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Original Article

Effect of a simple and adherent home exercise program on the physical function of community dwelling adults sixty years of age and older with pre-sarcopenia or sarcopenia

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Abstract. [Purpose] To evaluate the effect of a home exercise program on physical function in community dwelling elderly with pre-sarcopenia or sarcopenia. [Subjects and Methods] Fifty-two community-dwelling individuals, over 60 years and meeting the diagnostic criteria for pre-sarcopenia or sarcopenia, were randomly assigned to intervention group (n=34) and control group (n=18). The intervention group completed 6-months home exercise programs, combining walking with lower limb resistance exercises. Body mass index, skeletal mass index, body fat percentage, handgrip strength, single-leg standing, walking speed (comfortable and maximal), and knee extension strength were evaluated at baseline and post-intervention. Activity was assessed using the 25-question Geriatric Locomotive Functional Scale (GLFS-25) and quality of life using the Euro QOL questionnaire. [Results] Pre- and post-training assessments were completed by 76.5% and 77.8% of participants in the intervention and control groups, respectively. The intervention improved single-leg standing (60.5 s to 77.2 s) and knee extension strength (1.38 Nm/kg to 1.69 Nm/kg). In the control group, maximum walking speed (2.02 m/s to 1.86 m/s) and GLFS-25 score (2.9 to 5.1) worsened. Change of pre-sarcopenia/sarcopenia status was comparable for the intervention (15.4%) and control (14.3%) groups. [Conclusion] A 6-month home exercise program improved physical function in community-dwelling individuals with pre-sarcopenia or sarcopenia.

Key words: Sarcopenia, Pre-sarcopenia, Home-based exercise

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INTRODUCTION

Sarcopenia is an important and common health problem in elderly individuals. The European Working Group on Sarcopenia in Older People (EWGSOP)[1)] and the Asia Working Group for Sarcopenia (AWGS)[2)] have published an algorithm to diagnose sarcopenia based on the loss of muscle mass, and decrease in muscle strength and walking speed. The EWGSOP also defines pre-sarcopenia as an exclusive loss of muscle mass, with no symptoms.

Among healthy elderly women with a mean age of 71.2 years, the prevalence of sarcopenia and pre-sarcopenia was estimated at 7.6% and 13.3%, respectively[3)]. Sarcopenia has been associated with falls[4)] and disability[5)]. The loss of muscle

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mass is also a risk factor for hip fractures, decreasing the compression and bending strength of the femoral neck in people aged 50 years or older with pre-sarcopenia[6]. In fact, 58% of women with femoral neck fracture have sarcopenia, with pre-sarcopenia identified in another 17%[7].

Muscle strength training can be effective in increasing muscle mass and improving physical function, such as increased muscle strength and walking speed. Kim et al.[8] reported achieving an increase in muscle mass and strength by combining physical exercise with supplementation of essential amino acids among community dwelling women aged over 75 years. Using weightlifting apparatus for resistance training, Binder et al.[9] reduced lean body mass and increased maximal voluntary force of knee extension. Kemmler et al.[10] achieved a reduction in lean body mass and an increase in maximum isometric strength trunk extension and leg press by combining resistance training with a program of aerobic dancing and balance exercises. However, these interventions are strictly managed, require special equipment and a facility for carrying out the exercises, and require daily supervision by instructors to adjust the training stimulus. Therefore, these programs are impractical for use as community-based programs for the prevention and management of sarcopenia.

Muscle strength training could improve sarcopenia or pre-sarcopenia status, and overall physical function. However, elderly people are more likely to prefer resistance training methods that are 'easy to perform', and that do not require special equipment or supervision. Home exercises can provide a solution, as they do not require any particular facility, and direct guidance and coaching from instructors can be provided on a less frequent basis. Moreover, programs of home exercise are typically simple and safe to perform.

Previous studies have demonstrated benefit of a regimen of home exercises in improving strength in elderly individuals. Ito et al.[11] developed a daily program including one-minute single-leg standing and 5–6 repetitions of squats, with three sets a day. After 3 months, 87.4% of participants were still performing the program, with improvements in one-leg standing test. In a previous study, we demonstrated the effectiveness of three home exercises (single-leg standing, squats and heel-raises) in improving physical function in healthy community-dwelling adults over the age of 60 years[12]. Therefore, in this study, we planned to show effects of our 6-month home exercise program on pre-sarcopenia/sarcopenia status and overall physical function in community-dwelling elderly, ≥60 years old, with pre-sarcopenia or sarcopenia.

SUBJECTS AND METHODS

This study was part of the Ina Locomotive Syndrome (ILS) study. The ILS study is a community-based research study involving 341 healthy individuals, ≥60 years old, living in Ina, Saitama Prefecture, Japan. Prospective participants from the ILS study were randomized to the exercise intervention group or control group, using a 2:1.5 allocation ratio (Fig. 1). The skeletal muscle mass index (SMI) was evaluated by bioelectrical impedance analysis (BIA), and the cutoff values for sarcopenia based on the AWGS[2] criteria. Participants of presarcopenia in the intervention and control groups were screened to identify those with a SMI <7.0 kg/m^2 for men and <5.7 kg/m^2 for women. Sarcopenia were screened to identify those with a hand-grip strength <26 kg for men and <18 kg for women, add to criteria of presarcopenia. Of the 184 eligible participants in the intervention group, 34 were screened and provided consent. Of the 90 eligible participants in the control group, 18 were screened and providing consent. Ultimately, the intervention group was comprised of 29 (85.3%) with pre-sarcopenia and 5 (14.7%) with sarcopenia, and the control group 17 (94.4%) with pre-sarcopenia and 1 (5.6%) with sarcopenia. After baseline enrollment, 26 participants in the intervention group and 14 in the control group completed the post-intervention assessment (Fig. 1). Relevant descriptive variables of both groups were described in Table 1. The study was approved by the ethics board of the Faculty of Health and Medical Care of Saitama Medical University (No.113), and participants provided informed consent.

The home exercise programs included lower limb training (Locomotion-training)[13]. The following lower limb resistance exercises and balance exercise were used: squats, single-leg standing and heel raises. Duration of the intervention was 6 months. In the intervention group, physical therapists provided a guidebook to participants, providing information on correct methods to perform the exercises.

The exercises were prescribed in the previous report as follows. For single-leg standing, participants were instructed to maintain a single-leg standing posture for one minute, using light touch on stable desk or chair. For squats, participants were instructed to move slowly from a standing posture to a half-sitting posture over a 6-second movement time, and then to slowly return to their standing position, with 6 repetitions performed per set. Heel raises were performed, with 20 repetitions per set. Participants were instructed to complete three full set of exercises per day. For the walking component of the program, participants were instructed to walk rhythmically, while keeping a correct posture of the head and trunk, for 20–30 minutes per day. Participants in the control group were instructed to maintain their *usual* daily activities and exercise for 6-months.

Data were collected at baseline and at the end of the 6-month intervention. Evaluation included assessment of body composition and physical function, a self-report survey of quality of life (QOL) and activity function. Body composition (Skeletal Muscle Index: SMI; Body Mass Index: BMI; Body fat percentage) was measured by Bio impedance analysis, using a multi-frequency body composition analyzer (MC-190, TANITA Co.). The following assessments of physical functions were performed: handgrip strength, duration of single-leg standing, comfortable and maximum walking speed, and knee extension strength. Knee extension strength was measured using a hand-held dynamometer (μ-TAS F-1; ANIMA Corporation). The measured force was changed to torque by multiplying the length of lower leg, and normalized by the body weight

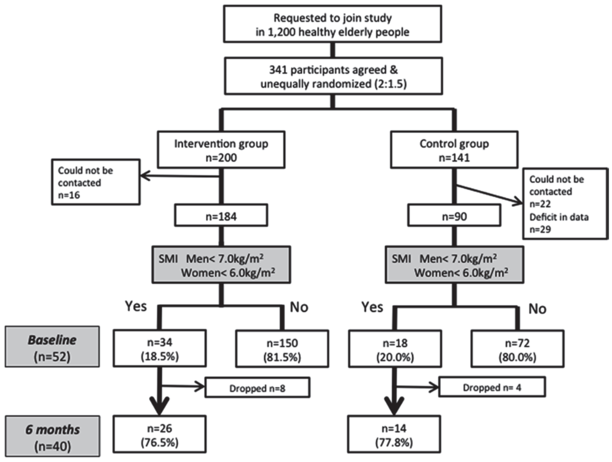

Fig. 1. Algorithm for the identification, selection and randomization of participants to the intervention and control groups
The flowchart includes participants who dropped out between the baseline and 6-month follow-up assessment. SMI: skeletal muscle index

Table 1. Participants characteristics at baseline

	Intervention group (n=34)	Control group (n=18)
Age (yrs)	69.2 ± 5.6	68.5 ± 6.2
Women (n) (%)	19 (55.9)	10 (55.6)
SP (n) (%)	5 (14.7)	1 (5.6)
BMI (kg/m^2)	20.3 ± 1.7	19.7 ± 2.0
SMI (kg/m^2)	5.88 ± 0.67	5.96 ± 0.62
%BF (%)	24.4 ± 6.1	21.9 ± 5.7
HGS (kg)	24.9 ± 7.1	27.9 ± 6.8
SLS (s)	51.6 ± 42.7	71.5 ± 43.1
WS (comfortable) (m/s)	1.44 ± 0.26	1.47 ± 0.25
WS (maximum) (m/s)	1.91 ± 0.28	1.98 ± 0.21
KES (Nm/kg)	1.39 ± 0.42	1.45 ± 0.46
GLFS-25	3.5 ± 3.5	3.2 ± 2.5
EQ-5D	0.906 ± 0.124	0.898 ± 0.118
Frequency of walking (n) (%)	Non: 22 (64.7) ≥2 d/w: 12 (35.3)	Non: 8 (44.4) ≥2 d/w: 10 (55.6)
Frequency of other than walking (n) (%)	Non: 20 (58.8) ≥2 d/w: 14 (41.2)	Non: 12 (66.7) ≥2 d/w: 6 (33.3)

Data are presented mean and standard deviation. Student's t-test for continuous variables and χ^2 test for categorical variables. yrs: years; SP: Sarcopenia; BMI: body mass index; SMI: skeletal muscle index; %BF: body fat percentage; HGS: hand grip strength; SLS: duration of single leg standing; WS: walking speed; KES: knee extension strength; GLFS-25: the 25-question Geriatric Locomotive Functional Scale; EQ-5D: Euro QOL; d/w: day per week

(Nm/kg)[14]. Two self-report questionnaires were used, the Japanese version of the Euro QOL (EQ-5D)[15] and the 25-question Geriatric Locomotive Functional Scale (GLFS-25)[16], with participants completing the questionnaire independently. In addition, at baseline, participants were interviewed about their frequency of 'walking' and 'physical activities other than walking' performed. Participants were interviewed to evaluate their *usual* frequency of exercise by choosing from the following four options: 'no exercise', 'one day a week', 'two days a week', or 'three days a week or more'. For analysis, the frequency of exercise was dichotomized into two categories, <2 days per week and ≥2 days per week.

Reviewing participants' daily training calendars assessed adherence to the exercise program for participants in the intervention group. The training volume completed for each exercise and the walking component of the program was calculated as the proportion of day's participants reported performing each component by the number of days of the intervention period.

Participants in both groups were re-evaluated on the AWGS criteria after the intervention.

Baseline characteristics were compared between the intervention and control groups using independent t-test for continuous data and χ^2 test for categorical data. Intervention effects were evaluated using the data from participants who completed both the baseline and 6-month assessments. Within-group change in body composition, physical function and questionnaire scores, between baseline and post-intervention, was evaluated using paired t-test, with repeated-measure two-way analysis of variance (two-way ANOVA) to evaluate interactions between measured variable, including calculation of the effect size (η^2). Between-group comparisons for all measured variables were evaluated at post-intervention using independent t-test. The proportion of change in sarcopenia and pre-sarcopenia status, from baseline to post-intervention, were evaluated using a chi-squared test. All statistical analyzes were performed using PASW Statistics (version 18; SPSS Japan Co.), with a $p<0.05$ considered as the level of significance.

RESULTS

At baseline, no significant difference was identified between groups (Table 1).

The proportion of 6-months of training completed for each exercise was as follows: 89.4% for squats, 92.0% for single-leg standing, 93.2% for heel-raise, and 71.7% for walking.

Change in measured variables, from baseline to 6-months, is reported in Table 2. A significant improvement in handgrip strength (24.8 kg to 26.1 kg), single-leg standing (60.5s to 77.2s) and knee extension strength (1.38 Nm/kg to 1.69 Nm/kg)

Table 2. Change in measured variables, from baseline to the 6-month assessment

		Main effect			Interaction effect	
		Intervention group (n=26)	Control group (n=14)	Between effect	Interaction effect	Effect size (η^2)
BMI	Baseline	20.2 ± 1.8	19.9 ± 2.1			0.029
kg/m^2	6 months	20.2 ± 2.1	19.6 ± 2.5			
	Time effect		*			
SMI	Baseline	5.91 ± 0.66	6.02 ± 0.57			0.023
kg/m^2	6 months	5.93 ± 0.65	5.95 ± 0.75			
	Time effect					
%BF	Baseline	24.1 ± 6.3	21.9 ± 6.0			0.004
%	6 months	23.3 ± 7.1	20.7 ± 6.5			
	Time effect					
HGS	Baseline	24.8 ± 7.4	28.6 ± 6.5			<0.001
kg	6 months	26.1 ± 8.0	29.7 ± 7.8			
	Time effect	**				
SLS	Baseline	60.5 ± 44.7	77.2 ± 41.5		*	0.132*
s	6 months	77.2 ± 45.5	61.6 ± 40.4			
	Time effect	*				
WS (comfortable)	Baseline	1.48 ± 0.27	1.48 ± 0.26			0.012
m/sec	6 months	1.46 ± 0.20	1.42 ± 0.17			
	Time effect					
WS (maximum)	Baseline	1.95 ± 0.30	2.02 ± 0.17		**	0.189**
m/sec	6 months	1.97 ± 0.24	1.86 ± 0.16			
	Time effect		**			
KES	Baseline	1.38 ± 0.42	1.55 ± 0.35		*	0.128*
Nm/kg	6 months	1.69 ± 0.46	1.49 ± 0.80			
	Time effect	**				
GLFS-25	Base line	2.7 ± 2.7	2.9 ± 1.6		**	0.139**
	6 months	2.5 ± 3.0	5.1 ± 4.1	*		
	Time effect		*			
EQ-5D	Baseline	0.909 ± 0.128	0.918 ± 0.114			0.021
	6 months	0.945 ± 0.100	0.917 ± 0.117			
	Time effect					

Data are presented mean and standard deviation. *$p<0.05$; **$p<0.01$. Post-hoc analysis of paired and independent t-tests. ANOVA, repeated-measure two-way analysis of variance. BMI: body mass index; SMI: skeletal muscle index; %BF: body fat percentage; HGS: handgrip strength; SLS: duration of single leg standing; WS: walking speed; KE: knee extension strength; GLFS-25: the 25-question Geriatric Locomotive Functional Scale; EQ-5D, Euro QOL

was identified in the intervention group. A significant decrease in BMI (19.9 kg/m^2 to 19.6 kg/m^2) and maximum walking speed (2.02 m/s to 1.86m/s), with a concomitant increase in GLFS-25 scores (2.9 to 5.1) were identified in the control group. The GLFS-25 scores were significantly higher for the control group at 6-months than for the intervention group. Two-way ANOVA identified a significant interaction between single-leg standing and knee extension strength, with a significant improvement identified for the intervention group. A significant interaction was also identified between maximum walking speed and the GLFS-25 score. In the control group, maximum walking speed and GLFS-25 scores decreased significantly, from baseline to 6-months. The effect size (η^2) of the intervention program was calculated for outcome variables that significantly improved from baseline to post-intervention: duration of single-leg standing, 0.132; maximum walking speed, 0.189; knee extension strength, 0.128; and GLFS-25 score, 0.139.

No significant change in sarcopenia and pre-sarcopenia status was identified (Table 3). Among the 26 participants in the intervention group, a normal status was identified for 4 participants (15.4%). Among the 14 participants in the control group, a normal status was identified in 2 participants (14.3%). No aggravation to sarcopenia was identified in either group over the duration of the study. In the intervention group, 3 of the 5 participants with sarcopenia improved to a pre-sarcopenia status. There was no change in status at 6-months for the 1 participant with sarcopenia in the control group.

Table 3. Change in sarcopenia and pre-sarcopenia status

	Normal		Pre-sarcopenia		Sarcopenia	
	Baseline*	6-month§	Baseline*	6-month§	Baseline*	6-month§
Intervention group (n=26)	0	4 (15.4)	21 (80.8)	20 (76.9)	5 (19.2)	2 (7.7)
Control group (n=14)	0	2 (14.3)	13 (92.9)	11 (78.6)	1 (7.1)	1 (7.1)

*p=0.399, §p=0.993. Fisher's exact test.
Data are presented number (%).

DISCUSSION

We evaluated the effectiveness of a 6-month home exercise program, combining walking and lower limb resistance exercises, among community-dwelling individuals, ≥60 years old, with sarcopenia and pre-sarcopenia. Adherence to the program of exercise was high, with completion of 70–90% of the total training volume. All components of the program were 'easy to perform' and did not require any special facility or equipment. Importantly, the selected exercises could be easily incorporated into participants' daily routine, with 1–2 minutes required to perform one set of the exercises, and the walking program maintained at a reasonable duration of 20–30 minutes. Despite the convenience of our program, 23.5% of participants in the intervention group (8 out of 34 participants) dropped-out of the study. Furthermore, 16 participants (8%) of the intervention group could not be contacted for baseline evaluation, because the schedule was not matched with theirs. Adherence might increase during the actual intervention, rather than the survey, although the reason for discontinuing the intervention could not be clarified in this study. However, Pisters reported that adherence was associated with pain, physical function, and self-perceived effect[17]. Thus, future effort is needed to improve adherence.

Our findings of significant improvement in handgrip strength, single-leg standing and knee extension strength indicated that a 'relatively simple' program of exercise is sufficient to improve muscle strength in middle-aged and elderly individuals with low SMI. A medium-to-large effect size[18] (η^2) of the program was identified for single-leg standing (0.132) and knee extension strength (0.128). Our program was effective in improving physical function in participants with pre-sarcopenia/sarcopenia, and in changing the status from sarcopenia to pre-sarcopenia in 3 of the 5 participants diagnosed with sarcopenia in the intervention group at baseline. Moreover, several participants with pre-sarcopenia changed to a normal status in both groups over the duration of the study. However, the exercise intervention did not produce a significant effect on the SMI. Based on these results, the gains in strength were likely obtained by facilitation of motor units rather than an increase in muscle mass. An increase in muscle mass requires an increase in the size of muscle fibers by activated satellite cells. Depending on exercise load, a program may preferentially facilitate the neural or structural pathways for muscle strength gains, with strength gains related to an increase in muscle mass requiring a longer time line for development. Future research on home exercise programs in elderly individuals with sarcopenia will need to examine the effects of loading on the neural and structural components of muscle strengthening.

Over the study period, BMI and maximum walking speed decreased for the control group, while the GLFS-25 score increased. Miyahara et al.[19] previously identified maximum walking speed, BMI and medical history, as well as employment status, as being significant factors associated with daily functioning of community-dwelling elderly individuals. Watanabe et al.[20] also reported that a decrease in walking speed and muscle mass were independent predictors of deteriorating physical function and activities. In our study group, we provide evidence of a natural decrease in physical and activity function over a 6-month period in individuals over 60 years of age with pre-sarcopenia or sarcopenia. This natural decline in muscle mass was associated with a decrease in maximum walking speed over the same 6-month period and a self-reported decrease in physical function. Therefore, our longitudinal data supported findings of previously published cross-sectional studies.

An important outcome of our study is the finding that regular performance of an 'easy to perform' home exercise program is effective in improving physical function in community-dwelling elderly people ≥60 years old with pre-sarcopenia or sarcopenia.

In the interpretation of our findings for practice, it is important to note that participants in our study were healthy individuals who voluntarily participated in our program of exercise. In addition, home exercise program could not standardized load in each participant.

A 6-month home exercise program, combining walking and resistance lower limb exercises, was effective in improving maximum walking speed and muscle strength in individuals, ≥60 years old with pre-sarcopenia or sarcopenia. Our program was effective in preventing an overall decline in physical function, although load of training were not sufficient to improve muscle mass.

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