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Falls incidence underestimates the risk of fall-related injuries in older age groups: a comparison with the FARE (Falls risk by Exposure)

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Abstract

Background: up till now, the risk of falls has been expressed as falls incidence (i.e. the number of falls or fallers per 100 person-years). However, the risk of an accident or injury is the probability of having an accident or injury per unit of exposure. The FARE (Falls risk by Exposure) is a measure for falls risk which incorporates physical activity as a measure of exposure. The objective of this study was to compare falls incidence and the FARE when expressing the age-related risk of fall-related injuries.
Methods: data of 21,020 community-dwelling elderly aged ≥55 years (60.3% women) obtained from a national survey (2000–05) were used to compare incidence of fall-related injuries and the FARE. In order to compare both measures, risk ratios (of both outcome measures) were calculated for each age group. Hierarchical regression analyses (linear versus exponential model) were conducted to check the best model fit when expressing falls risk by age for the total study population and for men and women separately.
Results: the risk of fall-related injuries, calculated on the basis of the incidence of fall-related injuries, showed a linear relationship with age, whereas the risk calculated on the basis of fall-related injuries corrected for exposure (falls risk by exposure, FARE) showed an exponential relationship. Calculations on the basis of the incidence of fall-related injuries underestimated the risk of fall-related injuries in people aged 70 years and older, and especially in women.
Conclusion: calculation of the risk of fall-related injuries based on the incidence of these injuries underestimates the risk of such injuries relative to that calculated on the basis of the FARE. FARE-based calculations enable the early identification of people at high risk of falls and provide a more sensitive outcome measure for studies evaluating falls prevention interventions.

Keywords: *physical activity, falls injury risk, elderly, age, gender*

Introduction

Falls are a major health problem. About 35% of community-dwelling elderly aged ≥65 years fall at least once a year [1]. Of these falls, approximately 70% results in injuries [2, 3]. Many falls are caused by an interaction between identifiable environmental hazards and increased individual susceptibility to hazards from accumulated effects of age and disease [1]. A fall can be such a traumatic experience which may make people so afraid of falling [4] that they reduce their physical activity [5, 6].

In the long term, reducing physical activity can lead to inactivity and diminished fitness, strength and balance control, increasing the risk of falls [1, 7]. Ultimately, falls can lead to a loss of independence and increased mortality [8].

Up till now, the risk of falls has been expressed as falls incidence (i.e. the number of falls or fallers per 100 person-years) [9]. From a general perspective, the risk of an accident or injury is the probability of having an accident or injury per unit of exposure [10]. The falls risk as expressed by the falls incidence implies that there are no differences in exposure to hazards. However, when studying the relationship between various levels of physical activity and falls, Wijlhuizen *et al.* [6] found that outdoor falls occurred more often among people who walked and bicycled more frequently. In addition, Ebrahim *et al.* [11] reported that brisk walking may increase the risk of falls. Therefore, Wijlhuizen *et al.* [12, 13] suggested that the level of physical activity could represent the level of exposure to hazards and should therefore be included in the expression of falls risk.

On the basis of these findings, Wijlhuizen *et al.* developed a measure for falls risk which incorporates physical activity, Falls risk by Exposure (FARE) [14], in which the number of fallers is expressed per 1,000 physically active person-days. This implies that the FARE differentiates between persons who have an equal number of falls per specified time period, but have different levels of physical activity during this period. According to the FARE, persons who have low exposure to hazards (low physical activity level) and nevertheless fall frequently are identified as having a relative high risk of falling compared with persons with comparable frequency of falls but higher exposure to hazards.

Wijlhuizen *et al.* [14] found an exponential relationship between difficulty controlling balance and falls risk as expressed by the FARE and a linear relationship when falls risk was expressed by falls incidence. Thus falls incidence underestimates the risk of falls in people who have difficulty controlling their balance. Wijlhuizen *et al.* recommended comparing falls incidence and the FARE when expressing the relationship between falls risk and other risk factors, such as age. This risk factor is generally used as a basic variable to show patterns of falls risk within a population in epidemiological reports. It is not known whether patterns of falls risk with increasing age will change if falls risk is expressed in terms of the FARE rather than falls incidence.

The aim of this study was to investigate whether, and in what way, the risk of fall-related injuries changes with age when that risk is adjusted for exposure, as occurs with the FARE. The risk of fall-related injuries was investigated because of the availability of a database that included data on injurious falls and physical activity. Because the FARE incorporates differences in the level of physical activity between people, it is expected to be a more sensitive measure than the incidence of fall-related injuries for detecting age groups at high risk of fall-related injuries.

Methods

Subjects

Data of 21,728 community-dwelling people aged ≥55 years (60.5% women) were obtained from the national survey Injuries and Physical Activity Netherlands (IPAN) [15]. The main objective of the IPAN survey was to provide a complete overview of all injuries resulting from accidents and falls (e.g. in traffic, sports) occurring in The Netherlands. Each year from 2000 until 2005, a random sample of the Dutch population was telephoned (which is a nationally representative sample), using random digit dialing. The number of interviewed subjects aged ≥55 years ranged from 3,259 to 4,314 per year (cross-sectional data). Exclusion criteria for participation were institutionalisation as a result of old age, physical or mental handicap and language problems. For this type of research approval from an ethics committee was not required [16].

Assessments

In the IPAN survey, subjects were asked about injuries resulting from accidents and falls sustained in the previous 3 months. A fall was defined as 'an unexpected event in which the participants come to rest on the ground, floor, or lower level' [17]. A fall-related injury is defined as a fall resulting in any injury (e.g. bruises, fracture, concussion) as reported by the respondent. Injuries that were not medically treated could also be reported. Only one fall-related injury per person, the most serious injury, was included. The subjects were asked about their age, gender and the number of days during an average week (both summer and winter) that they were physically active for at least 30 min at a moderate level (at least as heavy as brisk walking or bicycling) [18].

Analyses

Data were analysed by using SPSS software (SPSS, Inc., version 17.0). Subjects with a missing value for the level of physical activity were excluded from analyses; we included those who reported to be zero or more days physically active at a moderate level.

The final score for the level of physical activity included the average number of physically active person-days per week (during winter and summer). Stratification took place by gender and age group (55–59, 60–64, 65–69, 70–74, 75–79, 80–84 and ≥85 years).

The risk of fall-related injuries per age group was expressed in two ways: the falls injury incidence (the number of injured fallers in 3 months/number of subjects) * 100 and the FARE (the number of injured fallers in 3 months/total number of physically active person-days in 3 months) * 1,000 [14]. The total number of physically active person-days in 3 months was calculated as the average number of physically active person-days per week multiplied by 13.

In order to test gender differences in the incidence of fall-related injuries and the level of physical activity, a χ^2 test and a Mann–Whitney were used, respectively. Kruskal–Wallis tests were used to check for age differences and an interaction effect of age × gender in the incidence of fall-related injuries and the level of physical activity.

In order to compare the two ways of expressing the risk of fall-related injuries, for each age group risk ratios were calculated using the '55–59 years' group as a reference. Hierarchical regression analyses (linear versus exponential model) were conducted to check the best model fit when expressing falls risk by age for the total study population and for men and women separately. *P*-values <0.05 were considered to indicate statistical significance.

Results

General outcomes

In total, data of 21,020 subjects aged 55–98 years (60.3% women) were analysed; 708 subjects (3.3%) were excluded from analyses due to missing physical activity data. As shown in Table 1, the total study population had a mean of 4.5 (SD: 2.5) physically active days per week with no significant difference between men and women ($U = 5.282E7$, $P > 0.05$). The level of physical activity decreased significantly with increasing age ($Chi^2 = 443.66$, df = 43, $P < 0.001$), an effect that was stronger in women than men ($Chi^2 = 539.79$, df = 84, $P < 0.001$). The risk of fall-related injuries, as expressed by the incidence of fall-related injuries, was 4.2%, with a significantly higher incidence in women than men (respectively, 5.3% versus 2.5%; $Chi^2 = 17,658.46$, df = 1, $P < 0.001$). In addition, the incidence of fall-related injuries increased with age ($Chi^2 = 101.42$, df = 43, $P < 0.001$), an effect that was stronger in women than men ($Chi^2 = 223.36$, df = 84, $P < 0.001$).

Comparison of falls injury incidence and FARE

The age associated, risk ratio for fall-related injuries (relative to age group 55–59 years) was calculated, using both the fall-related injury incidence and FARE. Figure 1 shows the age-related trend for the total study population and Figure 2 shows this trend for men and women separately. The pattern of risk ratio for the two expressions was identical up to 65–69 years (Figure 1); the patterns were also similar for men up to 75–79 years in men and for women up to 65–69 years (Figure 2). Thereafter, the risk ratio for fall-related injuries increased with increasing age with the FARE in the total study population and in both gender groups.

The model fit results of the regression analyses, revealed that the incidence of fall-related injuries by age in the total study population as well as in both gender groups did not show a significantly better fit with the exponential model than with the linear model. However, when the risk of fall-related injuries was expressed in terms of the FARE, the exponential model provided a significantly better fit than the linear model ($P < 0.05$) (see the Supplementary data available in *Age and Ageing* online, table Appendix 1).

Table 1. Level of physical activity, incidence of fall-related injuries, and FARE scores by age in the Netherlands in 2000–05

Age group[a]	Subjects *n* (%)			Mean level of physical activity (SD)[b]			Number of injured fallers[c]			Falls injury incidence[d]			FARE score[e]		
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
55–59	2,224 (43.7)	2,863 (56.3)	5,087 (24.2)	4.5 (2.4)	4.8 (2.3)	4.7 (2.4)	41	117	158	1.8	4.1	3.1	0.32	0.65	0.51
60–64	1,813 (42.9)	2,415 (57.1)	4,228 (20.1)	4.6 (2.3)	4.9 (2.2)	4.8 (2.3)	45	119	164	2.5	4.9	3.9	0.41	0.77	0.62
65–69	1,567 (41.9)	2,176 (58.1)	3,743 (17.8)	4.7 (2.3)	4.7 (2.3)	4.7 (2.3)	40	105	145	2.6	4.8	3.9	0.42	0.78	0.63
70–74	1,181 (37.3)	1,989 (62.7)	3,170 (15.1)	4.6 (2.4)	4.4 (2.6)	4.5 (2.6)	24	120	144	2.0	6.0	4.5	0.34	1.06	0.78
75–79	871 (35.0)	1,615 (65.0)	2,486 (11.8)	4.4 (2.6)	4.2 (2.7)	4.2 (2.7)	30	97	127	3.4	6.0	5.1	0.60	1.11	0.92
80–84	481 (30.4)	1,102 (69.6)	1,583 (7.5)	3.9 (2.8)	3.5 (3.0)	3.7 (2.9)	18	72	90	3.7	6.5	5.7	0.73	1.42	1.19
≥85	209 (28.9)	514 (71.1)	723 (3.4)	3.6 (3.0)	2.8 (3.0)	3.1 (3.0)	13	36	49	6.2	7.0	6.8	1.32	1.90	1.70
Total	8,346 (39.7)	12,674 (60.3)	21,020 (100)	4.5 (2.4)	4.5 (2.6)	4.5 (2.5)	211	666	877	2.5	5.3	4.2	0.59	1.10	0.91

[a]Age group in years.
[b]Mean number of physically active person-days in 7 days.
[c]Number of injured fallers in 3 months.
[d]Number of injured fallers per 100 subjects in 3 months.
[e]Number of injured fallers in 3 months/total number of physically active person-days in 3 months * 1,000.

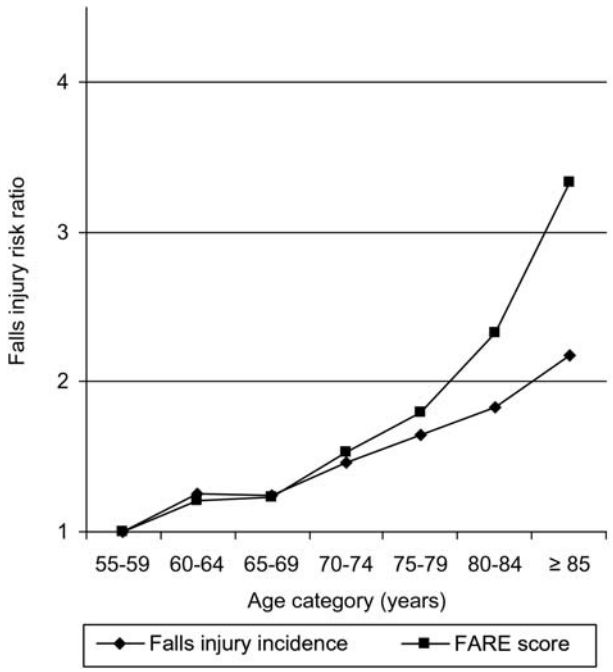

Figure 1. Falls injury risk ratios by falls injury incidence and the FARE for the total study population in the Netherlands in 2000–05.

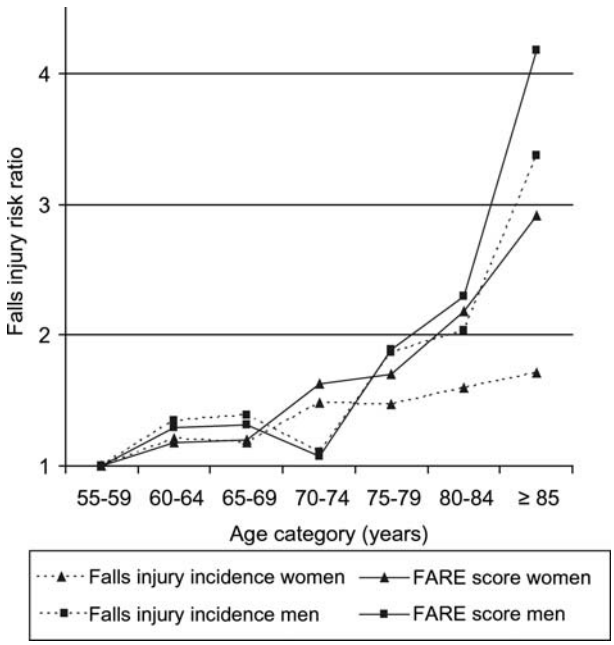

Figure 2. Falls injury risk ratios by falls injury incidence and the FARE for men and women separately in the Netherlands in 2000–05.

Discussion and conclusion

The objective of this study was to investigate whether the way in which the risk of fall-related injuries is expressed gives a better insight into the actual risks of such injuries with increasing age. The incidence of fall-related injuries showed a linear relationship between falls injury risk ratio and age, whereas the FARE showed an exponential relationship, for both men and women. These findings are comparable with the results of a study by Wijlhuizen *et al.* [14], who also found an exponential relationship between falls risk and balance control when falls risk was expressed in terms of the FARE rather than the usual falls incidence.

The exponential relationship showed by the FARE reflects the level of physical activity (i.e. exposure) that decreases with increasing age. Although no gender difference was found in an average level of physical activity, the decrease in physical activity with advancing age was greater in women than in men. Women are more likely to limit their physical activity as they age, probably in part due to their age-related greater fear of falling [5, 6, 19]. This decrease in physical activity (e.g. avoiding hazards) in elderly in general can be interpreted as a behavioural response to perceived difficulty in controlling balance [14]. Findings indicated that the risk of fall-related injuries is underestimated in people aged 70 years and older when the risk of such injuries is calculated with the currently widely used incidence of fall-related injuries. This underestimation is greater in women than men, and was seen at younger ages in women than in men (from 70 years versus from 80 years, respectively).

Study limitations

A limitation of this study is that it included only injured fallers, approximately 70% of all fallers [3]. However, including non-injured fallers would have resulted in a higher falls risk. It is not known whether including all falls would change the findings of this study. Another potential weakness is that the level of physical activity was based on self-report, the reliability and validity of which needs to be established [20]. Another limitation is the lack of a gold standard for the measure of exposure in the context of falls. We cannot assume that other measures of exposure will show comparable results as found in this study.

Relevance of the findings

Both the incidence of fall-related injuries and the FARE can be useful measures of falls risk depending on the research goal. The incidence of fall-related injuries might be a more useful measure when investigating falls risk and related hospitalisation or number of treatments because there is no need to incorporate exposure to hazards. However, the FARE is a more sensitive measure for epidemiological research to identify people at high risk of falls. When the incidence of falls is used to identify people at risk, people will not be identified as being at high risk if they have reduced their level of physical activity (exposure to hazards) because they are frightened of falling. Yet these elderly who do not fall frequently but who strongly reduce their level of physical activity should be targeted for falls prevention interventions [14]. Moreover, when investigating the effectiveness of falls

prevention interventions, it should be noted that the incidence of falls does not take intervention-induced changes in exposure into account [9]. This implies that if a falls intervention, for example, balance and mobility training, results in an increase in physical activity, but not in a decrease in falls, it is generally perceived as being ineffective when the incidence of falls is used as outcome measure [1], but not when the FARE would have used, which takes the changes in physical activity into account and could show that the risk of falls in fact decreases.

In conclusion, the risk of fall-related injuries with increasing age is underestimated when the incidence of fall-related injuries is used to calculate risk. For public health policy on falls prevention, use of the FARE will identify those people at high risk earlier than would be the case if the incidence of fall-related injuries were used. Early identification of individuals at high risk of falls will enable preventive measures to be taken for people with latent balance problems, instead of the current policy in which interventions focus on relatively old frequent fallers who often have complex chronic health problems that are difficult to treat. In addition, the FARE is a more sensitive outcome measure for evaluation research to detect the impact of falls prevention interventions.

Key points

- Falls incidence underestimates the risk of fall-related injuries compared with the FARE.
- FARE-based calculations enable the early identification of people at high risk of falls.
- FARE-based calculations provide a more sensitive outcome measure for studies evaluating falls prevention interventions.

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Supplementary data

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

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Severity of age-related hearing loss is associated with impaired activities of daily living

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Abstract

Background: age-related hearing loss is a common chronic condition; hence, it is important to understand its influence on the functional status of older adults. We assessed the association between hearing impairment with activity limitations as assessed by the activities of daily living (ADL) scale.
Methods: a total of 1,952 Blue Mountains Hearing Study participants aged ≥60 years had their hearing levels measured using pure-tone audiometry. A survey instrument with questions on functional status as determined by the Older Americans Resources and Services ADL scale was administered.
Results: one hundred and sixty-four (10.4%) participants reported ADL difficulty. A higher proportion of hearing impaired than non-impaired adults reported difficulties in performing three out of the seven basic ADL and six out of the seven instrumental ADL tasks. After multivariable adjustment, increased severity of hearing loss was associated with impaired ADL ($P_{trend} = 0.001$). Subjects with moderate to severe hearing loss compared with those without, had a 2.9-fold increased likelihood of reporting difficulty in ADL, multivariate-adjusted odds ratio (OR): 2.87 [95% confidence interval (CI): 1.59–5.19]. Participants aged <75 years with hearing loss compared with those without, had 2-fold higher odds of impaired ADL. Having worn or wearing a hearing aid was also associated with a 2-fold increased likelihood of impaired ADL.
Conclusion: functional status as measured by a common ADL scale is diminished in older hearing impaired adults. Our findings suggest that severely diminished hearing could make the difference between independence and the need for formal support services or placement.

Keywords: *age-related hearing loss, activities of daily living, Blue Mountains Hearing Study, hearing aid, elderly*

Introduction

It is well established that age-related hearing loss is associated with several indicators of negative well-being including reduced quality of life, social isolation and depressive symptoms [1–3]; however, there is a paucity of population-derived data on the association between hearing loss and functional disability.

Activities of daily living (ADL) measures are widely used to assess older adults for disability in carrying out daily functions (functional disability), including basic ADL such as washing and eating, and instrumental