Effects of a 6-Week Resistance-Training Program on Functional Fitness of Older Adults

Vinicius Cavani, Constance M. Mier, Anthony A. Musto, and Nanette Tummers

The purpose of this study was to determine the effects of 6 weeks of stretching and moderate-intensity resistance training on older adults’ functional fitness. Twenty-two older adults (69 ± 1 year) participated in a resistance-training program, and 15 (70 ± 4 years) participated in a control group. Training involved 3 sessions per week, each consisting of 1 set of 12–15 repetitions of lower and upper body exercises on resistance machines. Before sessions, participants performed 20 min of stretching exercises. A recently developed test battery (Rikli & Jones, 1999) to assess the physical parameters associated with independent functioning in older adults was performed before and after training. The combined stretching and resistance exercise resulted in significant ($p \leq .008$) improvements on all the functional tests except the 6-min walk. The results indicate that moderate-intensity resistance training in conjunction with stretching can improve functional fitness in older adults, enabling them to more easily perform activities of daily living.

Key Words: exercise training, strength, flexibility, endurance

Aging is an inevitable process associated with declining physiological and functional capabilities (Booth, Weeden, & Tseng, 1994; Fleg & Lakatta, 1988; Frontera et al., 2000; Kirkendall & Garrett, 1998; Möller, Bergström, Fürst, & Hellström, 1980). Specifically, age-related loss in muscle strength is related to impaired functional mobility (i.e., rising from a chair, gait velocity) in older adults (Bassey et al., 1992; Brown, Sinacore, & Host, 1995; Fiatarone et al., 1990; Hughes, Myers, & Schenkman, 1996; Scarborough, Krebs, & Harris, 1999). Confounding the age-related decline in functional capacity is a sedentary lifestyle (DiPietro, 1996; Huang et al., 1998). The effects of a sedentary lifestyle are evident in that resistance training has been shown to effectively reverse or at least slow the loss of muscle strength and consequently improve functional fitness and reduce the risk of falls among older adults (Ades, Ballor, Ashikaga, Utton, & Nair, 1996; Brandon, Boyette, Gaasch, & Lloyd, 2000; Buchner et al., 1997; Chandler, Duncan, Kochersberger, & Studenski, 1998; Fiatarone et al.; Hagerman et al., 2000; Hunter

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et al., 1995; Judge, Underwood, & Gennosa, 1993). This has important implications for older adults as performing activities of daily living becomes increasingly difficult, thus compromising an independent lifestyle. For example, increased muscle strength and endurance resulting from resistance training could translate into increased ability to perform activities such as carrying grocery bags, rising from a chair, gardening, or walking—activities that are carried out with ease by healthy younger individuals.

Significant increases in muscle hypertrophy and strength are well-known adaptations to resistance training in older men and women (Fiatarone et al., 1990; Häkkinen et al., 1998; Morganti et al., 1995; Pyka, Lindenberger, Charette, & Marcus, 1994). Those studies, however, incorporated high-intensity (<10 repetitions), multiple-set exercises. The current American College of Sports Medicine (ACSM) position stand on exercise training for the elderly population recommends that resistance training be performed 2–3 days/week, with a minimum of one set, performed at intensities requiring 10–15 repetitions, and that exercises include all the major muscle groups (ACSM, 1998). To study the effectiveness of these recommendations on functional fitness, we chose a recently developed battery of tests to assess functional fitness, defined as “having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue” (Rikli & Jones, 1999, p. 133) in independent older adults. These tests were designed to assess the physical parameters most associated with functional mobility in borderline frail to highly fit older adults: muscle strength, aerobic endurance, joint flexibility, agility, and dynamic balance.

The purpose of this study was to assess the effectiveness of a combined stretching and moderate-volume (one set), moderate-intensity (12–15 repetitions) 6-week resistance-training program on the performance of these functional-fitness tests in older adults. We hypothesized that this type of training program involving both upper and lower body exercises would result in improved performance on functional-fitness tests designed to assess muscle strength, flexibility, agility, dynamic balance, and aerobic endurance in older adults between the ages of 60 and 79 years.

Methods

PARTICIPANTS

Twenty-two individuals, 8 men and 14 women between the ages of 60 and 79 years (69 ± 1 year), volunteered to participate in the resistance-training program. Fifteen additional participants, 6 men and 9 women between the ages 60 and 75 years (70 ± 4 years), were recruited to participate in the control group. All the participants had medical clearance to participate in the testing and training sessions. Participants for the training program were solicited through advertisements. Control participants were solicited by word of mouth, or in the case of those interested in the training program, were asked whether they would wait 6 weeks before beginning the training program. Participants were either sedentary or moderately active and not engaged in any weight-lifting program on entry into the study. Individuals recruited as controls were asked to not participate in a formalized exercise program or to change their physical activity routine during the 6-week control period. All par-
Participants signed an informed consent form (approved by the Barry University institutional review board) before the testing and subsequent training.

Eleven participants in the training group and 9 in the control group reported risk factors for coronary artery disease that included high blood pressure or taking blood-pressure medication, cholesterol levels above 240 mg/dl or taking cholesterol medication, and taking medication to control blood glucose levels. Five participants in the training group and 2 in the control group reported signs or symptoms suggestive of cardiovascular disease, including heart murmur, palpitations, and, in the case of 1 training group participant, taking medication for angina. There were no musculoskeletal conditions that precluded any of the participants from exercise.

**TRAINING**

The resistance-training program consisted of three sessions per week (approximately 45 min in length) over a period of 6 weeks. During each session, three exercises to strengthen the lower body (leg press, leg extension, and leg curl) and six exercises to strengthen the upper body (chest press, rowing, shoulder press, arm curl, triceps press, and abdominal curls) were completed. Each exercise was performed using resistance machines. One set of 12–15 repetitions to fatigue was completed for each exercise. The exercise intensity was initially set at each individual’s 12-repetition maximum. When the individual could perform more than 15 repetitions, weight was increased by 2.5 lb for upper body exercises and 5 lb for lower body exercises. Participants in all training sessions were under close supervision by a qualified exercise leader to ensure proper technique and to minimize the risk of injury.

Before each training session, 20 min of stretching involving upper and lower body exercises were performed. Stretches were performed on all major muscle groups, as recommended by the ACSM (2000). Upper body stretches included horizontal arm adduction and anterior chest and hugging/shoulder protraction. Lower body stretches included hip flexion, hip internal rotation (performed supine), and hip extension (performed standing).

**FUNCTIONAL-ABILITY TESTS**

A complete battery of functional-ability tests was conducted before and after the 6-week period. These tests were designed to assess the physiologic parameters associated with independent functioning: lower and upper body strength, aerobic endurance, lower and upper body flexibility, and agility and dynamic balance. They have been validated for the assessment of the physiologic parameters that support physical mobility in older adults (Rikli & Jones, 1999).

The one-arm-curl test was used to assess upper body strength. Participants performed as many bicep curls as possible in 30 s while maintaining proper form. Women participants performed the arm curl using a 5-lb dumbbell, and the men performed the arm curl using 8 lb. Scoring was based on the total repetitions completed within 30 s.

The chair-stand test was used to assess lower body strength. Participants were asked to sit in a 17-in.-high chair with arms crossed over their chest. After a signal
participants completed as many “stand-ups” as possible within 30 s. Total repetitions completed within 30 s were used to score the participants’ performance.

A back-scratch test was used to assess upper body flexibility. Participants attempted to touch the fingers of opposing hands behind their back. The individual’s most flexible side was used for measurement. The distance in inches between opposing hands’ fingers was measured. Any overlap of the fingers was measured in positive increments, and distance between untouched fingers was measured in negative increments.

The chair sit-and-reach was used to evaluate lower body flexibility. Participants were asked to sit on the edge of a chair with the left knee bent at 90° and the left foot flat on the floor while keeping the right knee straight and right leg extended forward. Participants were asked to attempt to touch their toes using both hands. The distance in inches between fingers and toes was measured and given a negative value if the fingers did not reach the toes and a positive value if fingers extended beyond the toes.

An 8-ft up-and-go test was used to assess agility and dynamic balance. Participants were asked to sit on a chair. On cue, they stood up, walked as quickly as possible around a cone set 8 ft from the chair, and sat back down on the chair. Total time to complete the test in seconds was measured to assess performance.

A 6-min-walk test was used to assess aerobic endurance. Participants were asked to walk as far as they could in 6 min. Total distance walked in yards was measured to assess performance.

The order of tests performed was arm curl, back scratch, chair stand, chair sit-and-reach, 8-ft up-and-go, and 6-min walk.

**TEST–RETEST RELIABILITY OF THE FUNCTIONAL-FITNESS TESTS**

To determine the test–retest reliability of the functional-fitness tests, 8 participants (3 men and 5 women) with a mean age of 70 ± 6 years (ranging from 65 to 83 years) completed each of the tests twice. All tests were administered on the same day, with retesting occurring 2 days later. The same person administered all tests. Test–retest reliability was established by calculating the intraclass correlation coefficient and using a paired t-test to compare mean scores for each test. The intraclass correlation coefficients for all tests ranged from .954 to .988 (p ≤ .001). The paired t-test results showed no significant differences between Trials 1 and 2 among the tests (Table 1).

**Table 1** Results of the Paired t Test for Test–Retest Reliability (M ± SD, N = 8)

<table>
<thead>
<tr>
<th>Functional-fitness test</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm curl, reps.</td>
<td>23 ± 5</td>
<td>24 ± 5</td>
<td>.95</td>
</tr>
<tr>
<td>Back scratch, in.</td>
<td>-4.19 ± 6.79</td>
<td>-4.06 ± 6.65</td>
<td>.451</td>
</tr>
<tr>
<td>30-s chair stand, reps.</td>
<td>18 ± 6</td>
<td>19 ± 6</td>
<td>.83</td>
</tr>
<tr>
<td>Chair sit-and-reach, reps.</td>
<td>-1.19 ± 3.9</td>
<td>-1.69 ± 4.49</td>
<td>.104</td>
</tr>
<tr>
<td>8-ft up-and-go, s</td>
<td>5.37 ± 1.03</td>
<td>5.26 ± 0.93</td>
<td>.172</td>
</tr>
<tr>
<td>6-min walk, yd</td>
<td>584 ± 74</td>
<td>590 ± 71</td>
<td>.088</td>
</tr>
</tbody>
</table>
STATISTICAL ANALYSES

Student’s t test for independent samples was used to compare initial values between the trained and control groups. A two-way repeated-measures analysis of variance, with training as the repeated-measures factor, was used to determine significant training effects indicated by a significant interactive effect (Training × Group). The criterion for statistical significance was set at an alpha level of .05. Bonferroni adjustment for multiple tests was used to set the significance criterion to .008 (0.05 divided by 6). Group data are presented as $M \pm SD$.

Results

All 22 participants in the training group completed the 6 weeks of resistance training, averaging 16 sessions over the training period. No participant dropped out of the program, and no unusual pain or discomfort was reported by any of the participants during the training period. Results of the functional-fitness tests before and after training are presented in Table 2 for both groups. The initial values for each of the functional-fitness tests did not differ between training and control groups. Training resulted in a significant increase in arm curl, $F(1, 35) = 9.94, p = .003$; back scratch, $F(1, 35) = 8.21, p = .008$; chair stand, $F(1, 35) = 12.02, p = .001$; chair sit-and-reach, $F(1, 35) = 8.65, p = .006$; and 8-ft up-and-go, $F(1, 35) = 8.39, p = .006$. When the criterion for significance was adjusted for multiple tests, however, training did not significantly affect the 6-min walk, $F(1, 35) = 4.04, p = .05$.

Table 2 Results of the Functional-Fitness Tests After 6 Weeks ($M \pm SD$)

<table>
<thead>
<tr>
<th>Functional-fitness test</th>
<th>Control group (n = 15)</th>
<th>Training group (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Arm curl, reps.</td>
<td>19 ± 1</td>
<td>20 ± 1</td>
</tr>
<tr>
<td>Back scratch, in.</td>
<td>$-5.77 \pm 1.06$</td>
<td>$-5.87 \pm 0.94$</td>
</tr>
<tr>
<td>Chair stand, reps.</td>
<td>13 ± 1</td>
<td>14 ± 1</td>
</tr>
<tr>
<td>Chair sit-and-reach, in.</td>
<td>$-1.47 \pm 1.16$</td>
<td>$-1.99 \pm 0.99$</td>
</tr>
<tr>
<td>8-ft up-and-go, s</td>
<td>5.85 ± 0.34</td>
<td>5.81 ± 0.31</td>
</tr>
<tr>
<td>6-min walk, yd</td>
<td>603 ± 20</td>
<td>620 ± 21</td>
</tr>
</tbody>
</table>

*Significantly different ($p < .05$) from initial value as determined by two-way repeated-measures ANOVA. **Significantly different ($p \leq .008$) from initial value as determined by two-way repeated-measures ANOVA.
The relative changes in the arm curl, chair stand, 8-ft up-and-go, and 6-min-walk tests are presented in Figure 1. The number of repetitions performed during the arm-curl test increased 24% in the trained group, compared with a 5% increase in the control group. The number of repetitions performed during the chair-stand test increased 30% in the trained group compared with a 4% increase in the control group. The completion time for the course in the 8-ft up-and-go test decreased 15% in the trained group compared with a 1% increase in the control group. The distance covered during the 6-min-walk test increased 9% in the trained group compared with a 3% increase in the control group.

The absolute changes in the back-scratch and sit-and-reach tests are presented in Figure 2. Resistance training produced a significant improvement (1.3 in.) in back-scratch test scores, whereas no significant changes (−0.1 in.) occurred in the control group. Likewise, there was a significant improvement (2.28 in.) in chair sit-and-reach test scores for the training group, whereas no significant changes (−0.5 in.) were evident in the control group.

Discussion

The results of this study demonstrated that 6 weeks of a combined stretching and moderate-intensity resistance-training program resulted in improved performance
on functional-fitness tests designed to assess muscle strength, flexibility, agility, and dynamic balance in older adults. A limitation of our study is that the participants were not randomly assigned to the experimental and control groups. The results are important, however, for older adults wishing to begin an exercise-training program. We have shown that resistance training need not be high intensity and can be performed using single-set exercises to improve functional fitness in relatively healthy, independent older adults. Furthermore, the benefits for functional fitness occurred after a relatively short period of time.

It is well known that resistance training results in significant muscle hypertrophy and improvements in muscle strength among older adults and that these adaptations can continue over several months with a sufficient training stimulus (Häkkinen et al., 1998; Morganti et al., 1995; Pyka et al., 1994). Although the results of these studies clearly demonstrate the capacity of older adults to adapt to resistance training, the training programs used in the studies incorporated high-intensity, multiple-set exercises. Our study differs from previous ones in that we used moderate-volume (one set), moderate-intensity (12–15 repetitions) exercises, yet our results demonstrate significant improvements in functional fitness. Although the training stimulus in our study appears to have been sufficient to create positive changes in functional fitness, it is unlikely that muscle hypertrophy occurred during our training program and that any increases in muscle strength were the result of neural adaptations (Moritani & DeVries, 1980).

Although we did not test muscle strength directly using 1-repetition-
maximum or isokinetic tests, we incorporated two functional-ability tests (arm curl and chair stand) that have been validated as measures of muscle strength (Rikli & Jones, 1999). Our results are similar to those of previous studies that found improved chair-stand performance after resistance training in older adults (Brandon et al., 2000; Chandler et al., 1998; Phillips, Broman, Burkett, & Swan, 2001). One study is particularly noteworthy (Phillips et al.) in that the training program was very similar (10–15 repetitions, single set) to the one used in this study.

The results of this study demonstrated that older adults were able to gain significant upper and lower body range of motion, measured by the back-scratch and chair sit-and-reach tests, after 6 weeks of resistance training. A 20-min stretching session before resistance training might have been the primary reason for improved flexibility scores in our study. In fact, it is likely that the improved range of motion was solely the result of a stretching routine performed 3 days per week. Girouard and Hurley (1995) found 10 weeks of flexibility-only training to result in greater improvements in range of motion than did combined flexibility and strength training in older adults. It appears that for improvements in flexibility to occur, a resistance-training program must include a stretching routine.

Activities that require a quick move of the body through space or a sudden change in walking direction might be very difficult to perform in old age. These activities rely on balance and a level of muscle strength and power reserve, which decrease with age (Bassey et al., 1992; Brown et al., 1995; Fiatarone et al., 1990). We observed in this investigation that older adults were capable of improving their agility and walking velocity, as determined by the 8-ft up-and-go test, after 6 weeks of resistance training. To our knowledge, only one other study has reported improvements in the 8-ft up-and-go test after resistance training (Phillips et al., 2001). Other studies have shown resistance training to be effective for increasing gait velocity over a 6-m distance (Chandler et al., 1998; Fiatarone et al.; Hunter et al., 1995; Judge et al., 1993).

The age-related declines in muscle mass and strength are associated with a decrease in aerobic capacity (Fleg & Lakata, 1988). Previous studies have shown improvements in walking endurance after resistance training, as determined by increased time to fatigue during a treadmill test (Ades et al., 1996; Hagerman et al., 2000). Our results do not support those of these previous studies in that our training group did not demonstrate a significant improvement in the 6-min walk. Because the previous studies incorporated higher intensities, greater volumes, and longer training periods, it is possible that our resistance-training program did not provide adequate training stimuli for improvements in walking power to be demonstrated.

Work is needed to determine whether a moderate-intensity resistance-training program is adequate to provoke further improvements in functional fitness beyond 6 weeks. It is likely that the training stimulus would need to increase in order for functional fitness to continue to improve. Furthermore, there is a question as to the degree to which muscle strength limits functional-fitness-test performance and, therefore, to what extent increases in muscle strength would transfer to improvements in functional fitness.

For practical purposes, our study provides evidence that a resistance-training program need not be high intensity or high volume for benefits to be derived among a relatively healthy older population. This has important implications because high-intensity exercise is associated with increased injury and dropout rates (ACSM,
Resistance-training machines are not always available in exercise programs for elderly adults, and many adults are unable to attend programs offered at wellness or fitness centers. Therefore, it would be beneficial to determine whether use of free weights or resistance bands would be viable forms of resistance exercise to improve functional abilities.

References


