Osteoporos Int (2002) 13:42–47

Osteoporosis International

Original Article

Recent Decline in Heavy Outdoor Work Activity Predicts Occurrence of Fractures among the Home-Dwelling Elderly

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Abstract. The contribution of reduced physical activity of a defined duration to the risk of fall-related fractures and serious soft tissue injuries is not known. We conducted a prospective population-based study among the home-dwelling elderly to examine the association between a recent decline in physical activity and the occurrence of fall-related fractures and soft tissue injuries. The study population consisted of representative sample of home-dwelling older adults who conducted heavy outdoor work activity at least once a week at baseline (n = 284; 136 men, 148 women) and among whom in 93 persons (33%) heavy outdoor work activity was found to have declined during the 2½ years follow-up. Fall-related fractures (n = 24) and serious soft tissue injuries (n = 49) were recorded from the time of the follow-up examination until the end of a further follow-up period lasting 3½ years on average. A decline in heavy outdoor work activity did not predict the occurrence of soft tissue injuries (Mantel–Cox 0.795, p = 0.373), but a greater proportion of those with a decline (n = 14, 15%) than of others (n = 10, 5%) suffered fractures (Mantel–Cox 10.231, p = 0.001). Other risk factors for fractures were female sex (p = 0.03), slow choice reaction time (p = 0.02) and dependency as regards at least one basic activity of daily living (p = 0.01). According to the Cox proportional hazard model, the adjusted hazard ratio of fracture as regards a decline in heavy outdoor work activity was 2.7 (95% CI 1.14–6.62). A recent decline in heavy outdoor work activity predicts the occurrence of fractures, but not the occurrence of serious soft tissue injuries. Early recognition of a decline in physical activity may help in prevention of fractures among the elderly.

Keywords: Accidental falls; Aged; Fractures; Physical activity

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Introduction

The relationship between physical activity and the occurrence of falls in the elderly is complex: both high and low physical activity levels may result in an increased frequency of falls [1]. In general, moderate physical activity appears to be favorable as regards bone strength, as low physical activity increases the risk of hip fracture, and high past physical activity and recent moderate physical activity are protective in this regard [2–6]. As a minor exception to this, high levels of physical activity may increase the risk of ankle fracture in older women [7]. The nature of the physical activity does not necessarily play a key role in achieving favorable effects, as both occupational and recreational physical activity are associated with a reduced incidence of fractures in the weight-bearing skeleton [8].

Despite these positive effects of physical activity, evidence from randomized clinical trials regarding effective prevention of injurious falls and fractures is very limited [9–11]. Variation in the time spent in a sedentary lifestyle may be one factor contributing to this

difficulty in showing the beneficial effect of physical activity. The chance of re-establishing a normal activity status obviously decreases as the length of time spent in a sedentary lifestyle increases. Unfortunately, very little is known about the changes in the risks of falling and fracture soon after normal physical activity has first decreased. Therefore, we conducted a prospective population-based study among the home-dwelling elderly to examine the association between a recent decline in physical activity, and injurious falls. Fractures and other serious falling injuries were analyzed separately.

Materials and Methods

Study Population

The target population consisted of all home-dwellers born in 1920 or earlier and living in the five rural municipalities around the city of Oulu in Northern Finland on September 1, 1991 (n = 969; 377 men, 592 women) (Fig. 1). Information on deaths or moves to other districts was gathered from the official population register of Finland. Information about those moving to long-term institutionalized care during the study period was obtained from the facilities providing long-term care in the study area.

There were 825 persons (317 men, 508 women) participating in the recording of falls and in the baseline examination. A total of 595 persons (87% of those living and who had participated in the baseline examination; 214 men, 381 women) participated in the 2.5 year follow-up examination. The final study population consisted of the home-dwellers who had participated in the baseline and follow-up examinations and who engaged in heavy outdoor work activity at least once a week at baseline (n = 284; 136 men, 148 women). The participants with low physical activity at baseline were excluded (n = 311). The study protocol was approved by the institutional ethics committee, and informed consent was obtained before interviewing the patients.

Data Collection

The baseline examinations were performed from September 1, 1991 to February 29, 1992 by a physician, a physiotherapist and two nurses. The 2.5 year follow-up examinations were carried out by two nurses from April 26, 1994 to September 7, 1994.

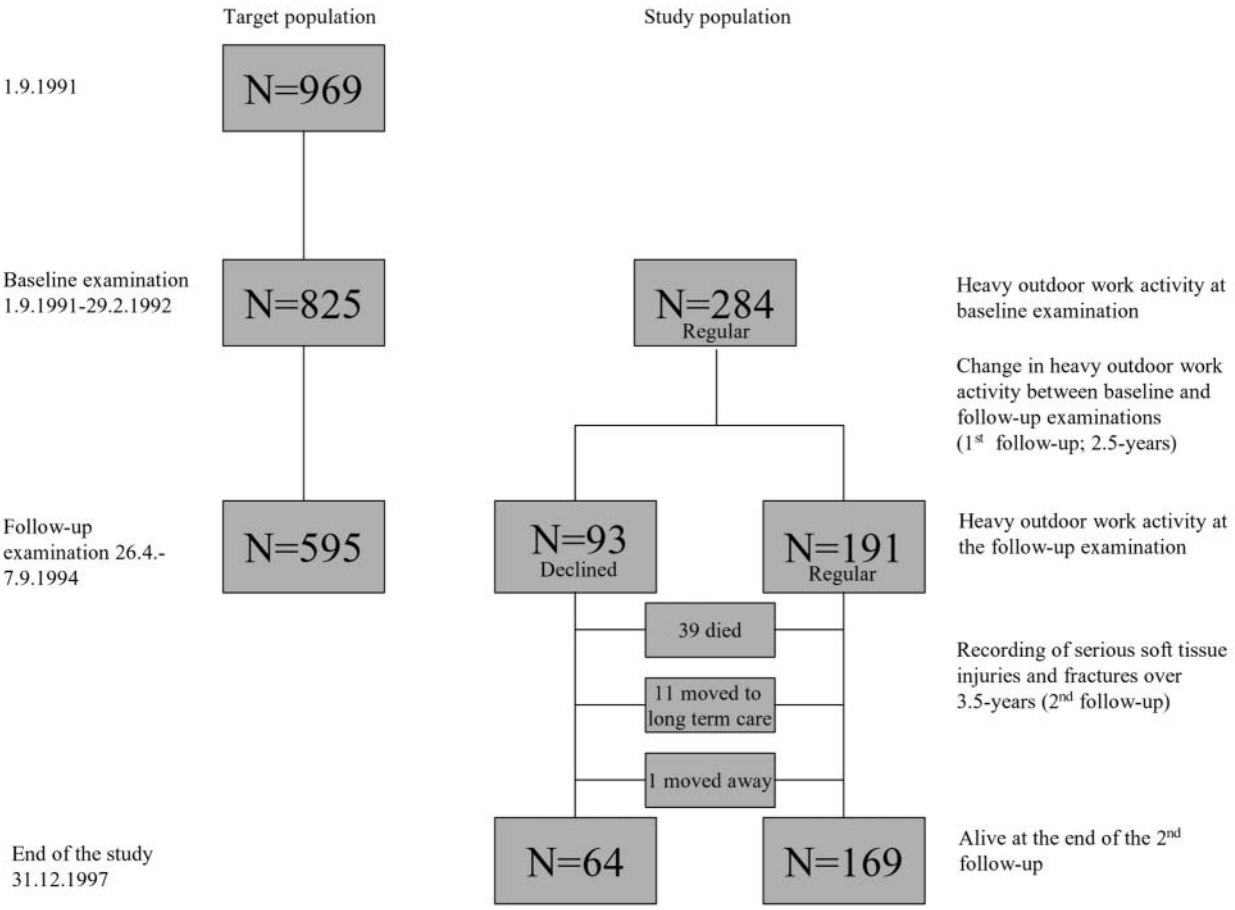

Fig. 1. Formation of the study population.

The main variable of interest was physical activity. It was assessed as heavy outdoor work activity, such as gardening or other heavy outdoor work, done at the time of inquiries. The frequency of heavy outdoor work activity was assessed by the question 'How often do you do heavy outdoor work nowadays?' The answer alternatives were: 1, never; 2, less than once a week; 3, once a week; and 4, daily. The study population consisted of those who at baseline performed heavy outdoor work activity at least once a week (regular heavy outdoor work activity, n = 284). They were similarly classified at the 2.5 year follow-up examination and those who had reduced heavy outdoor work activity from regular to none or less frequent than once a week ($n = 93$) belonged to the group who showed a decline in physical activity. Those who performed heavy outdoor work activity at least once a week or daily at the 2.5 year follow-up examination (n = 191) belonged to the group of regular physical activity.

Data concerning other risk factors for fractures and serious soft tissue injuries were collected by means of questionnaires, interviews and clinical tests.

The following variables were measured in 1991 and 1994. Functional abilities were assessed by five variables regarding activities of daily living (ability to use the lavatory, to wash and bathe, to dress and undress, to get in and out of bed and to eat). For the risk factor analyses, the participants were classified according to their independence in the activities of daily living (dependent/independent).

Chronic health disorders and the use of medication were recorded by the examining physician from the comprehensive medical records of the health centers. The participants were asked to bring their prescriptions and drug packages to the examination for additional information about current medication.

Cognitive status was assessed by a trained nurse, using the Mini-Mental State Examination (MMSE) test. We used its shortened version (sMMSE; variation of sum index 0 to 25). Depressive symptoms were recorded in the questionnaire, using the short version of the Zung Self-Rating Scale (variation of sum index 10–40) [12].

Fear of falling (never, sometimes, frequently, always) was asked in the questionnaire. The amount of recreational activity was assessed by asking the question 'Which of the following alternatives corresponds to your recreational activities nowadays?': 1, I have no recreational activities; 2, I practice recreational activities such as walking once or twice a week; 3, I practice recreational activities such as walking several times a week; 4, I practice recreational activities inducing sweat once or twice a week; 5, I practice recreational activities inducing sweat several times a week; and 6, I practice recreational activities such as competition sports several times a week.

Weight (kg) in light clothing and height (cm) was measured by the nurse. Body mass index (BMI, kg/m^2) was calculated from these values.

The following variables were measured only in 1991: visual acuity (poor if better eye $\leqslant 0.3$); choice reaction time in the better upper extremity, using a modified Digitest 1000 system (Digitest Oy, Muurame, Finland); peak expiratory flow (PEF, l/min) measured using a Mini Wright meter (Airmed, Harlow, UK); clinical knee extension strength, graded as normal (sufficient for normal instrumental activities and gait) or abnormal; walking speed (m/s) measured as the time spent in walking 10 m.

Recording and Definition of Falls and Injuries

Recording of falls and collection of data have been described in detail previously [13,14]. For this study, falls were recorded from the 2.5 year follow-up examination until a move to long-term care, a move away from the study area, death or until the end of the second follow-up period (December 31, 1997; 3½ years on average). Recording of falls was carried out by telephone calls every 3 months and by examining the medical records at the health centers and hospitals of the study area annually. Details of each fall were determined by a research assistant in telephone interviews and after discussion with one of the researchers.

A fall was defined according to the ninth revision of the International Classification of Diseases (ICD-9, 1987; E880A–E889A) as an unexpected event when the person fell to the ground from a higher level or from the same level. Thus, falls on stairs and on a piece of furniture were included, but a fall from a bicycle or a fall caused by a motor vehicle were not.

A serious injurious fall was defined as a fall leading to fracture, joint dislocation, a wound requiring suturing or other severe soft tissue injury [13,15].

Statistical Analyses

Soft tissue injury and fracture distributions in time were estimated using the Kaplan–Meier estimator, and the test was based on the Cox–Mantel procedure. Cox proportional hazard models were used to analyze times to the first injuries, and the results are presented as hazard ratios (HRs) with 95% confidence intervals (CIs).

To determine risk factors for fractures and serious soft tissue injuries, the measurements taken in 1991 and 1994 were used. If the variable was measured on both occasions the latter one was used in the analyses. When the risk factors for serious soft tissue injury were determined, participants who sustained a fracture due to a fall were excluded from the analyses. Continuous variables were dichotomized, using 1 standard deviation below (BMI, peak expiratory flow, walking speed) or over the mean (choice reaction time) as the cut-off point. Statistical analyses were carried out by Cox modeling. Variables showing a statistical significance of at least $p < 0.05$ were included in the proportional hazards models to analyze the simultaneous dependence of the risk factors for fractures and serious soft tissue injuries with regard to a decline in heavy outdoor work activity.

Results

In 1994 the mean age of the women (n = 148) was 78.0 (SD 4.3) years, and that of the men (n = 136) 77.1 (SD 4.1) years. The great majority of the participants (94%) were able to manage the activities of daily living without help. Eighty-six percent of the participants carried out recreational activities, 19% of the participants used some form of psychotropic medication, and 12% scored less than 20 points in the sMMSE. A regular frequency of heavy outdoor work activity was maintained by 191 (67%) persons and it declined in 93 persons (33%).

The sites of fractures are presented in Table 1. Altogether, 24 (8%) persons sustained a fracture due to a fall during the second (3.5 year) follow-up period. When the participants with fractures were excluded, 49 (19%) persons suffered a serious soft tissue injury during this time.

According to Kaplan–Meier analysis, serious soft tissue injury distributions did not differ between the persons who showed a decline in (n = 16, 20%) or maintenance of (n = 33, 18%) regular heavy outdoor work activity (Mantel–Cox 0.795, p = 0.373) (Fig. 2), the unadjusted hazard ratio for serious soft tissue injury as regards a decline being 1.3 (95% CI 0.72–2.38).

Table 1. Sites of fractures (n = 24) during the follow-up period

Site	No.	%
Hip	8	33
Rib	4	17
Humerus	3	13
Wrist	3	13
Metacarpal	2	8
Carpal	1	4
Patella	1	4
Vertebra	1	4
Shaft of femur	1	4

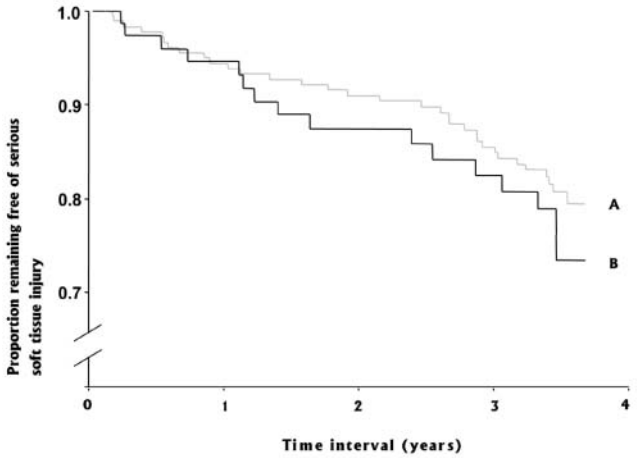

Fig. 2. Kaplan–Meier curves for serious soft tissue injuries. Curve A represents the elderly with regular heavy outdoor work activity (n = 181) and curve B represents the elderly with decreased heavy outdoor work activity (n = 79). Participants with fracture outcome were excluded from the analysis.

A significantly greater proportion of the home-dwellers with a decline (n = 14, 15%) versus those who maintained normal heavy outdoor work activity (n = 10, 5%) suffered fractures (Mantel–Cox 10.231, p = 0.001) (Fig. 3), the unadjusted hazard ratio for fractures as regards a decline being 3.5 (95% CI 1.54–7.82).

Other variables associated with an increased risk of fracture were female sex (p = 0.03), slow choice reaction time (measured in 1991; p = 0.02) and dependency as regards at least one basic activity of daily living (measured in 1994; p = 0.01) (Table 2). These variables, along with age and the status of heavy outdoor work activity, were entered in the Cox proportional hazard model.

The adjusted hazard ratio of fracture as regards a decline in heavy outdoor work activity was 2.7 (95% CI 1.14–6.62) (Table 3).

To explore the rather surprising finding that a decline in heavy outdoor work was associated with an increased risk of fracture but not with serious soft tissue injury, we examined the risk of a fall as regards a previous decline in heavy outdoor work activity. According to Kaplan–Meier analysis, the risk of a fall was significantly higher among the home-dwellers who showed a decline in heavy outdoor work (n = 57, 61%) compared with those who maintained normal heavy outdoor work activity (n = 106, 55%) (Mantel–Cox 4.530, p = 0.033). After excluding the participants with fracture outcome from the data, there was no difference in the risk of a fall as regards a decline in heavy outdoor work activity (Mantel-Cox 1.943, p = 0.1633). To further analyze the effect of falls on the risk of fracture we added the total number of falls between follow-up examination and the occurrence of the fracture in the final proportional hazard model. The adjusted hazard ratio of fracture as regards a decline in heavy outdoor work remained unchanged (HR 2.7, 95% CI 1.10–6.43).

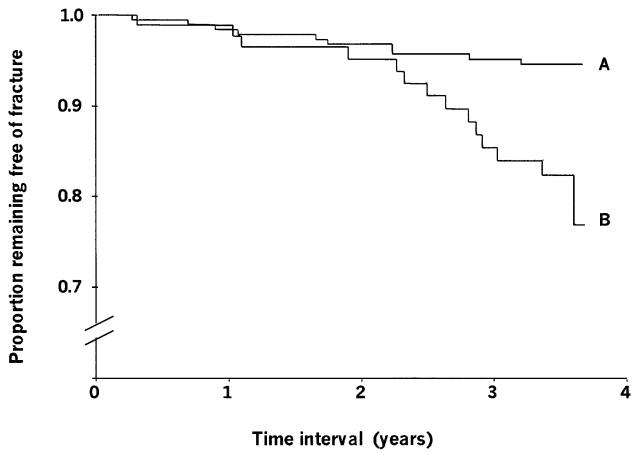

Fig. 3. Kaplan–Meier curves for fractures. Curve A represents the elderly with regular heavy outdoor work activity (n = 191) and curve B represents the elderly with decreased heavy outdoor work activity (n = 93).

Table 2. Relative risk of fractures in persons performing heavy outdoor work activity (n = 284), according to Cox univariate analysis

Variable	n (%)	Hazard ratio (95% CI)	p value
Female sex	148 (52)	2.6 (1.05–6.65)	0.030
Age $\geqslant$80 years	211 (74)	1.6 (0.68–3.72)	0.279
Low body mass index ($\leqslant$23.5 kg/m^2)	43 (15)	1.9 (0.70–5.05)	0.207
Slow choice reaction time ($>$76 ms)[a]	14 (5)	3.3 (1.12–9.65)	0.022
Low peak expiratory flow ($\leqslant$222 l/min)[a]	51 (18)	2.2 (0.92–5.43)	0.069
Abnormal knee jerks[a]	51 (18)	0.7 (0.20–2.24)	0.508
Reduced visual acuity[a]	22 (8)	2.2 (0.67–7.49)	0.181
Reduced knee extension strength[a]	12 (4)	0.9 (0.12–6.77)	0.979
Transient ischemic attack	16 (6)	0.9 (0.12–6.31)	0.875
Stroke	6 (2)	2.4 (0.32–17.7)	0.378
Low cognitive status (sMMSE $\leqslant$19 points)	34 (12)	1.5 (0.44–5.04)	0.514
Many depressive symptoms (sZung $\geqslant$27)	103 (37)	0.9 (0.40–2.07)	0.809
Fear of falling	46 (16)	0.7 (0.21–2.33)	0.553
Any psychotropic medication	53 (19)	0.8 (0.29–2.45)	0.742
Smoking	17 (6)	1.6 (0.38–6.93)	0.505
Slow walking speed ($\leqslant$0.84 m/s)[a]	30 (11)	0.9 (0.26–2.89)	0.809
Dependent in at least one ADL	18 (6)	4.2 (1.24–14.2)	0.012
No recreational activities	41 (14)	2.0 (0.75–5.39)	0.158
Decline in heavy outdoor work activity	93 (33)	3.5 (1.54–7.82)	0.001

ADL, Activities of daily living; sMMSE, shortened version of the Mini-Mental State Examination (variation of sum index 0 to 25 points); sZung, short version of the Zung Self-Rating Scale (variation of sum index 10 to 40 points).
[a]Variables measured in 1991.

Table 3. The final proportional hazard model on risk factors for fractures among the home-dwelling elderly

Variable	Coefficient	Standard error	Adjusted hazard ratio (95% CI)
Decline in heavy outdoor work activity	1.011	0.448	2.7 (1.14–6.62)
Female sex	0.783	0.481	2.2 (0.85–5.62)
Age $\geqslant$80 years	0.157	0.473	1.2 (0.46–2.96)
Slow choice reaction time	0.730	0.636	2.1 (0.60–7.22)
Dependent in at least one ADL	0.489	0.666	1.6 (0.39–6.88)

All variables in the table were simultaneously entered in the model.

Discussion

According to the results of the present study, a recent decline in heavy outdoor work activity predicts the occurrence of fracture, but not the occurrence of serious soft tissue injury. The association between a decline in heavy outdoor work activity and the occurrence of fracture was independent of several subject-related risk factors of fractures. Our results are consistent with earlier findings that the risks of hip fracture [4] and fracture in the weight-bearing skeleton [8] are associated with low physical activity. Gregg et al. [4] also found that women who were engaged in activities such as walking, gardening or social dancing for at least 1 h per week had a significantly reduced risk of hip fracture.

An increase in the risk of falling or bone loss may explain the increased risk of fracture in regard to a decline in physical activity. Both low and high physical activity may increase the risk of falls and injurious falls [1]. We found that a recent decline in heavy outdoor work activity was associated with an increased risk of falling and fracture but not of serious soft tissue injury. Indeed, fallers with fracture outcome were responsible for the increased risk of falling. However, the result of the multivariate analysis did not support the assumption that propensity to fall was responsible for the increased fracture risk. More likely, bone loss related to low physical activity [16] might explain this. We found that the difference in the risk of fracture appeared about 2 years after the decline in heavy outdoor work activity was observed, consistent with a contribution of accelerated bone loss. In general, bone loss seems to accelerate in the very elderly [17]. Exercise and high physical activity maintain or even increase bone mineral density among older women [18,19], but walking seems not to be very effective as regards preserving bone [19]. The most common recreational physical activity in the present study was walking (85%) and no significant association between recreational physical activities and fracture risk was found. Heavy outdoor work activities may involve elements which are beneficial for the quality and quantity of bone [20].

The present work, being a population-based prospective cohort study, has several strengths. The participation

rate was high and the data collected on falls and injuries have been evaluated as being reliable [13,14]. The baseline and follow-up examinations allowed us to focus our analysis on recent declines in heavy outdoor work activity, which has not been done in previous studies. Our study population consisted of home-dwellers living in rural municipalities where the great majority of people live in single-family or terraced houses, with gardening during summer and snow shovelling during winter as part of everyday life.

Our study also has limitations. The sample was rather small, resulting in a low statistical power and raising the possibility of false negative fracture risks found in regard to some potential risks, such as low BMI, low peak expiratory flow, reduced visual acuity, no recreational activities and low cognitive status. However, when these variables were fitted one at a time into the final proportional hazard model, the main result concerning fracture risk did not change. Despite this, our results need to be confirmed in studies with larger sample sizes. Previous studies have shown that low physical activity is associated with an increased risk of hip fracture but not with wrist or vertebral fractures [4]. Because of the small number of fractures, it was not possible to examine the relationships between a decline in heavy outdoor work activity and different fracture types. Bone mineral density was not measured in our study and consequently we cannot definitely confirm the assumption that progressive bone loss associated with a decline in heavy outdoor work activity was responsible for the increased fracture risk.

Our results suggest that the situations leading to a decline in physical activity among the elderly should be recognized early in order to help prevent an increased fracture risk. Controlled intervention is needed to examine the effectiveness of re-establishing the physical activity status in order to prevent fractures.

Acknowledgements. This study was supported by the Juho Vainio Foundation, Finland.

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Received for publication 18 March 2001
Accepted in revised form 3 August 2001