Submitted: 19.05.2024
Accepted: 25.07.2024
Early publication date:

Endokrynologia Polska
DOI: 10.5603/ep.100762
ISSN 0423–104X, e-ISSN 2299–8306

Fractures at various skeletal sites are dependent on different risk factors: the results from 10 years of prospective longitudinal observation in postmenopausal women from the RAC-OST-POL Study

Wojciech Pluskiewicz [1], ***Piotr Adamczyk*** [2], ***Bogna Drozdzowska*** [3], ***Hanna Hüpsch*** [4]

[1]*Department and Clinic of Internal Diseases, Diabetology, and Nephrology, Metabolic Bone Diseases Unit, Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice, Poland*
[2]*Department of Paediatrics, Faculty of Medical Sciences in Katowice, Medical University of Silesia in Katowice, Poland*
[3]*Department of Pathomorphology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice, Poland*
[4]*Department of Periodontal and Oral Mucosa Diseases in Zabrze, Faculty of Medical Sciences in Zabrze, Medical University of Silesia in Katowice, Poland*

Abstract

Introduction: The aim of the study was to present data on risk factors for fractures in various parts of the skeleton in a cohort of postmenopausal women during a 10-year prospective observation period. It can be hypothesised that fracture risk factors should be different for spine, hip, and peripheral fractures.

Material and methods: 640 postmenopausal women at mean baseline age was 65.0 ± 6.9 years were enrolled into the study. The cohort was randomly selected from the population of the entire Racibórz district. Data on the incidence of fractures and falls were updated annually during the 10-year follow-up period. Information on clinical risk factors for fractures was collected at baseline.

Results: During the observation period, 190 low-traumatic fractures were recorded in 129 patients. The following number of fractures was observed: hip 15, spine 30, non-hip fractures other than spine 145 (including 81 forearm fractures). The effect of falls was insignificant in the case of spine fractures (chi-square test: 3.64; $p = 0.06$). For all other skeletal sites, the incidence of fractures was significantly increased by falls, with the greatest effect observed for forearm fractures and non-spine and non-hip fractures (chi-square test for hip, forearm, and all non-spine, non-hip fractures was 6.43, $p < 0.05$; 42.7, $p < 0.0001$ and 66.7, $p < 0.0001$, respectively). To determine the factors having a significant impact on the incidence of fractures during the observation period, logistic regression was used separately in subgroups. The following risk factors were taken into account: age, height, body weight, bone mineral density (BMD) at the femoral neck as expressed by T-score, rheumatoid arthritis, steroid use, falls reported at baseline, and the total number of risk factors. Spine fractures depended only on T-score, odds ratio (OR) = 0.42 (0.23–0.76); hip fractures depended only on age, OR = 1.15 (1.07–1.24); forearm fractures depended only on age T-score, OR = 0.69 (0.51–0.92); and non-hip, non-spine on fall rate, OR = 1.86 (1.20–2.87).

Conclusions: Fractures at various skeletal sites recorded in long-term follow-up in postmenopausal women were dependent on various risk factors. Multivariate analysis identified a single, dominant risk factor for each fracture location analysed.

Key words: *clinical risk factors; falls; fracture; hip; peripheral fracture; wrist; women*

Introduction

Osteoporosis is one of the most common diseases in the elderly population. The process of bone tissue loss usually does not give any clear clinical symptoms, and the first manifestation is a low-trauma fracture [1]. Hip and spine fractures are the most harmful to overall health. Osteoporotic fractures are considered a late consequence of osteoporosis; therefore, the main goal of patient treatment is effective prevention. The first osteoporotic fracture is one of the most important risk factors for subsequent fractures [2]. A previous forearm fracture increases this risk 2-fold, and a spine or hip fracture increases the risk of subsequent fractures by up to 4–6 times. Therefore, one of the most important steps is the early identification of fracture risk factors. In general, the risk of fractures is influenced by the condition of the skeletal system and the tendency to fall due to functional status. Low bone mass detected by hip or spine densitometry increases the risk of fractures. Several so-called clinical risk factors have been identified. These include certain medications, comorbidities, smoking, high alcohol consumption, a diet low in calcium, early menopause, and the influence of genetic

Prof. Wojciech Pluskiewicz, Metabolic Bone Diseases Unit, Department and Clinic of Internal Diseases, Diabetology, and Nephrology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia, 3-Maja 13/15 street, 41–800 Zabrze, Poland, fax: (+48) 323 70 44 15, tel: (+48) 601 417 296; e-mail: wpluskiewicz@sum.edu.pl

factors, especially hip fractures in parents. Additionally, all circumstances affecting the functional condition and the risk of falling significantly increase the risk of fractures. All the above-mentioned risk factors for fractures should be taken into account when managing the patient. Notwithstanding this general recommendation, the role of risk factors is not always the same for fractures at different skeletal sites. For example, a spine or rib fracture can occur without a fall, and peripheral fractures of the forearm, arm, or ankle are almost always associated with a fall. Knowing the relative strength of previously outlined risk factors can improve preventive measures.

The aim of the study was to present data on risk factors for fractures at various sites of the skeleton in a 10-year prospective longitudinal observation. It can be hypothesised that fracture risk factors should be different for spine, hip, and peripheral fractures.

Material and methods

The study group was formed by the RAC-OST-POL study cohort recruited in 2010. The population was randomly selected from postmenopausal women over 55 years of age from the entire Racibórz district in southern Poland. At baseline, the total number of randomly selected women was 625. Baseline epidemiological data have been reported previously [3]. However, in addition to randomly selected women invited via letters sent by traditional mail, an additional 353 women who volunteered were included in the study. To present data in a larger cohort, we added these women to the previously described randomly recruited group. We checked whether the baseline incidence of falls was dependent on the method of recruitment (random or non-random). As shown by the chi-square test, the incidence of falls did not differ between them (33.8% in the random cohort and 33.1% in the non-random cohort, $p = 0.84$).

Therefore, further study analyses were performed in the entire cohort of 978 women [4–6]. The survey described in detail earlier [3] collected several data, including previous falls that occurred in the 12 months preceding the date of the review. Data on falls and osteoporotic fractures were collected at baseline in 2010 and annually thereafter for 10 years. One experienced researcher (WP) called all patients annually to collect the mentioned data. The following potential risk factors for fractures were collected at baseline: smoking, alcohol consumption, parental femoral neck fracture, medications (steroids or anticonvulsants), and comorbidities (type 1 and type 2 diabetes, depression, bronchial asthma, ulcerative colitis, kidney disease, liver cirrhosis, rheumatoid arthritis, thyroid disease, and Alzheimer's disease).

Statistical analysis

All calculations were performed using Microsoft Office Excel and Statistica software (StatSoft Inc., Tulsa, OK; www.statsoft.com) running on a PC. Descriptive statistics of quantitative variables were presented as means and standard deviations (SD). The normality of the distribution of the analysed data was checked using the Shapiro-Wilk test. To compare continuous parameters between subgroups, the t-test for independent samples was performed. The presentation of qualitative features was made by providing the number of subjects and the percentage in specific subgroups. The frequency of qualitative features between subgroups was compared using the chi-square test. Correlation analysis was performed using the Spearman correlation test. Finally, logistic regression identified the features most strongly associated with fractures. All p values < 0.05 were considered statistically significant.

Results

The mean baseline age, weight, height, and BMI were 65.0 ± 6.9 years, 74.5 ± 14.0 kg, 156.6 ± 6.6 cm, and 30.6 ± 5.4 kg/m^2, respectively. During the observation period, 190 low-traumatic fractures were recorded in 129 patients. The following number of fractures was observed: hip — 15 in 14 subjects, spine — 30 in 17 subjects, and non-hip non-spine fractures — 145 in 99 subjects (including 81 forearm fractures in 67 subjects).

Table 1 shows the clinical characteristics in the 4 subgroups according to the fracture site.

The nature of fractures in different parts of the skeleton is not uniform, and the role of falls may vary. To determine the significance of falls, their impact was examined separately for spine, hip, wrist, and all non-spine, non-hip fractures. The effect of falls was insignificant in the case of spine fractures (chi-square test: 3.64; df = 1, $p = 0.06$). For all other sites, the incidence of fractures increased significantly when falls occurred, with the greatest effect observed for forearm fractures and all non-spine and non-hip (chi-square test for hip fractures, forearm fractures, and all non-spine, non-hip fractures was 6.43, $p < 0.05$; 42.7, $p < 0.0001$ and 66.7, $p < 0.0001$, respectively).

Similar results were obtained when the number of falls recorded during the observation period was additionally taken into account — the results of Spearman's correlation analysis between the number of

Table 1. *Clinical characteristics of population studied divided according to fracture site*

Parameter	Spine fracture (n = 16)	Hip fracture (n = 14)	Wrist fracture (n = 67)	Non-spine and non-hip fracture (n = 99)
Age [years]	67.5 ± 7.1	71.6 ± 9.1*	66.7 ± 7.3	66.9 ± 6.8**
Height [cm]	155.3 ± 5.4	158.0 ± 4.4	157.3 ± 5.1	156.9 ± 5.4
Weight [kg]	69.2 ± 10.6	70.7 ± 8.6	74.5 ± 12.6	75.0 ± 13.5
BMI [kg/m^2]	28.7 ± 4.2	28.4 ± 4.0	30.2 ± 5.1	30.5 ± 5.5

BMI — body mass index; *significantly older than women with wrist fracture; $p < 0.05$; **significantly younger than women with hip fracture; $p < 0.01$. All other variables did not differ between groups

Table 2. *Correlation analysis between number of falls and fracture incidence according to fracture site and comparison between r values*

Parameter	Spine fracture (n = 16)	Hip fracture (n = 14)	Wrist fracture (n = 67)	Non-spine and non-hip fracture (n = 99)
r and p value	0.06, ns	0.11, p < 0.01	0.24, p < 0.0001*,**	0.28, p < 0.0001#,##

*significantly stronger than women with spine fracture, p < 0.001; **significantly stronger than women with hip fracture, p < 0.01; #significantly stronger than women with spine fracture, p < 0.001; ##significantly stronger than women with hip fracture, p < 0.01

falls and the frequency of fractures in various parts of the skeleton, as well as comparisons of the strength of the correlation, are presented in Table 2.

To determine the factors having a significant impact on the incidence of fractures during the observation period, logistic regression was used separately in subgroups. The following risk factors were considered, selected based on their known clinical significance and/or potential impact on fractures identified in univariate analyses: age, height, body weight, bone mineral density (BMD) of the femoral neck expressed by T-score, rheumatoid arthritis, steroid use, falls reported at baseline, and total number of risk factors. Spine fractures were dependent only on T-score, OR = 0.42 (0.23–0.76), hip fracture only on age OR = 1.15 (1.07–1.24), forearm only on T-score OR = 0.69 (0.51–0.92), and non-hip, non-spine on falls rate OR = 1.86 (1.20–2.87).

Discussion

The current study presents several observations regarding the role of risk factors for fractures at various skeletal sites. The most important finding is the observation that the incidence of fractures increased with the falls rate in long-term follow-up. Additionally, we have also proven that a greater number of falls also increases the risk of fractures. Another valuable finding for daily practice is the observation that each fracture site was associated with only one dominant risk factor. Spine and forearm fractures were dependent on the T-score, hip fractures depended only on age, and non-hip and non-spine fractures depended on the frequency of falls. Another unexpected finding was the observation that a greater cumulative number of clinical risk factors did not increase the incidence of falls.

We believe that the results obtained are important for practitioners. Some medical interventions that may increase BMD or reduce the incidence of falls may reduce the incidence of fractures.

A population-representative cohort and long-term longitudinal observation allowed us to present reliable data. Valuable conclusions emerge from the comparison of current results with those reported in the same population at baseline [4]. Baseline data showed that fractures occurred less frequently in women from the city of Racibórz than in women from rural areas. Baseline analysis also found that type 1 diabetes and depression influence fall rates. Previous analyses also showed a significant role of kidney diseases, rheumatoid arthritis and bronchial asthma, which was not demonstrated in longitudinal observation. Both analyses showed strong associations between fractures and falls.

We believe that the comparison of baseline data (4) and current longitudinal data suggests that the more reliable come from long-term follow-up.

Some studies published so far have also been based on longitudinal observations [7–11]. Only one study reported the results of a 10-year follow-up [11], while others reported shorter follow-ups ranging from 4 months to 3 years. In a study by Balogun et al. [11] the observed fall rate was 64%, which is very close to our result of 60%. The incidence of fractures was lower than in our study (17 *vs*. 20%), probably due to the lower mean age.

Some studies present data on preventive models (12-14). An interesting concept of fall prevention was established in 647 nursing home patients during a 9-month follow-up period [14]. The authors recommended limiting the physical activity, and the use of this restriction was associated with a higher incidence of fall-related injuries. Vitamin D levels should also be considered, because vitamin D can improve muscle function and reduce the incidence of falls.

In a long-term, 20-year observation of recreational gymnastics, Uusi-Rasi et al. [15] presented some procedures that have the potential to reduce the incidence of falls in older people. However, none of the cited studies included a separate analysis for the risk for fractures in specific skeletal sites. In this aspect, the results of our study are extremely innovative.

In some other studies of cross-sectional design (16-19) the results regarding the role of falls have been reported. We believe that despite some interesting information resulting from these studies, the most valuable data are those based on long-term follow-up. Our previous results, presented earlier, support the statement of priority given by long-term longitudinal studies.

ORIGINAL PAPER

The affected functional condition is especially dangerous for older people. American recommendations for patient management present procedures aimed at reducing the incidence of falls [20]. Polish recommendations also propose directions to improve muscle condition and reduce the risk of falls [21].

Our study has some limitations: we only studied women, and no data were collected on the exact date and place of falls (at home or outside). The role of vitamin D was not established in the current study, and we plan to conduct such an analysis in future studies.

However, the study design, the collection of a representative epidemiological sample, and long-term follow-up allowed us to obtain reliable data on the role of factors increasing the incidence of fractures.

Concluding, fractures at various skeletal sites recorded in long-term follow-up in postmenopausal women were related to different risk factors. There was only one dominant risk factor that increases the incidence of fractures at specific skeletal site. The impact of falls was most pronounced in the case of non-hip, non-spine fractures.

Data availability statement

The data may be available upon request

Ethics statement

The study was approved by the Ethics committee of Medical University of Silesia (KNW/0022/KB1/132/10). At baseline in 2010 year all participants gave their written informed consent.

Author contributions

W.P.: the concept and design of the study, the acquisition of data, an analysis and interpretation of data, drafting of the manuscript, the final approval of the submitted version (the first author). P.A.: an analysis and interpretation of data, drafting of the manuscript, preparing graphical presentation, the final approval of the submitted version. B.D.: an analysis and interpretation of data, a critical revision of the manuscript, the final approval of the submitted version. H.H.: an analysis and interpretation of data, a critical revision of the manuscript, the final approval of the submitted version.

Funding

No funding information.

Conflict of interest

The authors decare they have no conflict of interest

References

1. Raisz LG. Overview of pathogenesis in Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism. Wiley, Washington 2008: 203–206.
2. Kanis JA, Black D, Cooper C, et al. International Osteoporosis Foundation, National Osteoporosis Foundation. A new approach to the development of assessment guidelines for osteoporosis. Osteoporos Int. 2002; 13(7): 527–536, doi: 10.1007/s001980200069, indexed in Pubmed: 12111012.
3. Pluskiewicz W, Adamczyk P, Czekajło A, et al. Epidemiological data on osteoporosis in women from the RAC-OST-POL study. J Clin Densitom. 2012; 15(3): 308–314, doi: 10.1016/j.jocd.2012.01.003, indexed in Pubmed: 22425509.
4. Pluskiewicz W, Adamczyk P, Czekajło A, et al. Falls in RAC-OST-POL Study: epidemiological study in postmenopausal women aged over 55 years. Endokrynol Pol. 2016; 67(2): 185–189, doi: 10.5603/EP.a2016.0015, indexed in Pubmed: 26884285.
5. Pluskiewicz W, Adamczyk P, Drozdzowska B. Functional status as a predictor of the incidence of falls in 10-year follow-up: results from the RAC-OST-POL study. Endokrynol Pol. 2023; 74(4): 404–407, doi: 10.5603/ep.a2023.0046, indexed in Pubmed: 37577992..
6. Pluskiewicz W, Adamczyk P, Drozdzowska B. Impaired Functional Status Increases Fracture Incidence in 10-year Follow-Up: The Results from RAC-OST-POL Study. J Clin Densitom. 2023; 26(1): 104–108, doi: 10.1016/j.jocd.2022.12.009, indexed in Pubmed: 36567159.
7. Rikkonen T, Sund R, Koivumaa-Honkanen H, et al. Effectiveness of exercise on fall prevention in community-dwelling older adults: a 2-year randomized controlled study of 914 women. Age Ageing. 2023; 52(4), doi: 10.1093/ageing/afad059, indexed in Pubmed: 37097767.
8. Vranken L, Wyers CE, Van der Velde RY, et al. Association between incident falls and subsequent fractures in patients attending the fracture liaison service after an index fracture: a 3-year prospective observational cohort study. BMJ Open. 2022; 12(7): e058983, doi: 10.1136/bmjopen-2021-058983, indexed in Pubmed: 35896286.
9. Kim KM, Lui LY, Cummings SR. Recent fall and high imminent risk of fracture in older men and women. Age Ageing. 2022; 51(6), doi: 10.1093/ageing/afac141, indexed in Pubmed: 35753766.
10. Garcia PA, Dias JMD, Silva SLA, et al. Prospective monitoring and self-report of previous falls among older women at high risk of falls and fractures: a study of comparison and agreement. Braz J Phys Ther. 2015; 19(3): 218–226, doi: 10.1590/bjpt-rbf.2014.0095, indexed in Pubmed: 26083603.
11. Balogun S, Winzenberg T, Wills K, et al. Prospective Associations of Low Muscle Mass and Function with 10-Year Falls Risk, Incident Fracture and Mortality in Community-Dwelling Older Adults. J Nutr Health Aging. 2017; 21(7): 843–848, doi: 10.1007/s12603-016-0843-6, indexed in Pubmed: 28717816.
12. Masud T, Binkley N, Boonen S, et al. FRAX(®) Position Development Conference Members. Official Positions for FRAX® clinical regarding falls and frailty: can falls and frailty be used in FRAX®? From Joint Official Positions Development Conference of the International Society for Clinical Densitometry and International Osteoporosis Foundation on FRAX®. J Clin Densitom. 2011; 14(3): 194–204, doi: 10.1016/j.jocd.2011.05.010, indexed in Pubmed: 21810525.
13. Bischoff-Ferrari HA. Prevention of falls. In: Rosen CJ, Compston JE, Lian JB. ed. Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism. 7th ed. Wiley, Washington 2008: 222–225.
14. Vellas BJ, Wayne SJ, Romero LJ, et al. Fear of falling and restriction of mobility in elderly fallers. Age Ageing. 1997; 26(3): 189–193, doi: 10.1093/ageing/26.3.189, indexed in Pubmed: 9223714.
15. Uusi-Rasi K, Karinkanta S, Kannus P, et al. Does long-term recreational gymnastics prevent injurious falls in older women? A prospective 20-year follow-up. BMC Geriatr. 2020; 20(1): 37, doi: 10.1186/s12877-020-1428-0, indexed in Pubmed: 32007107.
16. Aranda-Gallardo M, Morales-Asencio JM, Enriquez de Luna-Rodriguez M, et al. Characteristics, consequences and prevention of falls in institutionalised older adults in the province of Malaga (Spain): a prospective, cohort, multicentre study. BMJ Open. 2018; 8(2): e020039, doi: 10.1136/bmjopen-2017-020039, indexed in Pubmed: 29476031.
17. Dukas L, Schacht E, Runge M, et al. Effect of a six-month therapy with alfacalcidol on muscle power and balance and the number of fallers and falls. Arzneimittelforschung. 2010; 60(8): 519–525, doi: 10.1055/s-0031-1296321, indexed in Pubmed: 20863009.
18. Jiang Yu, Xia Q, Zhou P, et al. Falls and Fall-Related Consequences among Older People Living in Long-Term Care Facilities in a Megacity of China. Gerontology. 2020; 66(6): 523–531, doi: 10.1159/000510469, indexed in Pubmed: 33022681.
19. Leslie WD, Morin SN, Lix LM, et al. Fracture prediction from self-reported falls in routine clinical practice: a registry-based cohort study. Osteoporos Int. 2019; 30(11): 2195–2203, doi: 10.1007/s00198-019-05106-3, indexed in Pubmed: 31372711.
20. Moyer VA. U.S. Preventive Services Task Force. Prevention of falls in community-dwelling older adults: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2012; 157(3): 197–204, doi: 10.7326/0003-4819-157-3-201208070-00462, indexed in Pubmed: 22868837.
21. Głuszko P, Sewerynek E, Misiorowski W, et al. Guidelines for the diagnosis and management of osteoporosis in Poland. Update 2022. Endokrynol Pol. 2023; 74(1): 5–15, doi: 10.5603/EP.a2023.0012, indexed in Pubmed: 36847720.