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Balance Improvement by Strength Training for the Elderly

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Abstract. [Purpose] Aging is associated with a progressive decline in overall muscle strength. Loss of lower limb strength leads to an increased risk of falls and a sedentary lifestyle. The purpose of this study was to investigate whether lower limb strengthening exercise leads to improved lower limb strength and balance function for the elderly. [Subjects] From a total of 74 respondents, 50 subjects were randomly assigned to either a training group (n = 30) or a control group (n = 20). The subjects ranged in age from 65 to 82 years. A randomized controlled trial compared the effects of strengthening exercise and balance function. [Methods] Leg extension and lower curl exercises were performed during the 12-week study. [Results] After training, the lower limb strength and balance of the individuals in the training group had significantly improved compared to the baseline. [Conclusion] Improvement in lower limb strength may lead to balance enhancement in neurologically intact older persons.
Key words: Balance, Elderly, Strengthening exercise

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INTRODUCTION

In humans, muscle strength, which can be defined as the force generation capacity of an individual, reaches its peak in the second and third decades of life, shows an imperceptible progressive decline until approximately 50 years of age, and then begins to decline thereafter at a rate between 1.4% to 2.5% per year, with more rapid losses after the age of 65 years[1, 2)].

Low levels of lower limb strength are associated with functional limitations in daily living[3)]. In addition, muscle weakness is associated with an increased risk of falls[4)], hip fractures[5)], and adverse physiological changes such as osteoporosis[6)].

Strength training is now widely recommended for older adults to increase muscle mass, strength, and ultimately, independence in activities of daily living[7)]. Strength training can be accomplished in a number of different ways, depending on the physiological, functional or performance goals.

Although some researchers have demonstrated that older adults are capable of significant improvements in lower extremity force measures with strength training, the effect of this type of training on balance measures has been rarely reported[8, 9)]. Postural sway increases with aging[10)]. Cross-sectional studies have used force platforms, which record the center of pressure, to estimate body sway[11)]. Older people have slightly higher measures of sway in double stance than younger persons. Increased postural sway increases the risk of falls according to studies of community-dwelling elderly[12)].

The purpose of this study was to investigate the effect of a vigorous resistance program on lower limb strength and balance of older persons.

SUBJECTS AND METHODS

Ninety subjects were recruited through advertising targeting individuals 65 years or older. Individuals with severe cardiac disease or orthopedic or neurological disorders that resulted in mobility impairment were excluded from the study. All the enrolled subjects of this study had normal cognition, as determined by a Folstein Mini-Mental State Examination score of 24. Of the participants, 16 were excluded because of cardiac or muscular problems, and the remaining 74 participants were randomly enrolled in 1 of 2 groups. The exercise group had twice as many subjects as the control group: 49 subjects were allocated to the exercise group, and 25 to the control group. During the experimental period, 24 participants dropped out owing to illness and were lost to follow-up. The participants were enrolled in this study after providing their informed consent in accordance with the ethical standards of the Declaration of Helsinki.

The intensity of exercise for the first week was 45–55% of 1RM, and it was progressively increased up by 65–75% at the 11–12week mark. The exercise group performed in

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Table 1. The general characteristics of the subjects

	Training group (n=30)	Control group (n=20)
Age (years)	72.4±3.4	69.5±3.6
Gender (male/female)	13/17	5/15
Body Mass Index	24.7±3.1	24.36±2.9

Table 2. Pre-and post-training measures

Items	Training group		Control group	
	Before training	After training	Before training	After training
Lower limb strength (time)	17.8±4.1	27.0±5.3*	20.0±4.6	20.9±4.1
2-minute step in place (time)	201.6±27.5	244.7±36.3*	210.3±17.0	210.0±15.5
Balance (cm^2)	41.7±23.2	73.3±0.3*	46.0±28.3	48.7±23.8

three sets of 10–12 repetitions. Between sets, a resting period of 60 seconds was allowed. Leg extension and curl exercises were performed using Milon exercise equipment (Milon, Emersacker, Germany), because the resistance of the equipment could be set digitally. To measure lower limb strength, each subject stood in front of an armless chair and was asked to take a seated position followed by a standing position as many times as possible within 30 seconds. During a 2-minute step in-place exercise, the examiner counted the elevation of only the right lower limb and informed the participant of the time at the end of the first minute and 30 seconds before the time was up. For balance, the limit of stability was measured using a BioRescue (RM Ingénierie, Rodez, France) with a safety bar. This study used the gross area (cm^2) measure. Data were analyzed with a commercially available statistical software program (PASW 18.0, IBM Inc, Chicago, IL, USA). The independent t test and χ^2 test were used to compare the baseline values between the 2 groups, and the paired t test was used to analyze the difference in effects after training. Values of $p < 0.05$ were considered statistically significant.

RESULTS

Table 1 lists the demographic data of the subjects. The groups were well matched. No one was injured by the training program.

After training, the lower limb strength, 2-minute step in place, and balance measurements of the training group were significantly higher than at baseline ($p<0.01$). However, lower limb strength, 2-minute step in place, and balance of the control group were not significantly different after 12 weeks ($p> 0.05$) (Table 2).

DISCUSSION

In our study, we investigated the effects of strength training and the influence of these strength-training exercises on the balance of elderly subjects. Our main finding was that the well-prescribed strengthening exercises led not only to enhanced strength but also to improved balance in the elderly persons.

Numerous studies utilizing traditional progressive strength training approaches have focused on the development of muscle strength and increased muscle mass to slow or reverse the effects of sarcopenia in older adults[13]. In the previous studies, these types of resistance training improved older adults' muscle mass, strength, and high-load power[14–16]. For the chair rise, a significant, moderate-to-large beneficial effect of progressive strength training was observed, although this was derived from only a small amount of data[1, 3, 17, 18]. The results of this research support the hypothesis that an exercise program emphasizing strengthening improves the static balance of the elderly. The improvement of static balance in the training group was greater than that of the control group.

Several studies have found that older individuals could undertake strength training and realize several physiological benefits[19, 20]. The findings of this study corroborate those of a previous 3-month study that randomized high-functioning men and women over the age of 70 years into power training and walking groups. This previous study included a combined training, 3 times per week, that consisted of knee extension and sitting leg press machine exercises, walking for 20 minutes, and performing postural control exercises, which included simple Tai Chi movements that could help balance function[15]. Increases in balance measures can be explained as greater tolerance of instability, increased resistance to gluteus medius muscle fatigue, or improved balance. The training provided in the present study resulted in modest strength gains (22%); however, these improvements in strength may not necessarily equate to improvements in function[21]. The effect of progressive strength training on measures of standing balance of 789 participants were not clear[1, 17, 18, 22–24]. Similar effect estimates were found when only 2 measures (i.e., timed position holding and balance during more complex activities such as the Berg Balance Scale) were examined separately.

The subjects involved in this study were healthy and willing to travel for non-assistive activities of daily living. The selection of active, high-level functioning subjects with good baseline characteristics would tend to limit the im-

provement possible from exercise intervention. Similar or greater improvements may be achievable in a less-active group of subjects.

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