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Original Article

Unsupervised low-intensity home exercises as an effective intervention for improving physical activity and physical capacity in the community-dwelling elderly

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Abstract. [Purpose] The purpose of this study was to examine the effectiveness of unsupervised low-intensity home exercises in improving physical activity and physical capacity for daily activities among the community-dwelling elderly. [Participants and Methods] We included 24 female older participants and divided them into two groups: 14 in the resistance training group and 10 in the fast walking group. The resistance training group performed shoulder joint flexion and abduction exercises using a resistance tube twice daily (in the morning and afternoon). Participants in the fast walking group walked fast for 3,000 steps once daily. Both groups continued the exercise intervention for 6 months. We measured the forced vital capacity, respiratory muscle strength, physical activity, walking distance in the 6-min walk test, grip strength, and knee extension strength before and after the intervention. [Results] The forced vital capacity significantly increased in the resistance training group, whereas the moderate-intensity physical activity time significantly increased in both groups and the vigorous-intensity physical activity time increased in the fast walking group only. We observed no intergroup differences in respiratory muscle strength, 6-min walking distance, grip strength, or knee extension strength. [Conclusion] The results of this study suggest that low-intensity home exercises can improve pulmonary function and physical activity and should be recommended for promoting health in the community-dwelling elderly.

Key words: Community-dwelling elderly, Low-intensity home exercise, Physical activity

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INTRODUCTION

Increased periodic physical activity is a strong preventative measure for cognitive function and cardiovascular risks among the elderly[1, 2)]. Conversely, decreased physical activity is strongly correlated with cardiovascular risks as well as incidences of social withdrawal, frailty, sarcopenia, cancer, diabetes, and other metabolic diseases[3)]. Walking, resistance training, recreation, and participation in local community activities are recommended to improve physical activity amongst the elderly[4, 5)]. However, exercise frequency remains low amongst the elderly, making it difficult to maintain the minimum amount of physical activity necessary to maintain health[6)].

In Japan, few studies have examined the amount of physical activity among community-dwelling elderly. In a study by

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Chen et al. focusing on this population in Japan, the researchers found average time spent sitting to be 485 minutes, an average light-activity time of 301 minutes, and an average moderate-vigorous intensity activity time of 16.8 minutes per day[7]. For elderly individuals who sit for an extended time, exercise is recommended to increase physical activity and improve health[8–10]. However, most resistance training protocols involve mainly the lower extremity and trunk[11–15]. Ideally, elderly individuals would undergo general resistance training at a vigorous-intensity, but vigorous-intensity exercise carries risks such as joint pain and increased blood pressure for this population[16]. Pollock et al. investigated resistance training results among 23 healthy, elderly individuals, reporting the occurrence of 2 injuries during training and 1 during strength evaluation[17]. Moreover, other reports cite significant improvement to muscular strength at a low intensity of 40–50% of 1 repetition maximum for 12 weeks[18–20]. Low intensity resistance training effectively increases muscular strength, with most routines focusing on the lower extremity. However, no such literature exists with regard to upper extremity, low intensity resistance training among the community-dwelling elderly. The World Health Organization recommends that community-dwelling elderly get at least 150 minutes of moderate-intensity activity and 75 minutes of vigorous-intensity activity per week to maintain health[21]. However, few studies have measured the actual amount of physical activity among community-dwelling elderly in Japan[22]. In addition, changes in the amount of physical activity over the medium-to-long term were seen when affordable, easily executable exercise were performed unsupervised. It follows that in order to increase the amount of physical activity among community-dwelling elderly, a training regimen should be developed that is low intensity, low risk, simple, resistant to changes in weather, and can be performed at home even in winter.

The purpose of this study was to examine the effectiveness of unsupervised home exercise intervention on pulmonary function and physical activity among community-dwelling elderly, particularly with respect to low intensity upper extremity resistance training and aerobic training by fast walking.

PARTICIPANTS AND METHODS

The participants of this study were twenty-four community-dwelling elderly women who expressed interest in participation upon seeing the flyer were included in the study, and informed consent was obtained from all participants. This study was conducted with approval by the Kanagawa Prefectural University of Health and Welfare Research Ethics Committee (Hodai No. 10-17) and Kyorin University Ethics Review Committee (approval number 2019-44).

The study design included a one-month baseline period for both groups before intervention in September of 2017 (pre-intervention), and an exercise intervention (6 months) period from October 2017 to March 2018. Twenty-four participants were separated into two groups: 14 in the upper body resistance training group (RT group) and 10 in the fast walking group for aerobic exercise (FW group). In the RT group, the average age was 77.0 years old, the average height was 152.6 cm, and the average weight was 54.5 kg. In the FW group, the average age was 74.9 years old, the average height was 152.5 cm, and the average weight was 53.2 kg. In both groups, exercises were performed daily for 6 months. Participants were fitted with a Suzuken Life Recorder Lifecoder Ex (Lifecoder) accelerometer from early morning to bedtime. The monitoring and feedback session was held once every 2 weeks to ensure that exercises were being conducted according to instructions and to download Lifecoder data.

The RT group used resistance tube (THERABAND®, TB21130) and performed shoulder joint flexion and abduction exercises with reference to the study by Thomas et al. on exercises that can be performed at home for the frail, elderly individuals[23]. Participants would grasp both ends of a 1.2 m-long resistance band, then perform flexion and abduction for both shoulder joints by extending the resistance tube horizontally to a position of 90 degrees at the shoulder joint. Exercises were to be performed with 3 sets of 10 repetitions twice daily in the morning and afternoon (Fig. 1). Exercise intensity was set to low as measured by fatigue level equivalent to 60 to 70 mm on the Visual Analog Scale (VAS) following completion of 10 repetitions. Four to 5 seconds were required for one exercise, and slow execution was prescribed so that 10 repetitions took 1 minute to perform.

The FW group was instructed to walk faster for 3,000 steps every day as reported earlier by Marshall et al[24]. Walking speed was set to an exertion level of "slightly tiring," or about 12 to 13 on the 15-level Borg Scale[25]. Walking could be carried out in the morning or afternoon. Step counts per day were measured by checking the number of steps already measured by the Lifecoder since morning and proceeding to walk speedily until 3,000 additional step were attained.

Participants wore Lifecoders continuously from waking up to bedtime every day, thereby measuring the level of physical activity and step counts. Lifecoder were attached at the waist belt. Participant were allowed to remove the device when bathing and at bedtime. Lifecoder data were extracted to Microsoft Excel 2010 spreadsheet format using behavioral tracking software Life-Lyzer 05 Coach Ver.2.2. Activity level was calculated from data obtained via Lifecoder with a range of 0 to 9, with 0 representing activity intensity of 0 corresponding to removal of the Lifecoder for bathing or sleeping, and a resting intensity of 0.5 during which the participant is sitting or in an otherwise resting position that produces minimal accelerometer readings. As the number of counts represents the average integer value over 4 seconds, the ratio was calculated based on a 24-h period before being converted to time. Exercise intensity calculated by Lifecoder is indicated by a Mets equivalent value from 0 to 9[26]. Accordingly, exercise intensity was calculated daily for each hour with an intensity of 1–3 representing light-intensity physical activity (LIPA), 4–6 representing moderate-intensity physical activity (MIPA), and 7–9 representing vigorous-intensity physical activity (VIPA)[26]. Next, the monthly average activity time per day for each intensity level was

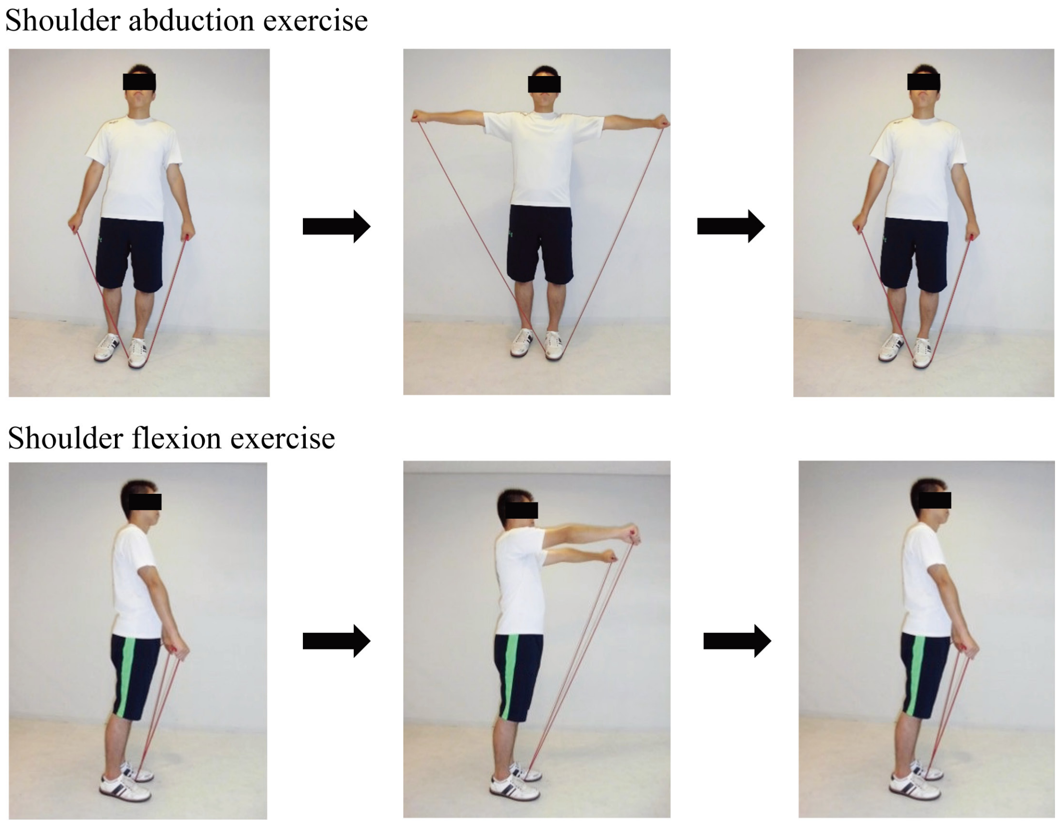

Fig. 1. Upper extremity resistance training in this study.

calculated for September 2017 (pre-intervention), October 2017 (1 month), November 2017 (2 months), February 2018 (5 months), and March 2018 (6 months). The year-end and New Year holidays involved comparably different activities from other month which made data collection difficult, so we excluded data from December 2017 and January 2018.

In addition, the average physical activity time per day for each exercise intensity per month multiplied by 7 was calculated as a 7-day equivalent activity time. The resulting value was used to represent weekly activity time.

The 6 minutes walking distance (6MD) by 6-minute walk test was conducted on a 25 m one-way walking path according to the ATS statement[27)]. Based on guidelines from the American Thoracic Society[28)], forced vital capacity (FVC), maximum expiratory pressure (PEmax), and maximum inspiratory pressure (PImax) were measured three times using a generic, simple spirometer (CHEST, HI-801). Of the three times, the one with sufficient effort to avoid artifact while providing favorable initial expiratory force was selected for later analysis. If there is a change in FVC, expiratory muscle strength may increase when exhalation volume increases, and inspiratory muscle strength may increase when inspiration volume increases. Therefore, spirometry was conducted in conjunction with HI-801. Grip strength was measured once for the left and right hands using a digital grip strength meter (TKK5401 manufactured by Takei Kikai Co., Ltd.), before the average value was taken. Knee extension strength was measured using a sensor pad in a position where the knee joint was bent 90 degrees in the sitting position at the end of a bed following Kato et al.[29)] in conjunction with an isometric muscular strength meter (Anima, μ-Tas MT-1). The device was fixed to the distal part of the lower extremity with a belt and measurement were recorded three times on both the left and right legs to obtain an average max value.

Statistical analysis was conducted using two-way analysis of variance and multiple comparison tests (Bonferroni method) to examine intergroup factors as well as to compare efficacy pre and post intervention. Next, Pearson correlation coefficient were calculated for LIPA time, MIPA time, VIPA time, 6MD, FVC, PEmax, PImax, grip strength, and knee extension muscle strength following the intervention. Based on the results of Pearson correlation analysis, multiple stepwise regression analysis was performed to assess for association of pre-intervention factors as the independent variable with post-intervention physical activity time as the dependent variable using age as an adjustment. Statistical package SPSS Ver.25 for Windows was used to carry out, and statistical significance was lower than 5%.

RESULTS

There were no significant differences between groups for any item before the intervention (Table 1). Table 1 shows LIPA, MIPA, and VIPA time pre and post intervention for both groups. The LIPA time did not differ between groups. The MIPA time was significantly higher in both groups after 6 months of intervention. The VIPA time was significantly higher in the FW group after 6 months of intervention. Physical activity time over 1 week increased significantly for MIPA in both groups, and VIPA time increased in the FW group alone.

Table 2 shows average daily LIPA, MIPA, and VIPA time by month. At LIPA, the RT group did not show a significant difference compared to pre-intervention, but there was significant difference at 2 months compared to 1 month or 5 months. The FW group did not significantly differ compared to pre-intervention or monthly. At MIPA, the RT group showed a significant increase compared to pre-intervention after 6 months. The FW group showed significant increase at 2 and 5 months compared to pre-intervention. At VIPA, there was no significant difference between groups compared to pre-intervention.

In the results of Pearson's correlation analysis, only MIPA time was correlated with 6MD and PImax (Table 3). Therefore, multiple regression analysis with MIPA time 6 months following intervention as the dependent variable and 6MD and PImax pre-intervention as independent variables showed that pre-intervention 6MD was closely associated with MIPA time after 6 months. Additionally, we performed a stepwise multiple regression analysis with pre-intervention age as an adjustment, and pre-intervention 6MD and PImax as independent variables. This analysis revealed that pre-intervention 6MD also associated with MIPA time 6 months following intervention (Table 4).

Table 1 shows 6MD, FVC, PEmax, PImax, grip strength, and knee extension strength before and after the intervention. FVC increased significantly following intervention in the RT group alone. There was no difference in 6MD, PEmax, PImax, grip strength, or knee extension strength.

DISCUSSION

The MIPA time significantly increased after 6 months of intervention in the RT group and after 2 and 5 months in the FW group. The possible reason for the increased MIPA time after 6 months in the RT group is because the exercises could be performed indoors during winter. Even during daily activities unassociated with muscle exercise, a MIPA could be maintained, leading to overall MIPA time cumulatively increasing after 6 months. Okayama et al. investigated seasonal variation in step count between August and March among community-dwelling elderly[30]. In March, the number of steps decreased by 60 to 70% compared to August, and the authors suggested that an exercise program executable during the winter months should be developed. The month before this study's intervention was the summer month of September. The MIPA time, which is an indicator of faster walking intensity, was significantly higher in March over winter than in September. Therefore, it was believed that resistance training of the upper extremity would serve as a sufficient recommendation for winter exercises. Low intensity resistance training using resistance tube is a less effective exercise method over the short term, but it allows individuals to continue exercising for a short time every day at home even during the cold winter. Resistance training also increases the duration of MIPA. For these reasons, it is a recommended exercise modality for the elderly.

Conversely, since the FW group was instructed to exercise mainly outdoors, there were cases in which suitable exercise habits could not be developed due to the weather, winter season, or other environmental conditions. Therefore, it is believed that participants were unable to attain a clear, cumulative benefit.

Calculating the correlation coefficient revealed 6MD to be significantly associated with MIPA time only. During the 6MD test, participants could take a break along the way. However, they were required to walk fast enough to meet the relative effort benchmark. As such, we considered walking activity that attained a maximum walking distance over a set period of 6 minutes to reflect a load corresponding to moderate-intensity exercises.

Multiple regression analysis was conducted for pre-intervention MIPA time after 6 months on 6MD, revealing a significant association with MIPA time after 6 months. The significant association of 6MD with MIPA did not change by an adjustment, and VIPA time pre-intervention was also significantly correlated. Therefore, 6MD is an important factor to consider when conducting MIPA and confirming a favorable pre-intervention 6MD and VIPA time as important requirements to maintain MIPA time after 6 months. Tsuneyoshi et al. used Lifecoder to find that the average MIPA time per day for healthy elderly adults in November was 19.6 minutes[22]. This result closely resembles the pre-intervention MIPA time found in our own study. In other words, the pre-intervention MIPA time for healthy elderly individuals found in the present study is considered to be reasonable. Pre-intervention MIPA time per day was 20.2 minutes for the RT group and 19.5 minutes for the FW group. Multiplying by 7, the weekly MIPA time for these groups were 141.4 minutes and 136.5 minutes, respectively. The World Health Organization (WHO) advocates ensuring at least 150 minutes of MIPA time per week for community-dwelling elderly individuals to maintain their health. Although the participants in this study were healthy elderly individuals, they did not meet the WHO criteria. In a study by Tsuneyoshi et al., the moderate-intensity activity time of healthy elderly people was 19.6 minutes[22]. When multiplied by 7, that number increases to 137.2 minutes. The WHO recommends that healthy, elderly individuals exercise at least 150 minutes per week, and we propose that the establishment of an exercise regimen for elderly people in Japan that satisfies this benchmark is of vital importance.

Table 1. Two-way ANOVA for both groups pre-intervention and 6 months post intervention

	RT Group		FW Group		Two-way ANOVA						
	Pre-intervention	6 months	Pre-intervention	6 months	Main effect period		Main effect intergroup		Interaction		Multuvariate comparison
					F	p	F	p	F	p	Period/intergroup
LIPA time (min/day)	56.1 (13.3)	53.2 (14.7)	50.0 (12.0)	50.9 (9.8)	0.41	0.528	0.68	0.419	1.562	0.225	
MIPA time (min/day)	20.2 (11.8)	25.1 (12.5)	19.5 (12.9)	24.3 (17.4)	17.66	<0.001	0.02	0.896	0.005	0.946	a** b*
VIPA time (min/day)	1.1 (2.2)	1.6 (2.4)	0.8 (1.2)	2.3 (3.4)	6.44	0.019	0.07	0.798	1.919	0.180	b*
LIPA time 7-days (min/week)	392.9 (92.8)	372.5 (103.1)	350.0 (84.3)	356.6 (68.7)	0.41	0.528	0.68	0.419	1.563	0.224	
MIPA time 7-days (min/week)	141.2 (82.7)	176.0 (87.5)	136.7 (90.4)	170.3 (121.9)	17.66	<0.001	0.02	0.896	0.005	0.946	a** b**
VIPA time 7-days (min/week)	7.8 (15.5)	10.9 (17)	5.7 (8.3)	16.3 (24.1)	6.47	0.019	0.07	0.798	1.936	0.178	b*
6MD (m)	538.7 (52.1)	536.6 (54.4)	556.7 (57.1)	557.0 (65.1)	0.04	0.847	0.69	0.414	0.062	0.805	
FVC (L)	2.34 (0.34)	2.43 (0.38)	2.30 (0.29)	2.37 (0.19)	9.91	0.005	0.14	0.711	0.060	0.809	a*
PEmax (mmHg)	57.6 (13.4)	55.9 (13.8)	55.8 (15.6)	57.5 (22.5)	<0.01	0.997	<0.01	0.988	0.280	0.602	
PImax (mmHg)	52.9 (15.5)	54.4 (16.1)	60.4 (18.2)	60.3 (22.4)	0.15	0.703	0.87	0.363	0.240	0.629	
Grip strength (kgf)	22.5 (3.7)	22.8 (3.6)	22.8 (4.3)	22.3 (4.4)	0.07	0.790	<0.01	0.957	1.212	0.283	
Knee extension strength (kgf)	20.7 (6.0)	19.8 (3.8)	23.8 (6.4)	21.8 (5.6)	4.07	0.056	1.36	0.257	0.607	0.444	

Mean (standard deviation).
There were no significant differences between groups for any item on pre-intervention.
RT: resistance training; FW: fast walking; LIPA: light-intensity physical activity; MIPA: moderate-intensity physical activity; VIPA: vigorous-intensity physical activity; 6MD: 6 minutes walking distance; FVC: forced vital capacity; PEmax: maximum expiratory pressure; PImax: maximum inspiratory pressure; a: significant difference between pre-intervention and 6 months in RT Group; b: significant defference between pre-intervention and 6 months in FW group.
*p<0.05, **p<0.01.

Table 2. Change of LIPA, MIPA and VIPA time

	RT Group					FW Group					Two-way ANOVA						
	PI	1 mo	2 mo	5 mo	6 mo	PI	1 mo	2 mo	5 mo	6 mo	Main effect period		Main effect intergroup		Interaction		Multuvariate comparison
											F	p	F	p	F	p	Period
LIPA time (min/day)	56.1 (13.3)	52.2 (12.0)	59.2 (16.1)	53.5 (16.6)	53.2 (14.7)	50.0 (12.0)	50.9 (10.6)	52.2 (10.6)	51.5 (12.6)	50.9 (9.8)	3.033	0.004	0.519	0.479	0.751	0.395	a** b*
MIPA time (min/day)	20.2 (11.8)	20.9 (11.6)	24.5 (11.8)	24.6 (11.7)	25.1 (12.5)	19.5 (12.9)	21.3 (11.0)	28.3 (16.9)	26.4 (12.8)	24.3 (17.4)	6.235	0.002	0.031	0.862	1.125	0.350	c* d** e*
VIPA time (min/day)	1.1 (2.2)	1.5 (2.9)	1.6 (2.8)	1.6 (2.7)	1.6 (2.4)	0.8 (1.2)	1.1 (1.5)	1.8 (2.5)	2.3 (3.4)	2.3 (3.4)	2.303	0.096	0.041	0.841	3.072	0.094	

Mean (standard deviation).
RT: resistance training; FW: fast walking; PI: pre-intervention; 1 mo: +1 month; 2 mo: +2 month; 5 mo: +5 month; 6 mo: +6 month; LIPA: light-intensity physical activity; MIPA: moderate-intensity physical activity; VIPA: vigorous-intensity physical activity; a: significant difference between 1 mo and 2 mo in RT Group; b: significant difference between 2 mo and 5 mo in RT Group; c: significant difference between PI and 6 mo in RT Group; d: significant difference between PI and 2 mo in FW Group; e: significant difference between PI and 5 mo in FW Group.
*p<0.05; **p<0.01.

Table 3. Pearson correlation coefficient for each endpoint after 6 months

	LIPA time	MIPA time	VIPA time	6MD	FVC	PEmax	PImax	Grip strength	Knee extension strength
LIPA time	-								
MIPA time	0.063	-							
VIPA time	−0.060	0.669**	-						
6MD	0.076	0.542**	0.298	-					
FVC	0.066	0.288	−0.017	0.402	-				
PEmax	−0.029	0.111	0.325	0.418*	0.261	-			
PImax	0.118	0.453*	0.187	0.392	0.331	0.134	-		
Grip strength	0.056	0.057	−0.070	0.367	0.311	0.430*	0.456*	-	
Knee extension strength	0.108	−0.038	−0.076	0.173	0.234	0.439*	0.299	0.523**	-

LIPA: light-intensity physical activity; MIPA: moderate-intensity physical activity; VIPA: vigorous-intensity physical activity; 6MD: 6 minutes walking distance; FVC: forced vital capacity; PEmax: maximum expiratory pressure; PImax: maximum inspiratory pressure.

Table 4. Pesults of linear regression analysis: factors associated with moderate-intensity physical activity time after intervention

		β	95% confidence interval		Standardized β	p
			lower	upper		
Model 1	Constant	−55.572	−110.782	−0.363		0.049
	PImax	0.134	−0.203	0.470	0.155	0.419
	6MD	0.133	0.029	0.238	0.499	0.015
Model 2	Constant	−40.088	−197.889	117.712		0.603
	Age	−0.164	−1.853	1.525	−0.039	0.842
	6MD	0.142	0.034	0.249	0.529	0.012

Dependent variable: moderate-intensity physical activity time after intervention.
Independent variable: PImax and 6MD at baseline.
Adjustment for Model 2: age.
Model 1: R^2=0.251 Analysis of variance F=4.846, p=0.019.
Model 2: R^2=0.228 Analysis of variance F=4.394, p=0.025.
PImax: maximum inspiratory pressure; 6MD: 6 minutes walking distance.

In the present study, we calculated the average MIPA time one week equivalent after 6 months of intervention. RT group was active for 176 minutes, the FW group was active for 170 minutes, and both groups exceeded the standard of 150 minutes or more proposed by the WHO. Exercise done by RT group is exercise that can be performed at home. Although fast walking may depend on the weather, both exercise types are effective for maintaining moderate-intensity activity time for healthy, elderly individuals. Therefore, low intensity resistance training using resistance tube is a low-risk and easy-to-continue method recommended for elderly people. However, when exercising, it is important to promote regular monitoring and encouragement.

In this study, the FVC improved significantly in the RT group, who performed upper extremity resistance training. Kera et al. showed that airway obstruction pressure, which is a measure of respiratory motor output, increased significantly when a 1 kg lifting exercise was performed to the shoulder joint level among healthy university students[31)]. Although the reason is not clearly understood, it has been shown that upper extremity movement increases respiratory motor output. Ries et al. found that intervention with upper body ergometer exercises in participants with chronic obstructive pulmonary disease resulted in a significant improvement in FVC and some crossover effects on upper extremity movement and respiratory muscle action[32)]. Mutluay et al. revealed significant improvement in FVC and increased endurance from interventions such as shoulder flexion and abduction, lateral flexion of the neck, and rotation of the trunk in participants with multiple sclerosis[33)]. The RT group in the present study is significantly different at the target age compared to participants in a study conducted by Kera et al., but the horizontal lifting exercises of the shoulder joint are similar[31)]. The RT group in our study, which uses resistance tube, may have experienced an increase in pulmonary output. The main muscle utilized in arm elevation by the RT group is the deltoid muscle. However, in order to contract the deltoid muscle efficiently, the scapula must be stabilized by muscle contraction of the peripheral shoulder and neck muscles. The peripheral cervical muscle assists in respiration, particularly during inspiration. In other words, the RT group, which used resistance tube, also increased engagement of inspiratory assist muscles via the upper extremity lifting exercises. As a result, we suspect that FVC improved with previous studies. Although it has been shown that pulmonary function among the elderly decline with age, low intensity resistance training using resistance tube may minimize the decline of pulmonary function.

In the present study, there was no significant decrease in the 6MD, knee extension strength, and grip strength used as evaluation for physical capacity. The low intensity exercise conducted in the present study was able to be sufficiently maintained, and the exercise regimen used may be considered an effective and low-risk method for elderly individuals. Conversely, grip strength was correlated with PEmax, PImax, and knee extension strength. Grip strength is an index of whole-body muscle strength, including shoulder abduction, hip flexion, ankle dorsiflexion, and so forth[34]. The results of the present study suggest that grip strength can be considered an index of respiratory muscle strength as well as joint action.

We have proposed that intervention with low intensity exercises that can be performed at home for the upper extremity for the healthy, community-dwelling elderly is an effective to enhance pulmonary function and to maintain muscle strength. Moreover, since MIPA time per week would be greater than 150 minutes, this exercise regimen conforms to the WHO recommendations on exercise time required to improve the health of elderly individuals. Low intensity home exercises for the upper extremity can be performed indoors, making exercise possible anywhere regardless of the weather and can be introduced to anyone with low risk. Since low intensity, upper extremity resistance training using resistance tube, may contribute to promote daily activity, long-term verification studies are necessary.

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Conflicts of interest

There are no conflicts of interest to declare.

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