Calcif Tissue Int (1996) 59:249–253

Calcified
Tissue
International

Prevalence of Vertebral Fractures in Chinese Men and Women in Urban Taiwanese Communities

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Received: 10 August 1995 / Accepted: 13 February 1996

Abstract. Reports on the prevalence (or incidence) rates of vertebral fracture have been available, but they are limited concerning non-white populations and men of all races. This study used the radiomorphometric method to survey the prevalence rate of vertebral fracture for ethnic Chinese women 40 years and older and Chinese men 65 and older who were randomly selected from four major cities in Taiwan. Three sets of reference values of the height ratios were used for middle-aged women, elderly women, and elderly men. The results showed that in Chinese women, the prevalence rate of vertebral fracture was low before age 50 and showed a steady increase thereafter. In men, the increase was small until age 80. The overall adjusted prevalence rate of vertebral fracture for women older than 65 was 20% and that for men, 12.5% (95% confidence interval 18–22% and 11–14%, respectively.) If only severe deformity was counted [height ratio lower than normal mean minus 4 standard deviations (SD), or Grade II deformity], the adjusted prevalence rate was 15.5% for elderly women and 9.5% for elderly men (95% confidence interval 14–17%, and 8–11%, respectively.) The overall adjusted prevalence rate for women aged 40 and over was 6.8% (95% confidence interval 5.7–8%), or 4.5% (95% confidence interval 3.6–5.5%) for Grade II lesions. Moreover, for subjects with fracture, elderly women tended to have more fractured vertebrae per person and more Grade II fractures than elderly men. Thus, Chinese women residing in cities of Taiwan had a relatively high prevalence rate of vertebral fracture, a finding compatible with that for United States or European white women, or for Japanese women residing in America. Elderly Chinese men also have a high prevalence rate of vertebral fracture. The age-specific female-to-male ratio of prevalence rate was about 1.5 to 2.3 between age 65 and 80, and close to unity after age 80.

Key words: Vertebral fractures — Chinese — Men and women.

Although vertebral fracture is the hallmark, and probably the most common fracture as a complication of various forms of osteoporosis, its epidemiology remains relatively less studied than that for hip fractures. Reports on the prevalence of vertebral fractures are relatively scanty and though investigators have used different methods of study, they have also reached different conclusions [1–6]. Recent studies in Europe have shown substantial variation of prevalence across different areas or nations. For instance, the prevalence was higher in the United Kingdom [5] and Denmark [7], and lower in Finland [4]. The information is relatively more scarce in men and in a non-white population. Studies on another osteoporosis-related fracture, the hip fracture syndrome, showed that Asians have lower bone mineral density (BMD) [8–10] and paradoxically lower risk of hip fracture [11–12]. It is not clear whether Chinese, as an Asian race, would also have lower vertebral fracture rate. For men, the risk of vertebral fracture has been reported to be higher [4], or several-folds lower [13], than that for women. Difficulties in sampling and differences in diagnostic criteria may have prevented collection of accurate epidemiologic data in the past, and caused variations in the reported prevalence of vertebral fracture. Because the most usual presentation of vertebral compression or deformity is asymptomatic or mild back pain [14], any clinic- or hospital-based data would tend to underestimate vertebral fracture and include more trauma cases [14]. Survey of the general population with roentgenogram would be more reliable for showing the actual prevalence rate of a community. This report describes a population-based survey of the prevalence of vertebral fracture of Chinese men and women residing in cities of Taiwan, using an age- and gender-specific morphometric method [15, 16] used in many recent reports [17].

Materials and Methods

Subjects

The study included 1322 men and 1318 women over 65, and 425 women between 40 and 65 years of age. They were all ambulatory and were randomly selected from communities through the general registration which covers all citizens of four of the major cities in Taiwan: Taipei, Taichung, Hualien, and Kaohsiung. Because there is a complete registration of all the residents on Taiwan island from their birth to their death, we could calculate the number of subjects needed for each age status to represent the age distribution of Taiwan. After having been randomly selected from the census

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Table 1. The means ± SD values of the height ratios (in %) of each level of vertebral bodies of the three groups[a]

	Ha/Hp			Am/Hp			Hp/Hp′		
	A	B	C	A	B	C	A	B	C
T4	92.3 ± 4.9	91.6 ± 4.2	90.4 ± 4.7	84.9 ± 4.6	87.1 ± 5.1	87.7 ± 5.1	101.2 ± 4.0	98.6 ± 5.1	98.9 ± 3.2
T5	91.9 ± 4.5	89.8 ± 5.8	89.5 ± 4.9	85.6 ± 4.2	87.3 ± 5.1	89.0 ± 3.4	102.3 ± 4.3	101.2 ± 5.2	101.3 ± 3.2
T6	89.7 ± 5.4	90.7 ± 5.2	89.5 ± 5.6	84.8 ± 4.0	88.1 ± 5.7	89.0 ± 4.9	103.0 ± 3.6	101.4 ± 6.2	101.6 ± 4.1
T7	90.3 ± 4.2	88.5 ± 5.3	90.3 ± 4.8	86.9 ± 3.8	86.9 ± 4.9	89.6 ± 5.3	102.2 ± 3.6	103.4 ± 6.0	102.4 ± 3.7
T8	92.2 ± 5.4	92.0 ± 6.0	90.8 ± 5.3	87.1 ± 4.2	88.3 ± 5.1	89.6 ± 4.7	102.5 ± 2.8	101.2 ± 6.2	102.4 ± 3.5
T9	93.9 ± 5.1	95.5 ± 5.5	93.4 ± 4.1	88.3 ± 4.2	90.5 ± 4.6	89.5 ± 4.9	103.2 ± 3.4	101.7 ± 4.3	101.3 ± 3.7
T10	93.1 ± 5.2	93.7 ± 6.3	93.3 ± 4.9	87.8 ± 3.9	89.9 ± 5.5	90.0 ± 4.9	106.0 ± 4.3	106.2 ± 5.4	105.9 ± 4.0
T11	89.0 ± 5.2	90.5 ± 6.4	89.5 ± 4.3	86.9 ± 4.2	87.6 ± 4.4	88.9 ± 4.0	108.6 ± 4.7	106.2 ± 5.3	107.7 ± 4.4
T12	89.9 ± 5.1	90.6 ± 6.3	89.1 ± 4.1	86.8 ± 4.2	87.5 ± 5.4	89.1 ± 4.9	108.1 ± 4.4	107.7 ± 5.3	107.6 ± 6.0
L1	91.5 ± 4.9	91.3 ± 6.5	87.9 ± 5.0	89.0 ± 4.0	90.3 ± 5.4	87.9 ± 4.1	104.3 ± 5.3	101.9 ± 4.7	101.6 ± 4.1
L2	96.1 ± 5.9	94.4 ± 6.4	90.6 ± 5.3	89.7 ± 4.1	89.8 ± 5.1	87.8 ± 3.5	102.3 ± 3.8	102.2 ± 4.9	101.7 ± 4.3
L3	98.3 ± 5.1	98.0 ± 5.7	94.7 ± 5.5	91.8 ± 3.8	92.0 ± 5.0	91.2 ± 4.0	100.6 ± 3.8	99.6 ± 4.0	98.8 ± 3.5
L4	101.8 ± 6.1	99.8 ± 6.1	98.4 ± 5.7	96.7 ± 5.6	96.2 ± 4.6	93.8 ± 6.3	94.5 ± 4.8	97.0 ± 5.6	95.0 ± 3.4
L5	106.4 ± 9.1	108.3 ± 9.0	108.7 ± 9.8	96.8 ± 5.8	97.5 ± 8.9	97.9 ± 7.5	96.5 ± 5.4	93.0 ± 5.7	92.9 ± 6.9

[a] A: Women aged 40–64; B: elderly women; C: elderly men

books of the cities in an age-stratified manner, the subjects were invited to local medical centers participating in this program. We invited 2864 men and 2920 women older than 65. Among them 1322 men agreed to attend this program; 116 were sick or not ambulatory and were unable to participate. The others refused, mostly for personal reasons such as lack of time or interest. Similarly, 1318 women participated. Their reasons for non-attendance were mostly lack of time or interest, fear of discovering untreatable diseases, and the need to take care of their grandchildren. There was an even response rate (42–50%) for each age group by 5-year intervals for both genders. We also recruited 425 ambulatory women aged 40–64 who participated in this survey program in a similar manner. The rate of attendance was similar for pre- or postmenopausal women (response rate 50 and 52%, respectively) in this group. Each participant was interviewed, physically examined, and then given standard lateral X-ray examinations of the thoracic and lumbar spine, separately. The tube-film distance was 120 cm. The thoracic and lumbar spine films were centered at T7 and L2, respectively.

Morphometry of Vertebral Bodies

Morphometry of the vertebral bodies was done according to the methods of Eastell et al. [15]. Each vertebral body, from T3 to L5, was measured for its anterior height (Ha), middle height (Hm), and posterior height (Hp) with a transparent meter to 0.5 mm with bare eyes. Fifty subjects with apparently normal vertebral bodies, as judged by the three authors (KST, PUC, and RSY), were selected arbitrarily from premenopausal women aged 40–50 years. Their Ha/Hp, Hm/Hp, and Hp/Hp′ ratios, where Hp′ is the Hp one level above for each vertebral body [T4 to L5], were calculated. Then vertebrae-specific mean and standard deviations (SD) of (Hp-Ha)/Hp, (Hp-Hm)/Hp, and (Hp′-Hp)/Hp′ were derived for each vertebra, and used as reference values. The presence of a vertebral fracture was defined by either an (Hp-Ha)/Hp, (Hp-Hm)/Hp, or (Hp′-Hp)/Hp′ ratio which is larger than the mean plus 3 SD, but smaller than the mean plus 4 SD values (Group I) or larger than the mean plus 4 SD values (Group II) of the normal controls for that particular vertebra [15] in this 40–65-year age group. Similarly, 40 sets of X-ray films of ''normal'' men aged 65–75, and 40 sets of X-ray films of ''normal'' women aged 65–75 were used to detect the presence of vertebral fracture. These apparently normal subjects were not excluded for calculating the fracture prevalence in each group. The measurement was carried out by only one of the authors. The coefficient of variations (CVs) of three ratios were between 0.5 and 1% for each vertebra for 10 repeated measurements on six subjects, two from each group.

Classification of Vertebral Fractures

An increase of the (Hp-Ha)/Hp ratio for a vertebral body to a degree more than mean plus 3 SD value of normal controls of that age group was called a wedge fracture. Similarly, a significant increase of the (Hp-Hm)/Hp ratio defined biconcave deformity. A vertebral body with wedge fracture was considered to have both wedge and biconcave deformities if its middle height was at least 1 mm less than its anterior height.

A significant increase of the (Hp′-Hp)/Hp′ ratio defined a crush fracture. If a vertebra already had a crush fracture, it was not further defined as having a biconcave or wedge fracture, regardless of its Ha and Hm. Meanwhile the Hp of this crushed vertebra was replaced by the posterior height one or more levels above it, depending on whether this one level above was normal or not, when we calculated the (Hp′-Hp)/Hp′ ratio for the vertebral one level beneath it.

Results

Based on the means and SDs derived from normal subjects of different ages and different genders (Table 1), the cutoff points used for either Group I or Group II fractures in different groups showed a small variation although they were similar. On the other hand, the absolute value of these cutoff values differed significantly from one vertebral level to another. In general, the criteria were most stringent for elderly women, less so for elderly men, and least so for middle-aged women.

Using these age-, gender-, and vertebra-specific criteria, the crude and adjusted prevalence rates of Groups I and II fractures of Taiwanese men and women are shown in Table 2. The adjusted overall prevalence rate of vertebral fracture was 20% for elderly women and 12.5% for elderly men. Before age 80, men showed only a slight increase in prevalence with increase in age, whereas women showed a steady increase of prevalence of vertebral fracture after age 50, and low rates before that age. The female:male ratio was about 2:1 before age 70 years, but after age 80, the difference between men and women was obscured. Adjustment of overall vertebral fracture prevalence of the elderly to the actual age distribution of 1993 resulted in a small increase in the crude rate because the age distribution of our subjects as similar to the actual age distribution of Taiwanese.

Table 2. Age-specific and overall prevalence rate of vertebral fracture of Chinese men and women living in cities

	Women		Men		Female: Male Ratio	
Age (yrs)	Gr.. II only 95% C.I. (%)	Gr. I + II 95% C.I. (%)	Gr. II only 95% C.I. (%)	Gr. I + II 95% C.I. (%)	Gr. II only	Gr. I + II
40–44	0% (0/68, ~)	1.5% (1/68, 0–2.9%)				
45–49	1/3% (1/73, 0–3/9 %)	2.7% (2/73,0–6.4%)				
50–54	3.4% (3/88, 0–7.2%)	4.5% (3/88, 0.2–8.8%)				
55–59	1.2% (1/83, 0–3.5%)	4.8% (4/83, 0.2–9.4%)				
60–64	3.9% (4/104, 0.2–7.6%)	6.7% (7/104, 1.9–11.5%)				
65–69	10.2% (63/618, 7.8–12.6%)	13.9% (86/618, 11.6–16.3%)	6.7% (34/507, 4.5–8.9%)	9.3% (47/507, 6.8–11.8%)	1.5	1.5
70–74	15.2% (66/434, 11.8–18.6%,	20.7% (90/434, 16.9–24.5%)	7.5% (36/481, 5.2–9.9%)	10.2% (49/481, 7.5–12.9%)	2.0	2.0
75–79	19.3% (39/202, 13.9–24.7%)	24.3% (49/202, 18.4–30.2%)	8.3% (22/265, 5.0–11.6%)	12.5% (33/265, 8.5–16.5%)	2.3	1.9
80+	25.0% (16/64, 14.4–35.6%)	29.7% (19/64, 18.5–40.9%)	21.7% (15/69, 12–31.4%)	27.5% (19/69, 17–38%)	1.2	1.1
Total (crude rate)						
⩾65	14.0% (12.4–14.6%)	18.5% (16.7–20.3%)	8.1% (6.6–9.6%)	11.2% (9.5–12.9%)		
Standardized rate (adjusted by age distribution of the Taiwanese population of 1993)						
⩾40	4.5% (3.6–5.5%)	6.8% (5.7–8.0%)				
⩾65	15.7% (13.7–17%)	19.8% (17.7–22.0%)	9.3% (7.7–10.9%)	12.5% (10.7–14.3%)		

Parentheses enclose actual numbers of persons with fracture over the total number of subjects in that age group, and the 95% confidence interval of the prevalence rate estimated

Table 3 shows the site and forms of vertebral fractures for men and women, neither showed a significant difference in the distribution of sites or forms of vertebral fracture. The most common form was wedge fracture, which occurred mostly at lower thoracic and upper lumbar vertebral bodies. Biconcave fractures primarily affected the lumbar vertebrae. Elderly women tended to have more than one vertebral fracture (19.4%, versus 9.4% in elderly men, Chi-square test: $P < 0.0001$), and the fracture tended to be mostly in the Group II category (75.3%), more than for their male counterparts, (63.3%, Chi-square test: $P < 0.0001$). Also, elderly women had proportionally more crushed fractures (15.3%) than their male counterparts (3.7%, Chi-square test: $P < 0.0001$).

In this survey, only six female cases, aged 44, 52, 66, 68, 70, and 78 showed their awareness of vertebral deformity. Only two (aged 52 and 70) stated that their vertebral deformity were from a fall to the ground. The others cannot attribute their vertebral deformity to any specific cause. Three elderly male subjects were aware of their vertebral fracture, two of them attributed it to some previous trauma to the spine.

Discussion

The final goal of any osteoporosis prevention or treatment program is to reduce its complicating fractures; among these, vertebral fracture is probably the most common, it occurs earlier than the more lethal hip fractures. The presence of vertebral fractures can be a future risk factor for hip fractures [18]. Recent reports also showed an association with increased long-term mortality rate [19]. Thus, information about the prevalence rate of vertebral fracture would greatly facilitate the understanding of the scale of osteoporosis, and help in policy making concerning the involutional osteoporosis of a particular population. Previous reports concerned mostly white populations, particularly women; many were based on hospital or clinical records, and used different diagnostic methods.

Most recent surveys have agreed that many of the fractures are asymptomatic, and their timing may be difficult to ascertain [5, 6, 14]. Thus, the actual incidence rate is difficult to calculate unless serial X-ray examinations are done. Prevalence rate rather than incidence rate is usually sought. In this study, ambulatory Chinese men and women in their middle or older ages were recruited to be surveyed for the prevalence of vertebral fractures. Overall, in these cities, 12.5% of the men (adjusted) and 19.8% of the women (adjusted) older than 65 had at least one vertebral fracture. If more stringent criteria were used, 9.3% (adjusted) of the men and 15.7% (adjusted) of the women older than 65 would show at lest a vertebral compression deformity. The estimated prevalence of vertebral fractures for all women older than 40 was 6.8% (Groups I and II) and 4.5% (Group II only) when the rate was adjusted to the age distribution of the Taiwanese female population in the year 1993.

To survey only ambulatory volunteers would potentially underestimate the actual prevalence rate of the general population because those who are not ambulatory or who were not willing to be studied might have a much higher prevalence of vertebral fracture. So the prevalence rate shown in this study, although relatively high among all the human races, may still be an underestimation.

The incidence rates of a population's vertebral fractures depend heavily on the definition or diagnostic criteria used. Some previous reports used subjective diagnostic methods, and were difficult to compare [1–4, 7]. Recent studies mostly used morphometric criteria. Because there is a marked difference in the contours of each vertebral body, using fixed ratio value for all vertebral bodies could be erroneous [20]. A set of vertebrae-specific ratios for diagnostic cutoff values would be more accurate [16, 20]. Recent reports from the European Vertebral Osteoporosis study group demonstrated that, even with identical methods performed by the same persons, men and women showed different reference values. Furthermore, different areas of Europe gave different reference values [21]. This shows the need to use gender- and age-specific criteria derived form the same population. This study also demonstrated small

Table 3. Distribution of the site and classification of verteral fractures of the 410 subjects found to have vertebral fractures in this survey

	Wedge		Biconcave		Combined		Crushed		Total		
	Gr. I	Gr. II	Gr. I	Gr. II	Gr. I	Gr. II	Gr. I	Gr. II	Gr. I	Gr. II	Both
T4	0	1	0	0	1	0	2	1	3	2	5
T5	1	6	0	0	0	0	0	2	1	8	9
T6	6	11	1	0	1	2	0	7	8	20	28
T7	9	17	0	3	1	1	0	10	10	31	41
T8	7	12	0	1	0	4	0	8	7	25	32
T9	4	13	0	3	0	1	0	12	4	29	33
T10	8	12	1	2	0	2	0	7	9	23	32
T11	26	32	1	3	0	6	2	8	29	49	78
T12	39	80	2	5	4	5	3	13	48	103	151
L1	39	58	4	14	2	11	1	7	46	90	136
L2	9	18	2	23	8	11	0	4	19	56	75
L3	2	12	2	5	3	7	1	2	8	26	34
L4	4	3	2	19	2	3	0	4	8	29	37
L5	1	0	0	6	0	1	0	1	1	8	9
Total	155	275	15	84	22	54	9	86	201	499	700

differences of reference ratios derived from different age groups and different genders. The reference values here are similar to the European values. The adjusted data showed that 12.5% (95% confidence interval 11–14%) of men and 18% (95% confidence interval 18–22%) of women older than 65 in this population had at least one Group I vertebral fracture. This prevalence rate for Taiwanese women aged 65–69 is similar to that of the 15% reported for white women in the midwestern United States [17], and the Japanese-American women of the same age [22]. The female to male ratio is also compatible with the recent findings of Cooper et al. [14], who reported a 2:1 ratio in incidence rate. Because in elderly men the prevalence rate increased sharply after age 80, this female-to-male ratio of incidence rate could be near unity at more advanced ages and higher, about 2:1, for subjects 65–80 years of age. It was previously demonstrated that spinal BMD of Taiwanese women residing in Taipei City area is similar to that of US white women [8]. It appears in this study that urban Taiwanese women have a similar level of spinal BMD and vertebral fracture rate as the US white women.

Although older women tend to have more fractures per person and more Gr. II lesions, elderly men, especially those who are over 80 years old, also have a high prevalence rate of vertebral fracture. This is in contrast to previous reports of male predominance [4, 23] or a female:male ratio of 5-fold or more [12], but is in concordance with recent reports using morphometric methods for surveillance of general populations [16].

Of all the vertebral fractures found in this study, only 37.3% in elderly men and 24.7% in elderly women were Group I category, similar to other reports [14, 15]. This reflects the relatively poor sensitivity of the morphometric methods used in this cross-sectional study. A small change in the dimensions of a vertebral body probably could not be detected by the two cutoff points used. It may also imply that once a vertebral body changes its shape because of the compressive forces imposed upon it, it did not remain a Gr. I fracture for long.

Trauma of varying degrees of severity to the spine may cause vertebral fracture. In a study based on clinical diagnosis, Cooper et al. [14] reported that 40% of all women with vertebral fracture recounted a history of spinal trauma. In this study only a small proportion of the subjects had noticed or recalled the presence of vertebral fractures before they were screened. An even fewer proportion of subjects gave a history of spinal trauma. This sharp contrast may be due to differences in the medical knowledge, culture, and lifestyle between the different populations. It demonstrated the importance of X-ray examination of the spine for accurate diagnosis of vertebral fracture in a survey for mostly asymptomatic subjects from the general population.

In conclusion, this survey for both men and women in Taiwan for vertebral fracture randomly selected and examined elderly men, middle-aged women, and elderly women. By using age-specific and gender-specific diagnostic criteria that were also vertebrae specific, it was shown that (1) elderly Taiwanese men and women had adjusted prevalence rates, 16% overall, similar to those of US and European white populations and Japanese; (2) elderly women had a higher prevalence rate of vertebral fracture than men of the same age (age specific F:M ratios = 1.1–2:1), and tended to be more severely affected when they fractured their spines; (3) elderly men, especially after age 80, also had a high prevalence rate of vertebral fractures.

Acknowledgments. This study was supported by grants from the Department of Health ROC (DOH82-HP-035-4M07, DOH83-HP29-44M01). The authors thank Ms. Tueh-Chu Wu, Chue-Yen Tai, Shih-Hwa Liu, Yu-Chiu Chow, and Shu-Jen Chung for their assistance, and Prof. Rong-Der Wang for his kind and thorough review of this manuscript.

References

1. Rowe CR, Sorbie C (1963) Fracture of the spine in the aged. Clin Orthop 26:34–38
2. Marshall DH, Horsman A, Simpson M, Francis RM, Peacock M (1984) Fractures in elderly women: prevalence of waist, spine, and femur fractures and their concurrence. In: Christiansen C, Arnaud CD, Nordin BEC, Parfit AM, Peck WA,

Riggs BL (eds) Osteoporosis. Proc Copenhagen Inter Symp on Osteoporosis, June 3–8, pp 361–363
3. Smith RW Jr, Rizek J (1966) Epidemiologic studies on osteoporosis in women of Puerto Rico and southeastern Michigan with special reference to age, race, national origin, and to related or associated findings. Clin Orthop 45:31–48
4. Harma M, Heliovaara M, Aromaa A, Knekt P (1986) Thoracic spine compression fractures in Finland. Clin Orthop 205:188–194
5. Cooper C, O'Neill TW, Silman A, on behalf of the European Vertebral Osteoporosis Study Group (1993) The epidemiology of vertebral fractures. Bone 14:S89–S97
6. Melton LJ III, Kan SH, Frye MA, Wahner HW, O'Fallon WM, Riggs BL (1989) Epidemiology of vertebral fractures in women. Am J Epidemiol 129:1000–10117
7. Jensen GF, Christiansen C, Boesen J, Hegedus V, Transbol I (1982) Epidemiology of postmenopausal spinal and long bone fractures. Clin Orthop 166:75–81
8. Tsai KS, Huang Km, Chieng PU, Su CD (1991) Bone mineral density of normal Chinese women in Taiwan. Calcif Tissue Int 48:161–166
9. Russell-Aulet M, Wong J, Thornton JC, Colt EWD, Pierson RN Jr (1993) Bone mineral density and mass in a cross-sectional study of white and Asian women. J Bone Miner Res 8:575–581
10. Sugimoto T, Tsutsumi M, Fujii Y, Kawakatsu M, Negishi H, Lee MC, Tsai KS, Fukase M, Fujita T (1992) Comparison of bone mineral content among Japanese, Korean and Taiwanese assessed by dual photon absorptiometry. J Bone Miner Res 7:153–158
11. Silerman SL, Madison RE (1988) Decreased incidence of hip fracture in Hispanics, Asians and blacks: California hospital discharge data. Am JP Public Health 78:1482–1483
12. Lau EMC, Cooper C, Wickham C, Donnan S, Barker DJP (1990) Hip fracture in Hong Kong and Britain. Int J Epidemiol 19:1119–1121
13. Pogrund H, Makin M, Robin G, Menczel J, Steinberg R (1977) Osteoporosis in patients with fractured femoral neck in Jerusalem. Clin Orthop 124:165–172
14. Cooper C, Atkinson EJ, O'Fallon WM, Melton LJ III (1992) Incidence of clinically diagnosed vertebral fractures—a population-based study in Rochester, Minnesota 1985–1989. J Bone Miner Res 7:221–227
15. Eastell R, Cedel SL, Wahner HW, Riggs BL, Melton LJ III (1991) Classification of vertebral fractures. J Bone Miner Res 6:207–215
16. Black DM, Cummings SR, Stone K, Hudes E, Palermo L, Steiger P (1991) A new approach to defining normal vertebral dimensions. J Bone Miner Res 6:883–892
17. Melton LJ, Lane AW, Cooper C, O'Fallon WM, Riggs BL (1993) Prevalence and incidence of vertebral deformities. Osteoporosis Int 3:113–119
18. Kotowicz M, Melton LJ III, Cedel SL, O'Fallon WM, Riggs BL (1990) Risk of hip fracture among women with vertebral fractures. Bone Miner 10:S272
19. Cooper C, Atkinson EJ, Jacobsen SJ, O'Fallon WM, Melton LJ III (1993) Survival following vertebral fractures: a population-based study. Am J Epidemiol 137:1001–1005
20. Smith-Bindman R, Cummings SR, Steiger P, Genant HK (1991) A comparison of morphometric definitions of vertebral fractures. J Bone Miner Res 6:25–34
21. O'Neill TW, Varlow J, Felsenberg D, Johnell O, Weber K, Marchant F, Delmas PD, Cooper C, Kanis J, Silman AJ, and European Vertebral Osteoporosis Study Group (1994) Variation in vertebral heights in population studies. J Bone Miner Res 9:1895–1907
22. Ross PD, Wasnich RD, Vogel JM (1988) Detection of prefracture spinal osteoporosis using bone mineral absorptiometry. J Bone Miner Res 3:1–11
23. Knowleden J, Buhr AJ, Dunbar O (1964) Incidence of fractures in persons over 35 years of age. A report to the MRC Working Party on fractures in the elderly. Br J Rev Soc Med 18:130–141