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DETERMINANTS OF CIRCULATING 25-HYDROXYVITAMIN D AND BONE MINERAL DENSITY IN YOUNG PHYSICIANS

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Abstract

Objective—To examine determinants of serum 25-hydroxyvitamin D [25(OH)D] and bone mineral density (BMD) in young physicians, a group not well studied previously.

Methods—We analyzed data from a questionnaire completed by young physicians as well as results of serum 25(OH)D, serum parathyroid hormone, and BMD measurements.

Results—Among 104 study subjects, 42% were white, 46% were Asian, 12% were “other” (10 Hispanic and 2 African American subjects), and 75% were women. The mean age and body mass index (BMI) were 28.1 years and 23.0 kg/m², respectively. White subjects had a higher mean serum 25(OH)D level (27.3 ng/mL) than did Asian subjects (15.9 ng/mL) and other subjects (22.3 ng/mL) ($P<.0001$). White subjects tended to have higher Z-scores than Asian subjects and other subjects for the hip ($P = .06$), trochanter ($P = .08$), and lumbar spine ($P = .08$). The serum 25(OH)D level was negatively associated with serum parathyroid hormone ($r = -0.44$; $P<.01$) but not with BMD. The prevalence of vitamin D insufficiency [serum 25(OH)D <30 ng/mL, 77% for the entire group] was higher ($P<.01$) in Asian subjects (93%) than in white subjects (61%) and other subjects (73%). Significant determinants of serum 25(OH)D included age, ethnicity, exposure to sunlight, use of vita-min D supplements, and family history of osteoporosis ($P<.05$ for all), and together with sex, calcium supplements, exercise, and BMI, these factors explained 49% of serum 25(OH)D level variability. Significant determinants of low BMD (osteopenia plus osteoporosis, prevalence 37.5%) included sex ($P = .002$) and BMI ($P<.0001$) but not serum 25(OH)D; Asian ethnicity reached borderline significance ($P = .088$). Age, sex, ethnicity, smoking, and BMI explained 20% to 30% of the Z-score variations.

Conclusion—In young physicians with a healthful lifestyle, determinants of low serum 25(OH)D and BMD included modifiable risk factors. Vitamin D insufficiency and low BMD could be important contributors to future osteoporotic fractures in this population.

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AUTHORS' CONTRIBUTIONS

Dr. Manickam analyzed the data and contributed to the writing of the article; Dr. Washington analyzed the data; Ms. Villagrana conducted research and performed the DXA scans; Dr. Benjamin conducted research; Dr. Kukreja participated in the planning and writing of the article; and Dr. Barengolts designed and conducted research, analyzed data, wrote the article, and assumed primary responsibility for the final content.

DISCLOSURE

The authors have no multiplicity of interest to disclose.

INTRODUCTION

Vitamin D has a major role in bone-related health and disease (1-9). Data from the National Health and Nutrition Examination Survey (NHANES) provide evidence of an increasing prevalence of vitamin D insufficiency in the US population (1). Vitamin D status is defined on the basis of serum 25-hydroxyvitamin D [25(OH)D] level as deficiency [serum 25(OH)D <20 ng/mL] and insufficiency [serum 25(OH)D <30 ng/mL] (1-11) and is affected by modifiable risk factors (3-10). Vitamin D insufficiency also has been identified as a problem in healthy young adults (1-5). In young adults, a negative relationship between serum 25(OH)D and serum parathyroid hormone (PTH) has been demonstrated (5-7), and vitamin D status may influence bone mineral density (BMD) (9). Young physicians represent a special group of young adults expected to have high health literacy and correspondingly healthful lifestyle. A few studies have evaluated vitamin D status in young physicians (4,5); however, the relationships of vitamin D status [serum 25(OH)D] with serum PTH and BMD have not been previously evaluated concomitantly in a young physician population. The objectives of this prospective cohort study were to examine the determinants of serum 25(OH)D and BMD and the relationship of serum 25(OH)D with serum PTH and BMD in a diverse population of young physicians (medical residents and medical students) working at an urban university hospital.

SUBJECTS AND METHODS

Study Population and Protocol

Healthy medical students and residents on a medical service rotation at an urban university hospital were recruited during the summers of 2007 and 2008. The exclusion criteria were current pregnancy, history of hyperthyroidism, liver disease, or kidney disease, and use of medications or recreational drugs that could affect bone metabolism. During a single study visit, vitamin D deficiency and low BMD risk factors were evaluated by a self-administered questionnaire, and height and weight were recorded. A blood sample was collected for serum 25(OH)D and serum PTH assays, and the serum was stored at -70°C . All study-related services were free of charge, and the study subjects did not receive any payment. The institutional review board approved the study, and all study participants provided written informed consent.

Vitamin D and PTH Assays

We measured serum 25(OH)D, PTH, and calcium as published previously (10). Serum 25(OH)D was measured by a direct, competitive-type chemiluminescence immuno-assay (CLIA) (Liaison, DiaSorin, Stillwater, Minnesota), with a reference range of 15 to 80 ng/mL (the laboratory participates in the Vitamin D External Quality Assessment Scheme). The intra-assay and interassay coefficients of variation (CVs) were 10.8% and 13.9%, respectively. Serum PTH was measured by a direct, 2-site, sandwich-type CLIA (Liaison, DiaSorin), with a reference range of 10 to 75 pg/mL. The intra-assay and interassay CVs were 3.0% and 6.9%, respectively. The analytical and clinical validations of these

automated, antibody-based and microparticle-based CLIA methods have been published previously (10).

BMD Assessment

BMD (in g/cm²) was measured by a QDR 4500 dual x-ray absorptiometry (DXA) scanner (Hologic, Inc., Bedford, Massachusetts) at the lumbar spine (L1 through L4) and nondominant hip (femoral neck, trochanter, and total hip), and Z-scores and T-scores were calculated by using the NHANES III reference database for the hip and the manufacturer's reference values for the lumbar spine. The DXA machine was calibrated daily with use of the anthropomorphic spine phantom supplied by the manufacturer. The CV for our DXA scan was 1.31% at the spine, 2.58% at the femoral neck, and 0.98% at the total hip.

Outcome Measures

For the current study, we defined vitamin D deficiency as serum 25(OH)D <20 ng/mL and vitamin D insufficiency as serum 25(OH)D <30 ng/mL, as indicated in multiple previous studies (1-11). We used a serum PTH level of >43 pg/mL to identify subjects with relative secondary hyperparathyroidism (PTH level in the upper reference range), on the basis of a previous study (12). BMD was defined as normal or low (osteopenia plus osteoporosis) on the basis of the World Health Organization and National Osteoporosis Foundation recommendations (13,14).

Determinants of Vitamin D Insufficiency and of Low BMD

The questionnaire validated for a female population (15) included questions relevant to known risk factors for vitamin D deficiency and bone density—that is, family history of osteoporosis, personal history of any fracture, use of calcium (mg daily) and vitamin D (IU daily) supplements, consumption of caffeine (number of cups daily) and alcohol (number of drinks weekly), history of smoking (current or past), exercise habits (number of 30-minute sessions weekly), exposure to sunlight (minutes per day per season), demographics (age, sex, and race or ethnicity), and medical history.

Statistical Analyses

The summary statistics (mean and standard deviation) for various variables in the entire group and stratified by 3 ethnic groups were calculated. We compared the 3 ethnic groups by using analysis of covariance for continuous variables and a χ^2 test for the categorical variables. Initially, we examined the relationship of serum 25(OH)D with serum PTH, body mass index (BMI), and BMD as continuous variables. We then examined these relationships with use of serum 25(OH)D as a categorical variable for its relationship with PTH [serum 25(OH)D <20 ng/mL and ≥20 ng/mL]. The univariate regression analysis was conducted to assess the bivariate relationship between serum 25(OH)D level and individual risk factors. To determine the simultaneous effect of potential risk factors on the outcome of serum 25(OH)D and BMD Z-scores, we performed multiple regression analysis including risk factors with $P < .15$. The final age- and sex-adjusted regression model included only risk factors with $P < .05$. We calculated odds ratios and 95% confidence intervals for determinants of low BMD (osteopenia plus osteoporosis) using the logistic regression analysis of the

entire group. All analyses were performed with use of SAS version 9.1 statistical software (SAS Institute Inc., Cary, North Carolina).

RESULTS

Subject Sample and Risk Factor Distribution

The descriptive characteristics and the distribution of risk factors for the entire study population and stratified by 3 ethnic groups, including white subjects, Asian subjects, and other subjects, are presented in Table 1 and Figure 1. The group of Asian subjects included South Asian and East Asian study participants (not determined by the questionnaire), and the group of “other” subjects consisted of 10 Hispanic and 2 African American medical students or residents. The ethnic distribution is representative of the medical students and residents on the medical service rotation at our hospital, which is 50% white, 39% Asian, and 11% other ethnicity (including 7% Hispanic and 4% African American). For the 104 study participants, ranges (minimum to maximum) for age, serum 25(OH)D, and BMI were 20 to 37 years, 3 to 56 ng/mL, and 18 to 34 kg/m², respectively. There were no medical conditions or medications expected to affect circulating vitamin D or bone density. The white physicians were taller and had higher serum 25(OH)D levels than did the Asian and other physicians. Among the 75 study participants (72%) 20 to 29 years old (age at peak BMD), 70.7% had normal BMD; osteopenia and osteoporosis were identified in 18 (24%) and 4 (5.3%), respectively (Table 1). In this group, osteoporosis was identified in 1 white subject, 3 Asian subjects, and none of the other subjects.

Comparison of Subjects With and Without Vitamin D Deficiency

Comparison of study subjects with vitamin D deficiency [serum 25(OH)D <20 ng/mL; n = 46] versus the rest of the study group for whom these data were available (n = 49) showed that the vitamin D deficiency group had a higher proportion of Asian physicians (44% versus 14%; $P = .003$), a higher prevalence of a family history of osteoporosis (54% versus 27%; $P = .01$), a decreased tendency to take supplements of both vitamin D (35% versus 61%; $P = .01$) and calcium (41% versus 63%; $P = .03$), and an increased likelihood to exercise (72% versus 41%; $P = .01$). The vitamin D deficiency group had a lower mean serum 25(OH)D level (12.5 ± 4.7 ng/mL versus 30.1 ± 8.4 ng/mL; $P < .001$) and a higher mean serum PTH level (53.7 ± 24.0 pg/mL versus 24.3 ± 19.4 pg/mL; $P < .001$). The vitamin D deficiency group versus the rest had a trend for lower BMD of the femoral neck (0.813 ± 0.119 g/cm² versus 0.860 ± 0.136 g/cm²; $P = .08$) and the hip (0.928 ± 0.120 g/cm² versus 0.978 ± 0.145 g/cm²; $P = .06$), a significantly lower BMD of the trochanter (0.683 ± 0.098 g/cm² versus 0.736 ± 0.116 g/cm²; $P = .02$), but no significant difference for BMD at the lumbar spine (1.020 ± 0.122 g/cm² versus 1.049 ± 0.137 g/cm²; $P = .28$). For the entire group, the physicians taking vitamin D in comparison with those not taking vitamin D supplements had a significantly higher mean serum 25(OH)D level (25.1 ± 8.6 ng/mL versus 18.3 ± 8.2 ng/mL; $P < .01$).

Relationship of Serum 25(OH)D With Serum PTH and BMD

The mean serum 25(OH)D level was higher in white subjects than in Asian subjects and other subjects ($P < .0001$), but the mean serum PTH level and the proportion of physicians

with relative secondary hyperparathyroidism (serum PTH = 43 pg/mL) were similar among the groups (Table 1). The serum 25(OH)D and serum PTH levels were significantly negatively associated in the entire group ($r = -0.44$; $P < .01$) as well as in white study subjects ($r = -0.48$; $P = .008$) and Asian subjects ($r = -0.38$; $P = .02$) but not in the other subjects ($r = -0.46$; $P = .26$), and the slopes of the relationship were similar (Fig. 2). There were trends for a positive relationship between serum 25(OH)D and BMD, but these did not reach significance at any site. The correlation coefficients (and P values) were 0.13 (.2), 0.17 (.11), 0.18 (.09), and 0.09 (.32) for the femoral neck, hip, trochanter, and lumbar spine, respectively.

Determinants of Serum 25(OH)D Level

In multiple regression analysis of the entire study group, independent determinants ($P < .05$ for all) of the level of serum 25(OH)D included age, ethnicity, family history of osteoporosis, use of vitamin D supplements, and exposure to sunlight (Table 2). These variables together with sex, calcium supplements, exercise, and BMI explained 49% of serum 25(OH)D level variation ($r^2 = 0.49$). In addition, sunlight-exposed white subjects had a mean serum 25(OH)D value 7.4 ng/mL higher ($P = .011$) than did unexposed white subjects; sunlight-exposed Asian subjects had a 10.8 ng/mL lower level of serum 25(OH)D than did sunlight-exposed white subjects ($P = .009$); and sunlight-exposed other subjects and sunlight-exposed white subjects had similar serum 25(OH)D levels ($P = .68$).

Determinants of BMD

In the logistic regression analysis of the entire study group, significant determinants of low BMD (osteopenia plus osteoporosis) included sex ($P = .002$) and BMI ($P < .0001$); Asian ethnicity was of borderline significance ($P = .088$) (Table 3). Female sex and increased BMI (for every 1 kg/m²) were associated with a decrease in odds of having low BMD of 88% and 42%, respectively. Multiple regression analysis for Z-scores of the femoral neck, hip, trochanter, and lumbar spine yielded similar results (data not shown). Age, sex, ethnicity, smoking, and BMI explained 20% to 30% of Z-score variation, including femoral neck ($r^2 = 0.21$), hip ($r^2 = 0.31$), trochanter ($r^2 = 0.28$), and lumbar spine ($r^2 = 0.21$). The 25-hydroxyvitamin D level was not a determinant of BMD in our study population.

DISCUSSION

We found a high prevalence of vitamin D insufficiency [serum 25(OH)D level <30 ng/mL] in our study group of apparently healthy young physicians who were medical residents or medical students working at an urban university hospital located at 42° latitude. The mean serum 25(OH)D level and the prevalence of low serum 25(OH)D (<30 ng/mL) in our study population (22 ng/mL and 77%, respectively) were similar to those reported by NHANES III (24 ng/mL and 77%, respectively) for young adults (1) and also previously reported for young physicians (4,5). A lower level of serum 25(OH)D in participants of nonwhite ancestry in our study was also consistent with data from NHANES III (1,2). In our study, significant determinants of serum 25(OH)D included age, ethnicity, exposure to sunlight, use of vitamin D supplements, and family history of osteoporosis—similar to those reported previously (4-9,15-23). Sunlight exposure in summer was a determinant of the serum

25(OH)D level in white and Asian subjects but not other subjects, consistent with the findings from other investigators that skin pigment is an important factor for the cutaneous synthesis of vitamin D₃ (4,5,8) and that exposure to sunlight assessed by season and latitude (7,9,24-26) could influence the serum 25(OH)D level.

One of the major determinants of serum 25(OH)D level in our study was supplemental vitamin D, in agreement with previous observations (7,8,19,20). In our study group, the use of vitamin D supplements (by 50% of subjects) was higher than that reported by NHANES III for young adults (age, 19 to 30 years); in NHANES III, it was 27% for men, 21% for women, 40% for white subjects, and 22% for both Hispanic and black subjects (27,28). In our study, the majority of physicians (82%) with a sufficient serum 25(OH)D level were either taking vitamin D supplements or had higher exposure to sunlight or both. In the group taking vitamin D supplements (400 IU daily), however, the mean serum 25(OH)D level was 25 ng/mL, which was below the sufficiency level of 30 ng/mL. Thus, even these young healthy educated adults with a healthful lifestyle did not achieve the goal for vitamin D sufficiency.

BMI, a known risk for vitamin D deficiency (2-6,9,15,18,22), did not have a significant role in vitamin D deficiency in our study participants. This discrepancy between previous data and the current study might be attributable to predominantly normal BMI in our study population.

We demonstrated a negative association between serum 25(OH)D and serum PTH levels. The serum 25(OH)D-PTH relationship and the threshold of serum 25(OH)D at which the PTH value begins to increase had been used to define vitamin D deficiency and relative secondary hyperparathyroidism. The serum 25(OH)D threshold had been shown to vary between 10 and 50 ng/mL and was dependent on multiple factors (15,20,25,29-32). In the limited range of serum 25(OH)D levels observed in our study, there was no threshold level at which the serum PTH value reached a plateau. A recent longitudinal cohort study demonstrated that serum PTH 43 pg/mL was associated with a higher risk of future fractures (12), and we used this level to define relative secondary hyperparathyroidism. On the basis of this definition, we found that more than 40% of the young physicians in our study had relative secondary hyperparathyroidism and potentially could be at a higher risk for future fractures.

In the current study, the prevalence of low BMD (37.5%) was fairly high. The majority of participants (72%) in our study were 20 to 29 years old—the age at which BMD reaches its peak—and in these physicians, the occurrence of low BMD (osteopenia plus osteoporosis) was also unexpectedly high (29%). Because the distribution of BMD scores was normal, it would be expected that osteopenia (T-score < -1) and osteoporosis (T-score ≤ -2.5) would be present in approximately 15% and 0.6%, respectively (13). Therefore, the prevalence of low BMD in our study population was almost double that of the expected prevalence among young healthy adults (13) and could be an important risk factor for future osteoporotic fractures (33). We found no relationship between BMD and the serum 25(OH)D level. Some (6,7,9,17,21,34), but not all (18,19,22,25,35), studies have reported a significant association between the serum 25(OH)D level and BMD. A meta-analysis of randomized trials of

vitamin D supplements in adults suggested reasonable evidence of an association between the serum 25(OH)D level and BMD predominantly in elderly women (36). Another meta-analysis of randomized trials of the effect of vitamin D supplementation on BMD in children and adolescents showed inconsistent results and suggested a possible positive association in those with serum 25(OH)D values <20 ng/mL (37). This latter meta-analysis could explain the lack of correlation between serum 25(OH)D levels and BMD in our study, inasmuch as about half of our study participants had serum 25(OH)D levels >20 ng/mL.

Our current study had limitations. We did not evaluate dietary calcium or vitamin D intake, circumstances of exercise (indoor or outdoor), and extent of body surface exposed to sunlight. Moreover, we had small numbers of Hispanic and African American study participants, and a self-selection bias for enrollment was possible.

CONCLUSION

In young physicians with a healthful lifestyle, determinants of low serum 25(OH)D and BMD included modifiable risk factors. Vitamin D insufficiency and low BMD could be important contributors to future osteoporotic fractures in this population.

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Abbreviations

BMD	bone mineral density
BMI	body mass index
CLIA	chemiluminescence immunoassay
CVs	coefficients of variation
DXA	dual-energy x-ray absorptiometry
NHANES	National Health and Nutrition Examination Survey
25(OH)D	25-hydroxyvitamin D
PTH	parathyroid hormone

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Fig. 1. Distribution of circulating levels of serum 25-hydroxyvitamin D [$25(OH)D$] in the 3 ethnic study groups. “Other” = Hispanic and African American study subjects (see “Results” section).

Fig. 2. Relationship between serum 25-hydroxyvitamin D [25(OH)D] and serum parathyroid hormone (PTH) in white study subjects ($r = -0.48$; $P = .008$), Asian subjects ($r = -0.38$; $P = .02$), and other subjects ($r = -0.46$; $P = .26$). “Others” = Hispanic and African American study subjects (see “Results” section).

Table 1Characteristics of Study Subjects Stratified by Ethnic Group^a

Characteristic	Study subjects			
	All	White	Asian	Other
Number (%)	104 (100)	44 (42)	48 (46)	12 (12)
Sex: female	78 (75)	32 (72.7)	36 (75.0)	10 (83.3)
Age (y)	28.1 (3)	28.0 (3.1)	27.9 (2.7)	29.1 (3.6)
Height (cm)	166 (9)	168 (8)	165 (9)	162 (3) ^b
Weight (kg)	63.8 (12.7)	66.6 (12.4)	62 (12.2)	60.8 (14.4)
Body mass index (kg/m ²)	23.0 (3.5)	23.4 (3.5)	22.7 (3.3)	23.2 (4.9)
Nonsmokers	98 (94.2)	42 (95.5)	46 (95.8)	10 (83.3)
Alcohol intake 3 drinks/wk	75 (72.1)	29 (65.9)	35 (72.9)	11 (91.7)
Caffeine intake 2 drinks/d	78 (75)	31 (70.5)	36 (75.0)	11 (91.7)
Family history of osteoporosis	42 (40.4)	16 (36.4)	21 (43.8)	5 (41.7)
History of previous fracture	32 (30.8)	19 (43.2)	11 (22.9)	2 (16.7) ^c
Calcium supplements 500 mg/d	55 (52.9)	23 (52.3)	27 (56.2)	5 (41.7)
Vitamin D supplements 400 IU/d	52 (50)	26 (59.1)	22 (45.8)	4 (33.3)
Exercise 3 sessions/wk	57 (54.8)	21 (47.7)	29 (60.4)	7 (58.3)
Sunlight exposure 60 min/d in summer	66 (63.5)	25 (56.8)	32 (66.7)	9 (75.0)
Serum calcium (mg/dL)	9.4 (0.3)	9.4 (0.3)	9.4 (0.4)	9.5 (0.3)
Serum 25-hydroxyvitamin D (ng/mL) ^d	21.6 (11.2)	27.3 (10.8)	15.9 (8.4)	22.3 (11.4) ^e
Serum parathyroid hormone (pg/mL) ^f	41.4 (26.1)	36.4 (28.0)	44.7 (25.1)	43.7 (23.2)
Bone mineral density (g/cm ²)				
Spine	1.036 (0.127)	1.064 (0.107)	1.007 (0.140)	1.048 (0.123)
Femoral neck	0.837 (0.127)	0.861 (0.105)	0.824 (0.137)	0.802 (0.148)
Hip	0.959 (0.134)	0.994 (0.107)	0.936 (0.147)	0.922 (0.151)
Trochanter	0.714 (0.112)	0.741 (0.098)	0.700 (0.118)	0.671 (0.115) ^g
Z-score				
Spine	-0.187 (1.132)	0.086 (1.010)	-0.440 (1.229)	-0.173 (0.993) ^g
Femoral neck	-0.448 (1.176)	-0.250 (1.010)	-0.516 (1.291)	-0.898 (1.196)
Hip	-0.173 (1.077)	0.105 (0.914)	-0.326 (1.174)	-0.577 (1.065) ^c
Trochanter	-0.143 (1.137)	0.130 (1.017)	-0.280 (1.207)	-0.592 (1.116) ^g
Body mass index <25 kg/m ²	78 (75)	30 (68.2)	37 (77.1)	11 (91.7)
Serum 25-hydroxyvitamin D (ng/mL) ^d				
<20	46 (48.4)	12 (29.3)	29 (67.4)	5 (45.5) ^h
>30	22 (23.2)	16 (39)	3 (7)	3 (27.3) ^h
Serum parathyroid hormone 43 pg/mL ^f	35 (41.7)	11 (33.3)	18 (42.9)	6 (66.7)
Bone mineral density				

Characteristic	Study subjects			
	All	White	Asian	Other
Low ⁱ	39 (37.5)	12 (27.3)	21 (43.8)	6 (50.0)
Low ⁱ for age 20 to 29 y ^j	22 (29.3)	6 (18.8)	14 (38.9)	2 (28.6)

^aData are shown as mean (standard deviation) or number (%). "Other" = Hispanic and African American.

^b $P < .05$.

^c $P = .06$.

^dData were available for 95 study subjects.

^e $P < .0001$.

^fData were available for 84 study subjects.

^g $P = .08$.

^h $P < .01$.

ⁱOsteopenia plus osteoporosis.

^jTotal of 75 study subjects.

Table 2Determinants of Serum 25-Hydroxyvitamin D Level^a

Independent variable	Estimate ± standard error of estimate	P value
Age (y)	-0.66 ± 0.32	.04
Sex: female versus male	4.07 ± 2.11	.06
Ethnicity		
Asian versus white subjects	-10.26 ± 3.08	.01
Other versus white subjects	-5.42 ± 5.52	.33
Family history of osteoporosis	-4.58 ± 1.94	.02
Calcium supplements 500 mg/d	2.75 ± 1.87	.14
Vitamin D supplements 400 IU/d	5.14 ± 1.94	.01
Exercise 3 sessions/wk	-2.47 ± 1.89	.19
Body mass index (kg/m ²)	0.18 ± 0.27	.51
Sunlight exposure 60 min/d in summer		
White exposed versus white unexposed subjects	7.41 ± 2.85	.01
Asian exposed versus white exposed subjects	-10.75 ± 4.02	.01
Other exposed versus white exposed subjects	2.74 ± 6.65	.68

^a Multiple linear regression analysis. These variables explained 49% of the circulating level of serum 25-hydroxyvitamin D variation ($r^2 = 0.49$). "Other" = Hispanic and African American study subjects (see "Results" section).

Table 3Determinants of Low Bone Density (Osteopenia Plus Osteoporosis)^a

Independent variable	Odds ratio	95% Confidence interval	P value
Age (y)	1.10	0.931 to 1.292	.271
Sex: female versus male	0.12	0.03 to 0.463	.002
Ethnicity			
Asian versus white subjects	2.53	0.872 to 7.346	.088
Other versus white subjects	4.37	0.578 to 32.215	.154
Body mass index (kg/m ²)	0.58	0.441 to 0.753	<.0001
Serum 25-hydroxyvitamin D (ng/mL)	1.032	0.97 to 1.099	.32
Smoking	<0.01	<0.001 to >999.9	.972

^a Logistic regression analysis. "Other" = Hispanic and African American study subjects (see "Results" section).