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Vertebral Deformities and Functional Impairment in Men and Women*

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ABSTRACT

The objective of this study was to assess the prevalence and health effects of vertebral deformities in men and women. The study was carried out as part of the cross-sectional baseline phase of The Rotterdam Study, a prospective population-based cohort study of residents aged 55 years or over of a district of Rotterdam, The Netherlands. The prevalence of vertebral deformities according to a modification of the Eastell method and concomitant functional impairment were assessed in a random sample of 750 men and 750 women. The prevalence of moderate (grade I) vertebral deformities was 8 and 7% in men and women, respectively. For severe deformities (grade II), these percentages were 4 and 8%. In men, the prevalence of both moderate and severe deformities increased with age. In women, however, the prevalence of moderate vertebral deformities remained constant, opposite to a marked increase in severe deformities. Moderate vertebral deformity was significantly associated with impaired rising in men only. Severe vertebral deformity was associated with a significantly increased risk of general disability and the use of a walking aid in both men and women, impaired bending in men, and impaired rising in women. It is concluded that (1) vertebral deformities are only slightly less common in men than in women from the general population and (2) severe progression with age occurs in women only and (3) severe vertebral deformity is, particularly in men, related to functional impairment. (J Bone Miner Res 1997;12:152–157)

INTRODUCTION

The impact of hip fractures on present-day health care systems in Western countries is considerable.[1,2] The frequency and consequences of vertebral fractures are, however, not as clear.[3] Yet, it may be expected that the number of vertebral deformities will grow in all aging populations. Because a considerable proportion of vertebral deformities do not come to medical attention, population-based research is needed to determine the size and consequences of this health problem.[4] Although vertebral fractures are considered uncommon in men, studies on the prevalence in men are deficient.[5,6] Investigations that allow comparison of the prevalence in men and women are virtually nonexistent. In women, severe deformities appear to contribute substantially to pain and disability.[4] For men, however, no such data are available. The present study shows the prevalence of vertebral deformities in persons from the general population in relation to age, gender, and several measures of functional impairment.

MATERIALS AND METHODS

The present study was conducted as part of the Rotterdam Study, a prospective population-based cohort study of determinants and prognosis of chronic diseases in the elderly.[7] The focus of the study is on cardiovascular, neurogeriatric, ophthalmologic, and locomotor diseases. The

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eligible population comprised all inhabitants aged 55 years or over of the district of Ommoord in Rotterdam, The Netherlands. Altogether, 10,275 persons, of whom 9161 (89%) were living independently, were invited to participate. The baseline examination of the Rotterdam Study included an interview at home and extensive investigations at the research center. In the independently living population, the response rate was 77% for the home interview and 71% for the center visit. Written informed consent was obtained from every participant. The Rotterdam Study has been approved by the Medical Ethics Committee of Erasmus University Medical School. The present study was performed in a stratified sample from independently living participants of the Rotterdam Study composed of 750 men and 750 women with balanced numbers (150) in the age groups 55–59, 60–64, 65–69, 70–74, and 75 years or over. The response rates in these age groups for participants with radiographs were 73, 74, 69, 63, and 47%, respectively. One-third of this population is part of the population of the European Vertebral Osteoporosis Study (EVOS).[8]

Lateral radiography of the spine from the fourth thoracic to the fifth lumbar vertebra was performed in each participant. Vertebral deformities were diagnosed according to a modification of the Eastell method.[9] This modification was proposed by Black et al. and reduces the false positive rate.[10] All computations were performed for men and women separately. The degree of deformity of each vertebra was assessed by measurement of the anterior height (AH), central height (CH), and posterior height (PH) of the vertebrae on levels (i) T4–L4 using a cross-wired cursor and an illuminated digitizing board. The following ratios were calculated: AH_i/PH_i, CH_i/PH_i, PH_i/PH_{i-1}, PH/PH_{i+1}, AH_i/AH_{i-1}, and AH_i/AH_{i+1}. The coefficient of variation for these ratios was approximately 3% for repeated measurements on the same radiograph. Deviation of one of these ratios below a given cut-off value indicates vertebral deformity. The modification requires that in case $PH/PH_{i\pm1}$ is reduced, the corresponding anterior ratio $AH/AH_{i\pm1}$ must also be reduced. Cut-off values were calculated as the vertebra-specific mean reference value for each ratio minus 3 and 4 SD. The reference values were obtained from 50 men and 50 women aged 55–60 years. From this group, two men were excluded because they had clinically visible vertebral deformities according to an expert radiologist. A deviation of any ratio between the 3 and 4 SD cutoff value was recorded as a moderate (grade I) deformity. A severe (grade II) deformity was recorded in case of a deviation below the 4 SD cut-off value. Subsequently, the degree of vertebral deformity was calculated for each participant. Moderate vertebral deformity was defined as at least one moderate deformity without severe deformities. Severe vertebral deformity in a participant was defined as one or more severe deformities. To obtain a continuous measure of deformity, the deviations of all ratios from the reference value, expressed as the number of standard deviations (*Z* score), were computed for each vertebra. Next, all *Z* scores were added up across the total vertebral column to achieve an overall continuous measure of deformity. No distinction between wedge, biconcave, or compression deformities was made in the present study.

The measures of functional impairment in the present study were selfperceived health, disability, use of a walking aid, back complaints, impaired rising, and impaired bending. Disability was assessed as the impairment in activities of daily living (ADL) using a questionnaire adapted from the Stanford Health Assessment Questionnaire as part of the home interview.[11] The questionnaire measured the amount of difficulty in eight components: dressing and grooming, rising, reaching, hygiene, eating, walking, grip, and activity. Each component was addressed by two to four component questions. The answers to these questions were scored on a four-point scale ranging from zero to three meaning (0) without difficulty, (1) some difficulty, (2) much difficulty, and (3) unable to do. The component score was defined by the highest score on any component question. The mean score of the eight component scores is the disability index. Disability was defined by an index of 0.5 or over. The interview also assessed selfperceived general health compared with people of the same age, the use of a walking aid, and back complaints during the past 5 years. As part of the physical examination at the research center, the study physician judged the difficulty in rising from a low chair (sitting height 37 cm) without using the arm rests and bending down to the floor to pick up an object. All participating physicians were extensively instructed on assessment and scoring methods; standardization procedures were carried out regularly. The same four-point scoring scale as for the disability assessments was used. Impaired rising and impaired bending was defined as score two or over. To validate these tests, selfassessed rising and bending from the interview were compared with physician-assessed rising and bending. The comparisons were made on a dichotomous scale, i.e., the presence or absence of impairment as defined above. The percentage agreement was 89% for rising and 91% for bending. Further, the Kappa statistic was calculated. It represents the amount of actual agreement as the percentage of the total agreement that occurs beyond the contribution of chance. The Kappa was 0.44 ($p < 0.001$) for rising and 0.40 ($p < 0.001$) for bending. Kappas between 0.21 and 0.40 are considered fair, between 0.41 and 0.60 are moderate.[12]

Data analysis

For reasons of poor technical quality, the radiographs of 26 men and 33 women did not allow reliable measurements of all vertebral heights, leaving 724 men and 717 women for the analyses. First, we compared some characteristics of the study population between men and women. In addition to the crude prevalence, the prevalence of vertebral deformities adjusted for the age distribution of the Dutch population at January 1, 1994[13] was calculated. The relation of vertebral deformities with age was examined using logistic regression. Similarly, subsequent analyses were carried out while adjusting for age. The occurrence of functional impairment in relation to vertebral deformity was assessed using three ways of scaling deformity. First, vertebral deformity was analyzed using two dichotomous variables indicating none, moderate, or severe deformity. Second, dose response was investigated by analyzing the number of de-

TABLE 1. MEAN (SD) VERTEBRAL ANTERIOR (AH), CENTRAL (CH), AND POSTERIOR (PH) HEIGHT RATIO REFERENCE VALUES FOR MEN

Level (i)	AH_i/PH_i	CH_i/PH_i	PH_i/PH_{i-1}	PH_i/PH_{i+1}	AH_i/AH_{i-1}	AH_i/AH_{i+1}
T4	0.954 (0.060)	0.905 (0.053)	—	0.942 (0.044)	—	0.992 (0.033)
T5	0.903 (0.045)	0.891 (0.032)	1.064 (0.050)	0.961 (0.041)	1.009 (0.034)	1.001 (0.068)
T6	0.871 (0.050)	0.871 (0.043)	1.043 (0.044)	0.975 (0.048)	1.004 (0.070)	0.997 (0.060)
T7	0.856 (0.055)	0.876 (0.042)	1.028 (0.050)	0.992 (0.039)	1.006 (0.061)	0.993 (0.069)
T8	0.854 (0.061)	0.880 (0.035)	1.009 (0.039)	0.988 (0.045)	1.012 (0.071)	0.947 (0.050)
T9	0.893 (0.069)	0.902 (0.043)	1.014 (0.046)	0.951 (0.042)	1.059 (0.053)	0.918 (0.049)
T10	0.924 (0.060)	0.897 (0.041)	1.054 (0.047)	0.919 (0.033)	1.093 (0.061)	0.970 (0.060)
T11	0.877 (0.063)	0.879 (0.038)	1.090 (0.039)	0.938 (0.040)	1.035 (0.064)	0.933 (0.064)
T12	0.882 (0.059)	0.886 (0.046)	1.068 (0.046)	0.968 (0.044)	1.077 (0.079)	0.954 (0.051)
L1	0.894 (0.048)	0.897 (0.038)	1.036 (0.046)	0.987 (0.045)	1.051 (0.057)	0.971 (0.059)
L2	0.910 (0.057)	0.887 (0.036)	1.016 (0.047)	1.013 (0.043)	1.034 (0.062)	0.959 (0.059)
L3	0.962 (0.056)	0.898 (0.041)	0.989 (0.042)	1.037 (0.042)	1.047 (0.068)	1.026 (0.056)
L4	0.969 (0.053)	0.946 (0.043)	0.966 (0.040)	—	0.977 (0.053)	—

TABLE 2. MEAN (SD) VERTEBRAL ANTERIOR (AH), CENTRAL (CH), AND POSTERIOR (PH) HEIGHT RATIO REFERENCE VALUES FOR WOMEN

Level (i)	AH_i/PH_i	CH_i/PH_i	PH_i/PH_{i-1}	PH_i/PH_{i+1}	AH_i/AH_{i-1}	AH_i/AH_{i+1}
T4	0.941 (0.070)	0.897 (0.057)	—	0.953 (0.047)	—	0.991 (0.061)
T5	0.904 (0.049)	0.885 (0.042)	1.052 (0.055)	0.962 (0.036)	1.012 (0.061)	0.979 (0.054)
T6	0.886 (0.043)	0.882 (0.038)	1.041 (0.039)	0.968 (0.037)	1.025 (0.055)	0.989 (0.052)
T7	0.869 (0.045)	0.880 (0.036)	1.035 (0.038)	0.984 (0.038)	1.014 (0.051)	0.986 (0.053)
T8	0.867 (0.054)	0.884 (0.035)	1.018 (0.039)	0.982 (0.040)	1.017 (0.054)	0.930 (0.063)
T9	0.917 (0.060)	0.903 (0.031)	1.020 (0.043)	0.960 (0.041)	1.080 (0.073)	0.948 (0.053)
T10	0.928 (0.050)	0.911 (0.032)	1.044 (0.045)	0.912 (0.075)	1.058 (0.059)	0.934 (0.087)
T11	0.908 (0.060)	0.901 (0.038)	1.109 (0.164)	0.931 (0.047)	1.087 (0.185)	0.931 (0.055)
T12	0.908 (0.054)	0.901 (0.037)	1.077 (0.053)	0.951 (0.041)	1.078 (0.063)	0.934 (0.045)
L1	0.927 (0.054)	0.903 (0.032)	1.054 (0.045)	0.974 (0.037)	1.074 (0.052)	0.939 (0.055)
L2	0.962 (0.056)	0.905 (0.035)	1.028 (0.040)	1.004 (0.037)	1.069 (0.062)	0.976 (0.060)
L3	0.990 (0.047)	0.922 (0.034)	0.997 (0.036)	1.048 (0.043)	1.028 (0.063)	1.002 (0.046)
L4	1.037 (0.071)	0.975 (0.056)	0.956 (0.038)	—	1.001 (0.046)	—

formities in relation to impairment, given the presence of at least one deformity. The third way of analysis used the continuous overall Z score as the independent variable. Because the data suggested that gender modifies the effect of vertebral deformity on the outcomes, the data were also analyzed in men and women combined with an interaction term for gender.

RESULTS

Tables 1 and 2 depict the mean values of all ratios in the reference group for men and women separately. In men, somewhat smaller values for the AH_i/PH_i and CH_i/PH_i ratios were found. Table 3 shows the crude prevalence of important characteristics of the study population stratified by gender. The prevalence of moderate vertebral deformity

TABLE 3. CHARACTERISTICS OF THE STUDY POPULATION BY GENDER

Characteristic	*Men*	*Women*	p
Age (years)	68 (8)	68 (8)	—
Moderate vertebral deformity (%)	8	7	0.29
Severe vertebral deformity (%)	4	8	<0.01
Poor self-perceived health (%)	9	11	0.11
Disability (%)	21	31	<0.01
Use of a walking aid (%)	4	6	0.11
Back complaints (%)	37	59	<0.01
Impaired rising (%)	3	5	0.07
Impaired bending (%)	6	5	0.71

Values are mean (SD) or percentage. p values refer to the comparison between men and women.

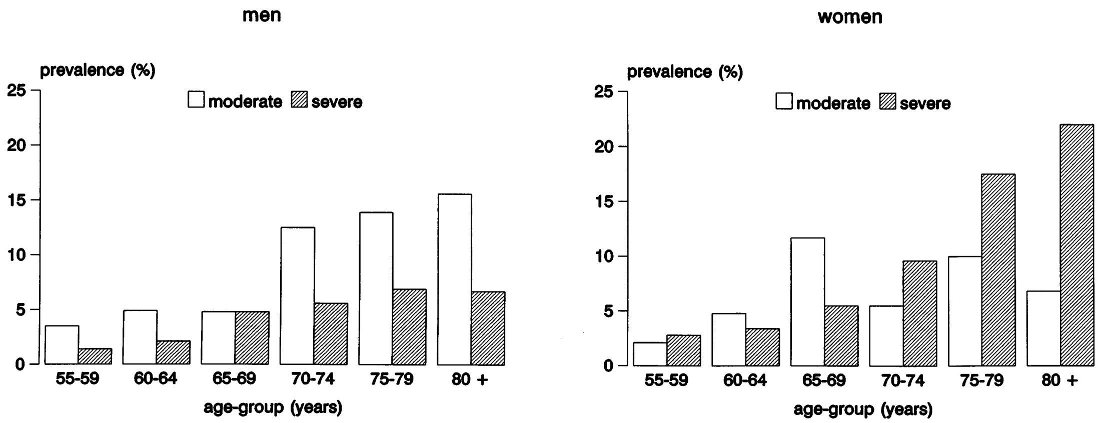

FIG. 1. The prevalence of moderate and severe vertebral deformities according to age and gender.

TABLE 4. THE ASSOCIATION BETWEEN FUNCTIONAL IMPAIRMENT AND VERTEBRAL DEFORMITY BY GENDER AND GRADE

Measure of functional impairment	*Men*		*Women*	
	Moderate	*Severe*	*Moderate*	*Severe*
Poor self-perceived health	0.5 (0.2–1.8)	2.3 (0.8–6.2)	0.5 (0.2–1.7)	1.8 (0.8–3.9)
Disability	0.7 (0.4–1.4)	3.1 (1.4–6.7)	0.9 (0.4–1.7)	1.8 (1.0–3.2)
Use of a walking aid	0.5 (0.1–2.1)	3.2 (1.0–10.6)	0.5 (0.1–2.4)	2.7 (1.2–5.9)
Back complaints	1.4 (0.7–2.9)	0.6 (0.2–2.1)	1.2 (0.5–2.8)	1.4 (0.6–3.1)
Impaired rising	3.5 (1.1–11.1)	2.9 (0.6–15.1)	0.5 (0.1–3.9)	2.6 (1.0–6.9)
Impaired bending	1.9 (0.7–5.4)	3.7 (1.1–12.3)	0.6 (0.1–4.5)	1.9 (0.6–5.5)

Values are age-adjusted relative risks with 95% confidence intervals between parentheses.

was somewhat higher in men, whereas the prevalence of severe vertebral deformity was considerably and statistically significantly higher in women. Moderate and severe deformities taken together were slightly more frequent ($p = 0.17$) among women (15%) than among men (12%). After adjustment for the age distribution of the Dutch population at January 1, 1994, the prevalence of moderate or severe vertebral deformity was 12% in men (8% moderate and 4% severe) and 17% in women (7% moderate and 10% severe). All aspects of functional impairment were more frequent among women than men, except for impaired bending. The differences were statistically significant for disability and back complaints during the past 5 years.

The prevalence of deformity according to gender, age, and severity is depicted in Fig. 1. The prevalence of both moderate ($p < 0.01$) and severe deformity ($p = 0.01$) increased with age in men. In women, no rise with age was found for moderate deformity ($p = 0.13$), whereas the prevalence of severe deformity increased markedly with age ($p < 0.01$).

The association between functional impairment and moderate and severe vertebral deformity is presented in Table 4. Moderate vertebral deformity was in general not related to impaired functional status, although in men a considerable and statistically significant relative risk for impaired rising was observed. Severe vertebral deformity, however, was related to all measures of functional status in men, with the exception of back complaints. The associations were statistically significant for disability, the use of a walking aid, and impaired bending. In women, the relative risks for measures of functional impairment of severe vertebral deformity were generally lower and statistically significant associations were observed for disability, the use of a walking aid and impaired rising. From those with moderate deformities, 13% had more than one deformity. For severe deformities this percentage was 26. No consistent relationship between the number of deformities and impaired functional impairment was found. When deformity was analyzed as a continuous variable (Table 5), relative risks were substantial for the use of a walking aid, impaired rising, and impaired bending in men and poor self-perceived health in women. Except for impaired bending, these relative risks were statistically significant. The magnitude of the relationship between vertebral deformity and functional impairment was not significantly affected by gender.

DISCUSSION

To our knowledge, this is the first population-based study to compare the health consequences of vertebral deformity between men and women. The overall prevalence was only

TABLE 5. THE ASSOCIATION BETWEEN FUNCTIONAL IMPAIRMENT AND VERTEBRAL DEFORMITY SCALED AS A CONTINUOUS AGE-ADJUSTED Z SCORE BY GENDER

	Men	*Women*
	z score deformity	*z score deformity*
Poor self-perceived health	1.09 (0.85–1.41)	1.23 (1.03–1.48)
Disability	1.07 (0.90–1.28)	1.07 (0.94–1.23)
Use of a walking aid	1.47 (1.03–2.09)	1.05 (0.85–1.30)
Back complaints	1.02 (0.83–1.25)	1.00 (0.84–1.18)
Impaired rising	1.52 (1.04–2.22)	1.00 (0.76–1.31)
Impaired bending	1.34 (0.99–1.83)	1.09 (0.85–1.41)

Values are age-adjusted relative risks with 95% confidence intervals between parentheses.

slightly higher in women. Moderate vertebral deformity, however, was slightly more frequent among men, whereas the prevalence of severe deformity was considerably higher in women. With advancing age, the prevalence of the two grades of vertebral deformity increased in men. In women, by contrast, the frequency of moderate deformity remained approximately constant, while the prevalence of severe deformity rose sharply. Finally, a marked association was observed between severe vertebral deformity and functional impairment, more clearly in men.

Four limitations of the present study are to be discussed. First, an underestimation of the true prevalence may have occurred if persons with vertebral deformities were, probably through concomitant health problems, less likely to participate. Because such a nonresponse bias tends to become more prominent with age, an underestimation of the increase with age may have resulted as well. However, an influence on the association of vertebral deformities with functional impairment is unlikely because this would only occur if those with functional impairment would be more likely to be nonresponders if they had vertebral deformities. Second, the cross-sectional design of the study does not allow conclusions about the time relationship of deformities and health outcomes. It remains, therefore, possible that impairment of locomotor functions preceded rather than followed the vertebral deformities. This sequence may have been realized through immobility inducing elevated bone resorption(14) and subsequent deformities. Third, an overestimation of the prevalence of deformities may have occurred because the presence of scoliosis on the X-rays was not accounted for. Fourth, we did not record the presence of spinal osteoarthritis. Because this condition may cause both deformities(15) and functional impairment through pain,(16) it may in part explain the observed relationship.

The comparison of the prevalence of vertebral deformities between studies is seriously complicated by the use of widely divergent methods. Therefore, we compared our results with the results from studies using similar methods only. Melton et al. reported prevalence data from a population-based study of vertebral deformities in women.(17) Standardized to the age distribution of our sample, the prevalence of vertebral deformities in this survey after exclusion of clinically unconfirmed grade I deformities was almost the same (17%) as the overall prevalence in our study (15%). The Chingford Study showed similar prevalence rates for moderate (9.7%) and lower prevalence rates for severe deformities (1.3%) among women aged 45–69 years.(18) In women aged 65–70 years from a very large population-based study, these prevalence rates were 13 and 6%, respectively.(4) As far as we know, only one study assessed the prevalence of vertebral deformities in men using vertebral morphometry.(6) In this study, the mean age was 64 years and the prevalence of moderate and severe deformities taken together was 10%. It should be noted, however, that approximately half of the participants were healthy volunteers. The prevalence of deformities that was reported for Rotterdam in the EVOS study(8) using the McCloskey algorithm,(19) which has an equally high specificity as the Eastell modification we used,(10) is similar to the prevalence in the current larger sample. The results of studies on the relationship between vertebral deformities and detrimental health outcomes vary considerably.(4,16,18,20,21) Among these, at least two investigators also conclude that severe rather than moderate deformities are associated with impaired health status.(4,21)

The strong increase in severe deformities in women after the age of 75 years was not accompanied by an increase in moderate vertebral deformities. This observation suggests that in elderly women moderate deformities further progress to severe vertebral deformities. Alternatively, although less likely in our view, a severe deformity in elderly women may result from a sudden collapse without being preceded by a moderate deformity. In men, no such pattern was found, suggesting less fragile vertebral bone than women. Apart from their higher BMD,(22) male vertebrae may remain stronger as a result of continued bone deposition during adulthood, resulting in a larger diameter as compared with women.(5) In addition, a lower rate of decline of trabecular connectivity in aging men may play an important role in maintaining vertebral strength.(23) Convincingly, vertebral deformities do not appear to be associated with functional impairment until they deteriorate to grade II. Possible mechanisms for the development of impaired locomotor function comprise an increased kyphoscoliosis, altered tension of the paravertebral musculature, as well as an impaired flexibility of the spine. Surprisingly, no consistent dose-response relationship was observed. This is probably due to the relatively low number of participants with multiple deformities. The observation of a less convincing association for the continuous measure of deformity suggests that the localized fracture rather than the overall shape of the spine determines functional impairment. Whereas the prevalence of both severe deformities and detrimental health outcomes was higher in women, a stronger association was found in men. It is unclear what explains this discrepancy. Possibly, men are loading their spines more heavily or in a different way that is not compatible with the altered shape of the spine. Nevertheless, vertebral osteoporosis appears to be a health problem in men as well, and clinicians should therefore be aware of this possibility when they encounter men with complaints that possibly relate to vertebral deformities.

In conclusion, (1) vertebral deformities are only slightly less common in men than in women from the general elderly population, (2) severe progression with age occurs predominantly in women, and (3) severe vertebral deformities are, particularly in men, related to functional impairment.

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REFERENCES

1. Sernbo I, Johnell O 1993 Consequences of a hip fracture: a prospective study over 1 year. Osteoporosis Int **3:**148–153.
2. Cooper C, Campion G, Melton LJ III 1992 Hip fractures in the elderly: a world-wide projection. Osteoporosis Int **2:**285–289.
3. Cooper C, Melton LJ III 1992 Vertebral fractures: How large is the silent epidemic? Br Med J **304:**793–794.
4. Ettinger B, Black DM, Nevitt MC, Rundle AC, Cauley JA, Cummings SR, et al. 1992 Contribution of vertebral deformities to chronic back pain and disability. J Bone Miner Res **7:**449–455.
5. Seeman E 1993 Osteoporosis in men: Epidemiology, pathophysiology, and treatment possibilities. Am J Med **95** (Suppl 5A):22S–28S.
6. Mann T, Oviatt SK, Wilson D, Nelson D, Orwoll ES 1992 Vertebral deformity in men. J Bone Miner Res **7:**1259–1265.
7. Hofman A, Grobbee DE, Jong PTVM de, Ouweland FA van den 1991 Determinants of disease and disability in the elderly: The Rotterdam Elderly Study. Eur J Epidemiol **7:**403–422.
8. O'Neill TW, Felsenberg D, Varlow J, Cooper C, Kanis JA, Silman AJ, on behalf of the European Vertebral Osteoporosis Study Group (EVOS) 1996 The prevalence of vertebral deformity in European men and women: The European Vertebral Osteoporosis Study. J Bone Miner Res **11:**1010–1017.
9. Eastell R, Cedel SL, Wahner HW, Riggs BL, Melton LJ III 1991 Classification of vertebral fractures. J Bone Miner Res **6:**207–216.
10. Black DM, Palermo L, Nevitt MC, Genant HK, Epstein R, Valentin RS, Cummings SR 1995 Comparison of methods for defining prevalent vertebral deformities: The Study of Osteoporotic Fractures. J Bone Miner Res **10:**890–902.
11. Pincus T, Summey JA, Soraci SA, Wallston KA, Hummon NP 1983 Assessment of patient satisfaction in activities of daily living using a modified Stanford Health Assessment Questionnaire. Arthritis Rheum **26:**1346–1353.
12. Landis JR, Koch GG 1977 The measurement of observer agreement for categorical data. Biometrics **33:**159–174.
13. Abrahamse APJ, Centraal bureau voor de statistiek 1995 Statistisch jaarboek 1995. SDU uitgeverij, 's-Gravenhage, The Netherlands.
14. Nguyen TV, Kelly PJ, Sambrook PN, Gilbert C, Pocock NA, Eisman JA 1994 Lifestyle factors and bone density in the elderly: Implications for osteoporosis prevention. J Bone Miner Res **9:**1339–1346.
15. Osman AA, Bassiouni H, Koutri R, Nijs J, Geusens P, Dequeker J 1994 Aging of the spine: Distinction between wedging in osteoarthritis and fracture in osteoporosis—A cross-sectional and longitudinal study. Bone **15:**437–442.
16. Symmons DPM, van Hemert AM, Vandenbroucke JP, Valkenburg HA 1991 A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women. II. Radiographic findings. Ann Rheum Dis **50:**158–161.
17. Melton LJ III, Lane AW, Cooper C, Eastell R, O'Fallon WM, Riggs BL 1993 Prevalence and incidence of vertebral deformities. Osteoporosis Int **3:**113–119.
18. Spector TD, McCloskey EV, Doyle DV, Kanis JA 1993 Prevalence of vertebral fracture in women and the relationship with bone density and symptoms: The Chingford Study. J Bone Miner Res **8:**817–822.
19. McCloskey EV, Spector TD, Eyres KS, Fern ED, 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.
20. Lyles KW, Gold DT, Shipp KM, Pieper CF, Martinez S, Mulhausen PL 1993 Association of osteoporotic vertebral compression fractures with impaired functional status. Am J Med **94:**595–601.
21. Ross PD, Ettinger B, Davis JW, Melton LJ III, Wasnich RD 1991 Evaluation of adverse health outcomes associated with vertebral fractures. Osteoporosis Int **1:**134–140.
22. Burger H, Daele PLA van, Algra D, Ouweland FA van den, Grobbee DE, Hofman A, et al. 1994 The association between age and bone mineral density in men and women aged 55 years and over: The Rotterdam Study. Bone Miner **25:**1–13.
23. Daele PLA van, Burger H, Algra D, Grobbee DE, Birkenhäger JC, Pols HAP 1994 Age-associated changes in ultrasound measurements of the calcaneus in men and women: The Rotterdam Study. J Bone Miner Res **9:**1751–1757.

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