Combined resistance and balance-jumping exercise reduces older women’s injurious falls and fractures: 5-year follow-up study

Saija Karinkanta1, Pekka Kannus1,2, Kirsti Uusi-Rasi1, Ari Heinonen3, Harri Sievänen1

1The UKK Institute for Health Promotion Research, Tampere 33501, Finland
2Medical School, University of Tampere, and Department of Orthopaedics and Trauma Surgery, Tampere University Hospital, Tampere, Finland
3Department of Health Sciences, University of Jyvaskyla, Jyvaskyla, Finland

Address correspondence to: S. Karinkanta. Tel: (+358) 32829111. Email: saija.karinkanta@uta.fi

Abstract

Background and objective: previously, a randomised controlled exercise intervention study (RCT) showed that combined resistance and balance-jumping training (COMB) improved physical functioning and bone strength. The purpose of this follow-up study was to assess whether this exercise intervention had long-lasting effects in reducing injurious falls and fractures.

Design: five-year health-care register-based follow-up study after a 1-year, four-arm RCT.

Setting: community-dwelling older women in Finland.

Subjects: one hundred and forty-five of the original 149 RCT participants; women aged 70–78 years at the beginning.

Methods: participants’ health-care visits were collected from computerised patient register. An injurious fall was defined as an event in which the subject contacted the health-care professionals or was taken to a hospital, due to a fall. The rate of injured fallers was assessed by Cox proportional hazards model (hazard ratio, HR), and the rate of injurious falls and fractures by Poisson regression (risk ratio, RR).

Results: eighty-one injurious falls including 26 fractures occurred during the follow-up. The rate of injured fallers was 62% lower in COMB group compared with the controls (HR 0.38, 95% CI 0.17 to 0.85). In addition, COMB group had 51% less injurious falls (RR 0.49, 95% CI 0.25 to 0.98) and 74% less fractures (RR 0.26, 95% CI 0.07 to 0.97).

Conclusions: home-dwelling older women who participated in a 12-month intensive multi-component exercise training showed a reduced incidence for injurious falls during 5-year post-intervention period. Reduction in fractures was also evident. These long-term effects need to be confirmed in future studies.

Keywords: exercise, injurious falls, fractures, older adults

Introduction

Fall-related injuries of older adults cause a lot of suffering and costs [1, 2]. Every third older adult aged 65 years or older falls each year, and half of them do so repeatedly [3]. It has been estimated that 22–45% of fallers sustain some injuries, and every tenth fall leads to a severe injury such as fracture or head injury [4–6]. Injurious falls and fractures predispose older adults to long-lasting functional decline and need for long-term care [7, 8]. Furthermore, a hip fracture increases the risk for other fractures and death [9–11].

Many risk factors for falls and fall-induced injuries are related to physical inactivity and decreased functional capacity, and also to bone fragility. All these can be modified by physical activity [12]. Many epidemiological studies show the association between physical activity and reduced fracture risk [13–17]. Some studies, however, suggest that physical activity, especially frequent walking, may increase older adults’ fracture risk—probably due to increased exposure to fall hazards [18–20]. Analysis of over 75,000 person-years at risk showed that physical activity decreased non-vertebral fracture risk at the weight-bearing skeleton but not at the non-weight-bearing sites.
(e.g. wrist) in adults aged 55 years or older [16]. Interestingly, Cauley et al. [15] showed that high physical activity decreased oldest-old (≥80 years) men’s fall risk but increased it in the young-old men, while decreased fracture risk in both groups. This may reflect the role of good physical condition in preventing injuries when falling—not falling per se.

A recent meta-analysis of randomised, controlled trials (RCTs) suggests exercise training as the single most effective intervention to prevent falls among community-dwelling older adults [21]. Typically the successful interventions have included both muscle strength and balance exercises in older adults with increased risk of falling [22, 23]. Much less is known about the effectiveness of exercise in preventing injurious falls or fractures.

Our four-arm exercise RCT (the KAAMU Study) showed that 12-month combined resistance and balance-jumping training (COMB) prevented functional decline and bone fragility in older home-dwelling women by improving physical performance, physical functioning and bone strength [24]. One year after the intervention, some benefits were still evident [25]. The purpose of this 5-year follow-up study was to assess whether this exercise intervention had long-lasting effects in reducing older women's injurious falls and fractures.

Methods

A 5-year hospital computerised patient register (the Pegasos patient information system, CGI, Finland) follow-up was conducted for all women who participated in the KAAMU Study.

Multi-component exercise reduces injurious falls

Participants

Initially, 149 women participated in the KAAMU Study, and they were randomly allocated to four groups: resistance training (RES), balance-jumping training (BAL), COMB and non-training control group (CON) (Figure 1) [24]. At baseline, the women were 70–78 years old and lived independently in their homes in the city of Tampere, Finland. They were mostly sedentary or participated in moderate intensity exercise at most twice a week. In addition, they had no medical contraindications to moderate-to-high intensity exercise, and their DXA-based T-score of the femoral neck was greater than −2.5, indicating no osteoporosis.

In all the exercise groups, supervised training was done three times a week for 12 months. The intensity of the training was set to moderate to high after a 6-week familiarisation period. The CON group participants were asked to maintain their pre-study level of physical activity. The details of the participation, measurements and the results have been published previously [24–26].

Current data collection and outcome measures

The original KAAMU Study intervention started in June (n = 68) and October (n = 81) 2002, and ended in respective months in 2003. In the present KAAMU5 study, after the pre-planned follow-up period of 5 years, participants’ healthcare visits between the end of the intervention and the end of the year 2008 were scrutinised using the Pegasos patient information system (CGI, Finland). In Finland, almost free of cost public health care is provided to all inhabitants and practically all older adults receive health care via this system.

![Figure 1. Study profile.](image-url)
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For this KAAMU5 study, an injurious fall was defined as an event in which the subject contacted the health-care provider (a nurse or a doctor) or was taken to hospital due to a fall; that is, falling was mentioned in the patient file text written by the health-care professional(s). An injured faller was defined as a person who had at least one injurious fall during the 5-year follow-up. The same researcher (S.K.) examined all the patient files and recorded the injurious fall events. The information concerning the original study group assignment was added to the database after all injurious falls were recorded. Of all 149 women in the original KAAMU Study, the register-based follow-up information was obtained from 145 women (97%) (Figure 1).

The primary outcome was the rate of injured fallers during the 5-year follow-up period. In addition, the rate of injurious falls and fall-induced fractures was analysed as secondary outcome.

The studies were approved by the Ethics Committee of the Pirkanmaa Hospital District (ETL-codes: R02010 and R08125). The use of the Pegasos register data was further approved by the Department of Social Services and Health Care of the city of Tampere.

Statistical analysis

The rate of injured fallers in the original intervention groups was assessed by Cox proportional hazards model, and the Kaplan–Meier method was used for estimating the survival curves. The Poisson regression model with log-linear link function was used to analyse the rates of all injurious falls and fall-induced fractures. Age at the beginning of the follow-up period was used as a covariate in all analyses.

The rate of injured fallers by training groups are presented as hazard ratios (HR) and rates of injurious falls and fractures by training groups as risk ratios (RR) using the control group as a reference group. The 95% confidence intervals (CI) were calculated for all ratios.

SPSS 20 statistical software was used for all statistical analyses. P values were two-sided, and those <0.05 were considered statistically significant.

Results

The follow-up data comprised 746.7 person-years, and the mean follow-up time was 5.1 years (Table 1). During the follow-up period, seven women (5%) died (one in RES, and two in BAL, COMB and CON groups each) and one woman (from BAL group) moved to long-term institutional care.

Eighty-one injurious falls were recorded in 61 (42%) women, and the majority (77%) of the injured fallers sustained a single injurious fall. Eleven women (18%) had two injurious falls and three women (5%) had three or more. Among the intervention groups, CON group showed the largest (49%) and COMB group the smallest (30%) proportion of injured fallers. In addition, incidence of injurious falls was the highest in RES group and the lowest in COMB group (Table 1).

Fall-induced injuries are compiled in Supplementary data, Appendix 1, available in Age and Ageing online. Altogether there were 26 fractures. The highest fracture incidence was seen in CON group (5.0 per 100 person-years) and the lowest in COMB group (1.6 per 100 person-years).

Risk for injurious falling

The Cox model showed a 62% lower rate of injured fallers in COMB group compared with CON group (HR 0.38; 95% CI 0.17 to 0.85) (Table 1). Kaplan–Meier survival curves for the first injurious fall in each group are illustrated in Figure 2. The injury-protecting effect of COMB training started early and lasted to the end of the follow-up.

Based on the Poisson regression analysis, COMB group had 51% lower risk for injurious falls (RR 0.49; 95% CI 0.25 to 0.98) and 74% lower risk for fractures (RR 0.26; 0.07, 0.97) than CON group (Table 1).

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<tr>
<th>Table 1. Descriptive data, HR, RR and their 95% confidence intervals of injured fallers, injurious falls and fractures by groups</th>
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<tr>
<td><strong>RES (n = 37)</strong></td>
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<td>Age at the beginning of the follow-up (mean and range)</td>
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<td>Injurious falls, incidence</td>
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<td>Injurious falls, RR</td>
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<td>Fractures, RR</td>
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RES, resistance training group; BAL, balance-jumping training group; COMB, combination training group; CON, control group; Ref., reference group.
Multi-component exercise reduces injurious falls

This 5-year follow-up of a 12-month exercise RCT among home-dwelling 70- to 78-year-old Finnish women showed a significant reduction in the rate of injured fallers, injurious falls and fractures in the COMB group. Women in this group had 51% less injurious falls and 74% less fractures. Furthermore, over 70% of the women in combination training group survived 5 years without an injurious fall, whereas less than half of the control women achieved this.

Previously, home-based balance and strength training (the OTAGO programme) has been shown to be effective in reducing injurious falls in persons aged 80 years or older but not in younger age groups [22, 23]. There are some differences between the OTAGO studies and our study. The intensity of our training was somewhat higher than that of the OTAGO programme since our programme included progressive RES in the gym (from 50 to 80% of 1RM) and various jumping exercises. Our follow-up was also longer, lasting up to 5 years after the end of the intervention. In addition, since our data were based on health-care registers, only the moderate and severe injuries requiring a health-care visit were included in the analysis.

Recent meta-analysis of 17 exercise RCTs of older people showed that interventions targeted to prevent falls were also effective in reducing injurious falls [27]. Moreover, the protective effect seemed more evident for the most severe fall-related injuries. A majority of the included studies were based on multi-component exercise training programmes, including typically both balance and muscle strengthening exercises, and are thus well in line with prior evidence concerning fall prevention by exercise [21]. However, the duration of interventions varied a lot between the studies: from 5.5 weeks to 18 months. Furthermore, the follow-up period for recording falls data was mainly restricted to the intervention period or for a short follow-up period thereafter (at most 18 months). Thus, based on the current scientific evidence, it is impossible to conclude whether exercise has any long-term falls preventive effects.

Our study suggests that intensive multi-component training has long-lasting positive effects on factors that protect older women from injurious falls. Apparently one such factor is good physical functioning. During the 12-month exercise intervention, the women who participated in our combination training improved their muscle strength, balance and agility, self-rated physical functioning, and bone strength, despite the rather good level of functioning already at the baseline [24]. The exercisers also rated their general health better after the intervention [26].

It may be questioned how long these exercise effects are likely to last. We assessed the participants’ physical performance and bone strength 1 year after the end of the intervention and found that about half the benefits achieved were still seen in balance, agility and bone strength in the combination training group (compared to controls). Instead, most of exercise benefits had disappeared in the pure RES and BAL groups [25]. Thus, at least during the first follow-up year, the women who had participated in the combination training group had better balance and stronger bones than the control women. Moreover, when examining the survival curve for the first injurious fall, the group differences were evident already at 12 months, favouring the combination group. However, it is not known how the group differences in balance and bone developed during the 5-year follow-up.

Another fall- and injury-protecting factor of our intervention might be motivational. During the 5-year follow-up, exercisers may have increased activities that were important in preventing injurious falls. On the other hand, we did not find any clear group differences in overall physical activity 1 year after the exercise intervention [25]. This does not, however, exclude the possibility that group differences in amount or intensity of physical activity may have occurred afterwards.

In addition to better neuromuscular functioning and increased physical activity, also other factors, such as changes in health status and medication, or psychosocial behaviour and status (e.g. fear of falling, cognitive disorders, depression and anxiety) may have modulated the group differences in rates of injurious falls. It seems, however, implausible that the systematic decrease seen in rates of injured fallers and injurious falls in the combination training women was only a coincidence and not related to the multi-component nature of the exercise intervention conducted. Moreover, these rates showed a logical, but statistically non-significant, beneficial trend in all exercise groups. A relatively small sample size per group limits these extended conclusions, however.
One important type of fall injuries is fractures. It is noteworthy that despite a clear association with bone fragility, a majority of hip and wrist fractures, and a third of vertebral fractures are caused by a fall-induced impact [12]. Consequently, exercise training has particular potential to prevent fractures in advanced age because of its notable effects on many risk factors related to both falling and bone fragility [12]. Recently, Kemmler et al. [28] included 10 controlled studies and El-Khoury et al. [27] 6 RCTs in their meta-analyses concerning fracture prevention by exercise. Exercise seemed to reduce the fracture risk by 51 and 61%, respectively [27, 28]. Since fractures were not reported as primary outcomes, the risk for publication bias was high and somewhat weakened the reliability of these meta-analyses. Our results, however, are well in line with these: the multi-component exercise reduced overall fracture risk 74%.

Our study has several strengths. First, this prospective follow-up study was based on a well-conducted RCT with significant improvements in physical functioning and bone strength. Second, our follow-up time was 5 years after the end of the intervention, and the analysis was based on both intention-to-treat principle and register-based confirmation of the injuries. Very often, falls and injuries have been registered during the exercise intervention only, and injurious falls have been based on self-reported or recalled data only. Finally, we were able to follow up 97% of the original 149 RCT participants, which increases the reliability of the results considerably.

Our study also has some limitations. First, it is possible that some injurious falls have been missed, because the fall may have occurred elsewhere from the home city and thus not registered to the local Pegasos system. On the other hand, if a severe injury had been treated in another hospital, the aftercare would have been in the local hospital or health-care centre and the injury would have been recorded anyway. Second, our follow-up method did not allow recording of non-injurious falls of the participants. Thus, the general incidence of falling in each group during the 5-year follow-up remained unknown. Third, lack of information concerning participants’ physical activity, physical functioning, co-morbidities and medication use during the 5-year follow-up limits the further examination of the cause-effect relationship between the intervention and outcome. Finally, our study did not include older men and thus the results concerned home-dwelling, independently living women only. In fact, women are more likely to fall and sustain injurious falls than men [29]. Judged from the similar associations between physical activity and fractures in men and women [13, 14, 17], there is no apparent reason to expect that exercise benefits would be essentially different among men.

In conclusion, a feasible training programme that includes muscle strength, balance and jumping exercises reduces older women’s risk for injurious falls and fractures for several years. However, future confirmatory studies are needed before such a multi-component exercise programme can be widely recommended for home-dwelling older women.

Key points
- Multi-component training includes muscle strength, balance and jumping exercises.
- One-year intensive multi-component exercise can reduce injurious falls for years in home-dwelling older women.
- Multi-component exercise may also reduce fractures.
- Multi-component exercise is recommended for home-dwelling older adults to prevent functional decline and fall-induced injuries.

Conflicts of interest
None declared.

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Supplementary data
Supplementary data mentioned in the text are available to subscribers in Age and Ageing online.

References
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