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Original Article

Multicomponent exercise for physical fitness of community-dwelling elderly women

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Abstract. [Purpose] The purpose of this study was to identify whether a 4-week multicomponent exercise program could improve the level of physical fitness of community-dwelling elderly women. [Subjects and Methods] Twenty-two healthy community-dwelling elderly women were randomly allocated to either an experimental or a control group. Experimental subjects performed a multicomponent exercise program that consisted of balance, strengthening, and stretching exercises for 4 weeks, whereas the control subjects did not perform any specific exercise. The subjects' level of physical fitness was assessed prior to and after training using the Senior Fitness Test which assesses muscle strength, flexibility, dynamic balance/agility, aerobic endurance, and body composition. [Results] Subjects in the experimental group showed significant improvements in lower and upper body strength, lower and upper body flexibility, dynamic balance/agility following training, but not in aerobic endurance or body composition. Significant group differences were shown in lower and upper body strength, lower body flexibility, and dynamic balance/agility. [Conclusion] The results suggest that a multicomponent training program that consists of balance, strengthening, and stretching exercises is a relevant intervention for the improvement of the level of physical fitness of community-dwelling elderly women.
Key words: Elderly women, Physical fitness, Multicomponent exercise

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INTRODUCTION

People 65 years and older comprise about 12% of the Korean population, with a significant increase projected within the next 20 years[1)]. The average life span of Koreans has increased rapidly over the past several decades[2)]. This extended life span has resulted in increased medical costs and age-related chronic disorders that are often accompanied by functional impairments.

Regular physical activity reduces the risk of various chronic diseases, e.g., cardiovascular disease and psychological problems in older adults[3)]. A study has also shown that physically active elderly adults demonstrate higher functional ability in activities of daily living than those with a relatively low level of physical activity[4)]. Conversely, among the elderly, limited physical activity is a major cause of diminished functional ability[5, 6)], which is significantly associated with a high risk of mortality[7)].

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Physical fitness is defined as "*the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies,*"[8)] and it has been used to estimate the level of functional ability of the elderly. The components of physical fitness, especially related to health, include muscle strength and endurance, cardiovascular and pulmonary endurance, flexibility, and body composition[9)]. Physical fitness is significantly related to the functional limitations of older adults regardless of chronic disease progress[10)]. This suggests that to maintain an adequate level of physical function, the elderly need to participate in appropriate physical fitness activities.

Decreases in physical fitness in older adults are associated with higher risks of fall[11)] and injury[12)]. A systematic review indicated that multicomponent exercises reduce the incidence of falls and risk of fall of elderly people[13)]. A multicomponent exercise program that includes resistance exercise, balance exercise, and functional training, has been recommended for improving in physical fitness[14)]. Recent studies have demonstrated that elderly women could improve physical fitness following multicomponent exercise, although the benefits were limited to only certain components of physical fitness[15, 16)]. Studies have also reported the positive effects of visual feedback on the static[17)] and dynamic balance of older adults[18, 19)]. In particular, the functional balance of elderly women significantly improved following 4 weeks of visual feedback-based training[19]. Nonetheless, the appropriate types and intensity of exercises that would benefit the physical fitness of community-dwelling elderly women have not been clearly identified.

We developed a 4-week exercise program that combines balance, strengthening, and stretching exercises with a visual feedback-based balance exercise for older adults. The purpose of this study was to investigate whether the multicomponent exercise program could improve the physical fitness (muscle strength, flexibility, aerobic endurance, dynamic balance/agility, and body composition) of community-dwelling elderly women.

SUBJECTS AND METHODS

Subjects

Twenty-two community-dwelling healthy elderly women from the Jeungpyung area in Korea were recruited through an advertisement. The study included female subjects who were aged 65 years or older, able to follow the instructions for testing and training, and able to walk 10 m without walking aids. Subjects who had any prior musculoskeletal problems, neurological diseases, or vestibular disorders that limited their exercise ability were excluded. Cognitive function was assessed using the Korean version of the Mini-Mental State Examination test[20]. Prior to participating in this study, subjects signed a written informed consent form in accordance with the ethical principles of the Declaration of Helsinki.

Methods

The subjects' physical fitness was assessed using the Senior Fitness Test which measures lower and upper body strength and flexibility, dynamic balance/agility, aerobic endurance, and body composition prior to and after the training[21]. The Senior Fitness Test is a valid measurement[22] and has shown an excellent test-retest reliability[21, 22].

Lower body strength was evaluated using the 30-second chair stand test which measures the number of sit-to-stand movements with arms crossed on the chest for 30 seconds. Upper body strength was assessed using the 30-second arm curl test. This test measures the number of right elbow flexion and extension movements completed in a sitting position while holding a 5-pound weight in a 30-second period. Lower body flexibility was evaluated using the chair sit-and-reach test. This test measures the distance between the tip of the subject's middle finger and the tip of the shoe, when a subject reaches to the foot maximally while sitting with one leg flexed (up to 90° of hip and knee flexion) and the other leg fully extended with the heel on the floor and the ankle flexed at approximately 90°. Upper body flexibility was assessed by calculating the distance between the tips of the subject's middle fingers using the back scratch test with two hands (one above the shoulder, the other under the shoulder). Dynamic balance/agility was evaluated using the 8-foot up-and-go test. This test measures the time it takes for a subject to rise from a sitting position, stand up, walk a distance of 8 feet from the chair, and return to sit in the chair. Aerobic endurance was assessed using the 2-minute step test which measures the number of times a subject is able to step in place with each knee lifted to a height at least even with the iliac crest. Body composition was evaluated by calculating body mass index (BMI) using the subject's weight in kilograms divided by her height in meters squared (kg/m^2).

For training, subjects were randomly allocated to the experimental and control groups. Subjects in the experimental group participated in a 4-week multicomponent exercise program consisting of 60-minute sessions, three times per week. Each multicomponent exercise session comprised three stages of group exercise (i.e., warming up, main exercises, and cooling down) and an individualized visual feedback-based balance exercise. Five minutes of warming up and 5 minutes of cooling down included head turns, head half circles, single arm crossovers, calf stretches, hamstring stretches, hand flexor stretches, and trunk side bending[21]. The main training exercises consisted of balance (20 minutes), strengthening (20 minutes), and stretching exercises (5 minutes). Subjects performed balance exercises while sitting, standing, standing from sitting, hopping, walking, and tandem walking. Strengthening exercise was focused on trunk muscles and the major muscle groups of the lower and upper extremities and used Therabands or body weight for resistance. Stretching exercise mainly involved the lower extremity muscles (e.g., hip flexors and ankle plantar flexors). Each exercise had 2–4 levels of difficulty that progressed based on the subjects' abilities. The subjects were allowed 1–2 minutes rest between exercises. For the visual feedback-based balance exercise, the subjects attended an individualized dynamic balance training program (5 minutes) using the Good Balance System (Metitur Ltd., Finland) following the group exercise sessions. Using visual feedback, each subject completed two tasks that focused on controlling the center of gravity and increasing the limit of stability, while standing on a computerized force platform[19]. The control group was instructed to maintain their level of activity without participating in any specific physical fitness exercises during the 4 weeks.

For statistical analysis, non-parametric statistical analyses were selected based on the results of the Shapiro-Wilk test of normality and Levene's test of homogeneity of variances. The Mann-Whitney U test was used to examine group differences in subjects' characteristics and dependent variables of physical fitness at the pre-training test. Changes in physical fitness variables following training were assessed in both groups using the Wilcoxon Signed Rank test. In addition, the Mann-Whitney U test was used to identify the changes in dependent variables over 4 weeks between the two groups. All data were analyzed by using the IBM SPSS Statistics Software 22.0 (IBM Co., Armonk, NY, USA). The level of statistical significance was chosen as 0.05.

RESULTS

No significant differences in subjects' characteristics were found between the experimental and control groups (Table 1). A significant group difference at the pre-training test was revealed only in upper body flexibility between the two groups ($p < 0.05$) (Table 2). Subjects in the experimental group demonstrated significant changes in lower and upper body strength, lower and upper body flexibility, and dynamic balance/agility following the 4-week multicomponent exercise program (Table 2). Lower and upper body strength increased 52.8% ($p < 0.01$) and 22.5% ($p < 0.05$), respectively. Lower and upper body flexibility improved 232.4% ($p < 0.01$) and 25.9% ($p < 0.01$), respectively. Dynamic balance/agility also improved 15.3% ($p < 0.05$). However, no significant changes were shown in aerobic endurance and body composition. Subjects in the control group showed a significant change (14.8% improvement) only in upper body flexibility ($p < 0.05$) over 4 weeks.

Significant group differences were found for changes in lower body strength ($p < 0.01$), upper body strength ($p < 0.05$), and lower body flexibility ($p < 0.01$), and dynamic balance/agility ($p < 0.05$). However, changes in upper body flexibility, aerobic endurance, and body composition were not significantly different between the two groups.

DISCUSSION

This study investigated the effects of a 4-week multicomponent exercise program comprised of balance, strengthening, and stretching exercises, and visual feedback-based balance exercise, on the physical fitness of community-dwelling elderly women. The incorporation of a multicomponent exercise program has been strongly recommended for elderly populations by the American College of Sports Medicine and the American Heart Association[3]. The outcomes of the present study show that the elderly women in the experimental group, who participated in the multicomponent exercise program, significantly improved their physical fitness levels of lower and upper body muscle strength, lower and upper body flexibility, and dynamic balance/agility following training. Their improvements in lower and upper body strength, lower body flexibility, and dynamic balance/agility were significantly different from those shown by the control group.

Lower and upper body strength of the subjects in the experimental group significantly increased following 4 weeks of training, but no changes were observed in the control group. The results of the experimental group are in agreement with those of previous studies[16, 23, 24]. Interestingly, the amount of improvement appears somewhat greater than those of the previous studies. The increase in muscle strength was noticeably higher in the lower-body (52.8%) than the upper-body (22.5%). The fact that the strengthening exercises used in this study contained more training for the lower extremities than the upper extremities may be accountable for the difference.

The experimental subjects' upper and lower body flexibility also significantly improved after training, which is consistent with findings of the earlier studies[23–25]. Conversely, other studies have reported no significant change in flexibility or only a change in lower body flexibility following multicomponent exercise training, although the training

Table 1. General characteristics of the subjects

Characteristics	Control (n=11)	Experimental (n=11)
Age (years)	68.9±3.3	71.4±3.4
Height (cm)	150.6±3.2	150.1±6.3
Weight (kg)	60.6±10.4	53.6±11.1
MMSE-K†	27.5±2.2	27.6±1.6

† MMSE-K: Korean version of Mini-Mental State Examination (maximum score=30)

Table 2. Changes in physical fitness following training

Variables	Group	Pre-training	Post-training	Change
Lower body strength (rep)	Control	14.2±5.0	15.0±5.5	0.8±4.6
	Experimental	12.3±3.8	18.8±4.3**	6.5±3.0††
Upper body strength (rep)	Control	15.8±4.3	16.1±6.0	0.3±3.3
	Experimental	15.1±5.4	18.5±5.1*	3.4±4.1†
Lower body flexibility (cm)	Control	12.2±9.4	7.6±6.0	−4.5±11.5
	Experimental	3.7±10.5	12.3±7.9**	8.6±6.1††
Upper body flexibility (cm)^	Control	−16.9±9.7	−14.4±9.7*	2.5±3.7
	Experimental	−8.1±7.7#	−6.0±7.3**	2.2±2.5
Dynamic balance/agility (sec)	Control	6.0±0.8	6.1±1.9	0.1±1.4
	Experimental	7.2±1.9	6.1±1.2*	−1.1±1.4†
Aerobic endurance (step)	Control	90.5±17.4	89.5±16.2	−0.9±9.4
	Experimental	90.2±27.7	90.6±24.0	0.4±8.3
Body composition (kg/m^2)	Control	26.4±4.0	26.5±4.2	0.1±0.5
	Experimental	23.7±3.9	23.6±4.1	−0.1±0.5

All values are shown as the mean ± SD.
There was a significant group difference in upper body flexibility at the pre-training test ($p < 0.05$).
^ The negative value indicates that the subject's middle fingers did not overlap each other during the back scratch test.
* and ** indicate significant differences ($p < 0.05$ and $p < 0.01$, respectively) between pre- and post-training according to the Wilcoxon Signed Rank test.
† and †† indicate significant group differences ($p < 0.05$ and $p < 0.01$, respectively) in mean changes in physical fitness variables following training according to the Mann-Whitney U test.

period of 12 weeks was longer than that of our study[15, 16, 26]. The improvement in flexibility was considerably greater in the lower body (232.4%) than in the upper body (25.9%). This trend is similar to the change in muscle strength described above. No significant difference between the two groups was revealed in upper body flexibility. This may be because the control group also demonstrated improvement in upper body flexibility over 4 weeks. The results are still inconclusive due to the significant difference between the two groups at the time of initial testing. In addition, the control subjects' lower body flexibility decreased 37.7% after 4 weeks. Although the change was not significant, the result suggests that older women who do not perform specific exercises may lose their lower body flexibility in a relatively short period of time.

A significant increase in dynamic balance/agility was observed following exercise training in the experimental group, but not in the control group. This result is consistent with the findings of other studies[23, 25–28]. Those studies demonstrated that dynamic balance can be enhanced by exercise programs, which specifically include a balance component[23, 26, 28], as well as other types of exercise, e.g., strengthening[27] and step aerobic training[25]. However, one study reported that a 12-week multicomponent exercise program including aerobic, endurance, balance, and flexibility exercises did not improve the dynamic balance/agility of elderly women[15]. Moreover, a recent systematic review revealed that the evidence for an effect of strengthening training on the balance of the elderly population is not conclusive[29].

No significant change in aerobic endurance was found in our study. In contrast, other studies that included aerobic exercise, either as a primary exercise[25], or as part of the exercise training[15, 24], have reported significant improvements in aerobic endurance. In addition, a study involving a 12-week multicomponent exercise training program (the Strong Women Program) that did not include aerobic exercise demonstrated a significant increase in the aerobic endurance of elderly women[23]. This suggests that to facilitate a change in the aerobic endurance of older women, an exercise training program that includes aerobic exercise or an extended period of exercise may be required.

There was no significant change in the subjects' body composition following training, which is consistent with the findings of previous studies[24, 25]. Altering the BMI of the elderly is difficult, regardless of the types of exercise or training periods involved. Our subjects presented with BMIs lower than the 50th percentile of normative data for community-dwelling adults age 60 and older[30] prior to training. This made modification of their BMIs even more difficult.

The exercise program in this study was group-based exercise that included balance, strengthening and stretching exercises. Group-based exercise improves balance control[31, 32] and decreases the risk of fall[13, 33] for elderly populations. In addition, group-based resistance exercise has been found to be more effective than home-based exercise at improving the physical fitness of the elderly[34]. Aging commonly causes not only muscle weakness[35, 36] but also balance and flexibility impairments[37]. A systematic review indicated that progressive resistance strengthening exercise improved lower limb strength, but not balance control[38]. Thus, we believe it is necessary to develop a training program that combines strengthening with balance and flexibility for improving the physical fitness of older adults. This study also included visual feedback-based balance training which is known to be an effective training method for the elderly[18, 19]. A training approach that combines group-based exercise with individual visual feedback-based exercise may facilitate the participants' motivation and activity enjoyment during exercise. In fact, the excellent attendance rate of 99.2% achieved in this study suggests that the subjects were highly motivated and engaged in the exercise program.

In summary, the results of this study demonstrate that a 4-week multicomponent exercise program including balance, strengthening, and stretching exercises is an effective intervention for improving the physical fitness of community-dwelling older women. Nonetheless, the outcomes may not be generalized to other elderly women because of the relatively small sample size. Further study of the multicomponent training program which includes aerobic exercise or an extended training period may provide a better understanding of the relationship between multicomponent exercise training and physical fitness in elderly populations.

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