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ORIGINAL PAPER

Fall-induced fractures of the calcaneus and foot in older people: nationwide statistics in Finland between 1970 and 2013 and prediction for the future

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Abstract
Background Although fall-induced fractures of elderly persons are a major problem, epidemiologic knowledge on their time trends is limited. We assessed the trends in fall-induced fractures of the calcaneus and foot in older Finns between 1970 and 2013.
Methods The current trends in the number and incidence (per 100 000 persons) of fall-induced fractures of the calcaneus and foot of older Finns were determined by taking into account individuals 50-year-olds or older who were admitted to Finnish hospitals for primary treatment of such injury in 1970–2013.
Results The number and raw incidence of these fractures increased considerably between 1970 and 2013, from 64 (number) and 5.6 (incidence) in 1970, to 325 and 15.0, respectively, in 2013. The age-adjusted incidence of fracture was higher in men than women and showed a clear rise in both sexes in 1970–2013, from 7.2 to 15.2 in men (111 % increase), and from 4.3 to 13.9 in women (223 % increase). A similar rise was observed in the age-specific incidences. If trends in the age-specific fracture incidence continue at the same rate as were observed in 1970–2013, and the 50-year-old or older population increases as predicted (by 15 % by the year 2030), the annual number of fall-induced fractures of the calcaneus and foot in this population will be 1.8 times higher in the year 2030 (580 fractures) than it was in 2013 (325 fractures).
Conclusions The number of fall-induced fractures of the calcaneus and foot among Finns 50 years of age or older has risen sharply between 1970 and 2013 with a rate that cannot be explained merely by demographic changes. Further studies should examine the reasons for the rise and possibilities for fracture prevention.

Keywords Calcaneus and foot · Epidemiology · Falls · Fractures · Older adults · Secular trends

Introduction

Fall-induced fractures in older adults are a major public health issue in Finland and other countries that have aged populations [1–7]. Commonly, these fractures occur in the spine, hip, and distal forearm [1, 2, 4, 5]. However, a considerable number of fractures also occur in the calcaneus, foot, ankle, knee, pelvis, and proximal humerus, and their treatment is also demanding and costly and may require special skills [1, 4, 5, 8–21].

Epidemiologic information on secular trends of these latter fractures is sparse. Previously, we reported a sharply rising time trend in the number and incidence rate of fall-induced fractures of the calcaneus and foot in the 50-year-old or older population in Finland between 1970 and 2005 [12]. We have now followed the population eight years more (to the end of 2013) to assess most recent changes. Moreover, the current database allowed us to analyse the oldest age group (persons 80 years of age or older) independently.

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Patients and methods

The data of the fall-induced fractures of the calcaneus and foot in Finland during 1970–2013 originated from the National Hospital Discharge Register (NHDR). This statutory, computer-based register is the oldest nationwide discharge register in the world and provides reportedly reliable data for injuries in the Finnish population (i.e., annual coverage of injuries and accuracy of injury diagnoses are very high, over 90 %) [3, 8, 22, 23].

The Finnish NHDR contains data on age, sex, place of residence, hospital number and department, place and cause of injury, diagnosis, day of admission and discharge, and place of further treatment. Injury diagnoses at discharge of the patient are based on all the available clinical and radiological information obtained from the patient during the hospital visit. Concerning the fractures of the calcaneus and foot, the final diagnosis was always based on both clinical and radiological information.

Throughout the study years, a fall-related fracture of the calcaneus and foot was defined as a fracture occurring in persons 50 years of age or older as a consequence of moderate or minimal trauma only (a slip, trip or fall from a standing height or less with resulting ankle–foot contusion or distorsion) [12]. Fractures caused by vehicular accidents and other types of high-energy trauma were excluded.

As in the previous study [12], the fractures of the calcaneus and foot (toe fractures excluded) of the 50-year-old or older Finnish population were recorded by evaluating both the primary and secondary diagnoses of the NHDR. The diagnoses were labelled with a five-digit code according to the eighth, ninth, and tenth revisions of the International Classification of Diseases (ICD-8, ICD-9, ICD-10) that indicated the type of fracture. Between 1970 and 1986, the eighth revision of the ICD and its codes for calcaneus and foot fractures (82500, 82510, 82501, and 82511) were used. Between 1987 and 1995, the corresponding ICD-9 code classes were 8250A–8252F and 8253A–8253X, and between 1996 and 2013 the corresponding ICD-10 code classes were S92.0, S92.1, S92.2, and S92.3.

Annual midyear populations were taken from the Official Statistics of Finland, the statutory, computer-based population register of the country [24]. In this register, every Finn is registered by his or her personal identification number and the register is quality-controlled continuously and updated by Statistics Finland, the Central Statistical Office of Finland.

The gender-specific, age-adjusted fracture incidence (per 100,000 persons) was calculated with direct age standardisation using the mean population of persons 50 years of age or older between 1970 and 2013 as the standard population or reference point. In this way, the fracture rates were amenable to comparison across study years and allowed estimation of the average annual individual risk for fracture of the calcaneus and foot [12]. The age-specific fracture incidences (per 100,000 persons) were calculated for four ten year age groups (50–59, 60–69, 70–79 and ≥80 years).

The fracture data were drawn from the entire population of Finland, the study thus completely covering the intended study population (Finnish nation). Thus, the absolute numbers and incidences of fall-induced fracture of the calcaneus and foot were not cohort-based estimates but actual complete population results, and therefore, the study, in full agreement with our previous studies [2, 3, 12], did not use statistical analyses with confidence intervals intrinsically needed for cohort- or sample-based estimations.

Finally, the above-noted age-specific incidence rates of fracture of the calcaneus and foot in 1970–2013 were used to predict the age-specific incidence rates in the years 2020 and 2030 by a linear regression model. Then, within each age and sex group, the predicted absolute number of fractures was obtained by multiplying the afore-mentioned incidence by the estimated number of inhabitants based on Finnish Population Projections 2014–2030 [25].

Results

The number of fall-induced fractures of the calcaneus and foot among 50-year-old or older Finns rose considerably between the years 1970 and 2013, from 64 in 1970 to 325 in 2013. The relative increase was 408 %. The crude incidence of fracture also showed a clear increase, from 5.6 in 1970 to 15.0 in 2013 (168 %), despite the fact that the Finnish population 50 years of age or older increased by 90 % (from 1.14 million to 2.17 million) during the 44-year study period. Concerning the age-adjusted incidence of fracture, in all study years the incidence was higher in men than women and showed a clear increase in both sexes from 1970 to 2013, from 7.2 to 15.2 in men (111 % increase) and from 4.3 to 13.9 in women (223 % increase).

The age-specific incidence of fall-induced fractures of the calcaneus and foot also increased in all age groups of men and women during the study period (Fig. 1). In men, the injury incidence rates in 1970 were 10.2, 5.3, 5.7 and 0.0 in the age groups of 50–59, 60–69, 70–79 and 80 years or older, respectively, versus 19.0, 15.0, 8.0 and 11.2 in 2013. In women, these incidence rates were 5.6, 3.4, 3.2 and 5.6 in 1970, versus 10.4, 9.9 14.4 and 36.4 in 2013. The afore-mentioned numbers and Fig. 1 also reveal that, among men, the fracture incidence was highest in the youngest age group (men 50–59 years of age), whereas among women, the incidence was highest in the oldest age group (women 80 years of age or older).

If trends in age-specific fracture incidence continue at the same rate as were observed between 1970 and 2013 (Fig. 1), and the 50-year-old and older population increases as predicted (15 % by the year 2030), the number of fall-induced fractures of the calcaneus and foot in Finnish older adults will be

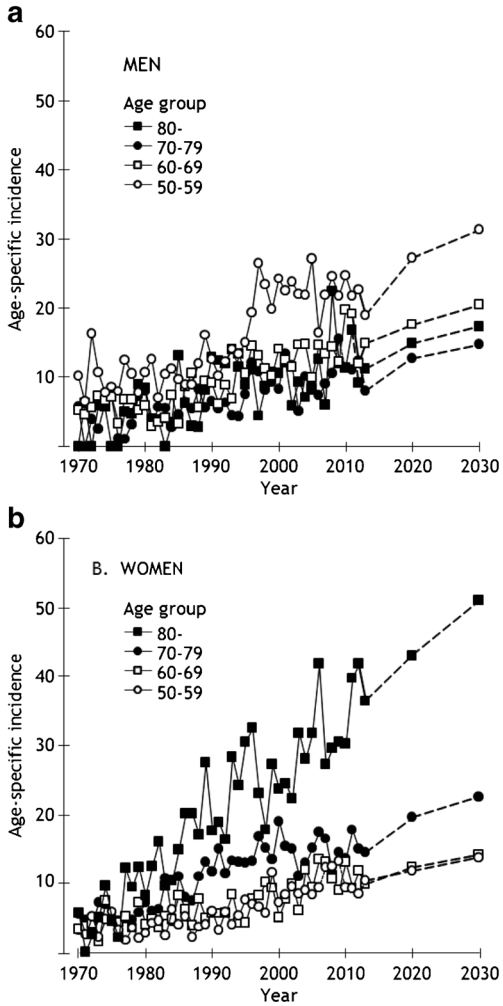

Fig. 1 Age-specific incidence (per 100,000 persons) of fall-induced fractures of the calcaneus and foot in Finnish men (**a**) and women (**b**) aged 50 years or older in 1970–2013. The *dotted lines* show the prediction of the incidences until the year 2030, as calculated using a regression model

1.8 times higher in 2030 (580 fractures) than was observed in 2013 (325 fractures).

Discussion

This nationwide epidemiologic study used the entire Finnish population 50 years of age or older to describe the trends in 1970–2013 for the absolute number and incidence of fall-induced fractures of the calcaneus and foot. The study showed that the incidence of these fractures was higher in men than women, and that overall number as well as age-adjusted and age-specific incidence of the fractures clearly rose from 1970 to 2013. As in the previous study [12], the fracture incidence was highest in the youngest age group of men (men 50–59 years of age or older), whereas among women, the same was true for the oldest age group (women 80 years of age or older).

Our current findings confirm previous observations from Finland and elsewhere that various fall-induced fractures and other injuries of older adults have been a rapidly growing problem in recent decades [2–7, 12, 16, 26, 27], and they suggest further that this undesirable trend has not stopped in the new millennium. It is also unfortunate that the further aging of the population is likely to increase the problem so that, by the year 2030, Finland is likely to face almost 600 fall-induced fractures of the calcaneus and foot among persons 50 years of age or older each year. Many other developed countries are likely to face similar problems, although detailed epidemiologic data from other countries are largely lacking. Although the homogeneity of our Finnish white population limits the direct generalizability of the results to different and more diverse populations, we feel that our findings also provide important and useful public health information for many other countries.

In this and our previous study of fall-induced fractures of the calcaneus and foot, the age groups for highest risk of fracture were rather different between women and men [12], and this may suggest gender-related differences in fracture mechanisms and contributing factors. Among women, a highest injury incidence was seen in the oldest age group (Fig. 1). This is a characteristic feature for many types of frailty-associated falls and related injuries of elderly people, and thus a very important public health issue [1, 2, 4, 5, 7, 11, 14, 16]. Men, however, showed two rather atypical injury characteristics: men's age-adjusted fracture incidence was higher than that in women, and the fracture incidence was highest in the youngest group of men (Fig. 1). Since the general incidence of falling is higher in elderly women than elderly men [3, 4, 6, 7, 28], it can be hypothesized that the younger groups of elderly men have an increased risk for severe, uncontrolled slips, trips, and falls than do their female counterparts. Further studies are, however, needed to confirm these findings and reveal the exact reasons for this gender difference. In this respect, the influence of gender difference in alcohol usage, risk-taking behavior, or any other indicator of hazardous lifestyle will be of interest [6, 7, 12].

Altogether, in Finnish older adults aged 50 years or older, the number of fall-induced fractures of the calcaneus and foot has increased sharply during 1970–2013. This rise has occurred with a rate that cannot be explained merely by the increase in the population at risk. Further studies are urgently needed to assess the exact reasons for the rise and examine possibilities for fracture prevention.

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Conflict of interest The authors declare that they have no conflict of interests.

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