Published in final edited form as:

J Clin Densitom. 2007 ; 10(1): 1–9.

RISK FACTORS FOR PREVALENT VERTEBRAL FRACTURES IN BLACK AND WHITE FEMALE DENSITOMETRY PATIENTS

Tamara J. Vokes, M.D.¹, Daniel L. Gillen, Ph.D.², Ann T. Pham, B.A.¹, and Jeanne M. Lovett, B.A.¹

¹ Department of Medicine, University of Chicago

² Department of Statistics, University of California, Irvine

Abstract

This cross-sectional study compared risk factors for prevalent vertebral fractures (diagnosed using densitometric spine image VFA) in 176 black and 345 white women recruited during their clinical bone mineral density testing at the University of Chicago Hospitals. We used logistic regression to assess the association of prevalent vertebral fractures and risk factors (age, height loss, history of non-vertebral fractures, BMD, and use of corticosteroids). The prevalence of vertebral fractures was 21% for both races. All risk factors of interest were significantly associated with vertebral fractures in white women. Among black women, only age and corticosteroid use were found to be significant predictors of presence of vertebral fracture(s). In women without history of corticosteroid use, the probability of having vertebral fracture(s) given age was lower ($p=0.02$) in black subjects. In 77 patients with a history of corticosteroid use, the probability of having vertebral fracture(s) was higher in black than in white women after adjustment for age ($p=0.045$), BMD ($p=0.045$), or cumulative corticosteroid dose ($p=0.08$). Fewer black women were prescribed pharmacologic therapy for osteoporosis, regardless of their BMD level and corticosteroid use. We conclude that use of corticosteroids may be associated with relatively greater vertebral fracture risk in blacks than in whites.

Keywords

bone densitometry; corticosteroid osteoporosis; fracture risk; racial differences; vertebral fractures; Vertebral Fracture Assessment (VFA)

INTRODUCTION

Vertebral fractures are the most common osteoporotic fractures, affecting approximately 700,000 persons per year in the USA. Although often not clinically recognized (1), vertebral fractures are important to detect because they have been associated with reduced quality of life (2), increased morbidity and mortality (3,4), and increased risk of future fractures (5,6). Clinical risk factors associated with vertebral fractures have been well studied in Caucasian and Asian

Corresponding author: Tamara Vokes Section of Endocrinology University of Chicago 5841 S. Maryland, MC1027 Chicago. IL 60637
Tel: 773-702-5718 tvokes@uchicago.edu

Presented in part at the 2006 Annual Meeting of the International Society of Clinical Densitometry

Funding support: supported by grant K23 AR048205-01A1 from the National Institute of Health

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populations (7–14). In contrast, there are no systematic studies of prevalence and risk factors for vertebral fractures in African Americans. Analysis of hospital discharge data for years 1972 to 1978 revealed lower rates of clinical vertebral fractures in blacks than in whites (15). However, this observation may be due in part to selection bias if blacks are less likely to seek medical attention, be hospitalized, or investigated for back pain, the usual presenting symptom of vertebral fracture. In a large observational population study NORA (National Osteoporosis Risk Assessment), the one year incidence of clinical vertebral fractures was lower in black than in white women (0.12% vs. 0.19%)(16), although the absolute number of vertebral fractures in black women was too low (only 7) to meaningfully assess risk factors. In Baltimore Men's Osteoporosis Study (17), radiographic vertebral fracture prevalence was higher in whites (29 out of 415 white, vs. 1 out of 127 black men). However, the true prevalence of vertebral fractures in African Americans may be underestimated in population studies because they usually exclude patients with significant medical problems, which may be more prevalent in African Americans. Consistent with this, a small study (106 subjects) of vertebral fractures found on chest radiographs of postmenopausal women in an inner-city hospital did not find racial differences in fracture prevalence (18).

In the present study we examined clinical characteristics associated with vertebral fractures in black and white women who had a Vertebral Fracture Assessment (VFA) examination during their bone mineral density (BMD) testing at the University of Chicago Medical Center. Vertebral fractures were diagnosed on VFA, a low radiation image of the thoraco-lumbar spine obtained using bone densitometers (19,20). In previous studies of vertebral fractures detected on radiographs in Caucasian populations, the most significant risk factors were age, height loss, history of prior fractures, and low BMD (9,10). We examined the association of these risk factors with vertebral fractures detected on the VFA. We also included history of corticosteroid use, which is a known risk for vertebral fractures (21,22) and is more prevalent in densitometry patients than in the general population.

METHODS

Study population

We present the results for 521 ambulatory women (176 black and 345 white) who were referred for BMD testing as part of their medical care between 2001 and 2005, and agreed to participate in a study of utility of radiographic texture analysis in osteoporosis (23), which also included VFA imaging. There were no specific inclusion criteria – the patients were recruited if the study coordinator was in the clinic, the densitometry technologist had time to obtain additional images, and the patients agreed to participate. However, patients who were treated by the author (TJV) were more likely to enter the study and also more likely to have more severe osteoporosis. There were no racial differences in the probability of participating in the study. The study was approved by the University of Chicago's Institutional Review Board and all patients signed a written informed consent. The subjects included in the analysis presented here are a subset of 651 consented participants from whom 130 subjects were excluded for the following reasons: 56 males and 32 Asian or Hispanic women because their number was too small to permit meaningful analysis; 23 (11 black) women because their VFAs were technically uninterpretable, i.e. part(s) of the spine were not sufficiently clear to determine whether fracture was present or not; and 19 (12 black) women because they had grade 1 vertebral fractures, for which it is unclear whether they represent true osteoporotic fractures or non-fracture deformities (24).

Procedures

All participants filled out an osteoporosis questionnaire which included information on personal and family history of fractures, young adult height and weight, habits (smoking,

alcohol and calcium intake, and activity level), medication history and history of other medical problems. Responses were supplemented by information obtained from the patients' medical record, when available. Height and weight were measured using standard clinic equipment.

VFA images and BMD measurements were obtained using Prodigy (GE Medical Systems, Madison, Wisconsin). VFA was classified (TJV) using a combination of visual and Genant semi quantitative (SQ) approach (25) in the following manner: each VFA image was inspected visually to decide whether it contained a fracture in any of the visualized vertebrae. Each vertebra that was judged as fractured by visual inspection was measured using built in morphometry and assigned a grade based on Genant SQ scale, where Grade 1 (mild) fracture is a reduction in vertebral height of 20–25%, grade 2 (moderate) a reduction of 26–40%, and grade 3 (severe) a reduction of over 40%. Subjects with no fractures were included in the non-fracture group, while those with grade 2 or higher fractures were included in the fracture group. Those with grade 1 fractures were excluded from analysis because grade 1 fractures are likely a mixture of some osteoporotic fractures and some non-fracture deformities (24), and not as predictive of future fractures as are higher grades (26). In 142 patients VFA reading was supplemented by review of radiographs performed as part of clinical care.

BMD was measured at the lumbar spine and proximal femur. The T-scores in all races are calculated using the white (Caucasian) database. In the present analysis we used the following T-scores as recommended by ISCD (27), and confirmed by our earlier study to best differentiate patients with and without vertebral fractures (28): for lumbar spine L1-L4 with elimination of artifact laden vertebrae; for proximal femur the lower of femoral neck or total hip measurement, and for overall BMD assessment, the lower of lumbar spine and proximal femur measurement. Because many of our study subjects had significant spinal osteoarthritis resulting in unreliable spine BMD measurement, T-score of the hip (lower of the femoral neck or total hip) is presented in analyses.

Definition of the variables used in analyses

Race/ethnicity was assigned by the densitometry technologist who performed the BMD testing, which requires assigning one of 4 categories: black, white, Asian and Hispanic. When the technologist was uncertain he/she asked the patient for clarification. *Height loss* was calculated by subtracting the measured height from the self-reported young adult height. *Non-vertebral fracture* was defined as any fracture occurring in adulthood (since age 25), in the course of usual physical activity, excluding fractures of the face, hands and feet, or those that occurred as a result of a motor vehicle accident. Corticosteroid use (systemic but not inhaled) was captured in two ways: as a continuous variable *cumulative steroid exposure* (expressed in grams of prednisone or equivalent) and as binary (yes or no) variable *steroid therapy* which was (based on recent recommendations (29)), defined as at least 5 mg/day of prednisone or equivalent for 3 months (0.450 gm cumulative steroid exposure). *Treatment* for osteoporosis was defined as patient receiving or having been advised to take any of the following medications: estrogen (excluding vaginal preparations) with or without progesterone, raloxifene, tamoxifen, alendronate, risedronate, nasal calcitonin, or teriparatide. (Ibandronate was not available at the time of this study.) Use of medication for osteoporosis (prior to, at the time of, or after the date of the study), duration and dose of corticosteroids, and any information that was missing in the initial questionnaire were obtained by calling the patients and reviewing their medical record, when available.

Statistical analyses

All analyses were performed using STATA statistical software package. Differences between black and white patients and/or between patients with and without vertebral fractures were compared using t-tests for continuous characteristics and chi-square tests for categorical

characteristics. The odds of having vertebral fracture as a function of the risk factors of interest were modeled using logistic regression. Multiplicative interaction terms were used to test differences in the association between each predictor of interest and the risk of vertebral fracture by race. The relationship between continuous variables, such as BMD T-score and age, was examined using linear regression. To examine whether there were racial differences in the prevalence of (or risk of having) vertebral fractures relative to age or BMD T-score, we used logistic regression which included age (or BMD T-score) and race as predictors and presence of vertebral fractures as outcome in subjects over 40 years of age. The predicted probability of vertebral fracture as a function of age and T-score was calculated as a function of the logistic model parameter estimates. In order to investigate potential effect modification by corticosteroid use, this analysis was performed separately for patients with and without history of corticosteroid use. In patients with history of corticosteroid use we also examined the predicted probability of having vertebral fractures as a function of cumulative corticosteroid dose in the two races, derived from the logistic regression which included race and grams of cumulative corticosteroid exposure.

RESULTS

Clinical characteristics of the study population are shown in Table 1. The prevalence of vertebral fractures (21%) and history of non-vertebral fractures (28–34%) did not differ significantly between the races. The majority of patients were postmenopausal (around 90%). Black patients were older, had longer duration of menopause, were heavier, and had higher T-scores and a lower percentage of patients with BMD criteria for osteoporosis (hip or spine T-score at or below -2.5). Fewer black women reported having had estrogen therapy and those that had, received it for shorter time than the white women. More of the black women reported history of corticosteroid use, probably reflecting the common clinical practice of referring black subjects for BMD measurement if they are receiving corticosteroids but not for general screening. Current height and the magnitude of height loss did not differ significantly between the races.

Association of risk factors and vertebral fractures

The association between clinical risk factors and prevalent vertebral fractures individually or in combination was examined using logistic regression analysis (Table 2). In the population as a whole (Panel A), all of the risk factors examined were significant predictors in univariate regression analysis, when controlled for age and/or BMD, or when combined in a multivariate logistic regression analysis. Duration of menopause and estrogen use were not significant predictors in models which included age (data not shown). While body weight and BMI did not have a significant effect in the regression model, height did, even in models that included height loss (data not shown). However, young adult height was not significantly associated with vertebral fractures. This suggests that the measured current height may reflect height loss that is due to vertebral fractures better than the height loss calculated based on self-reported young adult height, which was not obtainable in about 25% of our study subjects, and may have been inaccurate in others. Thus, we included measured height rather than calculated height loss in the final model.

We observed clear differences in the relationship between risk factors and probability of having vertebral fractures in black (Table 2, Panel B) and in white women (Table 2, Panel C). Risk factors for vertebral fractures reported in previous studies of Caucasians populations, i.e. age, height loss (or height), history of peripheral fractures, and low BMD (9,10), were strongly associated with prevalent vertebral fractures in white patients in our study (Panel C). Different results were obtained in black women. Although prevalence of peripheral fractures and the magnitude of reported height loss, as well as measured current height were similar in the two

racess (Table 1), a significant association of these risk factors with prevalent vertebral fractures was observed in white but not in black women (Table 2). BMD T-score was strongly predictive of presence of vertebral fractures in white women (Table 2, C), with odds ratio similar to that reported in population studies. In contrast, the association between BMD T-score and vertebral fractures was much weaker in blacks and largely accounted for by age (Table 2, B).

In black women, the only significant predictors of prevalent vertebral fractures were history of corticosteroid use and age (Table 2, B). Although in white women history of corticosteroid use expressed as binary variable was not significantly associated with vertebral fractures (Table 2, C), when cumulative corticosteroid exposure was included in the model as a continuous variable the odds ratios of having a vertebral fracture expressed per gram of corticosteroid dose were not significantly different between the races (Table 2). While the mean value for cumulative steroid exposure was higher in black than in white patients (35 ± 45 vs. 29 ± 27 gm, $p=0.47$), there was a large overlap between the groups and the difference was not significant. The lowest cumulative dose of corticosteroids in subjects with vertebral fractures was 2.4 gm of prednisone. The most common indications for receiving corticosteroids were rheumatologic (52%), pulmonary (19%), transplantation (10%), and gastrointestinal (9%) with no significant differences between the races, except for gastrointestinal (Crohn's disease) which was lower in blacks.

Racial differences in vertebral fracture risk relative to age, BMD and corticosteroid dose

In patients without history of corticosteroid use there was a significant ($p<0.001$) negative correlation between BMD T-score and age in both races; at any age the T-score was higher in blacks by about 0.7 T-score units ($p<0.001$). The probability of having a fracture given age was significantly ($p=0.02$) lower in blacks (Figure 1A), while the probability of having a vertebral fracture at any level of BMD was similar in the two races (Figure 2A). In contrast, *in subjects with history of corticosteroid use* the black subjects had higher probability of having vertebral fracture(s) at a given age ($p=0.045$, Figure 1B), or BMD ($p=0.045$, Figure 2B). Controlling these analyses for corticosteroid dose did not substantially change the results (data not shown). The probability of having vertebral fracture(s) relative to the cumulative corticosteroid dose was higher in blacks (Figure 3), although the difference was of marginal statistical significance ($p=0.08$), possibly due to small number of observations and/or difference between races in the range of corticosteroid doses used. It should be noted that all subjects included in the analysis in Figure 3 had received at least 450 mg of prednisone or equivalent. The data points corresponding to cumulative steroid dose of "0" were derived from the regression analysis, i.e. predicted rather than observed. Among our study subjects, the lowest cumulative corticosteroid dose in subjects with vertebral fractures was equivalent to 2.4 grams of prednisone.

Racial differences in treatment for osteoporosis

Fewer black women were given pharmacologic therapy for osteoporosis (18 vs. 37%, $p<0.001$), even among those who had BMD criteria for osteoporosis (21% vs. 37% of, $p=0.007$). The lower rate of osteoporosis therapy for black women was clearly observed in the subgroup of 428 women without history of corticosteroid use among whom 18% of blacks were prescribed therapy for osteoporosis compared to 36% of whites ($p<0.001$). We also examined the use of therapy for osteoporosis following the study (assuming that for at least some patients the BMD obtained at the time of the study was the first time diagnosis of osteoporosis was known to the treating physician). Among the 264 patients with T-score at or below -2.5 for whom we were able to obtain this information, high percentage (84%) of both races had been offered pharmacologic treatment for osteoporosis, although the percentage was higher in whites (89% vs. 70% of blacks, $p<0.001$). We do not have reliable information regarding the racial difference, if any, in compliance.

Among the 77 patients with history of corticosteroid use, the percentage of patients receiving therapy for osteoporosis at the time of enrollment into the study was higher in white than in black patients, although the difference was not statistically significant (42% of whites vs. 24% of blacks, $p=0.09$). After the study, more white than black patients were prescribed treatment for osteoporosis (87% vs. 47%, $p<0.001$), even among those with T-score at or below -1.5 (89% of white vs. 54% of black subjects, $p=0.002$).

DISCUSSION

Our study suggests that there are previously unreported racial differences in risk factors for vertebral fractures. Based on previously published studies of prevalence of clinical vertebral and hip fractures, one would expect lower fracture rates, but not necessarily different risk factors for vertebral fractures in black and white women (30). Risk factors for vertebral fractures, such as height loss (or low height), history of non-vertebral fragility fractures or low BMD, derived from studies of Caucasian populations, were strongly associated with vertebral fractures in our white but not in black subjects, possibly because of relatively smaller number of black patients. In contrast, use of corticosteroids was strongly predictive of vertebral fractures in our black subjects. Thus, we found higher risk of having vertebral fractures at any age or BMD level in black than in white subjects with history of corticosteroid use (Figures 1B and 2B). It is commonly believed that blacks are less vulnerable to osteoporosis than whites. Consistent with this view and earlier population studies (16,31), we find that among subjects who had not received corticosteroids, at any age the BMD T-score is higher (see results) and probability of having a vertebral fracture lower (Figure 2A) in black than in white women. In contrast, in our study, blacks seemed more vulnerable to corticosteroid effects on bone than whites (Figures 1B, 2B and 3).

The results we obtained in subjects who were not exposed to corticosteroids are similar to what was previously reported: we found that black subjects had lower probability of having a prevalent vertebral fracture at any age (Figure 1A), consistent with results of large population studies such as NORA (16). It should be noted however, that because vertebral fractures are often not clinically recognized, the exact age and BMD level at which they occurred is not possible to determine in a cross-sectional study such as ours. The latter may also explain our observation that the probability of having a prevalent vertebral fracture at any level of BMD is similar in black and white subjects (Figure 2A), although black women have been reported to have lower risk of incident non-vertebral fracture at any level of BMD (31).

The most intriguing finding from our study is that in corticosteroid treated subjects, the probability of having vertebral fracture(s) was higher in black subjects at any age or BMD T-score (Figures 1B and 2B). It is unlikely that this observation is due to higher cumulative corticosteroid dose, since adjusting for it did not substantially change the conclusions. Furthermore, the probability of having vertebral fracture(s) relative to the cumulative corticosteroid dose was if anything higher in black subjects (Figure 3). Although all of our study subjects were ambulatory, we can not determine from our data whether higher fracture risk may be explained by overall greater disease burden, or lower health status in our black than in our white subjects receiving corticosteroids. Our results are also consistent with a hypothesis that black subjects have greater vulnerability to corticosteroid effect on bone, possibly related to lower bone turnover (32) and diminished rates of bone formation (33) reported for African Americans. Since the primary mechanism of corticosteroid mediated decrease in bone strength is the impairment of osteoblastic bone formation (34,35), possibly mediated by decreased osteoclastic function (36), subjects with lower bone turnover may be more prone to fractures when exposed to corticosteroids.

We observe that the slope of the line relating probability of vertebral fractures to BMD was lower in corticosteroid treated (Figure 2B) than in other subjects (Figure 2A), consistent with the notion that the corticosteroid induced increase in fragility is only partly mediated by decrease in bone mass (21).

Similar to other investigators (37–39), we observe that fewer black than white patients were receiving therapy for osteoporosis, even among those who had BMD criteria for osteoporosis (T-score of -2.5 or less). Because at least some subjects were recruited into the study during their first BMD examination, we investigated medication use in the year following the study, and found that 84% of subjects who had T-score at or below -2.5 , had been offered pharmacologic therapy for osteoporosis, although the percentage of black women was still lower (70 vs. 89%, $p < 0.001$). While the rates of treatment are somewhat lower in our black subjects we are encouraged to find that in contrast to other studies (40), high percentage of osteoporotic women of both races were at least offered osteoporosis therapy. We do not have information regarding possible racial differences in compliance with osteoporosis therapy. Consistent with other studies (38), we find that among subjects with history of corticosteroid use lower percentage of black women received treatment for osteoporosis, probably due to common perception that blacks are relatively protected from osteoporosis. However, if our findings are confirmed, the approach to corticosteroid induced osteoporosis in blacks should be at least as if not more aggressive than in other racial/ethnic groups. There is currently no information regarding racial difference, if any, in response to pharmacologic therapy for corticosteroid induced osteoporosis.

There are some limitations to our study. This is not a population study and thus true prevalence and population risk factors for vertebral fractures in different races could not be determined. The other potential limitation is that we used VFA rather than radiographs for detection of vertebral fractures. We believe, however, that our conclusions are valid since, compared to radiographs, VFA has good sensitivity and specificity for grade 2 fractures or higher (41–44), and we eliminated from analysis subjects with grade 1 fractures. In addition, as mentioned earlier, we did not have information regarding the disease burden and overall health status of our subjects. Finally, the information regarding the cumulative corticosteroid dose was obtained from the study subjects and review of the medical records and thus may not be reliable in all cases.

Our study also has significant strengths. This is the first study to compare risk factors for radiographic vertebral fractures in black and white women. In addition, our study subjects are well characterized in terms of clinical characteristics and fracture history. Finally, our conclusions are likely to be applicable to other densitometry populations and thus useful when formulating practice guidelines for screening and treating black women, particularly those with history of corticosteroid use.

In summary, our study indicates that use of corticosteroids is a significant risk factor for vertebral fractures in blacks, with the strength of the association as great if not greater than in whites. Future prospective studies are needed to determine whether black subjects truly have increased susceptibility to fractures associated with corticosteroid induced osteoporosis, even though they have a lower risk of osteoporotic fractures overall. Such studies are also needed to formulate practice guidelines for screening and treating different populations, particularly in the face of receiving long-term treatment with corticosteroids.

Acknowledgements

We are grateful to Dr. Gary Robertson for his thorough and helpful criticism of the manuscript, to Dr. Halina Brukner for helpful editorial suggestions, to Deepti Singh, and Anca Guiu for data collection, and Gina Keys, William Wilson and Maureen Costello for performing bone densitometry.

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Figure 1.

Relationship between age and estimated probability of having vertebral fracture(s) modeled using logistic regression with age and race as predictors and prevalent vertebral fractures as outcome, in black (closed circles) and white (open circles) women over 40. **A.** Patients without history of corticosteroid use. **B.** Patients with history of corticosteroid use.

Figure 2. Relationship between hip BMD T-score and estimated probability of having vertebral fracture (s) modeled using logistic regression with hip T-score and race as predictors and prevalent vertebral fractures as outcome, in black (closed circles) and white (open circles) women. **A.** Patients without history of corticosteroid use. **B.** Patients with history of corticosteroid use.

Figure 3.

Relationship between cumulative steroid exposure (per gram of prednisone or equivalent) and estimated probability of having vertebral fracture(s) modeled using logistic regression with corticosteroid exposure and race as predictors and prevalent vertebral fractures as outcome, in black (closed circles) and white (open circles) women.

Table 1

Characteristics of the study population

	N	All (521)	Blacks (176)	Whites (345)
Non-vertebral fracture (%)	512	163 (32)	47 (28)	116 (34)
Vertebral fracture (%)	521	108 (21)	37 (21)	71 (21)
Age (mean±SD)	521	63.9 ± 13.3	66.8 ± 13.4 ‡	62.5 ± 13.1
Postmenopausal (%)		457 (92)	159 (90)	298 (86)
Years since menopause	374	20.0 ± 13.0	24.6 ± 13.5 §	17.8 ± 12.2
Ever estrogen Tx (%)	360	123 (34)	30 (25) *	93 (39)
Duration of estrogen Tx	123	7.5 ± 7.2	5.0 ± 8.3 *	8.4 ± 6.6
Steroid use (%)	506	77 (15)	34 (20) *	43 (13)
Height (inches)	521	63.1 ± 2.8	62.8 ± 2.5	63.3 ± 2.9
Height loss (inches)	413	1.1 ± 1.3	1.0 ± 1.1	1.2 ± 1.4
Height loss > 1.5 inches (%)	413	132 (32)	45 (31)	87 (33)
Weight (lbs)	521	151.8 ± 33.2	161.1 ± 33.3 §	147.0 ± 32.1
BMD T-score				
Lumbar spine	515	-1.6 ± 1.5	-1.3 ± 1.5 ‡	-1.8 ± 1.5
Hip	515	-2.2 ± 1.1	-1.9 ± 1.2 §	-2.3 ± 1.0
T-score ≤ -2.5 at hip or spine (%)	521	266 (51)	73 (42) †	193 (56)

N- number of subjects that had the data for the risk factor;

Comparing blacks and whites:

- * p<0.05,
- † p<0.01,
- ‡ p<0.001,
- § p<0.0001

Table 2
Association of risk factors and prevalent vertebral fractures derived from logistic regression with presence of vertebral fractures as a binary outcome and risk factor(s) alone or in combination as predictors.

Risk factor	N	A. All (521)		B. Blacks (176)		C. Whites (345)	
		OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
1) Age/10yrs	521	1.8 (1.5, 2.3)	<0.001	1.6 (1.1, 2.2)	0.010	2.2 (1.7, 2.8)	<0.001
Controlled for hip BMD	515	1.6 (1.3, 2.0)	<0.001	1.4 (0.9, 1.9)	0.095	1.7 (1.3, 2.2)	<0.001
2) Height/1" decrease	521	1.3 (1.2, 1.4)	<0.001	1.1 (1.0, 1.3)	0.130	1.4 (1.2, 1.5)	<0.001
Controlled for age	515	1.2 (1.1, 1.3)	<0.001	1.1 (0.9, 1.2)	0.464	1.3 (1.2, 1.4)	<0.001
Controlled for hip BMD		1.2 (1.1, 1.3)	<0.001	1.1 (0.9, 1.2)	0.423	1.3 (1.1, 1.4)	<0.001
* Controlled for age and BMD		1.2 (1.1, 1.3)	<0.001	1.0 (0.9, 1.2)	0.655	1.2 (1.1, 1.4)	<0.001
3) Non-vertebral fracture	512	2.4 (1.6, 3.8)	<0.001	1.7 (0.7, 3.7)	0.224	2.9 (1.7, 4.9)	<0.001
Controlled for age	506	2.2 (1.4, 3.5)	0.001	1.4 (0.6, 3.2)	0.439	2.7 (1.5, 4.8)	0.001
Controlled for hip BMD		1.9 (1.2, 3.0)	0.009	1.2 (0.5, 2.9)	0.633	2.3 (1.3, 4.1)	0.004
Controlled for age and BMD		1.8 (1.1, 2.9)	0.014	1.2 (0.5, 2.7)	0.755	2.3 (1.3, 4.2)	0.006
4) Hip BMD/T-score unit decrease	514	2.1 (1.6, 2.6)	<0.001	1.5 (1.1, 2.1)	0.011	2.8 (2.0, 4.1)	<0.001
Controlled for age		1.7 (1.3, 2.2)	<0.001	1.4 (1.0, 1.9)	0.076	2.2 (1.5, 3.1)	<0.001
5a) Steroid therapy (binary)	512	1.9 (1.1, 3.3)	0.018	3.4 (1.5, 7.8)	0.003	1.2 (0.6, 2.6)	0.637
Controlled for age	506	3.3 (1.8, 6.1)	<0.001	7.6 (2.8, 20.6)	<0.001	1.9 (0.8, 4.4)	0.133
Controlled for hip BMD		1.9 (1.1, 3.4)	0.024	3.3 (1.4, 7.6)	0.006	1.2 (0.5, 2.7)	0.674
Controlled for age and BMD		3.0 (1.6, 5.5)	0.001	6.7 (2.4, 18.7)	<0.001	1.7 (0.7, 4.1)	0.231
5b) Cumulative steroid exposure/10gm	512	1.2 (1.1, 1.4)	<0.001	1.1 (1.0, 1.4)	0.099	1.3 (1.1, 1.5)	0.003
Controlled for age	506	1.4 (1.2, 1.6)	<0.001	1.4 (1.1, 1.7)	0.001	1.3 (1.1, 1.6)	0.003
Controlled for hip BMD		1.2 (1.1, 1.4)	<0.001	1.3 (1.1, 1.5)	0.004	1.2 (1.0, 1.4)	0.110
Controlled for age and hip BMD		1.3 (1.2, 1.5)	<0.001	1.4 (1.1, 1.7)	0.002	1.3 (1.1, 1.6)	0.010
Age/10yrs	497	1.0 (1.0, 1.1)	<0.001	1.1 (1.0, 1.1)	0.020	1.0 (1.0, 1.1)	0.002
Height/1" decrease		1.2 (1.1, 1.3)	0.001	1.0 (0.8, 1.2)	0.970	1.3 (1.1, 1.4)	<0.001
Non-vertebral fracture		1.9 (1.2, 3.2)	0.012	0.9 (0.4, 2.3)	0.830	2.7 (1.4, 5.1)	0.002
Hip BMD/T-score unit decrease		1.6 (1.2, 2.0)	0.001	1.3 (0.8, 1.9)	0.263	1.8 (1.2, 2.7)	0.003
Cumulative steroid exposure/10gm		1.3 (1.2, 1.5)	<0.001	1.4 (1.1, 1.7)	0.002	1.3 (1.0, 1.5)	0.018

Abbreviations: OR, odds ratio; 95%CI, 95% confidence interval for the odds ratio. P value – significance of effect of a given risk factor.

Rows 1 through 5b show effect of each risk factor by itself (from the univariate logistic regression analysis) or controlled for other risk factors (from the multivariate logistic regression analysis). The last row shows the effect of each risk factor when all risk factors are combined in a multivariate analysis.

* Significant difference ($p < 0.05$) between races, derived from logistic regression which included race and the risk factor(s) of interest as predictors. "Height" designates measured current height with odds ratio of having vertebral fracture(s) increasing with decreasing measured height. The effect of corticosteroid use was examined as "Steroid therapy", a binary variable where patients who had used systemic corticosteroids (at least 5 mg/day of prednisone or equivalent for at least 3 months) were classified as steroid users and others as non users; and as "Cumulative steroid exposure" where odds ratios for vertebral fractures were calculated per 10 grams of prednisone or equivalent of total lifetime exposure to systemic corticosteroids.