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Fall Incidence in Frail Older Women after Individualized Visual Feedback-Based Balance Training

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Key Words

Falls · Balance training · Frail elderly · Fear of falling · Randomized controlled trial

Abstract

Background: The knowledge concerning balance training actually lowering fall rates among frail older persons is limited. ***Objective:*** The aim of this study was to examine the effects of a 4-week individualized visual feedback-based balance training on the fall incidence during 1-year follow-up among frail older women living in residential care. ***Methods:*** Twenty-seven older women from 2 residential care homes were randomized into exercise (n = 20) and control (n = 7) groups. Balance measurements were carried out before and after a 4-week training period and falls were monitored by monthly diaries for 1 year. An interview about fear of falling and physical activity was completed before and after the intervention and after the 1-year follow-up. ***Results:*** A positive effect of balance training on fall incidence was found. A dynamic Poisson regression model showed that during the follow-up the monthly risk of falling was decreased in the exercise group compared to controls (risk ratio 0.398, 95% CI 0.174–0.911, p = 0.029). In addition, the exercise group reported a reduced fear of falling and increased physical activity after a training period but these changes declined during the follow-up period. ***Conclusion:*** Individualized visual feedback-based balance training was shown to be a promising method for fall prevention among frail older women. High compliance (97.5%) with the training program showed that carefully targeted training programs can be carried out among older people with health limitations.

Introduction

Fall accidents among elderly people are known contributors to the loss of independence and mortality. In Finland the fall incidence is threefold greater among older people living in institutions compared to people of the same age living in the community [1]. It is estimated that every other older adults living in residential care facilities and nursing homes, who fall annually, will do so more than once [2, 3]. Recurrent falls and impaired balance are among the most important risk factors for falls and thus should be addressed in fall prevention programs [4–8].

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Table 1. Characteristics of subjects at randomization (means ± SD or percentage)

Measure	Group		Significance p value*
	exercise group	control group	
Age, years	80.7 ± 6.1	82.9 ± 4.2	0.397
Height, cm	158.3 ± 6.1	162.1 ± 5.4	0.154
Weight, kg	69.8 ± 13.8	71.6 ± 14.1	0.773
Systolic BP, mm Hg	153 ± 25	150 ± 16	0.735
Diastolic BP, mm Hg	81 ± 21	89 ± 8	0.320
Number of chronic diseases	2.8 ± 1.4	2.1 ± 0.4	0.188
Number of prescription medications	5.2 ± 3.1	4.3 ± 2.7	0.492
Diagnoses			
Heart disease	9/20 (45%)	3/7 (43%)	1.0
Hypertension	7/20 (35%)	2/7 (29%)	1.0
Rheumatoid arthritis	4/20 (20%)	1/7 (14%)	1.0
Use of walking aid (stick, walker)	14/20 (70%)	4/7 (57%)	0.653
Falls in past 12 months	7/20 (35%)	2/7 (29%)	1.0
Physical activity			
Only ADL	1 (5%)		0.424
<3 h/week	4 (20%)	3 (43%)	
3–4 h/week	11 (55%)	4 (57%)	
>4 h/week	4 (20%)		

ADL = Activities of daily living.

* Student's t test for continuous variables; χ^2 or Fisher's exact test (two-tailed) for categorical variables.

Multidisciplinary fall prevention programs among older people have reported positive results in relation to fall rates [6, 9–11]. However, with multiple preventive co-interventions it is not possible to estimate the effectiveness of an individual prevention measure. Although several exercise interventions have reported improvements in fall risk factors such as balance, muscle strength, and gait speed, results are conflicting about exercise actually lowering the fall rates [12–17]. Strength and balance training interventions have resulted in lower fall rates, or less injurious falls, in community-dwelling older adults [6, 18–20], and some promising results have been found among frail older adults [15, 16]. In contrast, others have found that exercise programs have not reduced falls among older individuals in long-term care facilities [21–23].

Uncertainty also remains about the preferred content of exercise [24, 25]. The specific balance training methods have included force platform balance training, tai chi, progressive functional balance training and home-based balance exercises [13, 14, 19, 20, 26–29]. These studies have emphasized the importance of targeting exercises to subsystems involved in balance control and the need for individualized programs that can be adjusted according to the subject's capability. However, individually tailored balance training interventions among residents of long-term care are scarce and the effects on falling have not been reported [30, 31].

The purpose of this study was to investigate the effects of a 4-week individualized visual feedback-based balance training on the incidence of falls during a 1-year follow-up among frail elderly women living in residential care. In addition, possible changes in the fear of falling and in physical activity were examined.

Subjects and Methods

This study was carried out in 2 residential care homes for older people with 79 inhabitants (72 females, 7 males). All women received an invitation to attend a meeting at which the protocol of the study was explained to them. 44 women were present and 32 of them volunteered to participate in the study. The inclusion criteria were: age 70 years or over; ability to stand without a walking aid; ability to see visual feedback from a computer screen, and ability to follow instructions for testing and training. Four volunteers were excluded because of health problems at the initial stage (1 awaiting hip surgery, 1 acute illness, 2 dementia). Subjects (n = 28) were randomly assigned to an exercise group (EG, n = 20) or a control group (CG, n = 8). One person from the control group was hospitalized during the trial

because of an acute illness and had to be excluded from the study. Since the study was carried out in two separate places the randomization was done in blocks. Eligible women were randomized unequally to the EG and CG to protect the numbers in the EG, in anticipation of a greater drop out in the EG. Randomization was carried out by drawing lots. The study was approved by the ethics committee of the University of Jyväskylä, and written informed consent was obtained from all subjects.

Anthropometric measures included body height and weight assessed by conventional methods. Blood pressure was measured by a digital meter (Omron HEM-705C, Omron Corporation, Tokyo, Japan) while sitting and having rested for 5 min. A structured interview on health, use of medication, level of physical activity [32], and number of falls during the previous year was completed. Fear of falling was assessed by a question: 'Generally speaking are you afraid of falling?', and the alternatives for an answer were: (1) no; (2) yes, some, and (3) yes, a lot. The characteristics of the subjects are summarized in table 1. At baseline the study groups did not differ with respect to age, anthropometric characteristics or blood pressure. No significant differences between the groups with respect to chronic diseases, number of medications in use, use of walking aids, frequency of falling, and level of physical activity were observed.

Balance measurements for both groups were completed before and after the intervention. After training, follow-up of falls for 12 months was carried out by monthly diaries. Falls were defined as unintentional changes in position coming to the rest on the floor or ground. The subjects were instructed to complete diaries daily and return them by mail at the end of each month. Participants were contacted by phone if no diary was returned, it was incomplete, or if a subject reported a fall(s). Injurious falls were those resulting in medical treatment (hospitalization, emergency department visits, physician visits).

The outcome measures for balance included balance tests on a force platform (Good Balance, Metitur Oy, www.Metitur.com) and Berg Balance Scale. Balance training was carried out using computerized force platform with visual feedback (Good Balance). The members of the EG attended 20- to 30-min-long individualized specific balance exercise sessions 3 times a week for 4 weeks. A more detailed description of the balance tests and the content of exercises can be found in a previous article [33]. All women, both in the EG and CG, were told to continue their normal daily routines.

Statistics

The baseline differences between the EG and the CG were analyzed by Student's t tests for independent samples, and χ^2 tests and Fisher's exact tests for discrete variables. Friedman's tests were used to detect changes within groups in categorical variables. In order to study the monthly risk of falling, a dynamic Poisson regression model was constructed. For each subject, the 12-month follow-up time was divided into 1-month periods and, for each period, the number of falls as well as the values of covariates were recorded separately. The main covariate of interest was the balance training. Since the risk of falling was assumed to be dependent on the previous falls, two covariates describing the falling history of the subject were included in the model. Those were the occurrence of previous falls during the follow-up time and the occurrence of falls in the previous year. The logarithms of the average number of falls during a 1-month period were dynamically modeled by a linear predictor describing the subject's observed history up to the period under consideration. The parameters in the model could then be expressed as baseline risk and risk ratios describing the effects of respective dichotomous covariates. The estimates were derived using the SAS software package. For more details about similar dynamic modeling, see Alho et al. [34] and Oja et al. [35].

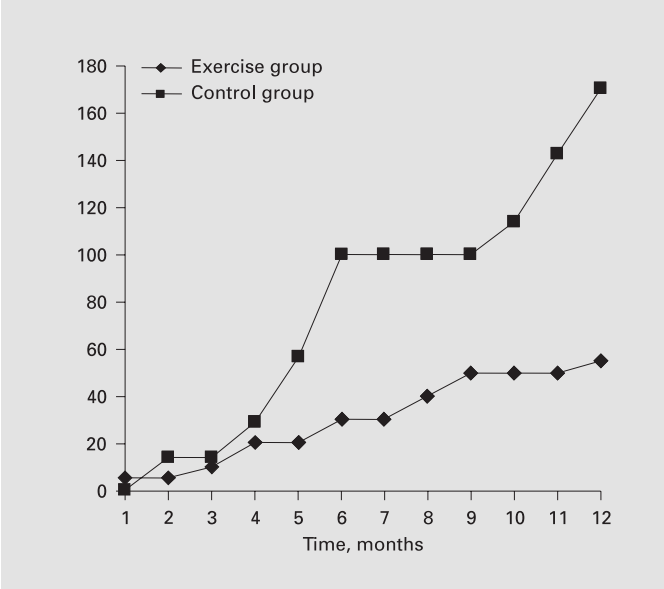

Fig. 1. The cumulative monthly incidence of falls in the exercise group and in the control group when all falls were included.

Results

Balance Performance and Fall Incidence

After training the EG showed improved balance control compared to the CG in the force platform balance tests and in the Berg Balance Scale as described in detail in a previous article [33]. During the 12-month follow-up time 55% (11/20) of the subjects in the EG and 71% (5/7) in the CG had fallen. Only 1 subject of the EG had 2 falls, whereas 3 subjects of the CG had recurrent falls. The total number of falls was 12 in the EG and 11 in the CG. The cumulative monthly fall incidence in both groups is shown in figure 1, describing the proportion of falls according to the number of subjects in a group. The value 100 means that there were 7 falls in the CG of 7 persons. The recurrent falls were significantly more common (Fisher's exact test, $p = 0.027$) in the CG (55%, 6/11) compared to the EG (8%, 1/12). In addition, the proportion of injurious falls was higher in the CG (36%, 4/11) compared to the EG (25%, 3/12), although no significant difference was found. The dynamic Poisson regression analysis

showed that the risk of fallingduring the 12-month follow-up was lower in the EG compared with the CG indicating that balance training had a significant preventive effect (table 2). It was also found that those women who had been falling during the 1 year follow-up time had a slightly increased but not significant risk of falling again compared to the others. Falls during the previous year before study did not have an effect on the risk of falling.

Physical Activity and Fear of Falling

The results of the weekly physical activity level and the rate of fear of falling at baseline, after training and at the 12-month follow-up are shown in table 3. After training the EG reported an increased level of physical activity compared to baseline. Measurements made after training also showed a decrease in the fear of falling in the EG compared to baseline. However, during the 12-month follow-up these changes declined. In the CG no significant changes compared to the baseline level of physical activity and rate of fear of falling were found.

Adherence to Training and the Follow-Up Period

The participation rate in the training program was high (97.5%).There were no drop outs during the training period and all participants started the 12-month follow-up. One subject was lost during the follow-up.

Table 2. Estimated risk ratios for monthly risk of falling obtained from the dynamic Poisson regression model

Explanatory variables	Risk ratio	95% CI	p
Balance training	0.398	0.174–0.911	0.029
Previous falls during the follow-up time	1.243	0.507–3.050	0.635
Falls in the previous year	0.942	0.387–2.297	0.896

Discussion

Our study is one of the first studies to show that specific balance training can significantly reduce the risk of falling in frail elderly women living in residential care facilities. Our results also indicate that the proportion of recurrent falls was significantly smaller in the EG compared to the CG. A trend the EG showing a smaller proportion of injurious falls compared to the CG was seen, although this difference did not reach statistical significance. Those women who had experienced a fall during 12-month follow-up had a slightly increased risk of falling again, whereas falls during the previous year did not have an effect on the risk of falling. This may be partly explained by the probable underreporting of falls retrospectively, implying that a similar bias is likely to be present in both groups. In addition, the EG reported decreased fear of falling and increased physical activity after the training period. It is assumed that since the physical activities included mainly domestic work, the

Table 3. Fear of falling and physical activity in the exercise group and the control group at baseline (before), after 4 weeks (after) and after 12 months (follow-up)

	Exercise group			Control group		
	before	after	follow-up	before	after	follow-up
Fear of falling						
No fear	7 (35%)	12 (60%)[a]	7 (37%)	2 (29%)	1 (14%)	1 (14%)
Some fear	8 (40%)	6 (30%)[a]	10 (53%)	4 (57%)	5 (72%)	4 (57%)
High fear	5 (25%)	2 (10%)[a]	2 (10%)	1 (14%)	1 (14%)	2 (29%)
Physical activity						
Only ADL	1 (5%)		1 (5%)		1 (14%)	2 (29%)
<3 h/week	4 (20%)	1 (5%)[b]	2 (11%)	3 (43%)	3 (43%)	4 (57%)
3–4 h/week	11 (55%)	10 (55%)[b]	12 (63%)	4 (57%)	3 (43%)	1 (14%)
>4 h/week	4 (20%)	9 (45%)[b]	4 (21%)			

ADL = Activities of daily living.

The number of subjects is given with percentages in parentheses. The change within groups was tested by Friedman's test.

[a] p = 0.020.

[b] p = 0.004.

increase may not account for the decreased risk of falling.

Only a few other studies have suggested partly positive results of training interventions on fall prevention among frail elderly people. Rubenstein et al. [15] showed that in fall-prone men combined strength and balance training reduced the activity-adjusted fall rates, but unadjusted fall rates were not significantly reduced. A 3-month program combining resistance, balance and functional training among geriatric patients with a history of injurious falls reported that the incidence of falls was reduced in the intervention group compared to the control group, but statistical significance was not reached [16]. In these studies the follow-up period for falls was 3 months which may make it difficult to demonstrate positive results. Studies not successful in reducing falls in frail elderly people have suggested that high drop-out rates, low adherence to the exercise programs, and the need for more intense individually tailored training programs could be the reasons for failing to show positive effects [22, 23].

Some earlier balance training interventions have shown a reduced risk of falling and reduced risk of multiple falls in community-dwelling older adults using specific balance training methods [13, 28, 36]. According to Hu and Woollacott [28] short-term balance training focusing on improving the organization of sensory information related to postural control showed that an EG had fewer falls during balance testing compared with a CG. However, falls in the natural environment were not studied. In the study by Wolf et al. [13] tai chi training was found to reduce recurrent falling, whereas computerized balance training was not found to be effective. What may have accounted for the different findings was the variation in training schedules. Shumway-Cook et al. [36] reported a reduction in the risk of falls using an individualized multidimensional exercise program. A limitation of this study was that the subjects were not randomized and the actual frequency of falls was not studied.

The specific balance training method used in our study proved to be easily adjusted to the health limitations of the group. By computerized balance training, individual adjustment of exercises was easy to do and continuous progression could be maintained. Furthermore, new equipment seemed to motivate older women and their adherence rate throughout the program remained high. We showed that frail elderly women improved their balance performance during a 4-week individualized visual feedback-based balance training [33]. Likewise, other recent studies have reported the positive effects of individualized short-term balance training among older adults with balance deficits [27, 30, 31]. In studies in which training was specifically focussed on the subsystems involved in balance control, improved selection of motor strategies, enhanced sensory integration and alterations in neuromuscular behavior have been suggested as possible mechanisms causing changes in balance control [27–30, 33]. Although individualized specifically targeted training may seem to demand high resources, positive effects can be achieved in a short period of time.

Training induced a reduction in the fear of falling, and an increase in the level of physical activity compared to baseline was seen. After training was finished these changes declined during the 12-month follow-up. This may show a typical relationship between fear of falling and physical activity. A person who is afraid of falling may restrict her activities, making her frailer which in turn increases the fear of falling. It has been suggested that in mobile, nursing home patients the fear falling was an important predictor of functional decline [37]. Individualized balance training may help persons to identify their own capabilities and limitations and thus help them to overcome fear. In accordance, few other studies have shown a reduced fear of falling after balance training [16, 36]. Apparently, a decrease in fear of falling demands the ability to restore a person's confidence in her mobility. A more detailed questionnaire on fear of falling might have given more information about the changes during the study. Although the relatively small sample size may limit generalization of our results, we showed that frail elderly people can benefit from a carefully targeted training program leading to balance improvements and a reduced incidence of falls.

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