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Efficacy of Elastic Resistance Training Program for the Institutionalized Elderly

Seyedeh Ameneh Motalebi, PhD; Jamileh Amirzadeh Iranagh, PhD; Fatemeh Mohammadi, PhD; Loke Seng Cheong, PhD

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Objective: This study aimed to assess the efficacy of a progressive resistance training program on dynamic balance and functional mobility among the institutionalized elderly.
Methods: A total of 45 institutionalized elderly from a senior welfare home participated in this quasi-experimental study. The exercise group ($n = 21$) attended a group-based program for 12 weeks, meeting twice a week. A 2-factor repeated-measures analysis of variance and independent and paired *t* tests were used to analyze the data.
Results: The results showed a significant improvement for the exercise group in the Reach Test for the forward ($\%\Delta = 18.51\%$), right ($\%\Delta = 20.0\%$), and left ($\%\Delta = 17.7\%$) directions and in the 6-Minute Walk Test ($\%\Delta = 12.09\%$, all $Ps < .001$) after the intervention.
Conclusion: The elastic band training provides a simple and inexpensive exercise program that improves the balance control and consequently functional mobility effectively.
Key words: aging, balance, elastic resistance training, functional mobility

Aging is associated with physical, psychological, and social changes that may lead to a significant level of dependency.[1] Among these, sarcopenia or progressive muscle strength or mass loss has been well documented.[2] It is a major factor for age-related weakness and frailty.[3] Muscle strength reduces by 1.5% per year after the age of 50 years and is accelerated at the age of 60 years and above,[4] as people in their 80s have 40% less muscle strength than in their 20s.[5]

Lower-extremity strength is the major factor for maintaining mobility and physical abilities. Strong lower-extremity muscles and flexible joints play key roles in balance performance.[6] Leg muscle weakness was documented to be an important predictor of balance impairment in older adults.[7] Balance ability is related to not only accurate sensory and neurological systems but also good muscle strength.[8]

Sufficient balance control is essential for independent and safe performance of activities of daily living such as walking, stair climbing, or bending forward.[9] According to Jonsson,[10] age-related balance deterioration has a negative impact on the ability to safely carry out activities of daily living. PrataI and Scheicher[11] also documented the association between balance and daily activities, indicating that elderly people who had better balance have a good level of independence. Muscle strength loss and balance impairment are 2 major risk factors for falls.[12] Moreland et al[13] in their meta-analysis study reported that older people with lower-extremity muscle weakness had 1.76 more risk for falls and 3.06 more risk for repeated falls.

Health care providers need to promote the exercise interventions that help increase the functional capacity and improvement of quality of life of institutionalized older adults.[14] Resistance or strength training has been shown to be the main intervention for preserving functional independence among older persons.[15] This training, combined with balance training, plays an important role in the reduction of falls in the elderly persons.[16,17] There is a little evidence that strength or resistance training by itself can improve the balance and reduce risk of falls.[18-20] Furthermore, the majority of previous studies have used gym-based training using fitness machines.[21] These programs are not economical or easily accessible for many older people. Many of the older people have difficulties traveling regularly to sport centers and maintaining their exercise program.

Elastic resistance devices (bands or tubes) are simple and practical equipment for strength training.[22] Elastic band is suitable for the elderly persons because of its low cost, simplicity, lightweight, portability, and flexibility despite its ability to provide strong resistance.[23] So, it is a good alternative instrument for resistance training among the elderly persons, including those residing in the institutions. However, there is a scarcity of research examining the feasibility and effectiveness of elastic resistance training (ERT), especially on balance performance and functional mobility in elderly subjects.[24] As such, the aim of the present study was to assess the efficacy of a simple exercise program in the institutionalized elderly.

Author Affiliations: Social Determinants of Health Research Center, Qazvin University of Medical Sciences, Qazvin, Iran (Drs Motalebi and Mohammadi); Department of Public Health, Urmia University of Medical Sciences, Urmia, Iran (Dr Amirzadeh Iranagh); and Institute of Gerontology, Universiti Putra Malaysia, Serdang, Selangor, Malaysia (Dr Cheong).

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Correspondence: Seyedeh Ameneh Motalebi, PhD, Social Determinants of Health Research Center, Qazvin University of Medical Sciences, Shahid Bahonar Blvd, 59811-34197, Qazvin, Iran (ammotalebi@yahoo.com).

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METHODS

This quasi-experimental design study was conducted in a senior welfare home, Rumah Seri Kenangan (RSK), Cheras, Malaysia. The study procedure was in agreement with the principles of Helsinki Declaration on medical research involving human subjects. The study procedure was approved by the ethical committee of Universiti Putra Malaysia: UPM/FPSK/100-9/2-MJKEtikaPen (IG_Jun (12)05)).

A convenience sample of 45 institutionalized older adults 60 years and older was recruited from RSK, Cheras, a social welfare home under the Ministry of Women, Family and Community Development, Malaysia. RSK is a governmental shelter home for older people who are poor. RSK is different from a nursing home, as its residents are in general less dependent. The participants were independent in daily activities, able to comprehend the study procedures and instructions and to follow the resistance exercise program, and did not have any medical problems (myocardial infarction in past 6 months, recent heart attack, uncontrolled hypertension [blood pressure >166/96 mm Hg], broken leg in the past 6 months, diagnosed osteoporosis, and diagnosed stage 3 and 4 heart failure) that contradicted their participation in the exercise program. Participants were excluded if they were undergoing balance or resistance training during past 3 months, suffered from the health issues that might confound the study results (lower-body neuropathy, stroke within the past year, Parkinson's disease, diagnosed vestibular disorders, sever visual impairments, and lower-extremity joint replacements).

INTERVENTION

The experimental group underwent a group-centered ERT of 2 days per week for 12 weeks. Elastic bands (Dura Band; DuraMedical Sdn Bhd, Selangor, Malaysia) in different colors (yellow, orange, green, pink, purple, and silver) were used for the training. Before starting the exercise program, the exercise group was familiarized with the different levels of the elastic bands and correct technique of the exercises during 2 sessions. The exercise intensity was approximated using the OMNI Rate of Perceived Exertion (OMNI RPE) scale.[25] For the first 2 weeks, subjects were trained at low intensity (3-4 on the OMNI scale), completing 1 to 2 sets of 8 to 10 repetitions. For the rest of the program, they completed 3 sets at a moderate intensity (5-6 on the OMNI scale). The subjects rested for 2 to 3 seconds between repetitions, 1 to 2 minute between sets, and 2 to 3 minutes between different exercises. The resistance was increased gradually for producing adequate adaptation of connective tissue. When the participants could perform 3 sets of 8 repetitions without any fatigue, the resistance was increased through replacing the band by the next color, progressing from the easiest to the most difficult. The subjects moved to a stronger band every 2 to 4 weeks.

The exercises were aimed to strengthen the major lower-limb muscle groups that are important for the balance control, namely, hip extension, hip adduction, hip abduction, hip flexion, knee flexion, resisted dorsiflexion, leg extension, resisted plantar flexion, and calf-raise. All exercises were performed in a sitting or standing position along a fence. The subjects could maintain their stabilities by holding the fence or a chair provided beside them during the exercise program. The subjects were encouraged to pull the band (concentric phase) and then return to the starting position (eccentric phase) slowly during 6 seconds. They were also instructed not to hold their breath during different phases of each repetition to prevent the exercise-inducing high blood pressure.

Each exercise session lasted for an average of 50 minutes, with 5 minutes of warm-up, 40 minutes of strength training by elastic band, and 5 minutes of cooldown. For warming up, the subjects were instructed to perform marching in place, brisk walking, and some light movement that mimics the actual exercises. For cooling down, the participants were recommended to walk slowly and perform some stretching exercises.

The training sessions were conducted under the supervision and guidance of the researcher and 4 qualified and trained instructors. The participants were called for joining the program in the initial sessions. The exercise group was supervised for proper technique, safety, and risk of injury. Research assistants also recorded the subjects' attendance during the exercise sessions on the record sheet. The participants within the control group were instructed to continue their current activities and to avoid starting any new exercise program during the study period.

ASSESSMENTS PROTOCOL

The outcome variables for this study were dynamic balance and functional mobility. Before measuring these variables, the subjects were interviewed to collect their demographic characteristics, medical history, physical activity behavior, and cognitive situation. Furthermore, some questions were asked to determine the subjects' orientation to person, place, time, and ability to follow the basic instruction to assess the mental status of the subjects and their capability to follow the exercise instructions.

Physical activity was assessed using the Godin-Shephard Leisure-Time Physical Activity Questionnaire to quantify the activity level of the subjects before starting the study. This questionnaire is commonly used in epidemiological, behavioral, and clinical studies and is a simple, self-administered instrument evaluating usual physical activity during the past 7 days.[26] The level of weekly activities was calculated by the following standard formula: Weekly leisure activity score = (9 × number of strenuous exercises per week) + (5 × number of moderate exercises per week) + (3 × number of light exercises per week). The individuals were categorized as

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active (scores >24), moderately active (scores between 14 and 23), and insufficiently active (scores <14).[27]

The medical report folders of the subjects were checked to assess for diagnosed health conditions. Body weight was measured in minimal clothes using a calibrated balance scale (SECA, Hamburg, Germany). Barefoot standing height was measured using a measuring tape fixed vertically to a wall.

Dynamic balance was evaluated using Reach Test (RT) in the 3 directions (forward, right, and left sides). The Forward Reach Test (FRT) is a maximum length that a person is able to reach forward while keeping the stable standing position.[28] The test has concurrent validity with the Berg Balance Scale (r = 0.7).[29] This test has shown interrater reliability (intraclass correlation coefficient [ICC] = 0.91) and retest reliability (ICC = 0.81) in a sample of healthy subjects.[28] To measure this test, the subject was instructed to stand next to a wall and elevate the arm up to the line of the shoulder with a closed fist. After that, the subject was asked to lean forward along the yardstick as far as possible without losing balance or taking a step. The distance was measured in centimeters using the difference between the first and second position scores of the third metacarpal on the measuring tape. For measuring the Lateral Reach Test (LRT), the subjects were asked to stand straight near and back toward the wall. They were instructed to elevate one hand (right and then left) up to the line of the shoulder and reach sideways as far as possible along the measuring tape mounted on the wall without losing balance. The subjects performed FRT and LRT in 1 practice trial for familiarization and 2 test trials. The best performance score of 2 trials was used in the analysis.

Mobility was measured using the 6-Minute Walk Test (6MWT). The 6MWT evaluates the maximum distance walked during 6 minutes. This test was originally used to measure the cardiovascular endurance[30]; however, more recently, it has been considered for measuring mobility and physical function. The test has concurrent validity with the chair stands (r = 0.67), standing balance (r = 0.52), and gait speed (r = −0.73).[31,32] The test has shown high retest reliability (ICC = 0.98) among people with Alzheimer disease.[33] The subjects were instructed to walk as fast as possible in a long corridor between 2 marked lines for 6 minutes. The assessor with a distance measuring wheel (5505E Measuremeter Revolution, Truemeter, Bury, Lancashire, United Kingdom) followed the subject closely from the behind. Some chairs were placed at certain distances for taking rest in the needed time. Blood pressure and heart rate were assessed before and after the test. This test was only performed once.

The FRT and LRT were measured thrice (baseline, week 6, and week 12); however, the 6MWT was measured twice. Two trained and qualified assessors collected the data. The assessors were trained how to measure the tests by verbal explanation, writing notes, and instructional videos. They were blind to the group allocation and previous measurement results in the mid- and posttest evaluations.

STATISTICAL ANALYSES

All statistical analyses were performed using SPSS software, version 19 (SPSS IBM, Armonk, NY) for Windows. Continuous data were reported as mean (standard deviation). Frequencies and proportions were used to describe the categorical variables. A 2-factor repeated-measures analysis of variance was used to determine the effect of intervention on the FRT and LRT. It was followed by pairwise comparisons using the Bonferroni correction for detecting within-group changes through 3 different measurements. For the 6MWT, a series of independent and paired t tests were applied to detect between- and within-group changes. All the data met the assumptions of normality, homogeneity of variance, and covariance matrices. Normality was checked using the Shapiro-Wilk test, skewness, and kurtosis. Significance level was set at $P < .05$.

RESULTS

Forty-five of 51 participants (male = 26 and female = 19) with a mean age of 70.7 ± 6.6 years successfully completed the program. The majority of the subjects were of Malay ethnicity (73.3%) and single (51.1% never married, 37.8% widowed, and 6.7% divorced). More than 80.0% of the subjects were illiterate (20%) or had primary level education (62.2%), whereas only 17.7% reported having secondary (13.3%) or tertiary (4.4%) education.

In terms of physical activity behavior, all the participants were placed in the insufficiently active (77.8%) or moderately active (22.2%) groups and none of them were in the active situation. Table 1 shows the comparison of the exercise and control groups on the demographic characteristics, physical activity behavior, body mass index classifications, and health conditions.

The results of statistical analysis showed significant differences between groups after completing the program for measures of the RT at the forward ($F_{1,43}$ = 8.01, $P < .01$, $\eta^2 = 0.157$), right ($F_{1,43}$ = 5.49, $P < .05$, η^2 = 0.113), and left ($F_{1,43}$ = 6.71, $P < .05$, $\eta^2 = 0.135$) directions. The pairwise comparison using the Bonferroni test showed that the RT in these directions increased significantly from pre- to mid-test evaluations and pre- to posttest evaluations but not for mid- to posttest evaluations. After implementation of the intervention, independent t tests showed significant differences between the intervention and control groups in the 6MWT (t = 2.36, $P < .05$). The results of paired t tests revealed significant improvements in functional mobility in the intervention group (t = −8.27, $P <$ .001) as well (Table 2). The percentage of changes in the outcome variables after completing the program in both the exercise and control groups is presented in the Figure.

DISCUSSION

The results of this study support the supposition that a 12-week moderate-intensity ERT can be an effective

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TABLE 1	Baseline Comparison of the Exercise (n = 21) and Control (n = 24) Groups on the Demographic Characteristics, Medical Conditions and Lifestyle		
Demographic Characteristics	**Exercise Group, n (%)**	**Control Group, n (%)**	P^a
Gender			
Male	11 (52.4)	15 (62.5)	χ^2 = 0.47, NS
Female	10 (47.6)	9 (37.5)	
Ethnicity			
Malay	14 (66.7)	19 (79.2)	FET = 4.25, NS
Chinese	5 (23.8)	1 (4.2)	
Indian	2 (9.5)	3 (12.5)	
Others	0 (0.0)	1 (4.2)	
Marital status			
Never married	10 (47.6)	13 (54.2)	FET = 2.78, NS
Married	2 (9.5)	0 (0.0)	
Widowed	7 (33.3)	10 (41.7)	
Divorced	2 (9.5)	1 (4.2)	
Education level			
No schooling	6 (28.6)	3 (12.5)	FET = 2.37, NS
Primary	11 (52.4)	17 (70.8)	
Secondary	3 (14.3)	3 (12.5)	
Tertiary	1 (4.8)	1 (4.2)	
Physical activity			
Active	0 (0.0)	5 (20.8)	FET = 3.61, NS
Moderately active	4 (19.0)	15 (62.5)	
Insufficiently active	17 (81.0)	4 (16.7)	
BMI classification			
<18.5	2 (9.5)	2 (8.3)	FET = 4.6, NS
18.5-22.9	5 (23.8)	7 (29.2)	
23-27.4	11 (52.4)	6 (25.0)	
≥27.5	3 (14.3)	9 (37.5)	
Medical conditions			
0-1	8 (38.1)	10 (41.7)	χ^2 = 0.60, NS
≥2	13 (61.9)	14 (58.3)	
Smoking			
No/ex-smoker	16 (76.2)	18 (75.0)	χ^2 = 0.01, NS
Current smoker	5 (23.8)	6 (25.0)	

Abbreviations: BMI, body mass index; FET, Fisher's exact test; NS, nonsignificant.
[a]Represents a comparison between groups.

program for improving dynamic balance and functional mobility among the institutionalized elderly. We used the RT to assess and quantify the dynamic balance ability. This test measures the stability limits in the leaning task.[34] The majority of the previous studies[18,35-37] have used this test only in the forward direction. However, we measured LRT (for right and left sides) in addition to the forward RT to assess mediolateral stability, which is essential for daily

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TABLE 2	Means and Standard Deviations in Balance Control and Functional Mobility Measures Before and After Intervention for the Exercise (n = 21) and Control (n = 24) Groups					
	Exercise Group			Control Group		
Test	T1, *M* (SD)	T2, *M* (SD)	T3, *M* (SD)	T1, *M* (SD)	T2, *M* (SD)	T3, *M* (SD)
FRT, cm	23.1 (4.4)	26.4 (4.6)[a]	27.4 (4.9)[a]	21.9 (5.2)	21.8 (4.5)	21.4 (5.6)
LRT, right, cm	16.7 (3.4)	19.4 (3.9)[a]	20.0 (3.9)[a]	16.4 (3.7)	16.1 (4.1)	15.8 (4.0)
LRT, left, cm	16.0 (3.8)	18.5 (3.5)[a]	18.8 (3.6)[a]	15.3 (3.1)	14.9 (3.6)	15.2 (4.1)
6MWT, s	348.6 (68.1)	…	390.7 (61.3)[a]	334.3 (67.5)	…	343.3 (73.4)

Abbreviations: FRT, Forward Reach Test, LRT, Lateral Reach Test; 6MWT, 6-Minute Walk Test; T, trial.
[a]$P < .05$.

activities.[38] Backward RT was not evaluated in the present study because many of the subjects preferred not to perform the test in that direction. In addition, leaning backward increases the risk of falling.[39]

Both the exercisers and controls in the present study showed fairly poor balance control at the baseline. The subjects leaned forward (22.46 cm) less than the normal value (29.60 cm), as suggested by Brauer et al[40] for community-dwelling elderly adults. The RT performance at the right (16.53 cm) and left (15.61 cm) directions also was lower than that reported by Brauer et al[41] (right side = 20.04; left side = 21.01) for healthy older adults. These differences could be related to the source of samples. The subjects of this study were living in the institution and they had sedentary lifestyle. This behavior is a potential contributory factor for less balance control among them. These results also were apparent in other studies that used similar sample from an institution or nursing home.[18,36]

It was observed a high dynamic balance improvement using RT for the forward (18.5%), right (20.0%), and left (17.7%) directions. The results of the present study are in accordance with the previous studies, which found significant dynamic balance improvement after a resistance exercise program. However, the effect of Progressive Resistance Training (PRT) on balance performance is controversial in the literature.[42,43] Although some studies have reported a significant effect of PRT on balance performance,[18-20,37] others have not confirmed it yet.[44-46] There are many potential reasons for these controversial results. It may be related to the heterogeneity of the subjects, different methods used for measuring the balance ability, modality of resistance training program, level of exercis intensity, variability in the sample size, insufficient statistical power, and low compliance or adherence rate to the program.[42]

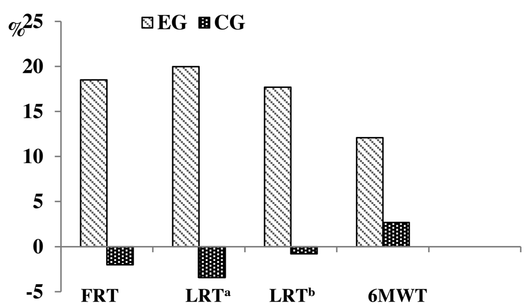

Figure. Percentages of changes measured in tests after the 12-week ERT in both EG and CG. EG indicates exercise group; CG, control group; FRT, Forward Reach test; RT[a], Reach Test for the right side; RT[b], Reach Test for the left side; 6MWT, 6-Minute Walk Test.

Functional mobility is required to perform everyday activities and to develop social or community involvement.[47] It is considered as an important indicator for independence in daily activities.[48] Impaired mobility is related to frailty and disability in elderly people.[49] The results of the present study are in the line with those of previous studies that have reported the effectiveness of resistance training on functional mobility in older people.[50-52] However, others have not found any significant improvements in functional mobility.[46,53] This inconsistency could be related to the source of samples and different methods used.

In this study, high improvement in balance ability may be the effective factor for increasing functional mobility. In fact, mobility for the elderly persons is related to a combination of leg muscle strength, gait, and balance ability.[54] Likewise, Justine et al[36] observed significant correlations between lower-extremity muscle strength (30 seconds sit-to-stand test) and the Timed Up and Go test ($r = -0.79$, $P < .01$) and distance completed in the 6MWT ($r = 0.71$, $P < .01$) among the institutionalized elderly. In addition, Bean et al[55] stated that ankle, knee, and hip muscle strength explained 59.0%, 57.0%, and 48.0% variance of the 6MWT, respectively. Some earlier studies also demonstrated the importance of leg muscle strength in increasing the functional mobility among older people.[52,56,57] Furthermore, Jankowska et al[58] showed a significant and positive correlation between the distance covered in the 6MWT and

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quadriceps strength. The present study used the resistance exercises that involved these main muscle groups and consequently showed a high and significant improvement in functional mobility.

PRACTICAL IMPLICATION

The results of this study suggest that group-based ERT can serve as a practical and effective way for eliciting balance control and functional mobility improvement in the institutionalized elderly. These positive effects have important roles in increasing quality of life and independency among this group of people. This activity can be incorporated into routine programs in community health promotion or care centers for older people to improve their physical function. Therefore, it could be more effective to evaluate and distribute optimal ERT programs for community or institutionalized older adults by policy makers, health care providers, physiotherapists, and geriatrics.

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