



Original Article

Effects of a 12-week marching in place and chair rise daily exercise intervention on ADL and functional mobility in frail older adults

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Abstract. [Purpose] To determine the effects of a 12-week intervention consisting of marching in place and chair rising daily exercise on activities of daily living and functional mobility (ability to quickly rise from a chair and walk) in frail older adults. [Subjects and Methods] Thirty-one participants were divided into exercise (n=18, age=77.6 ± 7.2 years; 11 males, 7 females) and non-exercise (n=13, age=79.6 ± 7.7 years; 7 males, 6 females) groups. The exercise group performed 12 weeks of training, 7 days per week, and 20 minutes per session. The exercise program consisted of low to moderate intensity marching in place and chair rising movements. The speed of movements was gradually increased over time. The Barthel index, mean power during chair stand, and time to complete a 10-m walk were assessed before and after the intervention. [Results] Significant improvements were noted in the exercise group compared to the non-exercise group for the Barthel Index (11.6%), mean power (33%), and 10-M walk (14.6%) with a medium effect size, and relative mean power (power/body mass) (32.9%) with a large effect size. [Conclusion] The progressive marching in place and chair rising exercise intervention appears to be effective in improving activities of daily living and functional mobility among frail older adults.

Key words: Muscular power, Frail older adults, Activities of Daily Living

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INTRODUCTION

Aging is associated with declines in activities of daily living (ADL) and physical function that can lead to physical impairment, disability, and loss of independence¹⁾. However, resistance exercise in older adults has been shown to counter the declines in muscle mass, strength, and power that are associated with aging and an inactive lifestyle^{2, 3)}. Nursing home residents are often sedentary and it has been reported that frail older women residing in a nursing home experience significant progressive loss of muscle mass⁴⁾. Therefore, performance of muscular strength exercise is encouraged not only for healthy older adults but also for frail people. Although strength deficits are prevalent in older adults, age-associated declines in muscle power start even earlier. Oftentimes, these occur in the third or fourth decades of life and it has been shown that the rate of muscle power decline is faster than that of muscular strength⁵⁾.

Muscular power is clearly an important factor in maintaining independence in aged people as well as to prevent falls⁶⁻⁸⁾.

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Recent studies have reported that muscular power might predict mobility and the ability to perform ADL, particularly when there are deficits in muscular power that limit the ability to quickly rise from a chair and walk^{9, 10}. From a systematic review¹¹, it would appear quite likely that power training has greater potential to improve functional performance in older adults than strength training. Most of the power training researches used either regular free-weight or machine-based exercises. Some of the studies used weight vests, air driven pneumatic equipment and elastic band. However, there are many older adults who have limited ability to perform active exercises especially weight-bearing exercises, due to orthopedic conditions, chronic musculoskeletal conditions, excess adiposity, poor balance, or simply due to age-associated sarcopenia^{12, 13}.

Power is defined as the product of force and velocity. Fujita et al.¹⁴ showed that a normalized relative value (%EMGmax) during squat exercise for the frail elderly persons was about 75%. Rice and Keogh¹¹ have previously established that this would equate to a relative-intensity level of light to moderate. Our hypothesis for the current study was that by increasing the speed of one's body mass-based squat exercise, the power of the performed exercise could be increased in frail older adults.

The purpose of this study was to determine the effects of a 12-week intervention consisting of daily low to moderate intensity marching in place and chair rising exercise on ADL and functional mobility (ability to quickly rise from a chair and walk) in frail older adults.

SUBJECTS AND METHODS

Thirty-one older volunteers who had not previously participated in an exercise program were divided into an exercise group (11 males and 7 females; average age 77.6 ± 7.2 years) and a non-exercise group (7 males and 6 females; average age 79.6 ± 7.7 years). Considering the small size of the facility, it was impossible to recruit the exercise group and non-exercise group from the same facility. For this reason, a similar non-exercise group was recruited from another facility.

Initially, 58 volunteers consented to participate into the study. However, five of them were excluded from the study as they could not be evaluated completely at pre-training test level. Twenty two participants out of the remaining 53 participants were excluded from the post-training testing due to reasons such as stopped coming to the selected nursing homes or because of suffering from illness at the time of post-testing. Thus the data of 18 participants in exercise group and of 13 participants in non-exercise group was used for statistical analysis.

The exercise group participants were invited via flyers distributed in a nursing home (Yasugi City, Shimane Prefecture, Japan) and the non-exercise group participants were recruited via flyers from a similar but different care center (Nagoya City, Aichi Prefecture, Japan). The average length of nursing home residence for all participants were 5.6 years that ranged from 1 year to 13 years. The non-exercise group attended the day service facility at their respective nursing home three times a week. The service consisted mainly of bathing and feeding. An exercise for 20 minutes a day, twice a week was instructed by the physical therapist to the chair-based group. However, this group exercise program mainly focused on relaxation therapy. Additionally, joint mobilization and facilitation-based physical therapy was provided to any participant when it was demanded or needed. This joint mobilization and facilitation-based physical therapy was provided to exercise group participants too when it was demanded or needed.

The nursing homes involved in this study provided assistance with only instrumental ADL to their residents and all participants of the current study were able to walk indoors independently. Assistance was not required for basic ADL such as eating, dressing, or taking a bath. However, assistance was needed to prepare food, readying the bathtub or shower, etc. None of the participants were suffering from uncontrolled hypertension, congestive heart failure, untreated ischemic heart disease, or untreated arrhythmia. No restrictions were placed upon them by their attending physician in regards to their participation in the exercise program. The ethical committee of Nagoya City University approved the study (Approval No. 23). All participants received written and oral instructions for the study and each gave their written informed consent before participation.

Exercise training was conducted at the nursing home over a 12-week period on 7 days per week for 25 minutes per day. Each session consisted of 5 minutes of stretching and calisthenics and 15 minutes of low to moderate intensity main exercises followed by 5 minutes of cool down and relaxation. Each session was led by trained instructors and was supervised by the research staff. Exercise session consisted of marching in place (MP) and chair rising (CR) exercises. Without using any exercise equipment, the speed of the performed movements was increased gradually over time following real time oral instructions from the exercise instructor. Details of performed exercises are described in [Table 1](#).

Height and body mass were measured by using Impedance measuring device (TBF-202, Tanita Co., Tokyo, Japan). Body mass index was calculated as body mass (kg) divided by the square of height (m). A version of the Barthel index (BI) adapted by Shah et al.¹⁵ that includes 10 scored items using a five-point scale was used to collect information about the need for assistance in performing ADL and to establish a degree of independence in the participants.

Mean power during chair stand (CSMP) was determined using a linear displacement transducer. The velocity during a single chair stand was measured using the Fitro Dyne device (Fitronic S. R. O. Co, Slovakia). This device is a linear-displacement transducer consisting of an optical sensor within a slotted disk attached to a nylon cord and a microcomputer. The disk rotates when the cord is extended and electrical pulses corresponding to linear displacement are generated. The optical sensor detects these pulses and determines the velocity of movement. The cord was attached to a pelvic-level belt to measure the speed of postural change during every millisecond (0.001 second) while going from a seated to a fully standing position. Power (W) was calculated as the product of body mass and velocity during the chair stand movement according to

Table 1. Contents of exercise program

Stage	Exercise	Contents (Daily exercise session duration: 25 minutes)
First (1 to 4 weeks)	Warm up and light exercise	NHK radio calisthenics
	Marching in place (MP)	MP using hip joint and knee joint (flexion <90°) 1 step/sec, 15 steps/set, 1 set
	Chair rising (CR)	1 stand/3–4sec, 15 stand/set 2 sets
Second (5 to 8 weeks)	Warm up and light exercise	NHK radio calisthenics
	MP with four different styles	1) MP using hip joint and knee joint (flexion <90°), 1 step/sec, 15 steps/set, 1set,
		2) MP by using hip joint and knee joint (flexion >90°), 1 step/sec, 15 stands/set, 1 set,
		3) MP by intending to touch the same side elbow and knee) 1 step 1 step/sec, 15 stands/set, 1 set,
4) MP by intending to touch the opposite side elbow and knee) step 1step/sec, 15 stands/set, 1 set.		
CR (with gradual speed up)	1 stand/2 sec, 15 stand/set, 2 sets	
Final (9 to 12 weeks)	Warm up and light exercise	NHK radio calisthenics
	MP with four different styles	1) MP using hip joint and knee joint (flexion <90°) 2 step/sec, 15 stands/set, 1 set,
		2) MP by using hip joint and knee joint (flexion >90°) 2 step/sec, 15 stands/set, 1 set
		3) MP by intending to touch the same side elbow and knee) 2 step/sec, 15 stands/set, 1 set,
4) MP by intending to touch the opposite side elbow and knee) 2 step/sec, 15 stands/set, 1 set		
CR (while further speeding up its movement intentionally/ willingly)	1) 1 stand/sec, 15 stand/set, 1 set,	
	2) 15 stands/set performed as fast as possible	

Table 2. Comparison of physical characteristics between groups at pre-test level

	Exercise group (n=18, M=11, F=7)	Non-exercise group (n=13, M=7, F=6)	Group Difference
Age (years)	77.6 ± 7.2	79.6 ± 7.7	
Height (cm)	152.1 ± 10.4	154.5 ± 10.1	
Body mass (kg)	49.9 ± 5.5	56.3 ± 10.4	*
BMI (kg/m ²)	21.8 ± 3.3	23.6 ± 3.7	
CSMP (W/kg)	3.61 ± 1.55	3.15 ± 1.21	

Values are in mean ± standard deviation. BMI: body mass index (body mass/height²×10²); CSMP-kg: CSMP (W) divided body mass (kg). *p<0.05.

the power evaluation technique described by Kato et al¹⁰).

The 10-meter walk (10M) test was used to evaluate the speed of walking a 6-meter distance¹⁶. A straight 10-meter walking course on a level ground was demarcated on the floor and participants were instructed to walk at their fastest voluntary speed. Participants started 2 meters behind the point where the timing was initiated in order to allow them to accelerate to their fastest voluntary speed before the timing started. Likewise, the ending point was marked two meters beyond the timed 6-meter section so they would not decelerate before completing the timed section. The duration in seconds needed to walk through the middle 6 meters of the course was used for analysis. As this is a timed test, a lower score indicates better performance. All tests were performed by all of the participants before and immediately after the training period of 12 weeks.

Unpaired t-tests were used for the comparison of groups before the exercise intervention. Gender ratio and length of nursing home residence of the groups was evaluated by performing the χ^2 test. The effects of the exercise intervention were evaluated with repeated measures analysis of variance (ANOVA). Effect size (ES) was also calculated for each test¹⁷. Cohen's definition of small, medium, and large ES (ES=0.2, 0.5, and 0.8, respectively) was used¹⁸. The significance level was set at $\alpha=0.05$.

RESULTS

No significant difference in gender ratio or length of nursing home residence was noted between groups. No significant differences at baseline were present between the exercise group and non-exercise group in any of the measured variables except body mass which was significantly higher in the non-exercise group (Table 2). All of the participants completed the training, and none suffered any injuries as a result of the training program.

After the 12-week exercise program, significant improvements were noted in the exercise group compared to the non-exercise group for the BI (11.6%), 10 M (14.6%), CSMP (33.0%), and relative CSMP (32.9%). The ES for BI, 10M, and

Table 3. Effect of exercise on body mass, body mass index, ADL, 10 m walk, and mean power during chair stand (CSMP)

Parameters	Group	Pre	Post	Change (%)	Effect size	Group effect	Time effect	Group × time effects
Body mass (kg)	EX group	49.9 ± 5.5	49.9 ± 5.5	0.1	0.0	*		
	C group	56.3 ± 10.4	56.0 ± 10.9	-0.7	-0.03			
BMI (kg/cm ² ×10 ²)	EX group	21.8 ± 3.3	21.8 ± 3.3	0.1	0.0			
	C group	23.6 ± 3.7	23.5 ± 3.9	-0.7	-0.03			
Barthel index (point)	EX group	78.3 ± 12.6	87.5 ± 15.4*	11.6	0.73		*	*
	C group	74.6 ± 14.6	77.3 ± 17.9	3.5	0.19			
10 m walk (sec)	EX group	12.5 ± 3.4	10.6 ± 3.7*	-14.6	0.56	*		*
	C group	13.9 ± 2.4	15.4 ± 4.5	11.9	-0.63			
CSMP (W)	EX group	183.2 ± 88.3	241.3 ± 134.3*	32.9	0.66		*	*
	C group	180.2 ± 84.5	177.9 ± 77.4	2.1	-0.03			
CSMP kg (W/kg)	EX group	3.6 ± 1.5	4.8 ± 2.4*	32.9	0.80		*	*
	C group	3.2 ± 1.2	3.1 ± 1.1	2.8	-0.08			

Values are mean ± standard deviation. BMI: body mass index; CSMP: mean power during char stand (W); CSMPkg: CSMP (W) divided body mass (kg). *p<0.05.

CSMP were medium while the ES for relative CSMP was large. No significant changes were noted in any measured variable in the non-exercise group (Table 3).

DISCUSSION

This study evaluated the effects of a 12-week intervention that included marching in place and chair rising exercises on ADL and functional mobility in frail older men and women. After the 12-week program, the BI, 10M, and CSMP (both absolute and relative values) significantly improved with medium to large ES. Furthermore, improvements in CSMP were greater than 30%.

One of our previous studies utilized receiver operator characteristic curve analysis to identify a threshold of chair stand power that is necessary to independently perform ADL in community-dwelling older women¹⁰). Results of that study identified the threshold of chair stand power to be 214 W with 82.1% sensitivity and 81.2% specificity. In the current study, the CSMP of the exercise group at baseline was much lower (183 ± 88 W) than the threshold of 214 W. However, CSMP significantly improved to a level well above (241 ± 131 W) the threshold after training.

A recent study reported improvement in physical function following high-speed power training with an average limb velocity of 0.88 m/sec in healthy older adults¹⁹). Others have found that even a progressive heavy-resistance training program of short duration (i.e., 8 weeks) can produce dramatic improvements in muscle strength as well as significant muscular hypertrophy in physically active older women²⁰). Although the participants of the current study were frail and not healthy like those of the two afore-mentioned studies, it appears that frail older adults are capable of achieving significant gains in function using a low to moderate intensity exercise program that requires no equipment other than a chair.

Chair-based exercise programs are often provided for older adults with limited mobility both in residential care and community settings²¹). A systematic review of well-designed randomized controlled trials has previously justified the effectiveness of chair-base exercise²²). However, the specific exercises used in the current study, along with the progressive increase in the speed of performing these exercises, have not been previously evaluated. The results of the current study indicate that this training method is an effective but safe mode of improving functional mobility and this may, in turn, lead to a reduction in the assistance needed as the aging process proceeds.

Previous research described the benefits of a dance-based aerobic exercise program that included single-leg stance, squatting, marching, and heel touching performed for 60 minutes per session, 3 days per week, for 12 weeks in older women²³). The participants of the current study could not continue the marching movement for much longer than what was achieved in the current study and therefore could not participate in exercise at a level employed by many other researchers. However, it is interesting that the progressive nature of the exercise program in this frail population was able to result in large improvements with less time spent exercising each day. This may be attributed to the high frequency of training in the current study. While many studies require participants to engage in activity for 60 minutes a day, it is usually for only 3 days per week with a total of 180 minutes per week. In this case, participants engaged in 25 minutes of exercise per day for 7 days a week and a total of 175 minutes each week. Thus the total time spent exercising each week in the current study was almost similar to that of the previous studies.

While several robust techniques are available for the analysis of gait including 3-dimensional motion capture systems, force plates, and electromyography techniques, most of these tools are only used for clinical research purposes²⁴). In practice,

walking analysis is often performed using the 10 M test, a simple method that requires only a stopwatch to assess gait speed over a distance of 6 meters²⁵). Although commonly called the 10 M test¹⁴), it is really a well-accepted misnomer in that only 6 meters are actually measured as two meters are not timed at both the beginning and end of the 10-meter course to allow for acceleration and deceleration. It is worth noting that although the current study did not incorporate walking directly as part of the exercise program, significant improvements in walking speed were observed. This may be due to a synergistic effect between marching in place and chair rising exercise. During the intervention, participants progressively increased the speed of movement and this appears to have translated into a faster gait speed. More research is needed to determine if these exercises can achieve similar results if performed separately or if it truly is a synergistic effect.

The BI is a popular instrument for assessing ADL²⁶) and its reliability and validity have been justified in previous studies either in its original form or in modified form^{27, 28}). The original BI assesses an individual's capacity to perform 10 daily tasks without assistance and provides a summed, overall score that reflects the individual's level of independence²⁸). Of the various modifications to the BI scoring system that have been suggested, Shah et al.¹⁵) proposed a five-point scale to increase the ability to detect changes in ADL and this version eventually became the preferred method.

A universally-accepted definition of frailty has yet to be developed. Fried et al.²⁹) have proposed an often-cited phenotypic definition of frailty based on readily identifiable physical aspects. According to them, three or more of the following characteristics support a diagnosis of frailty: unintended weight loss, exhaustion, weakness, slow gait speed, and low physical activity. Based on this definition of frailty, not all of our participants may have been frail, however all of them did need assistance to complete their ADL. It is also obvious that they had slower gait speeds as indicated by their baseline 10-meter walk (12.5 ± 3.4 sec) performance, reduced ability to perform ADL as indicated by their baseline BI score, and they had muscular weakness as indicated by their baseline CSMP (183 ± 88 W) level. Based on these measures, it can be argued that the participants were indeed frail.

A limitation of the current study was that the non-exercise and the exercise groups did not come from the same care giving facility. In addition, although the average body mass at baseline was significantly different between the groups, no significant difference was noted in the mean value of CSMP per kg of body mass. In the current study, it could not be determined if this difference in average body mass influenced the outcomes. Future study is needed to overcome this limitation.

In conclusion, the 12-week program of progressive marching in place and chair rising daily exercise seems to be effective in improving ADL and functional mobility, or the ability to quickly rise from a chair and walk, in frail older people.

Conflict of interest

None.

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