The effects of complex exercise on walking ability during direction change and falls efficacy in the elderly

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Abstract. [Purpose] This study was to assessed the efficacy of a complex exercise program for the elderly, with respect to the effects on walking ability during direction change and on falls efficacy. [Subjects] In total, 40 subjects were selected for this study and assigned randomly to either a complex exercise (n = 20) or a general exercise (n = 20) group. [Methods] The complex exercise consisted of resistance and aerobic exercises. The exercise program was conducted three times a week for eight weeks. We assessed outcome measures of the four square step test, the figure-of-8 walk test, and the falls efficacy scale. [Results] After the intervention, the four square step test, figure-of-8 walk test, and falls efficacy scale values increased significantly in both the complex exercise program and general exercise groups. The complex exercise group showed a more significant improvement than the general exercise group in the figure-of-8 walk test step and falls efficacy scale scores. [Conclusion] Complex exercise improved walking ability during direction change and falls efficacy in elderly individuals.

Key words: Complex exercise, Falls efficacy, Gait

INTRODUCTION

Walking is a factor that can predict a fall11). Successful walking is affected by the integration of complex cognition and neuromuscular, sensory, and skeletal factors, which can degenerate with disease and aging2). Age-related walking changes begin during a person’s 60s and 70s. Elderly walking is characterized by reduced velocity and increased basal plane. In particular, elderly persons have difficulty changing directions3), resulting in a high fall risk.

Statistical reports have shown that one in three persons over the age of 65 experience a fall annually9). Elderly persons who have fallen can worry about falling again and develop a phobia of falling, which leads to anxiety. The falling phobia results in reduced mobility, which limits a person’s activities and further increases the risk of falling, thus creating a vicious cycle5).

Increased balance, improved cardiovascular function, and good flexibility achieved through regular exercise are effective management strategies in reducing the risk of falling in elderly individuals6, 7). To improve their physical condition, elderly individuals have participated in various interventions, such as resistance exercises using elastic bands8), muscle strength exercises using equipment9), and tai chi exercises10). However, because they had to perform monotonous motions repeatedly, they lost interest easily, which resulted in low participation. It has also been reported that the limitations of locations, tools, and equipment required for exercising are some of the drawbacks of this approach11).

Thus, it is necessary to provide an interesting, efficient complex exercise program that can be performed anywhere, and that maintains a high level of motivation in the participants. As such, the aim of this study was to conduct a complex exercise program for the elderly, and determine the effects of the program on walking ability during direction change and on falls efficacy. The study also aimed to determine the applicability of this program to other complex exercise programs, and assess the improvements in the mobility of the elderly based on the effects of the program.

SUBJECTS AND METHODS

In total, 40 subjects who attended the Welfare Center in Gwangju city were selected for this study and assigned randomly to two groups: the complex exercise group (n = 20), which participated in a complex exercise program, and the general exercise group (n = 20), which did not participate in the complex exercise program. This study was approved by the hospital, and all participants provided their written informed consent. The complex exercise group consisted of twelve men and eight women (average age, 68.81±3.48 years; average height, 158.00±5.19 cm;
average weight, 58.94±11.36 kg), and the general exercise group consisted of seven men and 13 women (average age, 71.50±5.54 years; average height, 160.07±7.14 cm; average weight, 62.64±12.12 kg).

The selection criteria were as follows: a minimum of 24 points on the Korean Mini-Mental State Examination (K-MMSE), no medication due to mental illness, no orthopedic disease in the lower limbs, the ability to walk 10 meters or more independently, and the ability to understand the study objective and provide voluntary consent.

The complex exercise program consisted of resistance and aerobic exercises. An exercise using weight was conducted to improve muscle strength. A bridge exercise, arm and leg stretching in the prone position, the cat pose, and full-body stretching were performed to strengthen the trunk and increase flexibility. Aerobic exercise was achieved by setting the intensity level at 60–70% of the participants’ heart rate reserve, and walking training was conducted according to the participants’ individual capabilities. Full-body stretching and walking in place were performed for 5 minutes each as warm-up and cool-down exercises, respectively. The main exercises were performed for 30 minutes, including two 5-minutes rest periods, for a total of 50 minutes. The exercise program was conducted three times a week for eight weeks.

The four square step test (FSST) is a tool that evaluates complex walking ability. Subjects step over four bars placed on the ground orthogonally in the shape of a plus sign “+”; the height and length of which were 2.5 cm and 90 cm, respectively. The subject starts by walking over a bar from “zone 1,” one of the quadrants formed by the plus sign, and continues walking over the bars, one by one, in a clockwise direction, until he/she arrives back in the starting quadrant. Then, the exercise is repeated in the counterclockwise direction. During the test, if the subject touches a bar, loses his/her balance, or fails to put both feet in the same quadrant, the exercise is re-started. A mean value of three measurements is determined.

The figure-of-8 walk test (F8WT) measures walking skills in elderly persons with mobility impairments. It was developed to assess curved walking abilities in daily living, which cannot be measured by straight-line walking tests. The subject walks a “figure 8” pattern around cones, and the time and number of steps needed to complete the exercise are recorded. In this study, the inter-rater reliability time was 0.90 and the step count was 0.92, while intra-rater reliability time was 0.84 and the step count was 0.82.

The Falls Efficacy Scale (FES) is a self-administered questionnaire designed to determine the degree of self-confidence regarding falling; it represents fears experienced while conducting ten activities required for daily living.

The measurement data obtained with these tests were analyzed using SPSS version 17.0 for Windows. A paired t-test was conducted to determine within-group differences in the results before and after the experiment, and an independent t-test was conducted to determine between-group differences in the results before and after the experiment. The statistical significance level was set to \( \alpha = 0.05 \).

**RESULTS**

The results before and after the intervention are presented in Table 1. Changes in the FSST values showed a significant decrease in both the complex exercise program and general exercise groups (\( p<0.05 \)). There was a significant difference between the two groups.

Changes in the F8WT time showed a significant decrease in both groups (\( p<0.05 \)); however, no significant difference was found between the groups. Changes in the F8WT step count showed a significant decrease in both groups as well (\( p<0.05 \)). The complex exercise group showed a more significant improvement than the general exercise group did.

Changes in the FES values showed a significant improvement in both the complex exercise group and in the general exercise group. There was a significant difference between the two groups (\( p<0.05 \)).

**DISCUSSION**

In this study, a complex exercise program was prescribed to a group of elderly individuals, resulting in improved walking ability during direction change and in falls efficacy.

The FSST is a test that measures the ability to change direction while lifting a foot. There was a significant difference in the FSST scores between groups. This result indicates that the complex exercise group improved their direction change ability by improving their balance through regular exercise incorporating various movements. This finding is consistent with the results of another study, in which patients with chronic stroke participating in functional exercises incorporating various positions showed improved FSST scores, along with a speed moment more reduced than that of the general exercise group. Our results also support the study
results of Song et al.\textsuperscript{19}, who reported walking ability improvements through muscular strengthening and flexibility exercises.

The F8WT (time and step count) was conducted to determine the between-group differences in the walking abilities of the elderly participants before and after the experiment, and the results showed a significant difference in the F8WT step count, but not in the F8WT time. The F8WT (time and step count), which was conducted to determine the curve walking abilities of the elderly, showed a significant difference in the F8WT step count, which indicated that the complex exercise group took fewer steps and had a longer stride when passing over two barriers in the curved lane than the general exercise group.

This result was due to improvements in the balance of the complex exercise group when navigating a curved line, thereby requiring fewer steps. It has been reported that superior balance requires fewer steps and lengthens the stride required to maintain balance when walking around a curved line\textsuperscript{17}. In experiments that compared straight walking and curved walking abilities, the differences between the two types of walking were greater in a group of patients with Parkinson’s disease than in healthy subjects. In particular, the patients with Parkinson’s disease exhibited a smaller step width and stride length\textsuperscript{18}.

The lack of significant difference between the two groups in the time taken to complete the F8WT indicates that there was no significant difference in the time required to navigate a curved path. The F8WT specifies a gap between barriers of 1.5 meters and a width of 1.2 meters. When the elderly subjects passed over the barriers, they chose a long stride to pass over the barrier safely; thus, there was no significant difference between the two groups.

Will and motivation are important to changes in falls efficacy. Both groups experienced a positive psychological effect with respect to falling due to the regular exercises. A fear of falling can reduce flexibility and cause balance problems\textsuperscript{19}. Balance improved and fear of falling decreased due to the effects of the exercise program, thus improving falls efficacy. It has been reported that increased muscle strength improves balance, which increases safety in performing daily activities\textsuperscript{20}. In addition, increased lower extremity muscle strength has been found to correlate significantly with increased walking speed and falls efficacy\textsuperscript{21}.

In this study, a complex exercise program improved walking ability during direction change and falls efficacy in elderly individuals. In future research, the difference between the effects of various exercises and the complex exercise will be investigated. In addition, further studies comparing the effects of this complex exercise program on elderly patients suffering from a variety of diseases will be needed in the future.

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