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Original Article

Effects of exercise using a modified elastic band with a coconut shell on muscle strength and balance in community-dwelling older adults

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Abstract. [Purpose] To investigate the effects of exercise using a modified elastic band with a coconut shell on leg muscle strength and balance in older adults. [Participants and Methods] The study consisted of 30 participants aged 60 years and older. The participants were randomly assigned to either the exercise (n=15) or control groups (n=15). The exercise group used a modified elastic band with a coconut shell three days a week for four weeks. Both groups received a single educational session on fall prevention after a baseline assessment. The Functional Reach Test (FRT) and Timed Up and Go Test (TUG) were used to assess balance, respectively. The 30-second chair stand test (30CST) was also used to measure leg strength. All outcome parameters were measured at the beginning of the study, immediately after a single exercise session, and after four weeks of exercise. [Results] The FRT and 30CST significantly increased in the exercise group after four weeks of exercise. The TUG significantly decreased in the exercise group after completing the program. [Conclusion] This study demonstrated that exercise using a modified elastic band with a coconut shell could effectively improve leg muscle strength and balance in older adults.

Key words: Elderly, Fall prevention, Elastic band

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INTRODUCTION

Essentially, older individuals are expected to be able to participate in and enjoy life's events. One of the key determinants of functional ability in relation to social involvement is physical performance. Degenerative changes in the body contribute to a gradual decrease in strength, as well as a decline in balance abilities, thus increasing the risk of falls. Globally, falls are a leading cause of injury and death among older adults and a significant public health issue. Therefore, it is necessary to promote physical activity to enhance fall prevention[1, 2)].

It is well known that exercise can reduce the fall rate in older adults[3)]. Several studies have reported that resistance band exercise has proven to be useful in improving leg muscle strength and balance in older adults[4–8)]. The intensity of the natural load can be adjusted, making this form of exercise useful for strengthening muscles in the elderly. Interestingly, elastic bands are capable of being loaded from all directions[5)].

In addition, there is some evidence to suggest foot massage has the potential to help improve balance and reduce the risk of falls in elderly people[9–11)]. Motivation is also believed to be a critical factor in supporting sustained exercise, which in turn is associated with important health outcomes[12)]. Interestingly, the coconut shell has been used to induce body relaxation by self-massage in Thai local communities[13)].

Ideally, exercise equipment developed from a local innovation can enhance the accessibility of exercise. Possibly, the elderly living in communities may prefer to use exercise equipment that can be found locally to prevent falls. Low-cost

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equipment developed using household materials offers an alternative exercise choice, especially rubber bands and coconut shells.

To the best of the researchers' knowledge, there is currently no evidence to determine the effects of an exercise program combining a resistance band and foot massage on balance-related outcomes. Thus, the purpose of this study is to investigate the effects of exercise using a modified elastic band with a coconut shell on muscle strength and balance in community-dwelling older adults.

PARTICIPANTS AND METHODS

This randomized controlled trial study (RCT) consisted of 30 sample participants from a community dwelling under the following inclusion criteria: 1) aged 60 years and older, 2) able to stand and walk independently, 3) able to follow instructions, 4) received a Thai Mental State Examination (TMSE) score of more than 23 points, and 5) expressed a willingness to participate in the research.

The study excluded volunteers who presented with 1) a history of ischemic heart disease, heart failure, dizziness due to low blood pressure (hypotension), uncontrolled high blood pressure, deep vein thrombosis or acute arthritis/arthralgia, 2) open wounds in and around the feet, and 3) exercise adherence of less than 80 percent.

The sample size was calculated using G*Power 3.1.9.7 (University of Düsseldorf, Düsseldorf, Germany). A statistical significance level of 0.05, effect size 0.3 and power of 90% were used in the sample size calculation, which yielded 13 participants in each group. To allow participants to drop out, there were 15 in each group.

The study was approved by the University of Phayao Human Ethics Committee (UP-HEC 1.2/096/66).

All participants provided written informed consent prior to testing. The participants were randomly assigned to either the experimental or control group by a researcher.

The Functional Reach Test (FRT) and Timed Up and Go Test (TUG) were used to assess balance. The 30-second chair stand test (30CST) was used to measure leg strength. All outcome parameters were measured at the beginning of the study, immediately after a single session, and after four weeks of exercise.

The experimental group performed the exercise using elastic and a coconut shell three days a week for four consecutive weeks, while the control group did not perform the exercise. Both groups received a single educational session on fall prevention after a baseline assessment.

The FRT, TUG, and 30CST were used in this study in accordance with established protocols[14–18].

The FRT is widely used for assessing dynamic balance stability in elderly individuals. In this study, the FRT was used to assess the maximal distance an individual can reach forward beyond an arm's length in a standing position without loss of balance, taking a step, or touching the wall. The dominant arm was assessed three times, with the average distance used for analysis[14, 15].

The TUG is a simple, quick, and generally used clinical performance-based measure of lower extremity function, mobility, and fall risk. In this study, the TUG was used to assess the amount of time spent getting up from sitting on a chair to the bipedal position, walking three meters, turning, returning, and sitting on the chair again[16, 17].

The 30-second chair stand test (30CST) is commonly used for testing leg strength and endurance in older adults. In this study, the 30CST was used to assess the number of repetitions the participant returned to a full standing position in 30 seconds[18].

In this study, a home-based exercise program was established. The elastic band resistance training program consisted of the warm-up phase, exercise condition, and cool-down phase. Each program session lasted for around 45 minutes. During the warm-up phase, stretching (four positions), general active exercise (three positions), and self-foot massage (two positions) were performed, respectively. In the exercise condition, 11 positions involving upper and lower limb resistance were performed using a modified elastic band with a coconut shell. The participants performed 2–3 sets of 10–15 repetitions for each exercise. For the cool-down phase, self-foot massage (one position) and breathing exercise (two positions) were performed, respectively.

For the first two weeks of the program, all participants in the exercise group were asked to perform two sets of 10 repetitions per exercise position. After two weeks of the program, all participants in the exercise group were asked to perform three sets of 15 repetitions per exercise position for progressive overload training.

The exercise equipment was made from one piece of coconut shell (diameter × height: approximately 5 × 3 inches) and connected with an elastic band. For the first two weeks of the program, the elastic band was made from 240 rubber bands (diameter 1 inch), as shown in Fig. 1. After two weeks of exercise, an elastic band made from 360 rubber bands was then used for the purposes of training progression.

All participants in the exercise group received an exercise poster, logbook, and weekly phone call to assist and facilitate their exercises. Meanwhile, the control group was asked to maintain their activities of daily life and received a telephone call once a week.

Before the experiment, the researcher demonstrated the use of the elastic and coconut shell to individuals in the exercise group, who then performed the exercise to familiarize themselves with the process. The participants performed each 45-minute exercise session three times a week for four weeks under the supervision of a caregiver.

The SPSS statistical package version 26 (SPSS Inc, Chicago, IL, USA) was used to analyze the data. All baseline data were expressed as mean ± SD. Statistical analysis was performed using the parametric method, with the normality test having been satisfied. Significant differences in the baseline data between groups were examined using the unpaired t-test except for gender proportion, to which the χ^2 test was applied. The dependent variables were analyzed using a two-way mixed ANOVA on two factors, namely between-participants (group) applying two levels (groups: exercise, control) and within-participants (time) applying three levels (time: pre, post single session, and post four weeks of exercise). The significance level was set at $p<0.05$. Since significant differences were found in the interaction effect during post hoc analysis, Bonferroni correction was used to compare the differences between groups at the time of assessment, with α adjusted to 0.016, and the differences between times within groups, with α adjusted to 0.008. According to Cohen, the effect sizes should be classified as small (d=0.2), medium (d=0.5), and large (d≥0.8)[19].

RESULTS

A total of 30 participants were recruited. One participant in the experimental group left the trial due to exercise adherence of less than 80 percent and was not obtained final assessment. Therefore, data from 14 participants in the exercise group and 15 participants in the control group were finally analyzed.

The baseline characteristics of the participants are presented in Table 1. There were no statistically significant differences between the groups for all outcome parameters at the baseline assessment.

Table 2 reveals the significant effect of exercise using elastic coconut shell on FRT ($F_{(2,26)}=28.777$, $p<0.001$) and TUG ($F_{(2,26)}=43.309$, $p<0.001$) with effect sizes of 0.69 and 0.77, respectively, indicating a medium effect size. The results also revealed that exercise using the elastic coconut shell on 30CST ($F_{(2,26)}=53.397$, $p<0.001$) with an effect size of 0.80, indicating a large effect size.

Table 3 shows that exercise using a modified elastic band with a coconut shell significantly improved FRT, TUG, and 30CST in older adults.

DISCUSSION

The main findings of this study were that FRT, TUG, and 30CTS improved following the 4-week exercise program. However, immediate effects of a single session of exercise using a modified elastic band with a coconut shell on outcome parameters were not presented. Importantly, the exercise program for older adults had a medium to large effect. Therefore, the results suggest that the exercise training using a modified elastic band with a coconut shell had a moderate positive impact on lower limb muscle strength as well as balance.

To the researchers' knowledge, this is the first study to examine the immediate and short-term effects of exercise using a modified elastic band with a coconut shell on muscle strength and balance in older adults. It may be difficult to compare data reported across studies because of differences in the exercise equipment.

Fig. 1. A modified elastic band with a coconut shell.

Table 1. Participants' characteristics at analysis

Variables	Control group (n=15)	Exercise group (n=14)
Gender: Males/Females	7/8	7/7
Age (years)	64.6 ± 2.6	65.5 ± 1.8
Weight (kg)	59.3 ± 6.1	58.8 ± 6.8
Height (cm)	158.7 ± 8.6	160.2 ± 5.0

Values are reported as mean ± standard deviation (SD).

Table 2. Pre (0-week), post (1 session), and post (4-week) outcome measures of each group

Variables	Time	Exercise group (n=14)	Control group (n=15)
FRT (cm)	0-week	16.3 ± 3.7	16.6 ± 3.0
	1 session	17.4 ± 4.3	16.6 ± 3.3
	4-week	21.2 ± 4.3	16.5 ± 3.4
TUG (sec)	0-week	14.8 ± 2.5	14.0 ± 1.7
	1 session	14.8 ± 1.7	14.0 ± 1.7
	4-week	11.1 ± 1.1	13.9 ± 1.4
30CST (reps)	0-week	10.7 ± 0.9	10.3 ± 0.9
	1 session	10.6 ± 1.0	10.2 ± 0.9
	4-week	13.2 ± 1.1	10.3 ± 0.9

Values are reported as mean ± standard deviation (SD).
FRT: Functional Reach Test; TUG: Timed Up and Go Test; 30CST: 30-second chair stand test.

Table 3. Pre (0-week), post (1 session), and post (4-week) of all outcome measures

Variables	Group	0-week	1 session	4-week
FRT (cm)	Control group (n=15)	16.6 ± 3.0	16.6 ± 3.3	16.5 ± 3.4
	Exercise group (n=14)	16.3 ± 3.7	17.4 ± 4.3	21.2 ± 4.3[a, b]
TUG (second)	Control group (n=15)	14.0 ± 1.7	14.00 ± 1.7	13.9 ± 1.4
	Exercise group (n=14)	14.8 ± 2.5	14.8 ± 1.7	11.1 ± 1.1[a, b]
30CST (number)	Control group (n=15)	10.3 ± 0.9	10.2 ± 0.9	10.3 ± 0.9
	Exercise group (n=14)	10.7 ± 0.9	10.6 ± 1.0	13.2 ± 1.1[a, b]

Values are reported as mean ± standard deviation (SD).
[a]$p<0.01$: comparison with the value on after 1 session.
[b]$p<0.01$: comparison with the value on baseline assessment.
FRT: Functional Reach Test; TUG: Timed Up and Go Test; 30CST: 30-second chair stand test.

In a study published in 2016, Kwak et al.[5] suggested that elastic band resistance exercise can be an effective and easy-to-use instrument for elderly people in rural communities to improve balance, gait function, flexibility, and fall efficacy since it can be performed with reciprocal physical therapy. A recent study showed that a 30-minute session of group exercises using a low-resistance band had positive effects on the trunk balance and mobility of elderly individuals living in rural communities[7]. In another study, one session of Thai massage was found to provide immediate improvement in some gait parameters, balance performance, and body flexibility in the elderly[10].

One possible reason for the results in the present study is the combined effect of resistance exercise using the elastic band method and massage[5, 7, 10]. It has been suggested that low levels of lower limb strength are associated with functional limitations in older adults. Significantly, muscle weakness leads to an increased risk of falls among the elderly[20]. When exercising the upper extremities and lower extremities using a modified elastic band with a coconut shell, the physical strength of older adults could be increased due to integrative and physiological effects of strengthening and massage after 4 weeks of exercise program.

Additionally, another possible reason for the result in the present study is that older people normally have decreased flexibility. This affects balance by decreasing the activation of the muscle spindle and amplitude of the stretch reflex, which are important components of the proprioception senses[9, 10]. In this study, a self-foot massage using a coconut shell was believed to increase blood circulation, increase temperature, buffer the blood pH of muscle, and remove waste products, potentially contributing to improved performance and muscle recovery. Foot massage may possibly have neuro-mechanical and mechanical effects. Self-massage of the feet can stretch muscle, tendon, and ligament structures originating from the reflex of muscle relaxation, alter the length of sarcomeres, and activate proprioceptive nerve endings. The mechanical pressure of the massage helped to reduce tissue adhesion by lengthening, decreasing, or adhering to the connective tissue, giving rise to ankle flexibility. Furthermore, massage was found to arouse the proprioceptors on the cutaneous, Golgi tendon organ, joint receptors, and muscle spindles. Massage also stimulated the readjustment of the unproductive reflex to improve somatosensory information and balance performance[10, 11].

There were some limitations to the present study. Firstly, the main limitation of this study was study design. It would be greatly appropriated if hypothesis testing was proven by a crossover study design. In another way, it might be necessary to provide conventional resistance exercise for the control group with the same amount as the exercise group in order to prove the conclusion of the trial. Secondly, the results could not be generalized to all age groups of elderly adults since the study was conducted on volunteers aged 60–69 years. Further research is required to provide evidence to clarify this point.

Thirdly, the study only examined the short-term effects of exercise. Thus, future studies with a longer follow-up period are suggested. Lastly, the present study did not consider any incidence of risk of falling, and future studies should be conducted on individuals with a history of falls.

In conclusion, this study is the first to show that exercise using a modified elastic band with a coconut shell is not only an effective exercise strategy but also a strategic imperative for promoting exercise adherence. Above all, it offers an alternative exercise regimen for improving leg muscle strength and balance in the elderly.

The results of the current study may have implications for physiotherapists in managing the risks associated with falls in older people by improving leg muscle strength and balance.

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Conflict of interest

The authors report no conflicts of interest.

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