Effect of a Home Exercise Program on Dynamic Balance in Elderly With a History of Falls

Sharon L. Olson, Shu-Shi Chen, and Ching-Yi Wang

Objective: To determine exercise efficacy in improving dynamic balance in community-dwelling elderly with a fall history. Methods: Thirty-five participants were randomly assigned to a treatment (TG; n = 19, 77 ± 7 yr) or control group (CG; n = 16, 75 ± 8 yr). The TG received an individualized home exercise program, and the CG received phone calls twice per week for 12 weeks. Participants’ dynamic-balance abilities—directional control (DC), endpoint excursion (EE), maximum excursion (ME), reaction time (RT), and movement velocity (MV)—were measured using the Balance Master at 75% limits of stability. Functional reach (FR) was also measured. Results: At 12 weeks the TG demonstrated significant improvements in DC (p < .0025), EE (p < .0005), and ME (p < .0005), but the CG did not. No significant group differences were found for MV, RT, or FR. Conclusions: Excursion distances and directional control improved but not reaction time, suggesting that exercises requiring quick responses may be needed.

Keywords: limits of stability, physical therapy, geriatrics

Falls in older adults are a leading cause of physical disability, functional decline, emotional stress, and death (Fletcher & Hirdes, 2004; Stel, Smit, Pluim, & Lips, 2004; Stevens, Mack, Paulozzi, & Ballesteros, 2008). Falling is a multifactorial situation that results from the accumulated effects of intrinsic and extrinsic factors (Bucher, Szczesna, & Curtin, 2007). An expert panel on falls prevention pointed to muscle weakness, history of falls, gait deficits, and balance deficits as major factors for falls in the elderly (American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons, 2001). Approximately 10–25% of all falls have been attributed to poor balance (Shumway-Cook, Gruber, Baldwin, & Liao, 1997). Balance is a complex skill based on the interaction of dynamic sensorimotor processes and is dependent on the goal of the movement task, as well as the environmental context (Horak, 2006). The ability to control balance involves...
using strategies to stabilize the body’s center of gravity over the base of support during quiet standing or active movement—static or dynamic balance (Arampatzis, Peper, & Bierbaum, 2010). The limits-of-stability (LOS) measure is defined as the area over which an individual can lean in specified directions and displace the center of gravity without changing the base-of-support stance as defined by the position of the feet (Liston & Brouwer, 1996). The functional base of support declines about 16% per decade beyond age 60. Forward- and backward-leaning abilities also decline significantly after age 60; that population on average retains only 66% of the forward-leaning ability and 34% of the backward-leaning ability of those under age 60 (King, Judge, & Wolfson, 1994).

Exercises to improve joint flexibility, muscle strength, and balance have been the focus of many falls-prevention programs for older adults (Chang et al., 2004; Faber, Bosscher, Chin A Paw, & van Wieringen, 2006; Hauer, Pfisterer, Schuler, Bartsch, & Oster, 2003; Lin, Wolf, Hwang, Gong, & Chen, 2007). Ankle flexibility in particular has been shown to predict balance ability (Menz, Morris, & Lord, 2005). High-intensity strength training of postural muscles in older adults with balance impairment has been shown to result in improved functional-balance control (Hess & Woollacott, 2005). A published review of falls-prevention interventions concluded that balance training is a key component of exercise programs in the reduction of fall rates (Sherrington et al., 2008). In summary, these results imply that exercise is effective in improving various components of balance and that improved balance in turn reduces an individual’s risk of experiencing another fall.

Previous studies have used group exercise protocols, home exercise protocols, or individualized home exercise programs and found that all these exercise methods can improve balance, if exercise adherence is good, and that the program duration should be at least 12 weeks (Costello & Edelstein, 2008; Cyarto, Brown, Marshall, & Trost, 2008; Davis et al., 2010). The advantage of home exercise programs is that they can be less costly and do not require participant transportation, but program adherence and timely exercise progression can be problematic.

In a systematic review, Howe, Rochester, Jackson, Banks, and Blair (2008) concluded that balance in older adults can be improved with exercise programs and that muscle strengthening and dynamic-balance activities had a large impact on this improvement. They also reported the specific balance measures used in the reviewed studies and demonstrated that—for multiple interventions, as well as just balance and strengthening exercises—functional reach, the Berg Balance Scale, and measures of static stability were used most frequently. Fewer published intervention studies that have tested LOS have demonstrated that this measure of dynamic balance can capture specific balance components not addressed with other measures (Bulat et al., 2007; Islam et al., 2004; Tsang & Hui-Chan, 2004).

The purpose of this study was to assess the efficacy of home exercise programs developed to address balance deficits in a population of older adults with a recent history of falls by testing their dynamic-balance capability before and after a 12-week intervention. We hypothesized that improvements would be seen in specific LOS test parameters and the clinical functional-reach test in the treatment group compared with the control group.
Effect of Home Exercise on Falls

Method

Study Population

Community-dwelling participants were recruited from local senior citizen organizations by an individual who was blinded to group assignment. Inclusion criteria for all participants were being over 60 years of age, ability to follow commands, awareness of time and place, and having experienced a fall in the past year. A fall was defined as an event that resulted in the person landing on the floor or a surface below knee level that was not caused by a severe blow, unconsciousness, paralysis, or seizure (Lach et al., 1991). Participants were provided this definition of a fall and then asked to report the number of falls they had experienced during that time frame. They were interviewed and excluded if they reported acute or unstable medical conditions such as uncontrolled hypertension or diabetes, had been diagnosed with osteoporosis, or reported difficulty standing or walking for 10 min because of other health problems. A priori power analysis was conducted based on an effect size for functional reach developed from a pilot study of 17 participants with a history of falls who received a similar individualized 12-week intervention of flexibility, strengthening, and balance exercises, with baseline and postintervention functional-reach assessment. The calculated effect size of 1.42 was used to determine that a minimum group size of 7 participants was needed to achieve a power of .95. We therefore concluded that a minimum of 15 participants in each group at the end of the study would have sufficient power to avoid a Type II error at a .025 alpha level. Considering a possible attrition rate of 25% for this two-group study, we recruited 43 participants who consented to participate. Two recruited volunteers did not meet the study criteria, but 41 participants received a concealed assignment to either a treatment or a control group through use of a random-number table. As illustrated in Figure 1, 4 of the 41 original people who met the inclusion criteria and volunteered to participate, 1 in the treatment group and 3 in the control group, were excused from the study during the first week (Schulz, Altman, & Moher, 2010). One participant had an exacerbation of her rheumatoid arthritis, 1 developed severe lower back pain, 1 moved out of town, and 1 did not return from vacation for the first scheduled appointment. Therefore, 37 participants began the study. Informed consent was obtained from all participants before their participation, in accordance with the policies of the facility’s institutional review board.

Measures

All outcome assessments were conducted in a university balance laboratory. Dynamic balance was evaluated by the 75% LOS test on a computerized posturography platform (Portable Balance Master, Neurocom, International, Inc., Clackamas, OR), with software version 5.0. This test was selected based on the results of a previous project that demonstrated target achievement at 75% LOS to be very challenging for a different set of participants with fall histories. Jbabdi, Boissy, and Hamel (2008) also found that their population of community-living older adults reached less than 75% of their theoretical LOS in the forward direction and less than 55% in lateral directions. The posturography platform houses force-plate transducers used to compute vertical pressure from the standing participant’s feet. The software calculates the
Figure 1 — Flow diagram of study participants.
center of gravity and the theoretical LOS from the participant’s height and weight. A monitor positioned at eye level displays a central starting position and eight targets evenly distributed in cardinal and diagonal directions around the perimeter of a circle representing the 75% LOS.

The measured parameters of the 75% LOS test include directional control (DC), endpoint excursion (EE), maximum excursion (ME), maximum velocity (MV), and reaction time (RT). The DC value is the amount of toward-target center-of-gravity movement relative to away-from-target center-of-gravity movement. DC is expressed as a percentage of the total toward-target movement, and a higher percentage reflects better movement coordination. EE is the distance (%LOS) of the initial attempt to reach a target. A higher EE value indicates a more accurately anticipated amount of movement needed to reach the target. ME is the farthest distance (%LOS) toward the target achieved during the trial. MV (°/s) is the average speed of center-of-gravity displacement, and RT is the time in seconds between the command to move and the subject’s movement response.

Participants were instructed to stand barefoot on the force plate with their arms at their sides and to keep their feet in the same correct position on a permanent grid throughout the testing procedure. They wore a gait belt with loops that were used by an assisting researcher to ensure safety but not guide or interrupt their movement. When prompted by auditory and visual cues, participants were expected to move their bodies to shift the center-of-gravity cursor as accurately as possible toward each of eight targets within 8 s and to remain there until instructed to return to the starting position. One practice trial was undertaken to familiarize participants with the procedure before testing. Two test trials were then performed. The reported generalizability coefficients over 2 consecutive days for the DC, EE, ME, and MV measures of this test ranged from .58 to .87, suggesting a wide range of reliability values (Clark & Rose, 2001). We examined the procedural reliability of the LOS Balance Master test on our population by calculating the test–retest reliability using intraclass correlation coefficient (ICC) Model 2 analysis. Our results demonstrated a range of acceptable reliability values for two-trial averages, from .64 for DC and RT to >.90 for EE, ME, and MV.

Exercise Protocol

Most treatment-group participants exercised at home, but one third of them preferred to exercise in a local clinical facility or come to the laboratory twice a week for the intervention. Regardless of exercise location, the selected exercises could be carried out in a home environment. Each home exercise program addressed
the individual participant’s specific impairments in lower extremity joint range of motion, muscle strength, and balance, as determined at the treatment group’s baseline evaluation and the control group’s 12-week evaluation. Exercise difficulty was increased as the participants demonstrated progress, generally on a weekly basis. Flexibility exercises started with 10 repetitions throughout available range and progressed to 30 repetitions with a 5-s hold at end of range. Strengthening exercises started with a 10-repetition maximum using elastic-band resistance and progressed to three sets of 10 repetitions before the resistance level of the elastic band was increased. Balance exercises began with shifting the center of gravity over a stable base of support for as few as 5 min and progressed to 30 min of wide-ranging tasks including dynamic-balance activities such as grapevine stepping and tandem walking. All treatment-group participants were able to complete 24 sessions that included progressive flexibility, strengthening, and balance exercises as indicated by their baseline testing. See Table 1 for exercise program examples.

The principal investigator and two additional physical therapists, who received three training sessions in the exercise program by the principal investigator, provided the onsite monitoring and progression of exercises. They met weekly to discuss participant progress and the exercise progression to control for procedural differences. The therapists were to observe the exercise program and increase the level of exercise difficulty once milestones were met, similar to clinical reevaluation and progression of home exercise programs.

<table>
<thead>
<tr>
<th>Exercise program</th>
<th>Duration (min)</th>
<th>Focus</th>
<th>Type and frequency of exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5–10</td>
<td>Range of motion</td>
<td>To increase joint mobility (hip, knee, or ankle), participants moved actively through the available range and held at end range for 10 s, then progressed from 10 to 30 repetitions for each restricted joint.</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Strength</td>
<td>To strengthen weak lower extremity muscles, participants used graded-resistance, elastic exercise bands beginning with 10-repetition-maximum resistance and gradually increasing to 3 sets of 10 repetitions. Progressed with new 10-repetition-maximum resistance from one to three sets.</td>
</tr>
<tr>
<td>3</td>
<td>5–30</td>
<td>Balance</td>
<td>Balance tasks were individualized, according to participant need and ability. Time spent on weight-bearing balance activities progressed from 5 to 30 min as exercise tolerance increased. Examples included moving center of gravity to extremes of base of support in sitting and standing, static standing balance in tandem and single-leg stance with eyes open and closed, and dynamic balance activities such a grapevine steps, ball sitting and throwing, and fast gait activities with obstacles.</td>
</tr>
</tbody>
</table>
General Procedure

All assessments were conducted by one of two possible evaluators working together, with one evaluator ensuring patient safety while the other gave instructions and performed the tests. Each outcome measure was assessed by the same evaluator throughout the study. The evaluators were not blinded to group assignment, as they also monitored some of the exercise programs. At the baseline and 12-week testing sessions, LOS and functional reach were assessed in random order with rest periods as needed between tests. During the baseline session, each participant also received an individual evaluation that included a personal medical history, measurement of height and weight, and a brief musculoskeletal examination to assess lower extremity joint range of motion and muscle strength. Active range of motion of the hips, knees, and ankles was measured with a universal goniometer according to standard protocol (Norkin & White, 2009). A handheld dynamometer was used to test leg-muscle strength in standard postures for manual muscle testing (Wang, Olson, & Protas, 2002). Immediately after this baseline testing to determine deficits for each participant, individually prescribed exercises were started by the treatment group. They performed their progressive home exercise program independently but always under a physical therapist’s onsite monitoring and direction twice a week for 12 consecutive weeks. The duration of the exercise sessions ultimately averaged 55 min but varied slightly according to the initial endurance, strength, and flexibility, as well as the progress, of each participant. The control-group participants received friendly phone calls from two graduate research students twice per week between the baseline and 12-week testing, after which they were given a similar home exercise program but without onsite monitoring or postexercise testing. The students were directed to ask about recent health in general and whether the participant had fallen since the last phone call. If a fall had occurred, the students asked what the participant was doing at the time of the fall and whether he or she sustained injuries requiring medical assistance. This information was then recorded and placed in the participant’s record. These participants were advised not to begin additional physical activities or exercise programs during the 12 weeks.

Statistical Analyses

Demographic data were tabulated, with comorbidities expressed as an average number reported per person. The differences in baseline characteristics and fall incidence were compared between the treatment and control groups. The assumption of homogeneity of variance for the five parameters and functional reach was also tested. One-way analyses of variance (ANOVA) were conducted to determine differences in the five LOS parameters and the functional reach between the treatment and control groups at baseline.

For the 75% LOS test, a composite score for each parameter was calculated by averaging the scores from all eight targets for each trial, followed by averaging the trial scores. For the functional-reach test, the two trial scores were averaged. A two-factor multivariate ANOVA (MANOVA) with repeated measures over time for the LOS measures and a two-factor univariate ANOVA with repeated measures over time for the functional reach were conducted, with a Bonferroni adjustment of the alpha level to .025 to control for a Type I error. Follow-up univariate ANOVAs for the LOS measures were also conducted as warranted. When group-by-time interactions occurred, simple effects were tested, at a conservative alpha level of
.01, using one-way repeated-measures ANOVAs for the time factor. All data were analyzed using SPSS, version 16.

Results

Two control-group participants did not take the 75% LOS test at the 12th week. One was unable to perform the test in the time allowed, and a temporary electrical problem occurred at the time of the other participant’s 12-week test. Therefore, the final study sample analyzed was 35, with 19 participants in the treatment group and 16 in the control group (Figure 1). A number of participants reported comorbidities, namely, arthritis (n = 13), diabetes (n = 7), heart disease (n = 6), stroke (n = 5), Parkinson's disease (n = 1), traumatic brain injury (n = 1), visual problems (n = 9), hearing problems (n = 12), and dizziness (n = 18). One participant in each group reported falling more than 30 times in the past year, and we calculated two equivalent modes for fall frequency that were one (n = 9) or three (n = 9) falls. There were no significant baseline differences in the demographics, the number of comorbidities per participant, or the fall incidence between the two groups (Table 2).

The assumption of homogeneity of variance was tenable for the five LOS parameters (p ≥ .2) and the functional reach (p ≥ .5). For the 75% LOS-test data, there were no differences in any of the five parameters between the treatment and control groups at baseline. The results of the split-plot MANOVA revealed the effect of group to be nonsignificant, F(5, 29) = 0.20, p < .1; the effect of time to be significant, F(5, 29) = 7.03, p < .0005; and the group-by-time interaction to be significant, F(5, 29) = 6.27, p < .0005, according to Pillai’s criterion. A posteriori calculation showed power to be .97 for the MANOVA at .025 alpha.

Follow-up univariate analyses, as presented in Table 3, showed that there were statistically significant interactions for DC, F(1, 33) = 13.86, p < .0015, 1 – β = .89;

Table 2  Demographic Characteristics and Fall Incidence by Group (N = 35)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Treatment group (n = 19)</th>
<th>Control group (n = 16)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, M ± SD (range)</td>
<td>77 ± 7 (62–90)</td>
<td>75 ± 8 (61–87)</td>
<td>.49a</td>
</tr>
<tr>
<td>Weight, kg, M ± SD</td>
<td>73.4 ± 16.1</td>
<td>80.5 ± 15.3</td>
<td>.19a</td>
</tr>
<tr>
<td>Height, m, M ± SD</td>
<td>1.66 ± 0.13</td>
<td>1.67 ± 0.08</td>
<td>.67a</td>
</tr>
<tr>
<td>Race, n</td>
<td></td>
<td></td>
<td>.54b</td>
</tr>
<tr>
<td>White</td>
<td>14</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Gender, n</td>
<td></td>
<td></td>
<td>.88b</td>
</tr>
<tr>
<td>male</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>10</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Fall incidence</td>
<td></td>
<td></td>
<td>.26b</td>
</tr>
<tr>
<td>once only</td>
<td>7 (36.8%)</td>
<td>2 (12.5%)</td>
<td></td>
</tr>
<tr>
<td>occasional (2 or more times)</td>
<td>12 (63.2%)</td>
<td>14 (87.5%)</td>
<td></td>
</tr>
<tr>
<td>Average number of comorbidities per subject</td>
<td>2.2</td>
<td>1.9</td>
<td>.37a</td>
</tr>
</tbody>
</table>

aStudent’s t test. bChi-square test.
Table 3  Means, Standard Deviations, and ANOVA Results for the 75% Limits-of-Stability Test Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pretreatment (Week 1)</th>
<th>Posttreatment (Week 12)</th>
<th>Group × Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment group</td>
<td>Control group</td>
<td>Treatment group</td>
</tr>
<tr>
<td>Directional control, %</td>
<td>61.61 ± 14.81</td>
<td>68.59 ± 10.75</td>
<td>73.75 ± 11.17</td>
</tr>
<tr>
<td>Endpoint excursion, %</td>
<td>44.91 ± 10.70</td>
<td>51.37 ± 11.83</td>
<td>57.74 ± 7.90</td>
</tr>
<tr>
<td>Maximum excursion, %</td>
<td>56.78 ± 12.21</td>
<td>62.22 ± 12.80</td>
<td>70.37 ± 6.75</td>
</tr>
<tr>
<td>Movement velocity, °/s</td>
<td>1.89 ± 0.68</td>
<td>2.16 ± 0.95</td>
<td>2.40 ± 0.75</td>
</tr>
<tr>
<td>Reaction time, s</td>
<td>1.10 ± 0.26</td>
<td>1.01 ± 0.44</td>
<td>0.96 ± 0.22</td>
</tr>
</tbody>
</table>

*Significant difference, p < .025.
EE, $F(1, 33) = 24.37, p < .0005, 1 – \beta = 1.0$; and ME, $F(1, 33) = 11.52, p < .0025, 1 – \beta = .91$, but no interaction effects were found for MV, $F(1, 33) = 3.18, p < .1, 1 – \beta = .41$, or RT, $F(1, 33) = 0.15, p > .7, 1 – \beta = .07$. The main effect of time was significant for MV, $F(1, 33) = 17.56, p < .0005$, but there was no interaction. The one-way repeated-measures ANOVAs showed that there was a significant improvement in DC, $F(1, 18) = 13.85, p < .0025, d = 1.06$; EE, $F(1, 18) = 46.39, p < .0005, d = 2.33$; and ME, $F(1, 18) = 42.49, p < .0005, d = 2.54$, in the treatment group after 12 weeks of exercise, but not in the control group. The pre–post control-group effect sizes were $d = 0.6$ for DC, $d = 0.11$ for EE, and $d = 0.51$ for ME.

The one-way ANOVA showed that there was no difference in functional reach between the treatment and control groups at baseline. The split-plot ANOVA for functional reach demonstrated a significant main effect for time, $F(1, 33) = 15.04, p < .0005$, but neither main effect of group, $F(1, 33) < 0.0005, p > .9$, nor group-by-time interaction, $F(1, 33) = 0.02, p > .85, 1 – \beta = 0.05$, was found (Figure 2).

![Figure 2](image-url) — Means and standard deviations of functional reach for the treatment and control groups.
Discussion

The results supported the study hypothesis that a 12-week home exercise program can improve specific dynamic-balance skills of older community-dwelling adults with a history of falls. This outcome is similar to the findings of Donat and Ozcan (2007), who compared group- and home-based exercises undertaken by older adults with fall risk three times per week for 8 weeks and found significant balance improvement in both groups. Kamide, Shiba, and Shibata (2009) assessed balance in elderly women after a 6-month unsupervised home exercise program and demonstrated significant improvements in their balance measures as compared with a control group, suggesting that program supervision, as provided in the current study, is not needed to achieve improvement in a healthy population of older adults. However, Donat and Ozcan contacted participants monthly to encourage continued participation.

The treatment group demonstrated significant improvement in DC, EE, and ME, supporting the results of other studies that assessed these LOS parameters before and after exercise interventions focused on strength or balance control (Bulat et al., 2007; Islam et al., 2004; Tsang & Hui-Chan, 2004). The percent improvement in postintervention mean values of the treatment group was clinically meaningful for DC (20%), EE (29%), and ME (24%), but control-group DC and EE mean values decreased over time, and the mean value of ME for the control group increased only 0.05%. Not all current study measures improved in treatment versus control group; MV and RT did not have statistically significant interactions. Bulat et al. also did not demonstrate significant improvement in MV and RT at a .01 alpha level in their pretest–posttest assessment of an 8-week group exercise program for older veterans, but they did report a trend of improvement in those measures.

There was a statistically significant increase in mean MV across groups, with a mean score improvement of 27% in the treatment group and 9.7% in the control group. Within-group variance was therefore a likely factor in this nonsignificant interaction result for MV. The lack of any significant improvement in RT in our study contrasts with other work (Rooks, Kiel, Parsons, & Hayes, 1997) that demonstrated quicker foot-press reaction time after a 10-month intervention program for community-dwelling older adults consisting of either resistance training or walking activity as compared with a control group. However, their subjects were seated for the test and the reaction-time measurement did not entail an upright postural response. Vogler, Sherrington, Ogle, and Lord (2009) also demonstrated improved reaction time after 12 weeks of weight-bearing exercise in a population of older adults just dismissed from a hospital. They measured reaction time by a finger-press response, which also did not challenge upright postural stability. In addition, their population was not limited to older adults with a fall history, nor were groups stratified according to fall risk. Lajoie and Gallagher (2004) suggested that even verbal-response times during conditions of postural demand can differentiate participants according to fall history.

The exercise programs, which included flexibility, strength, and balance training as indicated, were specifically designed so that treatment-group participants could perform them safely on their own at home, even though they were monitored twice per week during this study to ensure program adherence, which was 100%.
No aggressive postural-perturbation exercises that would require rapid reactive responses were included in the home exercise programs because of safety concerns for this population at risk for falling. Therefore, the home exercise program simply might have been ineffective in improving anticipatory RT in the treatment group as compared with the control group.

Specificity of exercise is a factor to consider when designing interventions to improve specific balance components, as well as adding activities requiring quick responses, to improve RT and MV. Improvements in the other LOS parameters suggest greater ability to manage the larger moment arms created by the center of gravity shifting farther away from the base of support. Activities of daily living requiring large movements of the trunk during standing should be easier with this improved dynamic control.

Functional reach did not improve significantly more in the treatment group than the control group, a finding that differed from our pilot study’s results. Ballard, McFarland, Wallace, Holiday, and Roberson (2004) found similar results after a 15-week exercise program for elderly women consisting of resistance and balance exercises comparable to those used in the current study. Wernick-Robinson, Krebs, and Giorgetti (1999) suggested that functional-reach distance can be increased by a variety of movement strategies that do not always increase the moment arm produced when the center of pressure is behind the center of gravity. Without significant moment-arm increases during the task, the functional-reach test then becomes a more static and less dynamic measure of balance. Wernick-Robinson et al. cited hip flexion and trunk rotation as two strategies that produced a low moment arm. The current study evaluators encouraged participants to perform the functional reach correctly, but it is possible that subtle changes in movement strategy were not observed. Although functional reach is an accepted clinical measurement for dynamic balance, Wallmann (2001) found no significant relationship between the anterior displacement on the LOS test and the functional reach. Our study findings also suggest that instrumented LOS tests can capture aspects of dynamic balance not detected with the functional-reach test.

Study limitations include our choice to use the 75% LOS test rather than the 100% LOS test, so we might not have measured participants’ full capability (Clark & Rose, 2001; Clark, Rose, & Fujimoto, 1997), thereby creating a ceiling effect. However, examination of the composite scores suggested that this was not the case. Reaching for at least seven of the eight targets at 75% LOS was very challenging for our participants. In addition, evaluators were not purposefully blinded to participants’ group during the assessments, and tester bias might have affected the functional-reach measurement, which is a weakness of the study. However, the LOS assessment was automated and the results were retrieved and calculated at a later date by a third examiner who did not participate in either the testing or the intervention. Standard instructions were given to all participants, and they received no verbal guidance during the tests themselves. The wide variation in reliability of the 75% LOS measures, with ICC values less than .70 for DC and RT, is also a possible study weakness—it could account for a larger true-score error range.

Other limitations of this research were the relatively small sample size and the variation in dynamic-balance skills of the sampled population. The participants of the current study exhibited a wide age range and reported multiple comorbidities. However, this heterogeneity did not appear to affect the statistical power of our
overall analysis, which was high. This study also reflected the realities of clinical falls-prevention programs with heterogeneous populations.

The results of this study suggest that a home exercise program is safe and effective in improving selected dynamic-balance control parameters in older adults who have fallen. These positively affected parameters reflected the range and control of movement rather than the speed of movement, which is important for reacting to perturbations, a frequent cause of falling. More challenging balance exercises that require quick responses and higher speeds should be included, if the client can perform them safely in the home, to determine whether RT in weight bearing can actually be improved with exercise intervention. Regular exercise progression was integral to this study, and therefore frequent, periodic reevaluation is recommended for those exercising without supervision. Periodic group exercise sessions might be considered as a useful addition to a home exercise program to include perturbation exercises, as well as to increase the program difficulty and encourage adherence.

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References


