Effects of a Balance Training Program Using a Foam Rubber Pad in Community-Based Older Adults: A Randomized Controlled Trial

Tatsuya Hirase, PT, MS1; Shigeru Inokuchi, PT, PhD2; Nobuou Matsusaka, PhD, MD2; Minoru Okita, PT, PhD1

ABSTRACT

Background and Purpose: Exercise programs aimed at improving balance are effective in fall prevention for older adults. Guidelines indicate that unstable elements should be integrated in balance training with this population. Balance training on an unstable surface facilitates proprioception mediated by skin receptors in the soles of the feet and by mechanoreceptors in the joints and muscles. This randomized controlled trial examined whether balance training performed using a foam rubber pad was more beneficial than balance training performed on a stable flat surface in older adults.

Methods: Older adults using Japanese community day centers once or twice per week were enrolled in this trial. In total, 93 participants were randomized to 1 of 3 groups: foam rubber exercise group (n = 32), stable surface exercise group (n = 31), and control group (n = 30). Participants in the foam rubber and stable surface exercise groups attended a 60-minute exercise class once a week for 4 months and followed a home-based exercise routine. Outcome measures were the following performance tests: the one-leg standing test (OLST), the chair standing test, the timed up-and-go test (TUGT), and the tandem-stance test (TST). These assessments were conducted before the intervention, and at 1, 2, 3, and 4 months after starting the intervention.

Results: There were group × time interactions (P < 0.001) for all performance tests. The foam rubber exercise group showed significant improvements in the OLST, TST, and TUGT at 1 to 4 months compared with the control group (P < 0.02). The foam rubber exercise group also showed significant improvements in the OLST and TST at 2 and 3 months compared with the stable surface exercise group (P < 0.02). Within the foam rubber exercise group, the OLST, TUGT, and TST, at 1 to 4 months, were significantly improved compared with before the intervention (P < 0.01). Within the stable surface exercise group, the TUGT and TST, at 3 and 4 months, were significantly improved compared with before the intervention (P < 0.01).

Conclusions: This study confirms that balance training in older adults performed using a foam rubber pad is effective for improving balance ability, and that this improvement occurs 2 months earlier compared with balance training performed on a stable surface. These findings suggest that balance training performed using a foam rubber pad is beneficial to clients and service providers because the programs improve physical functioning with a reduced number of exercise sessions.

Key words: balance, foam rubber, older adults, randomized controlled trial

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INTRODUCTION

Worldwide, fall-related injuries and mortality in older adults are major health care concerns, and their incidence continues to rise.1 Approximately 30% of community-dwelling adults aged 65 years and older fall at least once a year, with 6% of these falls resulting in fractures.2,3 Falls are a risk factor not only for fractures but also for the development of traumatic cerebral or visceral hemorrhage, traumatic pain syndromes, functional limitations, dislocations, soft tissue injuries, excess health care costs, and increased mortality.4 Thus, because of the increased incidence of falls in older adults and the associated risk for other problems, fall prevention is a major health care priority.

Previous studies of fall prevention have shown that exercise interventions effectively reduced both the risk of falls and the actual number of falls in older adults by improving physical function.4,5 Poor balance and muscle weakness seem to be associated with an increased risk of falls in older adults.6 Numerous exercise programs aimed at improving balance and muscle strength have been conducted in the community.7-16 Recently, exercise programs aimed at improving balance ability have been shown to be effective in fall prevention for older adults.17

Researchers have reported that balance training improves lower extremity muscle strength in addition to balance.12-14 Many balance training programs for older adults comprise performance-based exercises aimed at improving static and

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dynamic balance, such as one-leg standing, tandem stance, reaching, and walking sideways. Such programs for older adults are traditionally conducted on flat, stable surfaces to help reduce the risk of falls and associated injuries. However, sports medicine research has reported that balance training performed on unstable surfaces significantly improves balance compared with balance training on stable surfaces. This may be because of improved proprioception mediated by skin receptors in the soles of the feet and by mechanoreceptors in the joints and muscles. Previous studies have reported that proprioception and posture are enhanced by the increase in the afferent input from mechanoreceptors in the muscles and joints caused by postural sway on unstable surfaces.

Guidelines for balance training indicate that unstable elements should be integrated in balance training with older adults. Several studies have reported that standing on a foam rubber pad affects the skin receptors in the soles and mechanoreceptors in the joints and muscles, and provide useful proprioceptive information for postural reactions. However, the effectiveness of balance training in older adults performed using a foam rubber pad compared with using a stable surface has not been fully tested and remains unclear; we thus undertook an investigation of such effectiveness in the present study. We hypothesized that balance training performed using a foam rubber pad would be effective in improving balance and reducing the number of falls of study participants, and that balance would improve at a faster rate compared with balance training on a stable surface.

METHODS

Participants
Older adults using community day centers in the Japanese cities of Nagasaki and Unzen once or twice per week were enrolled in the study. We selected 7 day centers where physical therapists worked together with community care staff. The physical therapists were asked to choose potential participants over the age of 65 years who were living at home, able to walk with or without a cane, and had at least 4 risk factors, as identified using the questionnaire for fall assessment reported by Suzuki. The questionnaire consisted of 15 items, which included questions about fall history, walking ability, muscle power, medical disorders, medication, vision and hearing, and fear of falling. A cross-sectional study showed that the number of risk factors identified by the questionnaire correlated significantly with the number of falls in the previous year, psychological status, and physical function related to muscle strength and balance. In addition, the questionnaire predicted falls with sensitivity and specificity of 59.4% and 83.1%, respectively, when a cutoff point of 4 risk factors was used. Specifically, older adults with at least 4 risk factors were regarded as high-risk fallers. This questionnaire has been widely adopted by community care staff for the assessment of falls among older adults in Japan.

Participants who had participated in exercise at least 4 times a month before the intervention, and who had musculoskeletal, neurological, or cardiovascular disorders that may be aggravated by exercise were excluded. Participants who were unable to respond to interview questions because of cognitive impairment were also excluded.

Written informed consent was obtained from each participant in accordance with the guidelines approved by the Nagasaki University Graduate School of Medicine and the Declaration of Human Rights, Helsinki, 2008.

Design and Randomization
This study was a randomized controlled trial conducted between October 2010 and September 2012. Participants who met the inclusion and exclusion criteria were randomized into 3 groups using the sealed envelope method. The randomized groups were as follows: (1) a group performing a balance training program on a foam rubber pad with 6 cm in thickness, 50 cm in width, and 40 cm in length (Airex® mat, Sakai Medical, Japan; Figure 1) (foam rubber exercise group); (2) a group performing the same balance training program on a stable flat surface (stable surface exercise group); and (3) a control group. Physical therapists working in the day centers assessed the participants and implemented the intervention program.

Intervention
Participants in the foam rubber and stable surface exercise groups were asked to attend a 60-minute weekly exercise class for 4 months that was supplemented with daily home-based exercises. The exercise program consisted of 10 minutes of warm-up, 40 minutes of balance training, and 10 minutes of cool-down. All exercise sessions were conducted with the participants in training groups of approximately 10 people.
The balance training program has been described in previous studies.\textsuperscript{15,18} The program included 10 exercises performed in a standing position as follows: double-stance standing, one-leg standing, neck hyperextension, free-leg swinging, heel and toe raises, neck and trunk rotation, touching the floor, walking in place, sideways walking, and walking (Table 1). The intensity of balance training over the 40 minutes was constant throughout the intervention period and was interrupted with breaks totaling 10 minutes, depending on the participants’ physical capacity. The study exercises were videotaped to ensure the consistency of the balance training given to the participants.

### Table 1. Balance Training Exercises in the Foam Rubber Exercise Group and the Stable Surface Exercise Group

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double-stance standing</td>
<td>Hold for 20 s; Repeat twice with eyes open, twice with eyes closed</td>
</tr>
<tr>
<td>One-leg standing</td>
<td>Stand on one leg with the other placed midway up the calf; Hold for 10 s, if possible; Repeat 3 times on each leg, once with eyes open and once more with eyes closed</td>
</tr>
<tr>
<td>Neck hyperextension</td>
<td>Stand while slowly hyperextending the neck and then tipping it down forward; Repeat 5 times with eyes open, 5 times with eyes closed</td>
</tr>
<tr>
<td>Free-leg swinging</td>
<td>Stand on one leg while moving the other slowly forward, side and back; Switch legs and repeat 3 times, then again with eyes closed; Initially, participants may slide feet over the floor, but later in the class they should try to progress to lift the leg completely off the floor</td>
</tr>
<tr>
<td>Heel and toe raises</td>
<td>Rock slowly up onto toes and hold, then roll back onto heels and hold; Repeat 3 times with eyes open, 3 times with eyes closed</td>
</tr>
<tr>
<td>Neck and trunk rotation</td>
<td>Stand while slowly rotating the neck and trunk; Repeat 3 times with eyes open</td>
</tr>
<tr>
<td>Touching the floor</td>
<td>Touch the floor while squatting down; Repeat 5 times with eyes open</td>
</tr>
<tr>
<td>Walking in place</td>
<td>Walk in place for 20 s; Repeat twice with eyes open</td>
</tr>
<tr>
<td>Sideways walking</td>
<td>Walk sideways, bringing the trailing foot just up to the lead one; Repeat 5 times with eyes open for approximately 7-m distance</td>
</tr>
<tr>
<td>Forward walking</td>
<td>Walk forward without looking at the ground; Repeat 5 times with eyes open for approximately 7-m distance</td>
</tr>
</tbody>
</table>

Regarding the daily home-based program, we ensured that the exercises were simple enough to be performed easily and continuously by older adults. Therefore, only 3 exercises (ie, one-leg standing, heel and toe raises, and walking in place) were selected from the balance training program for home-based repetition. The participants in the 2 exercise groups were given monthly training diaries to record their performance of the home-based exercise program. These training diaries were checked every week by the physical therapist working in each day center. The participants in the foam rubber and stable surface exercise groups were asked to perform the home-based exercise program on the foam rubber pad, and on the stable flat surface, respectively.

Participants in the control group participated in weekly social programs, including recreational activities, educational programs, and tea breaks. They continued their daily activities at the day centers, but performed neither balance training nor muscle strengthening exercises at the centers or in a structured setting at home.

### Assessment

Physical function, risk factors for falls, fear of falling, and the number of falls during the intervention period were assessed. Before commencing the study, the physical therapists received training from one of the authors (TH) on the assessment protocols.

Physical function was assessed using the following performance tests: the one-leg standing test (OLST),\textsuperscript{32} the chair standing test (CST),\textsuperscript{33} the timed up-and-go test (TUGT),\textsuperscript{34} and the tandem-stance test (TST).\textsuperscript{35} These tests were conducted twice, and the best value from the 2 tests was recorded. Physical function was measured before the intervention, and at 1, 2, 3, and 4 months after starting the intervention.

Risk factors for falls were identified using Suzuki’s fall assessment questionnaire.\textsuperscript{37} Fear of falling was evaluated using the modified Falls Efficacy Scale (FES) translated into Japanese. The FES used the same 10 items reported by Tinetti et al.,\textsuperscript{36} and each item was assessed on the following scale: 1, “I have no confidence to do so”; 2, “I have little confidence to do so”; 3, “I have some confidence to do so”; 4, “I have full confidence to do so.” The total score on the FES can range from 10 to 40, with high scores indicating greater confidence. These assessments were self-administered with guidance from the care staff at the day centers as needed. Risk factors for falls and fear of falling were evaluated before the intervention and at 4 months after starting the intervention.

A fall was defined as “unintentionally coming to rest on the ground, floor, or other lower level in a manner that did not result from a major intrinsic event or an overwhelming hazard.”\textsuperscript{37} Each participant was given a diary with a monthly sheet to record the number of additional falls during the follow-up period. The number of additional falls

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was recorded every week by a physical therapist working in each day center.

**Required Sample Size**

We searched previous literature examining the effect of balance exercise on elderly people living at home. The reports indicated a large effect size (0.8-1.3). Therefore, with a statistically significant level of 5% ($P = 0.05$), a statistical power of 80%, and an effect size of 0.8, a minimum of 26 participants were required per group. Allowing for a 10% dropout rate, a minimum of 29 participants were required per group.

**Statistical Analysis**

Statistical analysis was performed using SPSS 11.0 Japanese version for Windows (SPSS Inc, Chicago, IL). One-way analysis of variance was performed using an unpaired $t$ test with a Bonferroni adjustment to compare the age, height, weight, and physical function between the 3 groups before the intervention. Chi-square tests were used to compare sex distributions, the presence of falls in the year before the intervention, and the proportion of participants who dropped out during the intervention between the 3 groups. The Kruskal-Wallis test, combined with the Mann-Whitney $U$ post hoc test with a Bonferroni adjustment, was used to assess differences between the 3 groups in terms of the number of medications, the number of risk factors, and the FES scores at baseline and 4 months after starting the intervention. This test was also used to investigate the differences in the numbers of falls during the intervention at 4 months after starting the intervention.

The effect of exercise on each physical function item was analyzed using a 3 (group: foam rubber exercise group, stable surface exercise group, and control group) × 5 (time: baseline, 1, 2, 3, and 4 months after starting the intervention) analysis of variance. Post hoc Bonferroni tests were used to assess which group or time periods showed significant differences. A 2-sided $P$ value of $\leq 0.05$ was considered significant.

**RESULTS**

A flowchart outlining study participation is shown in Figure 2. A total of 171 individuals were screened for the potential participants. Seventy-eight of 171 potential participants were excluded because of refusal to participate ($n = 19$) and not meeting inclusion criteria ($n = 59$). Out of the 59 participants who did not meet inclusion criteria, 15 participants had severe musculoskeletal or cardiovascular disorders and 44 participants had exercised regularly 4 or more times a month before the initial interview. The remaining individuals ($n = 93$) were enrolled in the study, and were randomly allocated to the foam rubber exercise group ($n = 32$), stable surface exercise group ($n = 31$), or control group ($n = 30$).

A total of 7 participants (7.5%) withdrew from the trial. Three participants (9.4%) in the foam rubber exercise group were admitted to hospital because of serious illness (pneumonia [$n = 2$] and heart disease [$n = 1$]), 2...
participants (6.5%) in the stable surface exercise group were admitted to hospital with pneumonia, and 2 (6.7%) in the control group withdrew because of serious illness (pneumonia [n = 1] and heart disease [n = 1]). There was no significant difference between the 3 groups in terms of withdrawal from the study (P = 0.89). No participants dropped out as a result of the balance training program itself. In short, eighty-six of 93 participants completed the 4-month intervention: 29 in the foam rubber exercise group, 29 in the stable surface exercise group, and 28 in the control group.

During the intervention, participants who completed the study attended 95.5%, 93.3%, and 91.2% of all possible classes in the foam rubber, stable surface, and control groups, respectively. There was no significant difference between the 3 groups in terms of program adherence (P = 0.20). Participants in the foam rubber and stable surface exercise groups performed the home-based exercise program 3.5 (standard deviation [SD]: 2.0) and 3.4 (SD: 2.3) days per week, respectively. There was no significant difference between the 2 exercise groups in terms of their home-based program adherence (P = 0.75).

Baseline Characteristics
The baseline characteristics of the participants are summarized in Table 2. There were no significant differences between the 3 groups in terms of age, sex, incidence of falls in the previous year, number of medications, physical function, risk factors for falls, and FES scores (P ≥ 0.55).

Effects of Balance Training

Changes in physical function
Table 3 shows the changes in physical function over 4 months across the groups. For physical function assessments, there were significant group × time interactions (P < 0.001).

For the OLST, the mean values at 1 to 4 months after the intervention in the foam rubber exercise group were significantly better than those in the control group (P < 0.02), and the mean values at 2 to 4 months in the foam rubber exercise group were significantly better than those in the stable surface exercise group (P < 0.02). Within the foam rubber exercise group, the mean values at 1 to 4 months showed significant improvement compared with before the intervention (P < 0.01).

For the CST, the mean values at 2 to 4 months in the foam rubber exercise group were significantly better than those in the control group (P < 0.02). The mean values at 2 to 4 months in the stable surface exercise group were also significantly better than those in the control group (P < 0.02). Within the foam rubber exercise group, the mean values at 2 to 4 months showed significant improvement compared with before the intervention (P < 0.01). Within the stable surface exercise group, the mean value at 4 months showed significant improvement compared with before the intervention (P < 0.01).

For the TUGT, the mean values at 1 to 4 months in the foam rubber exercise group were significantly better than those in the control group (P < 0.02). Within the foam rubber exercise group, the mean values at 1 to 4 months after the intervention showed significant improvement compared with before the intervention (P < 0.01). Within the stable surface exercise group, the mean values at 3 and 4 months after the intervention showed significant improvement compared with before the intervention (P < 0.01).

For the TST, the mean values at 1 to 4 months after the intervention in the foam rubber exercise group were significantly better than those in the control group (P < 0.02), and the mean values at 2 and 3 months in the foam rubber

Table 2. Baseline Characteristics of Study Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Foam Rubber Exercise Group (n = 32)</th>
<th>Stable Surface Exercise Group (n = 31)</th>
<th>Control Group (n = 30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr—mean (SD)</td>
<td>82.1 (5.5)</td>
<td>82.0 (5.7)</td>
<td>82.2 (6.3)</td>
<td>0.99</td>
</tr>
<tr>
<td>Female—n (%)</td>
<td>23 (71.9)</td>
<td>23 (74.2)</td>
<td>19 (63.3)</td>
<td>0.62</td>
</tr>
<tr>
<td>Height, cm—mean (SD)</td>
<td>151.0 (6.1)</td>
<td>149.9 (7.2)</td>
<td>150.2 (6.0)</td>
<td>0.67</td>
</tr>
<tr>
<td>Weight, kg—mean (SD)</td>
<td>52.9 (9.1)</td>
<td>51.2 (7.7)</td>
<td>53.3 (9.1)</td>
<td>0.61</td>
</tr>
<tr>
<td>Medication, n—mean (SD)</td>
<td>5.4 (2.3)</td>
<td>5.9 (2.4)</td>
<td>5.8 (1.8)</td>
<td>0.75</td>
</tr>
<tr>
<td>Falls in previous year—n (%)</td>
<td>16 (50.0)</td>
<td>14 (45.2)</td>
<td>14 (46.7)</td>
<td>0.93</td>
</tr>
<tr>
<td>OLST, s—mean (SD)</td>
<td>4.9 (5.3)</td>
<td>4.7 (4.3)</td>
<td>5.6 (8.4)</td>
<td>0.86</td>
</tr>
<tr>
<td>CST, s—mean (SD)</td>
<td>13.6 (4.2)</td>
<td>12.8 (5.2)</td>
<td>13.5 (3.1)</td>
<td>0.71</td>
</tr>
<tr>
<td>TUGT, s—mean (SD)</td>
<td>13.6 (3.7)</td>
<td>13.9 (5.1)</td>
<td>14.1 (3.0)</td>
<td>0.92</td>
</tr>
<tr>
<td>TST, s—mean (SD)</td>
<td>18.3 (13.4)</td>
<td>16.3 (17.1)</td>
<td>17.2 (17.7)</td>
<td>0.89</td>
</tr>
<tr>
<td>Risk factors of falls, n—mean (SD)</td>
<td>6.9 (1.7)</td>
<td>7.3 (2.1)</td>
<td>7.1 (2.1)</td>
<td>0.90</td>
</tr>
<tr>
<td>FES score, points—mean (SD)</td>
<td>28.7 (4.5)</td>
<td>28.8 (5.7)</td>
<td>26.7 (6.7)</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Abbreviations: CST, chair standing test; FES, Falls Efficacy Scale; OLST, one-leg standing test; SD, standard deviation; TST, tandem-stance test; TUGT, timed up-and-go test.
exercise group were significantly better than those in the stable surface exercise group ($P < 0.02$). Within the foam rubber exercise group, the mean values at 1 to 4 months after the intervention showed significant improvement compared with before the intervention ($P < 0.01$). Within the stable surface exercise group, the mean values at 3 and 4 months after the intervention showed significant improvement compared with before the intervention ($P < 0.01$).

**Changes in risk factors for falls, fear of falling, and additional falls**

The mean (SD) number of risk factors for falls at 4 months for the foam rubber, stable surface, and control groups was 5.7 (1.9), 6.5 (2.4), and 7.6 (2.1), respectively. The mean (SD) FES scores for the foam rubber, stable surface, and control groups were 28.8 (4.5), 27.7 (6.0), and 24.4 (6.5), respectively. There were significant differences between the 3 groups in terms of the number of risk factors for falls and the FES score ($P = 0.002$ and $P = 0.01$, respectively). Post hoc analysis revealed that the fall risk factors and the FES score for the foam rubber exercise group were significantly improved compared with the control group ($P < 0.02$), but were not different from the stable surface exercise group.

There were no significant differences between the stable surface exercise group and the control group.

The mean (SD) number of additional falls during the intervention for the foam rubber, stable surface, and control groups was 0.24 (0.51), 0.59 (1.94), and 0.90 (1.45), respectively. The difference between the 3 groups was approaching significance ($P = 0.07$).

**DISCUSSION**

The main finding of this randomized controlled trial was that a balance training program was effective for improving physical function in community-dwelling older adults. Specifically, there were improvements in the performance of the OLST and TST, and TUGT identified as markers of static and dynamic balance, and dynamic balance, at 1 to 4 months in the foam rubber exercise group compared with the control group. There were no significant differences between the stable surface and control groups. However, the CST, identified as a marker of lower extremity muscle strength, was significantly improved at 2 to 4 months in both the foam rubber and stable surface exercise groups compared with the control group. For the OLST and TST, the mean values at 2 and 3 months were significantly better in the foam

| Table 3. Comparison of Physical Function Performance Tests Between the 3 Groups During the Intervention Period |
|-------------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Item                                            | Before the Intervention | After 1 mo | After 2 mos | After 3 mos | After 4 mos | F Value | Group |
|                                                 | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Time | Group |
| One-Leg Standing Test, s                        | Foam rubber exercise group | 4.9 (5.3) | 8.2 (7.5) | 11.5 (11.1) | 12.0 (11.8) | 12.0 (11.7) | 7.09** | 6.69** | 6.52** |
|                                                 | Stable surface exercise group | 4.7 (4.3) | 5.3 (5.2) | 5.3 (3.6) | 6.2 (5.4) | 6.9 (5.5) |             |             |             |
|                                                 | Control group | 5.6 (8.4) | 3.8 (5.2) | 3.3 (2.4) | 4.6 (4.7) | 4.2 (4.5) |             |             |             |
| Chair Standing Test, s                          | Foam rubber exercise group | 13.6 (4.2) | 12.5 (4.7) | 10.6 (2.7) | 10.3 (2.6) | 9.9 (2.8) | 10.67** | 5.24** | 5.47** |
|                                                 | Stable surface exercise group | 12.8 (5.2) | 12.5 (5.3) | 11.4 (3.0) | 11.2 (2.9) | 10.8 (3.1) |             |             |             |
|                                                 | Control group | 13.5 (3.1) | 13.7 (3.3) | 14.2 (4.2) | 14.0 (4.2) | 13.9 (3.9) |             |             |             |
| Timed Up-and-Go Test, s                        | Foam rubber exercise group | 13.6 (3.7) | 11.8 (2.9) | 11.3 (3.2) | 11.2 (2.6) | 11.3 (2.5) | 7.51** | 3.83* | 4.46** |
|                                                 | Stable surface exercise group | 13.9 (5.1) | 13.1 (4.7) | 12.7 (4.2) | 12.3 (3.8) | 12.1 (4.2) |             |             |             |
|                                                 | Control group | 14.0 (3.0) | 14.2 (3.6) | 14.8 (5.0) | 14.4 (4.8) | 14.6 (5.0) |             |             |             |
| Tandem-Stance Test, s                          | Foam rubber exercise group | 18.3 (13.4) | 27.4 (19.1) | 32.3 (19.6) | 35.6 (16.6) | 37.4 (17.6) | 18.76** | 6.04** | 6.74** |
|                                                 | Stable surface exercise group | 16.3 (17.1) | 19.3 (18.2) | 19.4 (17.2) | 23.8 (18.5) | 27.6 (20.1) |             |             |             |
|                                                 | Control group | 17.2 (17.7) | 15.8 (18.0) | 14.2 (16.2) | 16.9 (18.9) | 16.8 (19.2) |             |             |             |

Abbreviations: SD, standard deviation.

*Significant differences between the foam rubber exercise group and the control group.

Significant differences from preintervention (baseline).

Significant differences between the foam rubber and stable surface exercise groups.

Significant differences between the stable surface exercise group and the control group.

* $P < 0.05$; ** $P < 0.01$. 

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rubber exercise group than in the stable surface exercise group. Within the foam rubber exercise group, the OLST, TUGT, and TST, at 1 to 4 months, were significantly improved compared with before the intervention. Within the stable surface exercise group, the TUGT and TST, at 3 and 4 months, were significantly improved compared with before the intervention. These results suggest that balance training in older adults performed using a foam rubber pad is effective for improving balance ability, and that this improvement occurs 2 months earlier compared with balance training performed on a stable surface.

Previous studies reported that exercise performed on an unstable surface such as a balance board increased the sensitivity of muscle mechanoreceptors and facilitated the proprioceptive input to the spinal cord. McIlroy et al. showed that an increase in the afferent input from the cutaneous receptors in the soles of the feet acted to mediate the postural reflex when body sway increased on an unstable surface. Several studies have examined the relationship between Hoffmann reflex (H-reflex) modulation and postural stability. Researchers have reported that the amplitude of soleus H-reflex is depressed in relation to increased body sway during upright standing on a soft surface compared with that on a solid surface. The amplitude of soleus H-reflex modulation under such a condition was suggested to be predominately regulated by presynaptic inhibitory mechanisms that acted to prevent oversaturation of the spinal motoneurons. This inhibitory effect was suggested to alter the saturation of motoneuron excitability for receiving central descending commands. Taube et al. showed that the soleus H-reflex amplitude was down-modulated in parallel with improvement in balance control after balance training performed on a foam rubber pad, suggesting improvement in functional status resulting from more effective regulation of motor outputs.

From the above-mentioned studies, balance training performed on a foam rubber pad seems to lead to adaptations in the mechanisms regulating balance at supraspinal levels. In a study that was similar to the present study, Granacher et al. found that balance training performed on a foam rubber and stable surface influenced the postural reflex in older adults. Thus, previous research suggests that balance training performed using a foam rubber pad improves proprioception in the lower limbs and the sensitivity of the cutaneous receptors in the soles. These adaptations may explain why balance training performed using a foam rubber pad effectively improved balance in the present study. However, we acknowledge that we did not investigate the possible underlying mechanisms.

Regarding the CST, the mean values at 2 to 4 months in both the foam rubber and stable surface exercise groups were significantly better than those in the control group. There were no significant differences between the foam rubber and stable surface exercise groups. Previous studies reported that balance training improved lower extremity muscle strength as well as balance. The CST finding in the present study is consistent with these previous studies. Therefore, the results from our study suggest that a balance training program is effective for improving not only balance but also lower extremity muscle strength.

In the foam rubber exercise group, the mean value at 4 months for the FES scores was significantly improved compared with the control group. Fall-related emotional status, such as fear of falling or lack of confidence, is thought to be associated with poor functional performance and may be improved through increasing physical performance. This outcome was therefore secondary to improvements in physical function in this study. We suspect that once their physical function improved, participants in the foam rubber exercise group developed more confidence regarding falls.

Three (9.4%) of participants withdrew from the foam rubber exercise group, 2 (6.5%) of participants withdrew from the stable surface exercise group, and 2 (6.7%) of participants withdrew from the control group for the reasons previously noted. Of those participants who did not withdraw from the study, 95.5% and 93.8% of participants from the foam rubber and stable surface groups, respectively, completed all study exercises; 91.2% of participants in the control group participated in all of the day center’s weekly social activities. In addition, regarding the daily home-based exercise program, participants in the 2 exercise groups performed the exercises 3.5 (SD: 2.0) and 3.4 (SD: 2.3) days per week, respectively. There were no significant differences between the 3 groups in terms of study withdrawal and program adherence. From the above-mentioned results, we suggest that the balance training program was widely accepted by the participants and is safe and feasible as an ambulatory service provided at a day center.

In this current study, the balance training program on the foam rubber pad was likely to reduce the number of additional falls during the 4-month intervention ($P = 0.07$). A previous meta-analysis of fall prevention indicated that it took 6 or more months to reduce the actual number of falls significantly. Therefore, a longer-term intervention study may be required to show the effects of balance training using a foam rubber pad on fall prevention.

One limitation of the present study is that the same physical therapists assessed the participants and also conducted the intervention programs. Therefore, there is a possibility that our results were influenced by the physical therapists’ expertise and/or reporting bias at each day center. In addition, participants in the balance training groups may not have wanted to report the number of fall risk factors and FES to avoid disappointing their physical therapists. However, given the significant improvements in physical function observed in the balance training groups, participant attitudes seemed to have played a minimal role. In addition, the physical therapists who participated in...
the study received the same level of training from a senior physical therapist before initiating the trial, and the exercise program was videotaped to ensure consistency. We thus propose that the physical therapists’ expertise had a minimal effect on study results.

The balance training program used in this study had 10 different exercises. Gardner et al. reported that exercise programs should be simple, easily instituted, and provided at low cost if they are part of a public health program to be introduced widely in the community. We expect that a simpler training program than the one studied here may thus be accepted within the community. A previous study reported that performing a simply designed balance training program comprising 7 different exercises improved balance and fall rates. We recommend that future research investigates which exercises are most effective to provide a feasible program in the community.

CONCLUSIONS

Balance training performed by older adults using a foam rubber pad effectively improved balance ability and at a faster rate (2 months) compared with balance training on a stable surface. In addition, balance training improved lower extremity muscle strength and reduced participants’ fear of falling. These improvements required a fairly low time commitment of 1 day a week of structured exercise at the day center and a daily short exercise session at home. These findings suggest that balance training performed using a foam rubber pad would be widely accepted by day center clients, and would be beneficial to clients and service providers because the programs not only improve physical functioning but also reduce the number of exercise sessions. We propose that the use of a foam rubber pad in balance training is safe and feasible as an ambulatory service provided to older adults at a day center.

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