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Prevalence of Vertebral Fracture in Women and the Relationship with Bone Density and Symptoms: The Chingford Study

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ABSTRACT

A population survey was performed to estimate the prevalence of vertebral fractures in women aged 45–69 and to determine their relationship to bone density and symptoms. Subjects were 1035 women aged 45–69 (mean 55.4 years, response rate 77%) from the age-sex register of a large 11,000-person general practice in Chingford, London. Thoracic and lumbar spine x-rays were read by a semiautomated quantitative method. Vertebral fractures were diagnosed using a variety of morphometric methods, including a new method we recently developed and the published methods of Melton and Eastell. These methods all detect abnormal ratios between anterior, central, or posterior vertebral height and between observed posterior vertebral height and values predicted from the posterior height of adjacent vertebrae. Bone mineral density (BMD) of lumbar spine L1–4 and neck of femur was measured by dual-energy x-ray absorptiometry (DXA). Using our method, 147, 14.2% (95% CI 12.0–16.2%) of the 1035 women, had minor fractures (at least two vertebral ratios 2–2.99 SD below the mean) and 20, 1.9% (95% CI 1.2–3.0%) of the total, had severe fractures (at least two ratios more than 3 SD below the mean). In the 147 women with minor fractures, bone density of the spine was not significantly lower than in the other 868 women, and reported back pain or loss of height was no more common. Women with multiple minor fractures did have lower bone density, by 0.4 SD. In the 20 women with severe fracture, bone density was significantly lower, by 0.6 SD. Loss of height was more common, but back pain was not. Using the method of Melton the prevalence of deformity was 10.2% and, for the Eastell 3 and 4 SD method, 9.7 and 1.3%, respectively, which is similar to published data from the Rochester population. Minor vertebral deformities are common in postmenopausal women, but they are not usually associated with pain, loss of height, or (unless multiple) reduced bone density. This suggests that they may not be of clinical or pathologic importance. Severe deformities associated with low bone density are rare in U.K. women under the age of 70.

INTRODUCTION

VERTEBRAL FRACTURE is believed to be an important and common consequence of osteoporosis. In the population setting without clinical presentation, fractures are usually referred to as deformities. Surveys have shown that vertebral deformities are often asymptomatic,[1,2] and prevalence estimates can only be obtained from population surveys. One of the major problems in epidemiologic and clinical studies has been the lack of consensus on the definition of vertebral fracture, in part due to the difficulty in distinguishing the deformity following a fracture from normal anatomic variation.[3,4] Studies have used a variety of qualitative and quantitative methods, often subjective, for assessing vertebral fracture, which has resulted in a wide range of estimates of the frequency of the condition. Some

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estimates are that as many as one in four women aged over 50 are affected,[1] which obviously would have major public health implications, whereas others are low, with a Finnish study showing rates of only 1 in 200 in middle-aged women.[6] It is likely that differences in specificity between methods contribute to apparent differences in prevalence. Due in part to these problems, there is a marked lack of knowledge and epidemiologic data concerning vertebral fractures, in marked contrast to the many studies found on hip fracture.

The aims of this study were to estimate the prevalence of vertebral deformities in a sample of the female U.K. population aged 45-69 and to examine whether women with and without vertebral deformities differed in bone mineral density (BMD), symptoms, and other demographic variables. We used a new semiautomated method of vertebral definition that accounted for anatomic variation at different vertebral levels. In addition, to allow comparison of our U.K. data with other populations, we also used other published methods of fracture definition.

MATERIALS AND METHODS

Population sample

The age-sex register of a six-partner general practice containing over 11,000 patients was used to obtain the addresses of women aged between 45 and 69 years. All the women lived within 5 miles of the general practice, and 98% of the women were white. A socioeconomic profile was performed using the Acorn classification system, which is based on each subject's postal code and residence (CACI International, London). These codes were linked to one of four socioeconomic categories. The majority of the women (42%) belonged to group C1 (mid- to lower middle class, white collar workers), 32% were A/B, 17% C2, and 8% D/E.

All women within the age range were sent an invitation for a screening examination at Chingford Hospital, half a mile from the general practice, between November 1989 and May 1991, and a second letter was sent after 6 weeks if no initial response was obtained. Ethical approval was given by the local committee of Waltham Forest Health District.

Measurements

All women had height and weight recorded. A simple questionnaire was administered by a nurse, including details on back pain lasting more than 1 month in the last 10 years, as well as recalled height loss and change in posture (stooping). Bone mineral density of L1-4 was obtained using a Hologic QDR 1000 machine (precision 1%). In a lumbar vertebral deformity, the affected vertebra was omitted from the calculation. BMD measurement of the neck of the femur (NOF) was also obtained in 596 cases.

Lateral views were taken of the thoracic and lumbar spine (two films) at a standard target-to-film distance of 101 cm centered at T9 and L3, respectively. Radiographs were read after positioning on a rear illuminated digitizing tablet (Kontron). Using a transparent cross-wire cursor, the anterior, posterior, and central heights of each vertebra from T4 to L4 were measured and the results transferred directly to a computer data base. Normal ranges of vertebral shape were obtained from measurements in 100 females aged 45-50 years from within the study population who were free of back pain and known osteoporotic fractures. Mean ratios and standard deviations (SD) were calculated for each vertebra from T4 to L4. Across these vertebrae the anterior/posterior ratios had a mean value of 0.95, with a range of 0.91-1.04. This average ratio is similar to that derived in different populations by Black et al.[6] and Melton et al.[1] These data were used to run a number of different algorithms for defining fractures.

For our own method, which is described in detail elsewhere,[7] the predicted posterior height for each vertebra was derived from the posterior heights of up to four adjacent vertebrae. This predicted height was used to assess each vertebra for deformity. In contrast to other methods, ours requires the fulfillment of two criteria for the definition of deformity. The algorithm used had a false positive rate of 1% for 3 SD definition.[7]

Four types of deformity were defined as follows:

1. Anterior wedge: anterior to posterior ratio low and anterior to predicted posterior ratio low
2. Central collapse: central to posterior ratio low and central to predicted posterior ratio low
3. Posterior wedge: posterior to predicted posterior ratio low and anterior to posterior ratio high
4. Widespread collapse: anterior to predicted posterior ratio low and posterior to predicted posterior ratio low

Deformities in a particular vertebra were classified as minor if two ratios were 2-2.99 SD below the mean for that vertebral level and site. Deformities below the 0.1-centile limit (i.e., 3 SD) were classified as severe. The percentage decrease in vertebral height corresponding to these centile limits varied for each vertebrae. For example, the mean percentage decrease in height for an anterior wedge deformity [(P − A)/P × 100] approximated to 12.0% (range 10-14.0%) for 2 SD, 18% (14-21%) for 3 SD, and

TABLE 1. CHARACTERISTICS OF WOMEN (n = 1035)

Mean age (SD)	55.4 (6.8) years
Mean weight (SD)	66.9 (12.04) kg
Mean age menopause (SD)	49.1 (3.9) years
Mean height (SD)	161.3 (6.1) cm
Mean BMI (SD)	25.7 (4.4) kg/cm^2
No. (%) premenopausal	213 (20.7)
No. (%) ever used HRT	242 (23.5), 11 months median duration
No. (%) current use HRT	138 (13.3)
No. (%) hysterectomy	238 (23.1)
No. (%) ever-smokers	476 (46.0)
No. (%) current smokers	238 (23.1)
No. (%) alcohol > 4 U/week	452 (43.7)
No. (%) regular exercise	466 (45.0)

24% (19–28.0%) for 4 SD using our algorithm. These cutoffs are similar to those reported using another recently developed algorithm.[8] As the specificity of these techniques tends to be poor, largely due to the number of sites (39) measured within each spine, the false positive rate of our method was lowered by defining two criteria that must both be fulfilled for characterizing a deformity as present. We also used the Melton method, based on a 15% decrease in anterior, central, or posterior height relative to the adjacent vertebrae, adjusted for differences in vertebral shape. This method has an approximate specificity of 12%.[7] This method was later modified by Eastell et al., whereby deformities were defined by standard deviations below the mean rather than as a percentage, and has a specificity of approximately 10%.[7,8]

Statistics

The characteristics of these groups were compared using Student's *t*-test and chi-square for proportions after testing that the data approximated a normal distribution. To adjust for differences in age, analysis of covariance was used with SPSS software.

RESULTS

Invitations were sent to 1307 women. Of these, 81 had moved or died and 1095 attended the examination, a response rate of 77%. The characteristics of the population are given in Table 1. Adequate spinal radiographs for analysis were obtained on 1035 women aged 45–69. Age-specific prevalences are shown in Table 2. Using the 2 SD definition (minor deformity), 147 women were found to have deformities, with a prevalence of 14.2% (95% confidence interval, CI, 12.0–16.2) for the whole group aged 45–69. Using the 3 SD definition (severe), 20 women had deformities, a prevalence of 1.9% (CI 1.5–4.0). Of these 7 women had deformities lying below the 4 SD cutoff. They were generally older (60.1 years) and had lower bone density (0.83, SD 0.14). Only small increases were seen with age within the range studied. For the 3 SD group the two most frequent fracture sites were vertebrae L1 and T10.

The characteristics of those with vertebral deformity were compared with 868 individuals in whom no abnormality was detected (Table 3). Only minor differences were seen between those with no deformity and those detected at the 2 SD level. BMD of the lumbar spine and femur was not significantly different between these two groups. Using the 3 SD cutoff, age was significantly higher (59.4 versus 55.2 years, $p < 0.006$) and BMD spine was significantly lower [0.84 (0.13) versus 0.97 (0.16) g/cm^2, $p < 0.001$]. BMD NOF was also lower, but not significantly (p = 0.07). Other differences were not readily apparent, and no major differences in obesity (as measured by body mass index, BMI, height, or weight) were seen. Unexpectedly, back pain was reported less frequently in this group (30%) compared to normal controls (50.75%) (p = 0.1). However, the number reporting loss of height greater than 1 cm was higher (10.5 versus 4.8%, p = 0.2), as was recalled history of stopping (22.2 versus 11.8%). Fewer women had ever used hormone replacement therapy (HRT): 15 versus 24.4% (p = 0.2). No social class gradient was apparent within the fracture group, deformities being evenly divided between the social groups. The exclusion of the 100 women used to define the normal vertebral heights made no significant differences to the results.

Because of the potential confounding effects of age, analysis of covariance was used to examine the relationship between vertebral deformity and BMD (Table 4). No difference was found between controls and the minor deformity group after adjustment, and the BMD L1–4 of the severe group remained significantly lower (p = 0.007). The age-adjusted case-control difference amounted to 0.09 g/cm^2, or 0.6 standard deviations of the population variance for the severe group, and was less marked for the neck of the femur 0.04 g/cm^2 (0.3 SD).

We also examined whether women with multiple minor vertebral deformities differed from those with single deformities (Table 5). Women with two or more deformities had a lower bone density than those with single deformities (p = 0.02), although this did not reach the values found in the severe group. Similarly, reporting of loss of height increased with number of deformities.

The effect of the menopause on deformities was examined by dividing women into quartiles of years since meno-

TABLE 2. PREVALENCE OF VERTEBRAL DEFORMITIES BY AGE GROUP

	Age group		
Deformities	*45–54 (n = 264)*	*55–59 (n = 438)*	*60–69 (n = 333)*
Minor (2–2.99 SD)			
No.	31	64	52
Percentage (95% CI)	11.7 (8.0–16.7)	14.6 (11.2–18.6)	15.6 (11.6–20.4)
Severe (>3 SD)			
No.	2	9	9
Percentage (95% CI)	0.8 (0.09–2.7)	2.1 (0.9–3.9)	2.7 (1.2–5.1)

TABLE 3. CHARACTERISTICS OF WOMEN WITH VERTEBRAL DEFORMITIES COMPARED TO NORMALS[a]

	No deformity (n = 868)	*2 SD (n = 147)*	*3 SD (n = 20)*
Mean (SD) age, years	55.2 (6.8)	56.0 (6.9)	59.4 (5.6)[b]
Mean (SD) age menopause, natural, years	49.2 (3.8)	49.1 (5.8)	47.8 (2.4)
Mean (SD) height, cm	161.3 (6.1)	161.9 (6.1)	159.6 (8.0)
Mean (SD) weight, kg	66.9 (12.1)	66.7 (11.8)	65.6 (11.8)
Mean (SD) BMI, kg/m²	25.7 (4.4)	25.5 (4.4)	25.6 (3.6)
No. (%) hysterectomy	203/863 (23.5)	31 (21.1)	3 (15.0)
No. (%) ever use HRT	211/863 (24.4)	28 (19.4)[b]	2 (10)
No. (%) back pain > 1 week	440/867 (50.7)	80 (54.4)	6 (30.0)
No. (%) loss of height > 1 cm	41/853 (4.8)	13 (8.8)	2/19 (10.5)
No. (%) still menstruating	189/863 (21.9)	24 (16.3)	0 (0)
No. (%) hump or stoop	94/795 (11.8)	21/132 (15.9)	4/18 (22.2)

[a]Where information is missing for some individuals the demonimators are given.
[b]$p < 0.05$ versus no deformity group.

TABLE 4. MEAN AND 95% CONFIDENCE INTERVALS FOR BMD SPINE AND HIP BY CATEGORIES OF VERTEBRAL DEFORMITY

Category of deformity	*Mean BMD L1-4 (g/cm²)*	*BMD neck of femur (g/cm²)*[a]
None	0.97 (95% CI 0.96–0.98)	0.78 (0.77–0.79)
2 SD	0.95 (95% CI 0.89–1.01)	0.77 (0.74–0.80)
3 SD	0.84 (95% CI 0.79–0.89)[b]	0.70 (0.61–0.79)[c]

[a]Neck of femur data based on 596 women.
[b]Versus none, $p = 0.006$.
[c]Versus none, $p = 0.07$.

pause. For the minor deformity group no differences in prevalence of deformity were noted. The rate of severe deformity was higher in the women more than 13 years since the menopause (5.3%) compared with those within 3 years of the menopause (1.8%). No severe deformities were noted in the 213 premenopausal women.

To compare our results with those in previous studies, we also defined deformities according to the method of Melton et al.,[1] which identified 106 women as having deformities (10.2%) compared with an expected rate of 9.4% if the age-specific prevalence rates from Rochester were applied to the age distribution of our study population. At this level there were no significant differences in lumbar BMD (mean 0.94 SD, 0.18 versus 0.97 SD, 0.16), weight, or BMI between the groups. When only the 34 individuals with two or more deformities defined by this method were studied, a slight but nonsignificant case-control difference of 0.4 standard deviations was noted in the lumbar spine BMD ($p = 0.09$). Using the Eastell method,[8] a prevalence estimate of 9.7% for 3 SD and 1.3% for 4 SD was obtained in our subjects. Comparable figures obtained by applying the Eastell age-specific prevalence rates to our population are 8.4 and 1.9%. The Eastell algorithm for 3 and 4 SD produced results similar to those obtained with our method using our 2 and 3 SD levels, respectively; differences in BMD were noted only with at least two deformities at the single criterion 3 SD cutoff and in the small number of 4 SD individuals.

DISCUSSION

Using 99.9th percentile limits of deformity (3 SD) to define a (severe) vertebral fracture, we found that only 1.9% (95% CI 1.2–3.0) of U.K. females in the population aged between 45 and 69 were affected. These women have lower bone density than age-matched controls, although the difference is small (0.6 SD) and in line with other studies using clinical cases.[9] They are generally no more likely to be symptomatic than those with no abnormality, although they report loss of height or change in posture more frequently. Minor deformity detected either by our method as a 2 SD deviation from the mean or a simple 15% (Melton) reduction did not show any significant reduction in bone density, which suggests that these minor deformities (2 SD) may be normal anatomic variants, possibly representing reversible deformities[10] or artifacts of measurement not associated with osteoporosis. When individuals were identified as having two or more of these deformities, the mean BMD, however, was lower than controls. The significance of these minor deformities in terms of future fracture risk is unknown.

The limitations of the study should be discussed. The first is that the population sample chosen may not be representative of the U.K. female population. The area chosen was on the outskirts of London, and the vast majority of women were white (98%) and of middle class background as assessed by status of residence, which is

TABLE 5. CHARACTERISTICS OF INDIVIDUALS WITH SINGLE AND MULTIPLE MINOR VERTEBRAL DEFORMITIES[a]

	No. fracture (n = 570)	*2 SD Single fracture (n = 91)*	*Multiple (n = 26)*
Mean (SD) BMD, L1–4	0.97 (0.16)	0.96 (0.1)	0.90 (0.16)[b]
Mean (SD) BMD, neck of femur[c]	0.78 (0.12)	0.77 (0.13)	0.74 (0.14)
Mean (SD) age	55.2 (6.8)	55.8 (6.9)	56.6 (6.6)
BMI mean (SD), kg/m²	25.7 (4.4)	25.3 (4.6)	25.9 (3.1)
No. (%) back pain	440/867 (50.7)	67 (55.7)	16 (50.0)
No. (%) loss of height > 1 cm	41/853 (4.8)	9 (7.8)	4 (12.5)
No. (%) stooped	94/795 (11.8)	17/104 (16.3)	4.28 (14.3)
No. (%) ever use HRT	211/863 (24.4)	23 (20.0)	5 (15.6)

[a]Where data is missing for some individuals, the numbers involved are given.
[b]Versus no deformity, $p = 0.02$.
[c]Based on 596 individuals.

similar to the national average. Heights, weights, smoking and alcohol intake, exercise patterns, and BMIs were similar to those found in national surveys.[11] Rates of hysterectomy were also similar to those found in a larger rcent survey of women from different areas of London,[12] and current rates of HRT usage were 13% compared to recent national estimates of around 9%.[13] Nonresponders might have been more or less likely to have had vertebral deformities than responders, but the reasonable response rates achieved (77%) and the low rates of severe deformity make this unlikely to have markedly altered our estimate of the prevalence. Over 95% of individuals in this area are registered with a general practice, and it is unlikely that women obtained from this large health center list represented a biased or selected group of the population. We did not exclude women because of concomitant medication or diseases as some other surveys have done. This is because the numbers would have been small, and again we would be introducing additional selection. The present study included women on HRT, although the median duration of use was less than 1 year and unlikely to have markedly affected the estimate of prevalence. Some studies have excluded women with a history of back trauma from prevalence estimates. This may lead to an underestimate of fractures, however, as often the fall and the detection of fracture may have been coincidental. Moreover, the number of coincident fractures and history of trauma were extremely low. We believe, therefore, that our sample was representative of the majority of women in the United Kingdom.

The choice of a reference population to establish a normal range is controversial. Different authors have used different methods. Melton et al. used a small group of perimenopausal normal women,[1] and Black et al. used a large truncated sample of 65- to 69-year-olds.[6] When comparing the mean anterior to posterior ratios of these two groups with our own, we found only minor differences, allowing for differences in age and measurement technique. Our reference range had a mean ratio of 0.95, that of Melton et al., 0.97, and Black et al., 0.93. These data suggest that the study populations are similar and that vertebral dimensions do not change appreciably with age, as observed by Hedlund et al.[14] Black et al.[6] suggested that the choice of referent group when the prevalence is low is unlikely to alter significantly estimates of fracture rates; this is likely to be the case in our population samples.

At present there is no gold standard for measuring vertebral abnormalities, although a recent study of different methodologies concluded that the best classification systems included criteria for all three vertebral dimensions (anterior, central, and posterior).[3] Our algorithm is based on site,- and level-specific normal ranges of vertebral shape within the spine from T4 to L4. It is independent of the relationship between body size (height) and vertebral dimensions.

Few other studies have adequately surveyed both the lumbar and thoracic spine of large numbers of women in this age range, apart from the Rochester study, which we have discussed. Jensen et al.[15] found that 22.8% of a sample of 70-year-old Danish women had wedge of compression deformities (assessed visually). A recent study of 2992 U.S. women aged 65–70 found 10.2% had a 4 SD deformity, most of whom were symptomatic.[16] Deformities defined less strictly were not associated with pain or disability. No population-based survey has been carried out in the United Kingdom for suitable comparison, although a study of females aged 48–81 attending general practice waiting rooms found a prevalence of 7.8% using visual methods of fracture detection.[17]

Many of these differences may have emerged because of different ways of classifying a fracture, different ways of selecting populations, and differences in the ages studied, all of which could have a marked effect on apparent fracture prevalence. Despite methodologic problems, it is possible that differences in fracture rates exist between countries. Hip fracture rates in the United Kingdon are lower than in the United States and Scandinavia.[18] Although the prevalence of vertebral fractures in our study for women under 70 was similar to results reported from the United States when the same methods were used,[1,7,8] our own algorithm produced much lower estimates of prevalence for U.K. women. Our method, but not those of other authors, identified women who had lower spinal BMD and marginally lower BMD of the femoral neck. None of the methods for defining vertebral fractures identified a subgroup of women with increased likelihood of back pain. We therefore conclude that below the age of 70, significant vertebral deformities associated with low bone mass are uncommon in U.K. women. When they do occur, they are unlikely to be symptomatic.

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REFERENCES

1. Melton LJ, Kan SH, Frye MA, Wahner HW, O'Fallon WM, Riggs BL 1989 Epidemiology of vertebral fractures in women. Am J Epidemiol 129:1000–1011.
2. Bengner, Johnell O, Redlund-Johnell I 1988 Changes in incidence and prevalence of vertebral fractures during 30 years. Calcif Tissue Int 42:293–296.
3. Smith-Bindman R, Cummings S, Steiger P, Genant HK 1991 Comparison of morphometric definitions of vertebral fracture. J Bone Miner Res 6:25–34.
4. Cooper C, Melton LJ 1992 Vertebral fractures. Br Med J 304:793–794.
5. Harma M, Heliovaara M, Aromaa A, Knekt P 1986 Thoractic spine compression fractures in Finland. Clin Orthop 205:188–194.
6. 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.
7. McCloskey EV, Spector TD, Eyres KS, Fern DE, O'Rourke N, Vasikaran S, Kanis JA 1993 The assessment of vertebral deformity: A method for use in population studies and clinical trials. Osteoporosis Int 3:138–147.
8. Eastell R, Cedel SL, Wahner HW, Riggs BL, Melton LJ III 1991 Classification of vertebral fractures. J Bone Miner 6: 207–216.
9. Law MR, Wald NJ, Meade TW 1991 Strategies for prevention of osteoporosis and hip fracture. Br Med J 303:4453–459.
10. Nelson DA, Kleerekopper M, Haustad S, Peterson E 1991 Vertebral deformities in osteoporosis may be transient events: The "rebound" phenomenon (abstract). J Bone Miner Res 6(Suppl. 1):S275.
11. Knight I, Eldridge J 1984 The heights and weights of adults in Great Britain. OPCS Social Surveys Division, HMSO, London.
12. Spector TD, Brennan P, Harris P, Studd JWW, Silman AJ 1991 Does estrogen replacement therapy protect against rheumatoid arthritis? J Rheumatol 18:1473–1476.
13. Wilkes HG, Meade TW 1991 HRT in general practice: A survey of doctors in the MRC's general practice framework. Br Med J 302:1317–1321.
14. Hedlund LR, Gallaher JC, Meeger C, Stoner S 1989 Change in vertebral shape in spinal osteoporosis. Calcif Tissue Int 44:158–172.
15. Jensen GF, Christiansen C, Beosen J, Hegedus V, Transbol I 1982 Epidemiology of post-menopausal spinal and long bone fractures. Clin Orthop 166:75–81.
16. Ettinger B, Black DM, Nevitt MC, Rundle AC, Cauley JA, Cummings SR, Genant HK 1992 Contribution of vertebral deformities to chronic back pain and disability. J Bone Miner Res 7:449–456.
17. Cooper C, Shah S, Hand DJ, Adams J, Compston J, Davie M, Woolf A 1991 Screening for vertebral osteoporosis using individual risk factors. Osteoporosis Int 1:134–140.
18. Maggi S, Kelsey JL, Litvak J, Heyse SP 1991 Incidence of hip fractures in the elderly: A cross-national analysis. Osteoporosis Int 1:232–241.

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