Exercise Intervention Designed to Improve Strength and Dynamic Balance Among Community-Dwelling Older Adults

Ro DiBrezzo, Barbara B. Shadden, Blake H. Raybon, and Melissa Powers

Loss of balance and falling are critical concerns for older adults. Physical activity can improve balance and decrease the risk of falling. The purpose of this study was to evaluate a simple, low-cost exercise program for community-dwelling older adults. Sixteen senior adults were evaluated using the Senior Fitness Test for measures of functional strength, aerobic endurance, dynamic balance and agility, and flexibility. In addition, measures of height, weight, resting blood pressure, blood lipids, and cognitive function were obtained. Participants then attended a 10-week exercise class including stretching, strengthening, and balance-training exercises. At the completion of the program, significant improvements were observed in tests measuring dynamic balance and agility, lower and upper extremity strength, and upper extremity flexibility. The results indicate that exercise programs such as this are an effective, low-cost solution to improving health and factors that affect falling risk among older adults.

Key Words: resistive exercise, falls prevention, flexibility

Annually, approximately 30% of community-dwelling older adults fall once, and 10–20% fall two or more times (Gregg, Pereira, & Caspersen, 2000). Falling contributes to 90% of hip fractures in the United States (Carter, Kannus, & Khan, 2001). The economic burden of falling is substantial. Falling has been shown to contribute to 27% of hospital costs (Robertson, Devlin, Scuffham, Gardner, Buchner, & Campbell, 2001), and the average hospital cost of a patient admitted after falling is $12,000 (Rizzo et al., 1998). With the older adult population increasing worldwide, the problem will likely worsen with more fractures and even higher health-care costs.

As the primary contributor to fractures, falling in older adults needs to be addressed so that preventive measures can be taken. Over 130 risk factors have been attributed to falling (Donaldson & Khan, 2002). The most common of these

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include poor balance, lower extremity muscle weakness, slow reaction time, decreased lean body mass, impaired cognition and vision, syncope, and overall impaired mobility (Gregg et al., 2000; Rubenstein & Josephson, 2002). Poor lower extremity muscle strength might be an especially important fall-risk factor. Woollacott and Shumway-Cook (1990) found weak ankle dorsiflexors to be one of the primary muscular contributors to falling. Other factors that might contribute to falling include medications and their side effects, alcohol intake, poor footwear, and environmental conditions (Gregg et al.; Przbelski & Shea, 2001). The risk factors might also be psychological; older adults often have activity-related fear of falling (Kressig et al., 2001).

One preventive measure that can be taken to reduce or prevent falling is physical activity. Research suggests that exercise and other forms of physical activity can decrease the risk of falling by improving or maintaining balance, increasing bone-mineral density, increasing muscle strength, and improving or maintaining functional activities (Campbell, Robertson, Gardner, Norton, & Buchner, 1999; Carter et al., 2001; Gardner, Buchner, Robertson, & Campbell, 2001; Gregg et al., 2000; Henderson, White, & Eisman, 1998; Judge, Lindsey, Underwood, & Winsemius, 1993; Lord, Caplan, & Ward, 1993; Robertson et al., 2001; Schlicht, Camaione, & Owen, 2001; Shumway-Cook, Gruber, Baldwin, & Liao, 1997). According to Gregg et al., older adults involved in leisure-time physical activity can have a 20–40% lower risk of hip fracture than that of sedentary individuals. In addition, exercise and physical therapy have been shown to improve balance, strength, and functional tasks, as well as reducing functional decline (Gill et al., 2002).

Lower extremity strength appears to be an important factor in maintaining balance and preventing falls. Short-term (8- to 10-week) exercise programs that target lower extremity training have resulted in significant improvements in strength of the lower body and in balance among older adults (Schlicht et al., 2001; Yates & Dunnagan, 2001). Compared with sedentary women, older women participating in an exercise program have greater quadriceps strength, as well as faster reaction time and less body sway (Lord et al., 1993). Likewise, research by Barrett and Smerdely (2002) found that progressive resistance training among older adults improves both right- and left-side quadriceps strength and balance more than a flexibility-exercise program. Quadriceps strength plays an important role in functional activities involving standing, walking, and squatting movements. The simple task of standing from a seated position is affected by quadriceps strength, and active older adults require less time to complete the sit-to-stand activity (King et al., 2002; Lord, Murray, Chapman, Munro, & Tiedemann, 2002).

Forms of exercise other than resistance training can increase lower extremity strength. Aerobic dance combined with balance-training exercises such as single-leg standing, squatting, marching, and heel touching have been shown to improve lower extremity muscle strength, single-leg balance, functional reach, and walking time (Buchner et al., 1997; Engles, Drouin, Zhu, & Kazmierski, 1998; Shigematsu et al., 2002). These strength and balance improvements can lead to a decreased risk of falling.
In addition to resistance training and aerobic exercise, it has been suggested that more nontraditional methods of exercise might be effective tools for improving balance among older adults. Exercise balls are used clinically to help increase proprioception by providing an unstable base of support, thus challenging postural stability (Schlicht, 2002). Two short-term (8- to 10-week) programs have demonstrated improved balance in older adults after an exercise-ball intervention (Rogers, Fernandez, & Bohlken, 2001; Urbscheit & Wiegand, 2001).

Incorporating more than one type of exercise training might result in greater balance improvements than one type of exercise intervention alone. Verfaillie, Nichols, Turkel, and Hovell (1997) assigned 65- to 83-year-old adults to either a strength-training group or a strength-training and balance-/gait-training group. Although both groups experienced significant improvements in strength and gait speed, only the strength and balance/gait group improved significantly on balance measures. It was concluded that resistance training alone does not significantly improve balance and gait parameters. Balance and gait training are important components of any exercise program aimed at decreasing the risk of falls among older adults, so any exercise program for older adults should include exercises to improve both strength and balance (Gardner et al., 2001). The concept of incorporating a variety of exercises was important in the development of the intervention program described in this article.

**Purpose**

With the growing aging population, the number of falls will likely increase in the coming years. Exercise appears to play a key role in preventing falls among older adults. There is a need to develop and implement exercise-intervention programs to help increase strength, flexibility, and balance in older adults in an attempt to decrease the risk of falls. Exercise classes for seniors meet not only the health needs of older adults but also the programming needs of senior centers. The purpose of this intervention was to implement a simple, low-cost exercise program and evaluate its effectiveness at improving functional strength, flexibility, and balance among community-dwelling adults age 60 and over. In addition to this purpose, the exercise program was uniquely designed to make it accessible to rural seniors who were already participating in activities at a local senior center. By holding the exercise classes in the senior center, researchers in essence “brought the program” to the seniors it served.

**Method**

**PARTICIPANTS**

Nineteen senior adults were recruited to participate in this exercise program. All were regular attendees of two local, rural, senior community centers. They were recruited with flyers, sign-up sheets, and follow-up flyers posted at the local senior
Three participants were dropped from the final analysis reported here because of attendance rates less than 50%. The final sample consisted of 16 older adults (13 women and 3 men) ranging in age from 60 to 92 years. The participants were in varying degrees of health. Some had previous exercise experience in formal physical rehabilitation settings, group-exercise classes at other facilities, or individual exercise programs on their own. All participants signed a written informed-consent form before participating in the testing and exercise program.

PROCEDURES

The procedures used in this research were approved by the Institutional Review Board of the University of Arkansas, Fayetteville. To obtain baseline data, we conducted pretesting using the Senior Fitness Test protocol developed by Rikli and Jones (1999). The Senior Fitness Test is a comprehensive protocol designed for assessing the functional-fitness levels of people 60 years of age and older. The participants were evaluated for height, weight, resting blood pressure, arm-curl test (upper extremity strength), chair-stand test (lower extremity strength), 6-min walk (aerobic endurance), 8-ft up-and-go (dynamic balance and agility), back-scratch test (upper extremity flexibility), and chair sit-and-reach test (lower extremity flexibility). The components of the Senior Fitness Test have intraclass reliability estimates of $r \geq .80$ and criterion validity of $r \geq .70$ (Rikli & Jones). In addition, participants completed the Mini-Mental State Examination (MMSE) as a screening measure of orientation, immediate and delayed recall, attention and calculation, language, praxis, and reading comprehension. A health survey was also distributed to all participants to assess health history and activity level. All testing was completed approximately 1 week before the exercise program began. Thirteen participants also completed a blood screening to determine total cholesterol, LDL, HDL, triglycerides, and fasting glucose levels.

Participants completed a 10-week exercise program consisting of three 1-hr classes per week. The exercise sessions were conducted at the local senior center. Stretching, balance, and strengthening exercises followed a warm-up. Upper body strengthening exercises were performed with dumbbells, elastic bands, or an exercise ball on alternating days. The same resistance source was not used for two consecutive exercise sessions. Participants often performed exercises with the exercise ball with a partner. They performed lower extremity exercises while seated or standing depending on their individual abilities. To increase exercise intensity and promote balance training, participants were encouraged to sit on the exercise ball for lower body exercises whenever able. At each session, the instructors included strength and balance exercises for each muscle group but tried to keep variety in the exercise routine. Exercises were chosen from the list provided in Table 1. This list of exercises was compiled from recommendations set forth by the National Institute on Aging (2001) and the American Council on Exercise (1998), as well as the experience of the researchers. Each exercise was performed for one set of 20 repetitions.
To establish a baseline level of strength and therefore an appropriate starting point for the strength program, a three-repetition maximum (3-RM) was used. Exercise equipment available for this program included dumbbells (3, 5, and 8 lb) and exercise bands ranging from least resistance (white) to greatest resistance.

<table>
<thead>
<tr>
<th>Program component</th>
<th>Sample exercises</th>
<th>Approximate time</th>
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<tbody>
<tr>
<td>Warm-up</td>
<td>Walking</td>
<td>7–10 min</td>
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<tr>
<td>Initial stretching</td>
<td>Straight-arm stretch</td>
<td>7–10 min</td>
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<td>Overhead stretch</td>
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<td>Triceps stretch</td>
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<td>Shoulder stretch</td>
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<td>Quadriceps stretch</td>
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<td></td>
<td>Seated hamstring stretch</td>
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<td>Lower extremity strengthening</td>
<td>Hamstring flexion</td>
<td>15 min</td>
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<td></td>
<td>Leg extension (seated)</td>
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<td></td>
<td>Knee lifts</td>
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<td></td>
<td>Hip adduction and abduction</td>
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<td></td>
<td>Ankle point and flex</td>
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<td></td>
<td>Ankle circles</td>
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<td></td>
<td>Bottom squeeze</td>
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<td>Chair squat</td>
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<td>Wall squat</td>
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<td></td>
<td>Standing side leg raise</td>
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<td>Upper body strengthening</td>
<td>Biceps curl</td>
<td>10 min</td>
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<td></td>
<td>Triceps extension</td>
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<td>Lateral raise</td>
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<td>Rear raise</td>
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<td>Chest press</td>
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<td>Rotator fly</td>
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<td>Forearm curl</td>
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<td>Shoulder-extension pullback</td>
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<td></td>
<td>Internal-rotator raises</td>
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<td>Balance exercises</td>
<td>Single-leg balance</td>
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<td></td>
<td>Static sitting on a ball</td>
<td>5–10 min</td>
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<td>Dynamic sitting on a ball</td>
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<td>Side twists</td>
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<td>Overhead side bends</td>
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<tr>
<td>Final stretching</td>
<td>See list for initial stretching</td>
<td>7–10 min</td>
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Note. Exercise sessions were conducted 3 days each week, lasted for 60 min, and included exercises from each of the above program components. This set of exercises was developed based on recommendations from the National Institute on Aging (2001) and the American Council on Exercise (1998).
The baseline exercise-tolerance test was conducted during the first exercise session. Exercise tolerance was established for any exercise in which external resistance was used. Participants were asked to perform the selected exercise three times using a 3-lb dumbbell. Those who could complete this task were then asked to try 5 and 8 lb until the task could not be performed for three repetitions. Participants who could not lift 3 lb for three repetitions were moved to exercise bands beginning with the lightest resistance and moving through progressively heavier resistance until the task could not be performed for three repetitions. The final weight or resistance level in which three repetitions could be performed was considered the participant’s maximal tolerance for that exercise. Initial exercise intensity was prescribed by using dumbbells one step lighter than maximal and two steps lighter for those using exercise bands. For example, a participant whose maximal was 5 lb began at an exercise intensity of 3 lb. Initial exercise intensity for exercises using no external resistance (body weight only) was prescribed as the number of repetitions the participant could complete.

Progression was individualized. Whenever participants felt that the last three repetitions of a set were “easy,” they were encouraged to increase the amount of resistance by using the next-size-heavier dumbbell or the next-thicker exercise band. Although intensity was determined by self-perception, participants were taught that the initial exercise intensity was considered moderate and their maximal effort from the first session was hard. For exercise using only the resistance of the participant’s body weight, participants were encouraged to progress by adding additional repetitions.

After completing the 10-week program, participants were posttested using the Senior Fitness Test protocols and the MMSE. Preprogram and postprogram measures were compared using paired-samples t tests. Significance level was set at .05 and data were analyzed using the Statistical Package for the Social Sciences (SPSS® version 12.0).

**Results**

The mean age of participants in this study was 74.9 ± 8.8 years. Mean height was 64.1 ± 3.6 in., and mean weight at the beginning of the program was 179.9 ± 45.3 lb. An important factor to consider when analyzing data from exercise interventions is program adherence. The 16 participants included in the data analysis completed 23 (77%) of the 30 exercise sessions.

Several health- and fitness-related improvements were observed at the end of the 10-week exercise program. Table 2 presents the results of pre- and postfitness testing. Although participants made improvement in most health and fitness areas after the 10 weeks, not all improvements were statistically significant. Significant improvements were observed in HDL ($t = -3.09$, $p = .009$), 8-ft up-and-go ($t = 4.60$, $p < .001$), chair stand ($t = -3.26$, $p = .005$), arm curl ($t = -2.37$, $p = .03$), and back scratch ($t = -3.04$, $p = .008$). Nonsignificant improvements were observed in body weight, systolic blood pressure, diastolic blood pressure, LDL, the 6-min
walk, and chair sit-and-reach. There was a slight increase in total cholesterol, but this was accompanied by a decrease in LDL and a significant increase in HDL. There was no statistical difference between the pre- and post-exercise-program scores on the MMSE.

### Discussion

Observed improvements in measures of fitness can be traced to the nature of the exercise modalities. Targeted upper extremity strengthening exercises using the dumbbells, elastic bands, and the exercise ball were likely effective in significantly increasing upper body strength as measured by the arm-curl test. Performance on the chair stand, a measure of lower extremity strength, also improved significantly with the use of simple leg exercises using the participants’ own body weight as resistance. Designed for patients in a rehabilitation setting, these types of leg exercises might also be effective in increasing lower extremity strength in healthy older adults. Other researchers have demonstrated that targeted lower extremity training results in improved lower body strength (Schlicht et al., 2001; Yates & Dunnagan, 2001). Lower extremity strengthening exercises were designed to increase both anterior and posterior leg-muscle strength. The strengthening of both muscle groups might have contributed to the improvements seen in the 8-ft up-and-go test, which measures dynamic balance and agility. In response to forward sway, the gastrocnemius, hamstrings, and trunk-extensor muscles contract to maintain balance. Conversely,
during backward sway, the tibialis anterior, quadriceps, and rectus abdominis contract (Adrian & Cooper, 1995). Participants contracted each of these muscles either while performing the leg exercises or when using the exercise balls.

Observed changes in the back-scratch test might also be a reflection of the exercise modalities implemented. The back-scratch test increased to a greater degree than the sit-and-reach test. When warming up and cooling down during the exercise sessions, more emphasis might have been unintentionally placed on stretching the upper body than the lower body. The stretching exercises and resistance exercises were designed to increase range of motion and strength, respectively.

The observed improvements in dynamic balance were likely attributed to the specific exercise protocols. Balance activities including single-leg standing, as well as static and dynamic sitting on the exercise balls, might have contributed to the significant improvement in functional dynamic balance as measured by the 8-ft up-and-go test. The findings of this study concur with those of Urbscheit and Wiegand (2001), who evaluated balance after an 8-week exercise-ball intervention. The participants were particularly challenged with the exercise balls. When the balls were first introduced, static sitting on the balls presented a challenge to some of the participants. To help participants balance on the ball, chairs were placed beside them for safety in the event of lost balance. As the participants became more comfortable sitting on the balls, they were allowed to performed dumbbell, elastic-band, or leg exercises while sitting on them. The balls were also used for upper extremity strengthening and flexibility while standing. These exercises included holding the balls over their heads and away from their torsos with straight arms. Holding the ball away from the body causes the center of gravity to shift in a superior and anterior direction, theoretically forcing participants to recruit back and abdominal muscles in order to maintain balance and posture. Balance exercises such as these help maintain postural control, which is an essential element in maintaining balance. The aging process places older adults at a greater risk for disease and neuromotor dysfunction. If a disease disrupts the postural-control system, the ability to maintain balance is also likely to be affected. Physical activity slows the deterioration of the musculoskeletal system, helps prevent disease, and maintains and improves postural control (Buchner et al., 1997).

As indicated with the lack of alteration in the MMSE, there was no measurable change in cognitive skills among the participants, although participant attitudes about exercise in general appeared to improve. Participants’ enthusiasm for exercise was enhanced as they began to observe the benefits of the program and feel better. Some participants voluntarily responded verbally by saying they enjoyed attending the class because it was fun or they began to lose weight, feel stronger, or feel more confident in their physical abilities. Feedback from the participants indicated that they enjoyed the program and deemed it worthwhile. For many, the psychological impact of the program was just as significant as the physical one. The instructors observed the participants attending not only for the physical benefits of exercise but also for the social interaction. Many came because they wanted to interact with others and were encouraged to participate by their peers,
an observation consistent with literature reports that those with social support from
family, friends, or experts tend to have better exercise behaviors (Resnick, Orwig,
Magaziner, & Wynne, 2002). As the program progressed through the 10 weeks,
class attendance increased. Initial participants encouraged their friends to attend
the exercise classes. During the 10-week program, each session was conducted in
a straightforward, fun group format, which has been shown to increase physical
activity among older adults (Day et al., 2002; Nied & Franklin, 2002; Van der Bij,
Laurant, & Wensing, 2002).

Limitations

Despite the positive results of this study, it does have certain limitations that need
to be addressed. Because there was no control group, it cannot be stated for certain
that improvements are related directly to participation in the exercise program.
Although poor muscle strength, flexibility, and balance have all been identified
as risk factors for falling, the actual prevention of falls by this exercise program
was not evaluated. Certain assumptions can be made about changes in the risk for
falls among exercise participants because of improvements in risk factors related
to falling, but we cannot say for certain that this exercise program decreased the
number of falls among the participants.

Other factors not assessed in this research but used in the design of the
exercise program are long-term compliance and cost effectiveness. This program
was designed with low cost and ease of administration in mind in order to pro-
mote exercise among senior adults who cannot or will not participate in traditional
gym-based exercise programs. The program was conducted in two rural senior
community centers. No fitness facilities exist in these communities. To encourage
participation, classes were held before lunch or after other organized events to
which seniors came at the center. In addition, the exercises were kept simple and
the program was relatively unstructured, so that future classes could be taught by
individuals already employed at the senior center, keeping costs low for both the
centers and the participants.

The addition of a control group, questioning concerning participant fall
history, and a study of cost effectiveness and long-term follow up should be
incorporated into future research to determine the degree of impact that physi-
cal activity has on real-world fall occurrence. An exercise program that focuses
more on the individual needs of participants might also be more effective. In this
study, some participants were unable to complete all of their exercises for various
health-related reasons including inability to stand for a long period of time. An
individualized program would reduce feelings of exclusion from the group but
would require more instructors and possibly more time. Individually tailored
exercise programs have been shown to reduce the frequency of falls (Feder, Cryer,
Donovan, & Carter, 2000). A study involving more senior centers from different
geographical areas would allow for more accurate generalizability of conclu-
sions.
Implications and Conclusion

Exercise programs such as the one used in this study are an informative, effective, and low-cost solution to improving older adults’ health. Physical activity is critical to maintaining strength, flexibility, and balance. These components are essential in decreasing the risk of falls among older adults. A physically active older adult is at a lesser risk of developing diseases that lead to poor posture, gait abnormalities, and loss of balance. After 10 weeks, the exercise intervention described here resulted in improved scores on the 8-ft up-and-go and chair-stand tests, which are functional indicators of two major risk factors for falling among older adults: poor balance and lower extremity muscle weakness. Programs such as the one described in this article are needed to encourage and educate older adults on the benefits of physical activity, including maintaining and improving balance. Those programs can be simple and inexpensive in addition to having a beneficial impact on the lives of the participating older adults, their families, and society.

References


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