Determinants of osteoporotic thoracic vertebral fracture.

Screening of 57,000 Finnish women and men

Seppo Santavirta[1], Yrjö T. Konttinen[2], Markku Heliövaara[3], Paul Knekt[3], Peter Lüthje[4] and Arpo Aromaa[3]

A population sample of 27,000 Finnish women and 30,000 men was studied for the presence of a thoracic vertebral fracture. In both sexes, the prevalence of such fractures increased with age: after 40 years of age in the men and after 55 years of age in the women. The interaction of sex and age was significant, and even when the other determinants were adjusted for. In the women aged 35–44, 55–64, and 75 years or more, the prevalence per 1,000 was respectively 2.4, 5.1, and 29, and in the men in the corresponding age groups 5.2, 15, and 28. A previous history of trauma was a fracture determinant in both sexes. In the men, but not in the women, there was an increased risk of fracture when there was a history of tuberculosis and/or peptic ulcer, and in current smokers. Thus, contrary to observations on extremity fractures, the men had an increased risk of sustaining a thoracic vertebral fracture compared with the women. This may reflect differences in the development of osteoporosis in the axial skeleton versus the appendicular skeleton.

[1]Orthopedic Hospital of the Invalid Foundation, Helsinki, Finland; [2]Hospital for Joint Diseases, New York, N.Y., U.S.A.; [3]Social Insurance Institution, Helsinki, Finland; and [4]Kuusankoski District Hospital, Kuusankoski, Finland
Correspondence: Dr. Seppo Santavirta, Orthopedic Hospital of the Invalid Foundation, Tenholantie 10, SF-00280 Helsinki, Finland. Tel +358–0 47481. Fax +358–0 418224
Submitted 91-06-02. Accepted 91-10-17

We report a population-based, cross-sectional epidemiologic study on determinants of thoracic vertebral fractures in 57,480 Finnish citizens. Our specific aim was to investigate the prevalence and determinants of thoracic vertebral fractures. A thoracic vertebral compression fracture represents a manifestation of age-related osteoporosis (Härmä et al. 1986), and hypotheses on the causes and consequences of osteoporosis might thus be detected in epidemiologic studies by identifying the determinants of this fracture type.

Population and methods

The study subjects were 27,278 women and 30,202 men aged 15 years and over who participated in the population-wide, multiphasic health survey of the Social Insurance Institution of Finland between 1966 and 1972. The osteoporosis study was part of a large-scale comprehensive health survey that was carried out by a mobile unit in 34 communities in different parts of Finland. The main emphasis of the study was on screening for cardiovascular diseases and their risk factors. The examined groups comprised either the whole population of a community or a random sample of it. The participation rate in the survey was 83 percent (Aromaa 1981, Reunanen et al. 1983). The participation rate varied considerably by age, being 77 percent in those aged 15–29 years, 89 percent in those aged 30–59 years, 83 percent in those aged 60–69 years, 64 percent in those aged 70–79 years, and 35 percent in those aged 80 years or more.

Thoracic vertebral compression fractures were reviewed independently by 2 radiologists from 100 mm × 100 mm anteroposterior and lateral photofluorograms. The diagnosis of thoracic vertebral compression fractures was based exclusively on radiographic findings (Edeiken et al. 1990). Wedge-shaped and collapsed vertebrae were identified from the Th1 to the Th12 level, and were recorded with good agreement and no systematic difference (kappa = 0.69) between the original and reference readings, as described in a previous study, which also reported the distribution of wedge and compression fractures (Härmä et al. 1986).

Background information was collected with a premailed questionnaire, which included questions about medical history (list of current or previous illnesses, including specific questions for 25 diagnoses), symptoms, life style, habits (e.g., smoking), use of medicines (names of drugs currently being used),

Table 1. Prevalence of thoracic-spine fractures by sex and age

Age	Women			Men		
	No. of subjects examined	No. of subjects with fractures	Prevalence per 1,000	No. of subjects examined	No. of subjects with fractures	Prevalence per 1,000
15–24	6,676	9	1.3	7,188	11	1.5
25–34	4,959	8	1.6	6,700	18	2.7
35–44	4,927	12	2.4	6,126	32	5.2
45–54	4,432	10	2.3	4,651	34	7.3
55–64	3,703	19	5.1	3,666	53	15
65–74	2,029	31	15	1,474	28	19
75–	552	16	29	397	11	28
Total	27,278	105	3.9	30,202	187	6.2

occupation, and parity in women. The questions were checked and completed, when necessary, by a nurse at the examination. Relative weight was measured by the body mass index, weight/height^2 (kg/m^2). A body mass index between 20.0 and 24.9 kg/m^2 was considered normal (Bray 1989), and was used as the reference.

A logistic model was used to estimate adjusted odds ratios and their 95 percent confidence intervals. We chose as the items in the logistic regression model factors that, according to current knowledge, could be risk factors for osteoporosis and that were available. The entry variables that were used to explain the prevalence of a thoracic fracture(s) were age, history of trauma, history of tuberculosis, history of peptic ulcer, current smoking (smoker/nonsmoker), body mass index, use of corticosteroids, thyroid diseases, diastolic and systolic blood pressures, use of antihypertensive medication, self-assessed general health, history of diabetes or antidiabetic medication, plasma glucose measured 1 hour after a 50-gram oral glucose load, occupational group, and parity in women.

Results

The number of vertebral fractures recorded in 30,202 men was 187, and in 27,278 women 105; the age-adjusted odds ratio was 1.85 (95 percent confidence interval 1.45–2.36). In both sexes, the prevalence increased with age. In the men, the prevalence increased gradually with age, whereas in the women an abrupt rise was found after aged 65 years (Table 1). The great majority of these fractures were asymptomatic, as no differences were found between those with and without fractures as regards self-assessed general health and the use of analgesics.

A previous history of trauma was a determinant of vertebral fracture in both sexes (Table 2). In the men, but not in the women, there was an increased prevalence of fracture in those with a history of tuberculosis and/or peptic ulcer, as well as in current smokers. Systolic or diastolic blood pressure or use of antihypertensive medication, glucose tolerance (value after 1 hour), history of diabetes or antidiabetic medication, history of thyroid disease, or current use of oral corticosteroids were not associated with the fracture prevalence in either sex. Further, in the women, the number of births was not associated with the prevalence.

The interaction term of sex and age remained significant (P = 0.003), and even when all the other determinants (Table 2) were adjusted for.

Discussion

Recently, differential osteoporotic involvement of the axial and the appendicular skeleton has been described and used as a classification basis for Types I and II osteoporosis (Riggs et al. 1981, 1982). In these two disease subsets, there is also a differential involvement of the trabecular and the cortical bone mass: Type I affects mainly trabecular bone, and Type II affects both the trabecular and the cortical bone stock (Riggs and Melton 1986). Differential effects of endocrine dysfunction on bone mineral densities further testify for complex disease and site-specific effects (Seeman et al. 1982).

Our results on the occurrence of thoracic vertebral fractures in men at an early age compared with women in a population-based representative sample support the idea of a compartmentalized skeletal involvement of osteoporosis. In general, women are claimed to

Table 2. Association of various factors with the prevalence of thoracic spine fractures as estimated by multiple logistic analysis

	Women					Men				
Factor	No. of subjects examined	No. of subjects with fractures	OR_c	OR_a	95% CI	No. of subjects examined	No. of subjects with fractures	OR_c	OR_a	95% CI
Age (per each 10 years)	27,278	105	1.58	1.60	1.46–1.74	30,202	187	1.52	1.52	1.42–1.62
History of trauma										
No	25,271	85	1.00	1.00		22,292	113	1.00	1.00	
Yes	2,007	20	2.96	1.99	1.21–3.27	7,910	74	1.85	1.39	1.03–1.87
History of tuberculosis										
No	26,396	104	1.00	1.00		29,082	166	1.00	1.00	
Yes	882	1	0.29	0.24	0.03–1.71	1,120	21	3.28	2.40	1.51–3.82
History of peptic ulcer										
No	26,892	103	1.00	1.00		29,210	168	1.00	1.00	
Yes	386	2	1.35	0.80	0.19–3.27	992	19	3.33	2.08	1.28–3.38
Currently smoking										
No	22,686	94	1.00	1.00		14,816	74	1.00	1.00	
Yes	4,594	11	0.58	1.05	0.55–2.02	15,386	113	1.47	1.52	1.12–1.06
Body-mass index (kg/m^2)										
< 20.0	3,634	8	0.75	1.32	0.60–2.87	2,790	6	0.34	0.44	0.19–1.02
20.0–24.9	11,849	35	1.00	1.00		15,069	96	1.00	1.00	
25.0–29.9	7,930	36	1.54	0.88	0.55–1.42	10,307	69	1.05	0.89	0.65–1.23
> 30.0	3,865	26	2.28	1.00	0.59–1.69	2,036	17	1.31	0.95	0.56–1.61
Occupational group										
white-collar	4,534	16	1.00	1.00		3,856	17	1.00	1.00	
agricultural	5,312	32	1.71	0.81	0.43–1.51	7,392	56	1.72	1.14	0.66–1.98
industrial	3,043	10	0.93	0.74	0.34–1.64	13,163	90	1.55	1.60	0.95–2.70
other	9,474	29	0.87	0.85	0.46–1.57	5,792	24	0.94	1.33	0.71–2.48
housewives	4,915	18	1.04	0.59	0.29–1.17					

OR_c Crude odds ratio.
OR_a Odds ratio adjusted for all the other factors listed in this table.
95% CI 95 percent confidence interval of OR_a.

have many more osteoporotic vertebral fractures than men; and in patients of older age, sex ratios up to 8:1 have been described (Hansson et al. 1982, Jensen et al. 1982, Rose et al. 1982, Hedlund et al. 1987). This does not hold, however, for asymptomatic vertebral fractures in a population-based sample (Härmä et al. 1986). It is possible that women are more predisposed to receive the diagnosis of osteoporosis than men, this thus being a possible cause of a discrepancy between clinical series and population-based samples (Pogrund et al. 1979, Cummings et al. 1985, Buchanan et al. 1987, Melton et al. 1989).

Osteoporosis can be defined as an absolute decrease in the amount of bone, leading to fractures after minimal trauma (Ray et al. 1987). The occurrence of such a distinct event is therefore a reflection of both osteoporotic weakening and exposure to trauma (Aniansson 1984). Several studies suggest the importance of repeated falling, and the use of sedative drugs and alcohol as risk factors for osteoporotic fractures in the appendicular skeleton (Sheldon 1965, Gryfe et al. 1977, Seeman et al. 1983, Bikle et al. 1985, Ray et al. 1987). The occurrence of, e.g., multiple rib and vertebral fractures has for a long time been used as a clinical indicator of chronic alcoholism.

Our study, documenting a prereported occurrence of a unspecified trauma and subsequent detection of a hitherto unknown thoracic vertebral fracture, suggests a role for external impact in the pathogenesis of axial compression fractures.

Some comments are also warranted about the other factors that we unexpectedly found to be associated with the prevalence of thoracic vertebral fractures. Smoking is a suspected causal contributor to osteoporosis (Seeman et al. 1983, Cummings et al. 1985). The association between the history of tuberculosis and fractures may reflect sequelae of mycobacterial spondylitis rather than osteoporosis. On the other hand, peptic ulcer might lead to the development of osteoporosis through malabsorption, especially in patients

who have been treated with stomach resection, which was commonly practiced in Finland during the past decades.

There appears to be a discrepancy in age and sex between several bone-density measurement studies (Riggs et al. 1981, 1982, McBroom et al. 1985), and the prevalence profile of vertebral body compression fractures further supports a role of the precipitating trauma or of other, as yet, unidentified factors. This is also supported by our finding that men are at an increased risk of sustaining a thoracic vertebral compression fracture at a relatively young age.

Riggs et al. (1986) have reported that in women before menopause little, if any, bone is lost from the appendicular skeleton, but substantial amounts of bone are lost from the axial skeleton. Thus, factors in addition to estrogen deficiency must contribute to involutional osteoporosis in women, because about half of the overall vertebral bone loss occurs premenopausally (Riggs et al. 1986). Besides bone mass, also bone quality may be important (Heaney 1989). Age-dependent changes contribute to thoracic vertebral fractures also in men, and the fracture risk increases with increasing age. It is possible that greater exposure to trauma in men may explain part of the observed difference. It has also been reported that in men the age-dependent decrease in bone mineral density in the spine, as measured by dual-photon absorptiometry, is approximately one fourth of that in women (Riggs et al. 1981, Riggs and Melton 1986). Considering this, and with regard to our present findings on actual occurrence of thoracic vertebral fractures, it appears that determinants other than bone mineral density probably also contribute to the development and natural history of thoracic vertebral compression fractures.

Acknowledgements

This study was financially supported by The Sigrid Juselius Foundation and The Finnish Academy.

References

Aniansson A, Zetterberg C, Hedberg M, Henriksson K G. Impaired muscle function with aging. A background factor in the incidence of fractures of the proximal end of the femur. *Clin Orthop* 1984; 191: 193–201.

Aromaa A. Epidemiology and public health impact of high blood pressure in Finland (In Finnish with English summary). *Publ Social Insur Inst*, Helsinki, Finland 1981; AL: 17.

Bikle D D, Genant H K, Cann C, Recker R R, Halloran B P, Strewler G J. Bone disease in alcohol abuse. *Ann Intern Med* 1985; 103 (1): 42–8.

Bray G A. Classification and evaluation of the obesities. *Med Clin North Am* 1989; 73 (1): 161–84.

Buchanan J R, Myers C, Greer R B, Lloyd T, Varano L A. Assessment of the risk of vertebral fracture in menopausal women. *J Bone Joint Surg* (Am) 1987; 69 (2): 212–8.

Cummings S R, Kelsey J L, Nevitt M C, O Dowd K J. Epidemiology of osteoporosis and osteoporotic fractures. *Epidemiol Rev* 1985; 7: 178–208.

Edeiken J, Dalinka M, Karasick D. Metabolic and dystrophic bone disease. In: *Edeiken's roentgen diagnosis of diseases of bone* (Eds. Edeiken, J, Dalinka, M, Karasick, D) 4th ed. Williams & Wilkins, Baltimore 1990: 1085–304.

Gryfe C I, Amies A, Ashley M J. A longitudinal study of falls in an elderly population: I. Incidence and morbidity. *Age Ageing* 1977; 6 (4): 201–10.

Hansson L I, Ceder L, Svensson K, Thorngren K G. Incidence of fractures on the distal radius and proximal femur: Comparison of patients in a mental hospital and the general population. *Acta Orthop Scand* 1982; 53 (5): 721–6.

Heaney R P. Osteoporotic fracture space: an hypothesis. *Bone Miner* 1989; 6 (1): 1–13.

Hedlund R, Lindgren U, Ahlbom A. Age- and sex-specific incidence of femoral neck and trochanteric fractures. An analysis based on 20,538 fractures in Stockholm County, Sweden, 1972–1981. *Clin Orthop* 1987; 222: 132–9.

Härmä M, Heliövaara M, Aromaa A, Knekt P. Thoracic spine compression fractures in Finland. *Clin Orthop* 1986; 205: 188–94.

Jensen G F, Christiansen C, Boesen J, Hegedus V, Transbol I. Epidemiology of postmenopausal spinal and long-bone fractures. A unifying approach to postmenopausal osteoporosis. *Clin Orthop* 1982; 166: 75–81.

McBroom R J, Hayes W C, Edwards W T, Goldberg R P, White A A. Prediction of vertebral body compressive fracture using quantitative computed tomography. *J Bone Joint Surg* (Am) 1985; 67 (8): 1206–14.

Melton L J, Kan S H, Frye M A, Wahner H W, O Fallon W M, Riggs B L. Epidemiology of vertebral fractures in women. *Am J Epidemiol* 1989; 129 (5): 1000–11.

Pogrund H, Makin M, Robin G, Menczel J, Steinberg R. Osteoporosis of the spine, pelvis and hand. A comparative study in a femoral neck fracture series. *Clin Orthop* 1979; 139: 156–63.

Ray W A, Griffin M R, Schaffner W, Baugh D K, Melton L J. Psychotropic drug use and the risk of hip fracture. *N Engl J Med* 1987; 316 (7): 363–9.

Reunanen A, Aromaa A, Pyörälä K, Punsar S, Maatela J, Knekt P. The Social Insurance Institution's coronary heart disease study. Baseline data and 5-year mortality experience. *Acta Med Scand* (Suppl 673) 1983; 214: 1–120.

Riggs B L, Wahner H W, Dunn W L, Mazess R B, Offord K P, Melton L J. Differential changes in bone mineral density of the appendicular and axial skeleton with aging: relationship to spinal osteoporosis. *J Clin Invest* 1981; 67 (2): 328–35.

Riggs B L, Wahner H W, Seeman E, Offord K P, Dunn W L, Mazess R B, Johnson K A, Melton L J. Changes in bone mineral density of the proximal femur and spine with aging. Differences between the postmenopausal and senile osteoporosis syndromes. *J Clin Invest* 1982; 70 (4): 716–23.

Riggs B L, Wahner H W, Melton L J, Richelson L S, Judd H L, Offord K P. Rates of bone loss in the appendicular and axial skeletons of women. Evidence of substantial vertebral bone loss before menopause. *J Clin Invest* 1986; 77 (5): 1487–91.

Riggs B L, Melton L J. Involutional osteoporosis. *N Engl J Med* 1986; 314 (26): 1676–86.

Rose S H, Melton L J, Morrey B F, Ilstrup D M, Riggs B L. Epidemiologic features of humeral fractures. *Clin Orthop* 1982; 168: 24–30.

Seeman E, Wahner H W, Offord K P, Kumar R, Johnson W J, Riggs B L. Differential effects of endocrine dysfunction on the axial and the appendicular skeleton. *J Clin Invest* 1982; 69 (6): 1302–9.

Seeman E, Melton L J, O Fallon W M, Riggs B L. Risk factors for spinal osteoporosis in men. *Am J Med* 1983; 75 (6): 977–83.

Sheldon J H. Falls in old age. In: *Medicine in old age* (Ed. Agate, J N) Pitman, London 1965: 199–207.