First Edition, 127-133, Kyodo Isho Shuppan, 2003.

17) Podsiadlo D,Richardson S.: The timed "Up and Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991; 39: 142-148.

18) Morice A,Smithies T.: Tow-, six-, and 12-minute walking test in respiratory disease. Br Med J. 1982 ; 285 : 6337.

19) Dorman PJ, Waddell F, Slattery J, et al.: Are proxy assessments of health status after stroke with the Euro Qol questionnaire feasible,accurate,and unbiased? Stroke. 1997; 28: 1883-1887.

20) Kuwano M, Kanda N,Shimizu K,et al.: Health-related QOL of post-stroke patients evalu-ated using Euro Qol, Japanese Journal of Geriatrics. 2001; 38: 831-833.

21) Study Group on Prevention and Support of/to Individuals Confined Indoors: A manual for prevention and support of/to individuals confined indoors. Ministry of Health, Labour and Welfare, 2005.

22) Miyashita M: Textbook for health promotion leaders, Third Edition, Japan Health Promo- tion & Fitness Foundation, 2004.

23) Miyahara Y, Takeshita J.: Relationship between exercise capabilities and lifespan in elderly people in local communities, Journal of Japanese Physical Therapy Association. 2004; 31 (3) : 155-159.

24) Ohata K, Ichihashi N, Tateuchi H,et al.: Changes in body position control following repeti-tion of reach exercise, Journal of Japanese Physical Therapy Association. 2003; 30(1): 1-7.

25) Feigenbaum MS, Pollock ML.: Prescription of resistance training for health and disease. Med Sci Sports Exerc. 1999; 31(1): 38-45.

26) Shinkai S: Setting a standard physical strength level as a target for elderly people living at home to avoid development of disabilities requiring daily life assistance. Tokyo Metropoli-tan Institute of Gerontology. 2001; 151-157.

27) Bischoff HA, Stahelin HB, Monsch AU, et al.: Identifying a cut-off point for normal mo-bility:a comparison of the timed 'up and go' test in community-dwelling and institution-alized elderly women. Age Ageing. 2003 ; 32: 315-320.

低負荷抵抗運動プログラムが要援護高齢者の日常生活活動能力に及ぼす影響

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要　旨

要援護高齢者の廃用性症候群のプログラムとして低負荷プログラムに着目した．従来の手法である集団体操プログラムとの比較及び頻度・期間別の効果を検証した．また，その効果について運動機能初期測定値との関連性やADL，QOL改善に影響を及ぼす要因について検討した．対象は3タイプのリハビリテーションプログラム（集団体操週1回6ヵ月プログラム，低負荷週1回6ヵ月プログラム，低負荷週2回3ヵ月プログラム）のいずれかを受けた要援護高齢者467人のうち，プログラム別に年齢、性別、ADLレベルを揃え抽出した51人ずつの群とした． 集団体操週1回6ヵ月プログラムは抗重力位の運動，低負荷週1回6ヵ月プログラム・低負荷週2回3ヶ月プログラムは，Borg scaleの指数11（楽である）を目安とした低負荷で，6種類のトレーニング機器を用いた運動で構成した．運動機能テスト，ADL評価，QOL評価より効果を比較検証したところ、集団体操週1回6ヵ月プログラムより低負荷週1回6ヵ月プログラムの方が歩行及び姿勢制御能力面で改善を示した．頻度・期間別での比較では低負荷週2回3ヶ月プログラムがさらに筋力及びバランス能力面で改善した．低負荷週2回3ヶ月プログラムでは，ADLに影響を与える因子として，姿勢制御能力，柔軟性，年齢，QOLに影響を与える因子として，移動持久性，姿勢制御能力が確認できた．尚，姿勢制御能力は初期測定値が低くても，本プログラムより改善の可能性を大いに含むことが示唆された．