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Effectiveness of elongation band exercise on the upper limb strength and range of motion among older adults

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An elongation band (EB) is used to improve the physical strength of older adults. However, the evidence of its effect on the upper limb is a deficiency. This study investigated the effectiveness of EB exercises on upper limb function in the elderly. Participants were divided into two groups: EB (n=16) and control (n=14). The EB group performed exercises in a sitting position using an EB while the control group performed active stretching exercises without bands. The exercise regimen consisted of four shoulder joint movements. Each group performed the exercise for 20 min per day, 5 days per week over a period of 2 months. Measurements included upper limb muscle strength, shoulder joint range of motion, and grip strength. Measurements were performed at baseline, and 1 and 2 months after the intervention. Analysis of covariance was used to compare differences between the groups. The EB group demonstrated significant increases in muscle strength (upper trapezius, deltoid, middle trapezius muscle), shoulder joint range of motion (right shoulder flexion, internal rotation, external rotation, left shoulder joint extension), and grip strength. In conclusion, EB exercises increased upper limb muscle strength, shoulder joint range of motion, and grip strength in older adults.

Keywords: Elongation band training, Shoulder joint, Geriatric, Range of motion, Muscle strength

INTRODUCTION

Upper limb function plays an important role in activities of daily living such as reaching, carrying, lifting, pushing, pulling, and handling and manipulating objects (Carmeli et al., 2003). However, compared with younger individuals, older adults exhibit a significant decline in muscle strength and flexibility (Milanović et al., 2013). In particular, in terms of flexibility, research has shown that shoulder flexibility/range of motion declines by approximately 5–6 degrees per decade (Stathokostas et al., 2013). Moreover, it has been reported that upper limb impairment, including pain and stiffness, increases significantly with age, and is associated with functional impairment (Morita et al., 2001). This emphasizes the need for effective intervention(s) to prevent further decline in upper limb function among older adults.

Incorporating resistance training as part of a preventive exercise program can improve flexibility, balance (Lopes et al., 2019), muscle strength (Kim et al., 2021), and functional capacity in older adults (de Oliveira et al., 2017). The exercise training described in these reports, however, was performed using an elastic band, with exercise load intensity set at approximately 70% of maximum muscle strength (de Oliveira et al., 2017; Kim et al., 2021; Lopes et al., 2019). The main concerns with exercise training among older adults include limited training environment(s) and the increased risk for injury from intense exercise. As such, for older adults to continue exercise, it is critical that the exercise(s) be simple and safe to perform at home.

Elongation bands (EBs) have recently been proposed as a simple way to improve motor performance (Nishimura and Miyachi, 2020). EBs are highly extensible elastic bands that can be used

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with automatic movements while expanding in the longitudinal direction of the limb or trunk. Although programs including EBs are regarded to be a simple self-exercise strategy, few studies have examined their impact on motor function (Miyachi et al., 2021; Nishimura and Miyachi, 2020), especially on upper limb function. As such, the purpose of the present study was to investigate the effect(s) of EB exercises on upper limb function in a sample of older adults.

MATERIALS AND METHODS

Design

A randomized control, single-blinded study was designed in accordance with the CONSORT (consolidated standards for reporting of trials) statement for transparent reporting. This study was approved by the Research Safety and Ethical Review Committee of the Tokyo Metropolitan University Arakawa Campus (approval No. 19108).

Participants

Participants 70–80 years of age were recruited from an orthopedic clinic in Bunkyo, Tokyo, Japan. Individuals with orthopedic diseases, those with limitations in the activities of daily living due to upper limb dysfunction, and cognitive deficit (Mini Mental State Examination score < 21) were excluded.

Sample size

The primary outcome measure was upper limb strength. The power calculation was based on a recent meta-analysis investigating the effectiveness of resistance exercise on upper limb muscle strength in older adults (Di Lorito et al., 2021). A sample size program was used to calculate the number of participants using the T-statistic. The standard normal deviation for α was 1.96, the standard normal deviation for β was 0.84, and the standardized effect size was 1.18. The total number of participants required was 26; however, to compensate for the possibility of dropouts, an additional 20% (i.e., 32 participants) was recruited and enrolled.

Intervention

In this study, 32 eligible participants were randomly assigned to the experimental group (i.e., EB) and a control group, with 16 participants in each group, and the duration of the intervention was 8 weeks (Fig. 1). The EB group performed home-based exercises using an EB (ELT Health Promotion Laboratory Inc., Otsu, Japan) while the control group performed the same stretching exercises, without the band, for 20 min per day, 5 days per week. All exercises were performed in a sitting position, with subjects holding the maximum extension position for 10 sec, 15 sec each

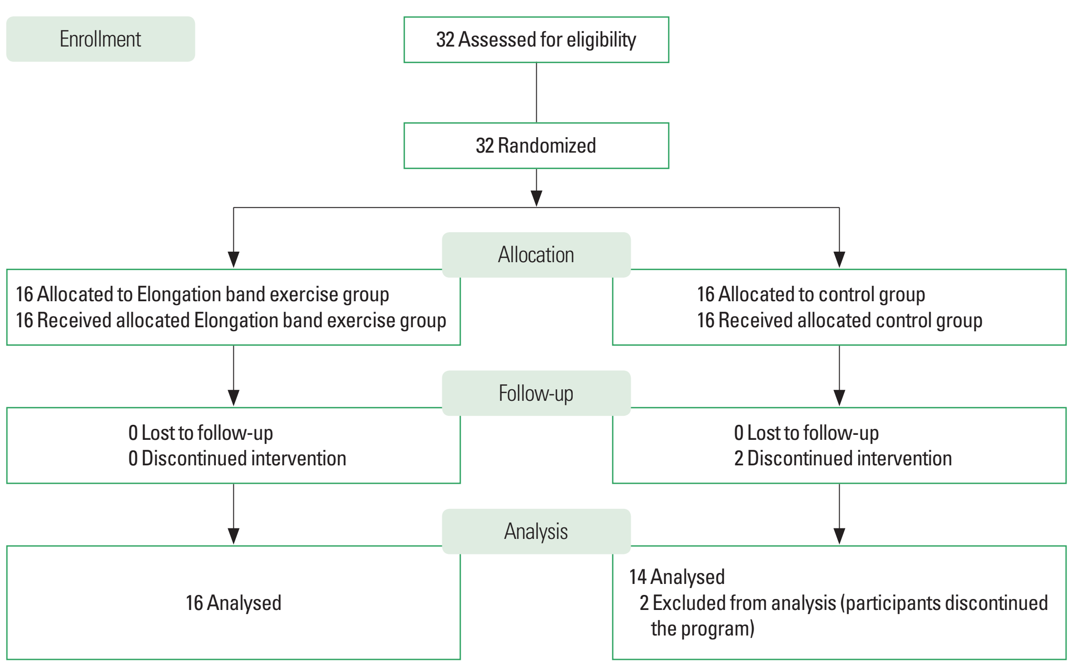

Fig. 1. Flowchart of participants throughout the study.

Table 1. Elongation band exercise program

Exercise component	Motion	Exercise program
Elongation band exercise Frequency: 5 days/wk Duration: 30 sec. each repetition, 5 sets Position: sitting	Shoulder horizontal abduction	Pass the fingers through holes at both ends of the band, the upper limbs are flexed 90°and then abducted, and the band is extended horizontally to both left and right sides as far as possible while keeping both upper limbs and chest tight.
	Trunk rotation	Place the band under the buttocks, hook it over both elbows, insert the fingers into the holes of the band, and rotate the upper body to the left and right as much as possible while keeping the thoracic vertebrae in the extended position with the hands and shoulders maximally open with the hands clasped behind the head.
	Shoulder flexion	Step on the middle of the band with a foot to hold it in place, then both thumbs are inserted into the holes at the ends, hook them, and stretch the band to the maximum vertical position.
	Diagonal flexion	Place the right fingers in the middle hole of the band, step on the band with the left foot to hold it in place and extend the hand to the maximum diagonal. For each exercise, participants are instructed to stretch the band as far as possible.

exercise performed for 30 sec, for a total of five sets. Subjects were checked once per week to ensure that they were performing the exercises with the correct form. Table 1 summarizes the exercise programs used.

Outcome measurements

The study outcomes included muscle strength of the upper limbs, active range of motion of the shoulder joint, and grip strength. The assessor was a physical therapist with 3-year experience who was blinded to the participants. All outcomes were measured at 3 timepoints: before, 1 month after, and 2 months after the start of the study.

Muscle strength in the upper limb

A digital muscle strength meter (Power gauge, Nanba Seisakusho Co., Ltd., Tokyo, Japan) was used to evaluate muscle strength in the upper limbs. Measurements were performed with the subjects in accordance with the action of each targeted muscles included the upper trapezius and deltoid were measured in sitting position, for middle trapezius and latissimus dorsi were measured in prone position. Each muscle was measured twice, and the average value was calculated and recorded as muscle strength.

Range of motion

Range of motion of the joints was measured with subjects in the sitting position using a digital goniometer (Easy-Angle, Meloq AB, Stockholm, Sweden). Subjects were instructed to actively flex, extend, abduct, internal rotate, and external rotate their shoulders as much as possible. Measurements were performed twice, alternately on the right and left sides, and the average score was calculated and recorded as the baseline range of motion.

Grip strength

A handgrip dynamometer (TKK-5401, Takei Kikai Kogyo Co., Ltd., Niigata, Japan) was used to evaluate grip strength. Subjects were instructed to grip the handgrip dynamometer forcefully and the measurements were performed twice with subjects in the upright position, alternately on the right and left sides, and the average value was calculated and recorded as the grip strength.

Table 2. Participants' demographic data

Variable	Group		Total (n=30)	*P*-value
	EB (n=16)	Control (n=14)		
Age (yr)	77.19±5.2	76.43±5.1	76.83±5.0	0.768‡
Gender				0.404†
Male	4 (25.0)	5 (35.7)	9 (30.0)	
Female	12 (75.0)	9 (64.3)	21 (70.0)	
Height (cm)	149.94±27.8	159.71±9.8	154.50±21.6	0.346‡
Weight (kg)	63.00±26.4	61.00±10.3	62.07±20.2	0.174‡

Values are presented as mean±standard deviation or number (%).
EB, elongation band exercise.
†Statistical analysis using chi-square test. ‡Statistical analysis using *t*-test.

Data analysis

Data obtained in this study were processed and analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA); differences with $P<0.05$ were considered to be statistically significant. Descriptive statistics for the mean, frequency, percentage, and standard deviation were used to analyze data from both groups. Comparisons of demographic data between the groups were performed using the chi-squared test and *t*-test. Differences within the groups before and after the intervention were performed using repeated measures analysis of variance. Analysis of covariance was used to analyze differences in all outcomes between the groups.

RESULTS

Baseline characteristics

Thirty participants (EB group, n=16; control, n=14) were as-

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Table 3. Comparison of change in muscle strength overtime (N·m)

Variable	Elongation band exercise			Control		
	Baseline	1 Month	2 Months	Baseline	1 Month	2 Months
Upper trapezius†	138.48±26.93	173.41±38.95*	222.69±45.84*	131.71±29.20	136.39±29.77	144.5±28.18*
Deltoid†	78.03±22.29	86.41±23.72	100.84±26.37*	95.29±28.64	93.32±26.13	93.04±28.93
Middle trapezius†	71.50±28.52	78.66±28.46*	95.03±31.53*	87.93±25.77	92.50±41.52	89.29±34.95
Latissimus dorsi	75.00±23.66	78.66±28.46	96.44±26.12*	87.93±25.77	92.50±41.52	97.57±44.15

Values are presented as mean±standard deviation.
*P<0.05, statistically significant difference within-group. †P<0.05, statistically significant difference between-group determined by analysis of covariance with baseline values as a covariate.

Table 4. Comparison of change in shoulder joint's range of motion overtime (degree)

Variable	Elongation band exercise			Control		
	Baseline	1 Month	2 Months	Baseline	1 Month	2 Months
Right						
Flexion†	154.06±13.32	160.44±14.19*	169.63±13.28*	157.43±13.42	160.64±12.02	164.68±10.11*
Extension†	58.13±12.38	56.63±6.61	62.03±4.28	56.43±8.04	57.64±4.11	56.32±6.92
Abduction†	165.44±11.22	172.22±7.67	173.63±7.51	162.46±19.10	164.82±18.01	166.71±11.78
Internal rotation†	46.88±22.03	53.38±12.04	65.06±8.93*	53.00±12.86	55.89±12.14	58.75±12.38
External rotation†	70.06±11.92	77.91±11.08	83.13±9.22*	72.71±14.45	72.36±12.92	73.43±13.51
Left						
Flexion†	153.72±13.79	158.40±10.94*	170.91±8.99*	156.93±13.96	160.79±12.62*	162.75±12.29*
Extension	54.31±10.04	58.94±7.44	63.97±4.53*	59.93±10.45	62.00±12.76	60.86±10.05
Abduction	161.06±25.34	166.00±21.78	168.38±22.31	159.61±15.64	151.57±41.91	165.21±12.92
Internal rotation†	44.34±20.52	51.13±13.87	63.28±8.86*	54.36±16.25	59.64±17.90	57.46±13.96
External rotation†	72.28±14.56	73.66±12.85	82.50±7.22	68.32±11.00	70.46±13.57	71.25±12.27

Values are presented as mean±standard deviation.
*P<0.05, statistically significant difference within-group. †P<0.05, statistically significant difference between-groups determined by analysis of covariance with baseline values as a covariate.

sessed. No significant differences in terms of age, sex, height, or weight were observed between the groups (Table 2).

Upper limb muscle strength

In the EB group, improvement in muscle strength was observed in all muscles. The upper and middle trapezius muscles exhibited significant improvement at both 1 and 2 months compared with baseline. Significant improvement was observed at 2 months for the deltoid and latissimus dorsi muscles. Significant improvement within the control group was observed only in the upper trapezius muscle at 2 months. Differences between the groups were found in the upper trapezius ($P<0.001$), deltoid ($P<0.001$), and middle trapezius ($P<0.05$) (Table 3).

Shoulder joint range of motion

The EB group exhibited significant improvement in shoulder flexion on both sides at 1 and 2 months. For right shoulder internal and external rotation, significant improvement was observed at 2 months. The left shoulder exhibited significant improvement in extension and internal rotation at 2 months. Meanwhile, the control group exhibited significant improvement only in shoulder flexion on both sides. Differences between the groups were observed on both sides. On the right side, there were significant differences in all movements, including flexion ($P<0.05$), extension ($P<0.05$), abduction ($P<0.05$), internal rotation ($P<0.05$), and external rotation ($P<0.05$). For the left side, the differences between-groups were observed in flexion ($P<0.001$), internal rotation ($P<0.05$), and external rotation ($P<0.05$) (Table 4).

Grip strength

For grip strength, a significant improvement was observed only in the right hand of the EB group. There was no significant improvement in grip strength among those in the control group. Regarding differences between the groups, Results revealed a sig-

Table 5. Comparison of change in grip strength overtime (kg)

Variable	Elongation band exercise			Control		
	Baseline	1 Month	2 Months	Baseline	1 Month	2 Months
Right†	19.59±5.00	20.43±5.40	23.71±5.35*	24.81±6.88	24.45±7.60	24.02±6.78
Left†	19.23±5.63	19.63±5.49	22.88±4.97	24.27±7.04	23.53±6.86	23.52±7.54

Values are presented as mean±standard deviation.
*$P<0.05$, statistically significant difference within-group. †$P<0.05$, statistically significant difference between-group determined by analysis of covariance with baseline values as a covariate.

nificant difference in improvement in grip strength in both the right and left sides among those in the EB group ($P<0.001$) and ($P<0.05$), respectively (Table 5).

DISCUSSION

The present study aimed to investigate the effectiveness of EB exercise for upper limb function, including muscle strength, range of motion, and grip strength among older adults. Results demonstrated that EB exercise was effective in improving shoulder function among older adults.

In terms of muscle strength, participants in the EB group exhibited significant improvement in upper limb muscle strength (upper trapezius, middle trapezius, and deltoid) compared to the control group, which could be attributed to the EB exercise. In this study, EB exercise was performed with various movements of the shoulder joint, including flexion, abduction, internal rotation, and external rotation. While performing the exercise, the shoulder flexors are contracted voluntarily in the form of decreased neural activity in the shoulder extensors to maximize contraction force (Rowlands et al., 2003; Sharman et al., 2006). This effect of reciprocal inhibition in antagonists may enable agonist muscles to be activated efficiently during exercise (Miyachi et al., 2021). Meanwhile, the EB exercise requires subjects to hold the band at the end range for 15 sec, which could produce isometric contraction of muscles in the shoulder complex, which may improve muscle strength (Myers et al., 2015). Therefore, muscle strength in the upper trapezius, middle trapezius, and deltoid muscles was improved. This is consistent with the study by Nishimura and Miyachi (2020) in that EB exercise could improve muscle strength in hip extension and abduction compared to exercise without the band. However, in the present study, the strength of the latissimus dorsi muscle was not significantly different between the groups. We hypothesized that this may be because the exercise movements less involved shoulder adduction and extension, which are the primary roles of the latissimus dorsi in shoulder movement (Veeger and van der Helm, 2007).

Regarding range of motion of the shoulder joint, the results demonstrated that the EB group exhibited a significant increase compared to the control group in all directions except extension and abduction of the left shoulder. A study by Miyachi et al. (2021) investigated the immediate effect of exercise using an EB on hip abductor muscles, and found that EB exercise was more effective than general training in terms of increasing the activity of agonist muscles while suppressing antagonist muscle activity. Our recent study addressed the movement of the shoulder joint in various directions, which could be explained through the mechanism of reciprocal inhibition, which during the movement, the agonist is contracted while the antagonist is relaxed (Hindle et al., 2012). Relaxation of the antagonist results in a decrease in neural activity (Rowlands et al., 2003). This inhibition of the antagonist, along with the shortening contraction of the agonist muscle, permits the muscle fibers of the antagonist to elongate even further, producing greater stretching and creating a larger inhibitory effect on the antagonist (Etnyre and Abraham, 1986; Sharman et al., 2006). In addition, using a shortening contraction of the agonist muscle to place the antagonist muscle on stretch, followed by a static contraction of the antagonist muscle (holding the band for at least 15 sec), appears to have the greatest impact on enhancing the range of motion (Decicco and Fisher, 2005; González-Ravé et al., 2012; Sharman et al., 2006).

In terms of grip strength, participants in the EB group gained significantly more strength than the control group. We postulated that this could be a result of the increased shoulder strength because the shoulder-wrist complex is linked by a synergistic pattern (Dounskaia et al., 2020), and research has suggested a positive correlation between grip strength and shoulder strength (Horsley et al., 2016; Mandalidis and O'Brien, 2010; Nascimento et al., 2012). For this reason, we inferred that the increase in grip strength in the EB group may be related to increased shoulder strength.

The overall finding was similar to a previous study that used EB exercise for an older adult with Parkinson's syndrome and found that elongation and exercise could improve motor function, such

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as muscle strength and range of motion (Nishimura and Miyachi, 2020). The EB has low resistance and high extensibility. Therefore, exercises involving an EB has clinical utility as a home-based self-exercise for older adults to perform safely at home without causing excessive load on each joint of the upper limb and could promote upper limb function and prevent deterioration due to the aging process.

A limitation of this study is that the number of participants in each group was not equal because two participants in the control group dropped out, which may have affected the results. Additionally, there is a lack of studies using EBs targeted to improve upper limb function in older adults; as such, further research is needed to support our findings.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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