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Research Article

Bones of Inequality: Racial and Ethnic Health Disparities in Femur and Spine Bone Mineral Density from NHANES 2005-2020

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Abstract

Background. Bone Mineral Density (BMD) is a key indicator of skeletal strength and a predictor of osteoporosis and fracture risk. This study characterized femoral and spinal BMD across adulthood (ages 20-85+) by establishing race/ethnicity-specific reference values, quantifying age-related declines, examining femur-spine cross-site correlations and their relationships with Body Mass Index (BMI) and assessing osteoporosis prevalence in the U.S. adult population. Methods: Data from 19,736 adults with femur BMD and 15,140 with spine BMD were drawn from National Health and Nutrition Examination Survey (NHANES) 2005-2010, 2013-2014 and 2017-2020. Complex Samples GLM models estimated BMD marginal means by sex, age and race/ethnicity.

Findings: Men had higher BMD than women across all sites and ages. Non-Hispanic Black adults exhibited the highest BMD, followed by Other Hispanic and Mexican American adults, whereas Non-Hispanic White adults consistently had lower BMD and the Other Race group showed the lowest or most variable values. Ward's triangle demonstrated the steepest percentage decline from the 20s to the 80s (40-50% in men; 47-53% in women), followed by the femoral neck (20-29% in men; 26-32% in women). Femoral sites were highly intercorrelated (r = 0.82-0.98), as were lumbar spine sites (r = 0.84-0.97), while femur-spine correlations were moderate (r = 0.55-0.70). BMI showed weak but positive correlations with all BMD sites (r = 0.20-0.36 for femur; r = 0.17-0.35 for spine). Non-Hispanic Black adults had the most favorable bone-health profile (92% of men and 73.4% of women classified as normal), whereas Non-Hispanic White and Other Race women had the highest osteoporosis (5.1%-6.1%) and osteopenia (40.7%-45.7%) prevalence.

Conclusion: Consistent racial and ethnic disparities were observed, supporting targeted screening, prevention and public health strategies to reduce osteoporosis risk.

Keywords: Bone Density; Aging; Osteoporosis; Health Status Disparities; NHANES; Femoral Neck; Lumbar Spine

Abbreviations

BMD: Bone Mineral Density; BMI: Body Mass Index; DXA: Dual-energy X-ray Absorptiometry; NHANES: National Health and Nutrition Examination Survey

Introduction

Bone Mineral Density (BMD) is a key indicator of skeletal strength and an established predictor of osteoporosis and fracture risk [1,2]. Osteoporosis is defined by low BMD and is associated with a markedly increased risk of hip, spine and wrist fractures [3,4].

These fractures contribute to substantial morbidity, loss of independence, increased healthcare utilization and higher mortality in older adults. Accordingly, age-related declines in BMD have important clinical and public health implications.

Numerous studies have established BMD reference values across diverse populations [5-16]. Consistent evidence shows that BMD peaks in the mid-20s or early-30s depending on skeletal sites, remains relatively stable through early adulthood and then gradually declines after age 40-50 [17]. This decline underlies the increasing risk of osteoporosis with advancing age, particularly among women, who experience accelerated bone loss during the peri- and early postmenopausal periods. Men typically maintain higher BMD than women, even after adjusting for body size and lean mass. Prior work also indicates that osteoporotic women tend to be older, have lower body mass index (BMI) and have shorter period of estrogen exposure [15]. National estimates indicate that 12.6% of U.S. adults aged 50 years and older have osteoporosis at the femoral neck or lumbar spine, with prevalence nearly five times higher among women (19.6%) than men (4.4%) [18]. Longitudinal studies further documented age-related bone loss of approximately 0.002-0.006 g/cm² per year across multiple skeletal sites in both sexes, with more pronounced loss in women after menopause [19].

Racial and ethnic disparities in BMD and osteoporosis have also been observed [17,20-32]. Non-Hispanic Blacks generally displayed the highest BMD levels and lower rates of bone loss, resulting in the lowest osteoporosis prevalence compared with Non-Hispanic White, Hispanic and Asian adults [21,22]. Findings for Hispanic adults relative to Non-Hispanic White adults have been mixed, with studies reporting higher, comparable and lower BMD values [17,25,29,30]. Although U.S. data on Asian adults remain limited, most studies suggested lower BMD compared with other racial/ethnic groups [33].

Understanding racial and ethnic differences in BMD is essential for identifying high-risk populations, developing equitable screening strategies and guiding public health initiatives aimed at reducing fractures and long-term skeletal morbidity. However, major gaps remain. Few studies have mapped BMD trajectories across the entire adult lifespan (20-85+) while simultaneously accounting for gender and racial/ethnic differences. Few studies examine both femoral and spinal sites in parallel across race/ethnicity. Decadal decline rates and percentage decline by race/ethnicity are poorly characterized. Other Race and Hispanic subgroups are understudied. Despite documentation of disparities, osteoporosis screening guidelines still rely heavily on thresholds based on Non-Hispanic White reference populations, with limited race/ethnicity-specific normative data. These gaps underscore the need for a comprehensive, population-based analysis.

Although racial and ethnic differences in BMD have been reported, comprehensive evaluations spanning the full adult lifespan, while simultaneously comparing multiple femoral and spinal sites and quantifying the magnitude of age-related decline, remain limited. Accordingly, this study aimed to: (1) establish age-specific reference values for femoral and spinal BMD across five major racial/ethnic groups (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black and Other Race - including multiracial adults); (2) quantify decadal and percentage declines in femoral and spinal BMD by race/ethnicity; (3) examine correlations among femoral BMD, spinal BMD and BODY MASS INDEX (BMI); and (4) estimate the prevalence of osteoporosis across racial/ethnic groups. These insights help identify high-risk populations, guiding clinical screening practices and strengthening public health strategies aimed at reducing osteoporosis and its long-term consequences.

Methodology

Study Design and Data Source

This observational cross-sectional study used data from the National Health and Nutrition Examination Survey (NHANES), a nationally representative survey conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC). NHANES employs a complex, multistage probability sampling design to assess the health of the U.S. noninstitutionalized population. Data were collected through structured in-home interviews followed by standardized physical examinations at Mobile Examination Centers (MECs).

DXA Exam

Dual-energy X-ray Absorptiometry (DXA) is the standard method for assessing bone mineral density due to its speed, precision and low radiation exposure (<20 μSv) [34]. NHANES administered DXA scans of the proximal femur and lumbar spine during the 2005-2010, 2013-2014 and 2017-2020 cycles. The scans were acquired on Hologic QDR-4500A fan-beam densitometers (Hologic, Inc., Bedford, Massachusetts) using Apex software.

The femur scans provided bone measurements for (1) total femur, (2) femoral neck, (3) trochanter, (4) intertrochanter and (5) Ward's triangle. The left hip was routinely scanned unless the participant self-reported a fractured left hip, a left hip replacement or a pin in the left hip. The spine scans provided bone measurements for the total lumbar spine and individual vertebrae L1-L4. DXA outputs included Bone Mineral Content (BMC, gm), bone area (cm^2) and BMD (gm/cm^2).

Participants were excluded from DXA scanning if they (a) were pregnant (positive urine pregnancy test and/or self-report at the time of the DXA examination), (b) had a self-reported history of radiographic contrast material, such as dyes or barium, in the past 7 days or (c) weighed more than 450 pounds (DXA scanner table limit). Additionally, participants were excluded from the femur scan if they had fractured both hips, had bilateral hip replacements or had pins in both hips. Participants were excluded from the spine scan if they reported a Harrington rod in the spine for scoliosis. Participants with valid DXA measurements for the femur and/or lumbar spine were included in this study.

Ethical Approval

NHANES obtained written informed consent from participants aged ≥12 years and written assent from children aged 7-11 years. The NCHS Research Ethics Review Board approved all NHANES data collection procedures. Because this project involved secondary analysis of publicly available, de-identified NHANES data, the University of Wisconsin-Milwaukee Institutional Review Board determined that it did not constitute human subjects research and did not require further review.

Data Analysis

Data were analyzed using IBM SPSS Statistics (version 31). Outliers were identified within each sex × age-group stratum for each BMD site using the 1.5×IQR rule and were removed prior to modeling. To evaluate consistency across survey years, factorial Generalized Linear Models (GLMs) were fit for each skeletal site with fixed effects for sex, age group (20-29 through 80-85+) and survey year. When no survey-year differences were detected, the full dataset was analyzed using models including sex, age group and race/ethnicity. As the high BMI may result in spuriously high BMD, additional GLMs incorporating BMI were used to assess covariate effects; when BMI was significant, BMI-adjusted estimates were reported [35]. Scheffé post-hoc tests were applied to compare race/ethnicity within each sex × age stratum. Estimated Marginal Means (EMMs) were generated for sex × age × race to facilitate preliminary pattern assessment.

Complex Samples GLM (CSGLM) models were then fit to incorporate sampling weights, strata and clustering. An initial unadjusted model (Model A) included fixed effects for sex, age group, race/ethnicity and all two- and three-way interactions. A second model (Model B) added BMI as a continuous covariate. For both models, weighted estimated marginal means and 95% confidence intervals were obtained and race/ethnicity effects were tested at $\alpha = 0.05$ using Scheffé-adjusted comparisons where appropriate. Two indices quantified age-related bone loss. (1) The decadal change (ΔBMD/10-yr) was calculated as the difference in mean BMD (g/cm^2) between consecutive 10-year age groups (e.g., 30-39 minus 20-29, 40-49 minus 30-39, etc.); (2) Percent change (%Change): calculated relative to peak BMD (ages 20-29) using:

$$\%Change = \frac{BMD_{age\ group} - BMD_{20-29}}{BMD_{20-29}}\ x\ 100$$

Pearson correlation matrices were computed within each racial/ethnic group to examine associations among femoral BMD, spinal BMD and BMI. Finally, the WHO BMD categories were derived by calculating sex-specific T-scores for each participant using the young-adult (20-29 years) reference mean and SD for each skeletal site. Participants were then classified as osteoporotic ($T \leq -2.5$), osteopenic ($-2.5 < T < -1.0$) or normal ($T \geq -1.0$) and prevalence was computed within each race/ethnicity × sex group.

Results

Study Sample

After removing outliers (208 for femur, 187 for spine), the analytic sample included 19,736 adults with femur BMD data and 15,140 adults with spine BMD data, with mean ages of 53.6 (SD 16.8) and 50.3 (SD 16.4) years, respectively (range: 20-85 years). Of these, 14,203 participants had complete DXA measurements for both the femur and lumbar spine.

DXA completeness did not differ significantly by age (p = .137). A chi-square test indicated a modest but statistically significant association between gender and DXA availability ($\chi^2(1) = 6.02$, p = .014), although standardized residuals were small (|SR| < 2), suggesting no strong cell-level contributions. In contrast, race/ethnicity was strongly associated with DXA completeness ($\chi^2(4) = 174.73$, p < .001). Mexican American and Other Hispanic adults were more likely to have both femur and spine data, whereas Non-Hispanic White adults were the most likely to have only one BMD site available.

Table 1 summarizes the demographic characteristics. Gender distribution was balanced across samples. The sample was predominantly Non-Hispanic White (47% for femur; 44% for spine), followed by Non-Hispanic Black (20-21%), Mexican American (16-18%), Other Hispanic (9-10%) and Other Race, including multiracial adults (8%).

	Femur BMD (n = 19,736)	**Spine BMD (n = 15,140)**
Age, mean (SD); range	53.6 (16.8); 20-85	50.3 (16.4); 20-85
Gender (%)		
• Male	51.4	48.6
• Female	48.6	51.4
Survey Year (%)		
• NHANES 2005-2006	17.5	21.4
• NHANES 2007-2008	23.7	26.2
• NHANES 2009-2010	25.3	24.7
• NHANES 2013-2014	15.7	13.9
• NHANES 2017-2020	17.8	13.8
BMI Category (%)		
• Underweight (<18.5)	1.4	1.6
• Normal (18.5-24.9)	27.8	28.6
• Overweight (25.0-29.9)	36.4	35.1
• Obese (>=30.0)	33.9	34.3
• Missing	0.5	0.4
Education Level (%)		
• Less than 11th grade	25.9	26.0
• High school graduate/GED	23.8	23.6
• Some college or AA degree	28.0	28.3
• College graduate or above	22.2	22.0
• Missing	0.1	0.1
Race/Ethnicity		
• Mexican American	16.1	18.1
• Other Hispanic	9.3	9.5
• Non-Hispanic White	46.7	44.1
• Non-Hispanic Black	20.0	20.4
• Other Race - Including Multi-Racial	8.0	7.9
BMI: Body Mass Index		

Table 1: Demographic characteristics of the study sample.

Lifespan Patterns of BMD

BMD values were consistent across survey years (p = 0.982). Significant differences were observed by sex, age group and race/ethnicity (all p < .001) and BMI was a significant covariate (p < .001). Across femur skeletal sites, BMD peaked in early adulthood (ages 20-29), declined gradually beginning in the 30s and showed a steeper decrease after age 50. The most pronounced declines occurred after age 70, with the lowest BMD values observed among adults aged 85 and older. Across femoral regions, the intertrochanter consistently showed the highest BMD, reflecting its substantial cortical bone composition, followed by the total femur, femoral neck and trochanter, with Ward's triangle exhibiting the lowest values.

At the lumbar spine, BMD remained relatively stable through the 30s and 40s but declined markedly after age 55, particularly at L1 and L2. Consistently across all racial/ethnic groups, L3 and L4 exhibited higher absolute BMD values compared with L1 and L2. Some fluctuation in spine BMD was observed in the 70-79 and 80-85+ age groups. The sharp declines in the 80-85+ category likely reflect small subgroup sample sizes after stratifying by sex and race/ethnicity, resulting in less stable estimates.

Gender Differences in BMD

Men had higher BMD than women at every skeletal site and in every age group. The sex gap was largest at the femoral neck and total femur, where men's BMD exceeded women's by approximately 8-12% in early adulthood, widening to 15-20% after age 60. After age 70, women experienced a steeper rate of BMD decline, resulting in markedly lower femoral and spinal values compared with men.

Race/Ethnicity Disparity

Table 2 presents age-specific femoral BMD reference values by race/ethnicity, with Figure 1 illustrating femoral BMD by sex and race/ethnicity. Across all femoral sites, including the total femur, femoral neck, trochanter, intertrochanter and Ward's triangle, a consistent racial and ethnic gradient was observed. Non-Hispanic Black adults exhibited the highest BMD, followed by Other Hispanic and Mexican American adults, who showed intermediate levels. Non-Hispanic White adults consistently had lower BMD, while the Other Race group showed the lowest or most variable values, likely reflecting heterogeneity and smaller sample sizes. Table 3 provides corresponding spine BMD reference values by race/ethnicity and Figure 2 displays BMD of the total lumbar spine and vertebrae L1-L4 by sex and race/ethnicity. A parallel pattern emerged at the spine. Across total spine and vertebral levels L1-L4, Non-Hispanic Black adults again showed the highest BMD across total spine and vertebrae L1-L4, followed by Hispanic groups; Non-Hispanic Whites consistently had lower values and the Other Race group demonstrated the lowest or least stable estimates.

Decadal Change

Table 4 summarizes decadal change (ΔBMD/10-yr) and percent change (%Change) in femoral BMD by race/ethnicity, while Table 5 presents the corresponding declines for spine BMD. Overall, BMD loss per decade was greater in women than in men, with the most pronounced declines occurring after age 50.

Femur Sites: Among men, Non-Hispanic White and Other Race groups showed the steepest femoral declines, particularly at Ward's triangle, reaching losses of 0.12-0.15 g/cm² per decade. Non-Hispanic Black men experienced more modest declines (approximately 0.02-0.10 g/cm²), while Mexican American and Other Hispanic men demonstrated intermediate losses. Among women, Mexican American and Other Hispanic groups exhibited the greatest postmenopausal declines (up to 0.11-0.12 g/cm² at Ward's triangle). Non-Hispanic White women showed moderate losses (about 0.05-0.10 g/cm²), whereas Non-Hispanic Black women had the smallest declines (about 0.02-0.07 g/cm²). Declines among Other Race women were variable and often minimal, likely reflecting subgroup heterogeneity and small sample sizes.

Spine Sites: Across all lumbar regions, decadal BMD changes were small in men but substantially larger in women, especially after midlife. The greatest declines occurred at L1 and L2, followed by modest losses at L3-L4. By race/ethnicity, Other Hispanic and Other Race men showed the largest lumbar declines, while Non-Hispanic Black men consistently exhibited the smallest losses. Among women, Mexican American, Other Hispanic and Other Race groups showed the greatest declines, whereas Non-Hispanic Black women maintained the most preserved lumbar BMD across ages and spine levels.

Percent Change

Femur Sites: Across all femoral regions, Ward's triangle showed the greatest deterioration in both men and women. Among men, Ward's triangle experienced the steepest decline (about 40-50%), followed by the femoral neck (20-29%). Total femur, trochanter and intertrochanter sites exhibited more moderate declines (12-17%). Among women, Ward's triangle also showed extremely large declines (47-53%), followed by the femoral neck (26-32%). The trochanter and intertrochanter demonstrated moderate-to-large declines (20-30%), while total femur declined by approximately 18-28%. Overall, women experienced a higher percentage loss than men at every femoral site.

Spine Sites: In men, lumbar spine BMD declines were smaller than those observed at the femur, with most reductions ranging from -1% to -14%, depending on vertebral level and race/ethnicity. Other Hispanic men showed the steepest spine losses (10-14%), while Non-Hispanic Black men had the smallest declines (0-5%). Degenerative changes in older adults contributed to apparent increases at some levels, particularly L3-L4. Women exhibited substantially larger spine BMD declines than men, especially after age 50, with reductions generally ranging from -14% to -28%. The greatest losses were observed in Other Hispanic and Mexican American women.

Correlations

Across all racial and ethnic groups, the correlation patterns among BMD measures were highly consistent, with only minor differences in magnitude. Femoral sites showed very strong associations: total femur, femoral neck, trochanter and intertrochanter correlated closely (r = 0.82-0.98), with intertrochanter BMD demonstrating the strongest association with total femur BMD (r = 0.97-0.98). Ward's triangle correlated moderately to strongly with other femoral regions (r = 0.70-0.88) but remained the weakest linked site, reflecting its higher trabecular content and greater measurement variability. Spine sites also showed consistently strong associations, with total spine BMD correlating highly with L1-L4 (r = 0.92-0.97) and intercorrelations among L1-L4 similarly strong (r = 0.84-0.97), especially between adjacent vertebrae. Femur-spine correlations were moderate across groups (r = 0.55-0.70), with Ward's triangle again demonstrating the lowest cross-site associations (r = 0.48-0.58). Non-Hispanic Black adults had slightly lower femur-spine correlations (r = 0.47-0.65), while Hispanic and Other Race adults showed the strongest cross-site relationships. BMI exhibited weak but consistently positive correlations with all BMD sites, ranging from r = 0.20-0.36 for femoral regions and r = 0.17-0.35 for lumbar spine levels.

Prevalence of Osteoporosis

Among men, osteopenia prevalence was 9.3% in Mexican Americans, 11.0% in Other Hispanics, 16.2% in Non-Hispanic Whites, 8.1% in Non-Hispanic Blacks and 18.4% in the Other Race group. Osteoporosis prevalence was low across all groups: 0.1% in Mexican Americans, 0.0% in Other Hispanics, 0.6% in Non-Hispanic Whites, 0.1% in Non-Hispanic Blacks and 0.3% in the Other Race group. Overall, the Other Race group had the highest osteopenia prevalence (18.4%), while Non-Hispanic Black men had the best bone health, with 92% classified as normal. Among women, osteopenia prevalence was substantially higher: 31.0% in Mexican Americans, 32.7% in Other Hispanics, 40.7% in Non-Hispanic Whites, 23.6% in Non-Hispanic Blacks and 45.7% in the Other Race group. Osteoporosis prevalence was 3.0%, 3.9%, 6.1%, 2.9% and 5.1%, respectively. Non-Hispanic Black women demonstrated the most favorable bone health profile, with 73.4% having normal BMD.

			Total femur			**Femoral neck**			**Trochanter**			**Intertrochanter**			**Ward's triangle**		
Age	**Race/Ethnicity**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**	
Male		N		L	U		L	U		L	U		L	U		L	U
20-29 yr	Mexican American	298	1.08	1.06	1.09	0.97	0.95	0.98	0.8	0.78	0.81	1.27	1.25	1.28	0.88	0.86	0.9
	Other Hispanic	93	1.11	1.08	1.15	0.99	0.96	1.02	0.84	0.81	0.87	1.3	1.26	1.34	0.9	0.86	0.93
	White	449	1.08	1.07	1.09	0.96	0.95	0.97	0.81	0.8	0.82	1.27	1.26	1.28	0.87	0.86	0.89
	Black	229	1.16	1.14	1.18	1.04	1.01	1.06	0.87	0.85	0.89	1.36	1.34	1.38	0.95	0.92	0.98
	Other Race	58	1.09	1.06	1.12	0.96	0.93	0.99	0.81	0.78	0.84	1.29	1.25	1.33	0.88	0.84	0.92
30-39 yr	Mexican American	230	1.06	1.05	1.07	0.92	0.91	0.93	0.78	0.77	0.79	1.26	1.25	1.27	0.79	0.77	0.8
	Other Hispanic	106	1.06	1.04	1.08	0.92	0.9	0.95	0.79	0.76	0.81	1.26	1.23	1.28	0.8	0.77	0.83
	White	531	1.03	1.02	1.04	0.89	0.88	0.9	0.78	0.77	0.79	1.21	1.2	1.22	0.75	0.74	0.76
	Black	193	1.12	1.1	1.14	0.98	0.96	1	0.83	0.82	0.85	1.32	1.3	1.35	0.85	0.82	0.87
	Other Race	73	1	0.98	1.03	0.86	0.84	0.89	0.73	0.71	0.75	1.2	1.17	1.23	0.74	0.7	0.78
40-49 yr	Mexican American	325	1.02	1.01	1.04	0.86	0.85	0.88	0.76	0.75	0.77	1.21	1.2	1.23	0.7	0.69	0.72
	Other Hispanic	146	1.02	1	1.04	0.85	0.83	0.87	0.76	0.75	0.78	1.22	1.2	1.24	0.68	0.66	0.71
	White	692	1.03	1.01	1.04	0.85	0.84	0.87	0.78	0.77	0.79	1.21	1.2	1.23	0.67	0.66	0.69
	Black	286	1.09	1.07	1.1	0.93	0.92	0.95	0.81	0.8	0.82	1.28	1.27	1.3	0.76	0.73	0.78
	Other Race	132	1.02	1	1.05	0.85	0.83	0.87	0.78	0.75	0.8	1.22	1.19	1.24	0.67	0.64	0.7
50-59 yr	Mexican American	314	1.01	0.99	1.03	0.84	0.82	0.85	0.75	0.73	0.77	1.21	1.18	1.23	0.64	0.61	0.66
	Other Hispanic	194	1.01	0.99	1.02	0.83	0.81	0.85	0.75	0.73	0.77	1.2	1.18	1.22	0.62	0.6	0.64
	White	879	1	0.99	1.02	0.82	0.81	0.83	0.77	0.76	0.78	1.19	1.18	1.2	0.61	0.6	0.62
	Black	441	1.07	1.05	1.09	0.9	0.88	0.92	0.81	0.79	0.82	1.26	1.24	1.29	0.7	0.68	0.71
	Other Race	218	0.97	0.94	1	0.8	0.77	0.83	0.73	0.7	0.76	1.15	1.12	1.18	0.6	0.56	0.64

60-69 yr	Mexican American	345	1	0.98	1.01	0.81	0.79	0.82	0.74	0.73	0.76	1.19	1.17	1.2	0.59	0.58	0.61
	Other Hispanic	236	0.99	0.97	1.01	0.81	0.79	0.82	0.74	0.73	0.76	1.19	1.16	1.22	0.6	0.58	0.61
	White	801	0.98	0.97	0.99	0.79	0.78	0.8	0.76	0.75	0.77	1.16	1.15	1.17	0.55	0.54	0.57
	Black	617	1.05	1.04	1.07	0.88	0.86	0.89	0.8	0.78	0.81	1.25	1.23	1.27	0.65	0.63	0.67
	Other Race	186	0.98	0.94	1.02	0.79	0.75	0.82	0.74	0.71	0.77	1.18	1.13	1.24	0.58	0.54	0.61
70-79 yr	Mexican American	122	0.94	0.91	0.97	0.76	0.73	0.79	0.7	0.67	0.72	1.12	1.08	1.17	0.51	0.48	0.55
	Other Hispanic	72	0.97	0.93	1	0.76	0.73	0.79	0.72	0.68	0.76	1.16	1.13	1.2	0.52	0.49	0.55
	White	815	0.97	0.95	0.98	0.77	0.76	0.78	0.75	0.74	0.76	1.14	1.12	1.16	0.52	0.51	0.54
	Black	239	1.03	1.01	1.06	0.86	0.83	0.88	0.8	0.77	0.82	1.22	1.19	1.24	0.6	0.57	0.63
	Other Race	100	0.95	0.92	0.98	0.76	0.72	0.79	0.72	0.69	0.76	1.13	1.09	1.17	0.53	0.49	0.57
80-85 yr	Mexican American	31	0.9	0.85	0.94	0.71	0.67	0.75	0.68	0.64	0.72	1.07	1	1.13	0.44	0.4	0.48
	Other Hispanic	28	0.93	0.89	0.96	0.71	0.67	0.75	0.7	0.66	0.74	1.11	1.07	1.16	0.47	0.41	0.53
	White	581	0.93	0.91	0.94	0.74	0.72	0.75	0.72	0.71	0.74	1.09	1.07	1.11	0.48	0.46	0.49
	Black	67	0.99	0.94	1.03	0.79	0.75	0.83	0.75	0.72	0.79	1.16	1.11	1.22	0.52	0.48	0.57
	Other Race	27	0.95	0.9	0.99	0.76	0.7	0.82	0.7	0.66	0.75	1.14	1.08	1.19	0.52	0.46	0.58
Female																	
20-29 yr	Mexican American	233	0.96	0.95	0.97	0.87	0.86	0.88	0.7	0.69	0.71	1.13	1.11	1.15	0.83	0.81	0.84
	Other Hispanic	113	0.97	0.94	1	0.88	0.85	0.92	0.72	0.69	0.75	1.14	1.11	1.18	0.84	0.8	0.87
	White	449	0.99	0.98	1	0.9	0.89	0.91	0.74	0.73	0.75	1.16	1.14	1.17	0.84	0.83	0.86
	Black	202	1.02	1.01	1.04	0.96	0.94	0.97	0.75	0.74	0.77	1.19	1.17	1.21	0.9	0.88	0.92
	Other Race	53	0.96	0.93	0.98	0.88	0.84	0.91	0.71	0.69	0.73	1.13	1.1	1.16	0.83	0.79	0.87
30-39 yr	Mexican American	218	0.96	0.95	0.97	0.86	0.84	0.87	0.71	0.69	0.72	1.14	1.12	1.15	0.78	0.77	0.8
	Other Hispanic	105	0.97	0.95	0.99	0.88	0.85	0.9	0.73	0.7	0.75	1.15	1.11	1.18	0.8	0.77	0.83
	White	457	0.97	0.96	0.98	0.86	0.85	0.87	0.72	0.72	0.73	1.14	1.13	1.15	0.77	0.76	0.78
	Black	207	0.99	0.97	1	0.89	0.87	0.91	0.73	0.72	0.75	1.16	1.15	1.18	0.8	0.78	0.82
	Other Race	55	0.93	0.9	0.96	0.82	0.8	0.85	0.7	0.67	0.73	1.09	1.07	1.12	0.74	0.7	0.77
40-49 yr	Mexican American	303	0.96	0.94	0.97	0.83	0.81	0.84	0.71	0.7	0.72	1.14	1.12	1.16	0.72	0.71	0.74
	Other Hispanic	175	0.95	0.93	0.96	0.83	0.81	0.85	0.71	0.7	0.73	1.12	1.11	1.14	0.71	0.69	0.73
	White	754	0.94	0.94	0.95	0.82	0.81	0.83	0.72	0.71	0.72	1.11	1.1	1.13	0.69	0.68	0.71
	Black	309	0.99	0.98	1	0.9	0.88	0.91	0.75	0.74	0.76	1.17	1.15	1.18	0.77	0.75	0.79
	Other Race	142	0.94	0.92	0.96	0.81	0.79	0.83	0.71	0.69	0.73	1.11	1.09	1.14	0.69	0.66	0.72
50-59 yr	Mexican American	281	0.89	0.87	0.9	0.75	0.74	0.77	0.65	0.64	0.67	1.06	1.05	1.08	0.61	0.59	0.63
	Other Hispanic	200	0.91	0.88	0.93	0.77	0.75	0.78	0.69	0.66	0.71	1.08	1.06	1.11	0.62	0.6	0.64
	White	797	0.88	0.87	0.89	0.75	0.74	0.76	0.67	0.66	0.67	1.05	1.04	1.06	0.59	0.58	0.61
	Black	418	0.92	0.9	0.93	0.82	0.8	0.83	0.69	0.67	0.7	1.09	1.07	1.11	0.65	0.63	0.67
	Other Race	237	0.86	0.83	0.89	0.74	0.71	0.76	0.64	0.63	0.66	1.03	0.99	1.06	0.59	0.55	0.62
60-69 yr	Mexican American	332	0.83	0.82	0.84	0.69	0.68	0.7	0.61	0.6	0.62	1	0.98	1.01	0.52	0.5	0.53
	Other Hispanic	235	0.84	0.82	0.86	0.7	0.68	0.72	0.63	0.62	0.65	1.01	0.99	1.04	0.54	0.52	0.56
	White	792	0.84	0.83	0.85	0.71	0.7	0.72	0.64	0.63	0.65	1.01	0.99	1.02	0.53	0.52	0.55
	Black	472	0.88	0.86	0.9	0.78	0.76	0.79	0.66	0.65	0.68	1.04	1.02	1.06	0.58	0.56	0.59
	Other Race	177	0.85	0.82	0.88	0.71	0.68	0.75	0.63	0.61	0.66	1.02	0.98	1.06	0.55	0.51	0.6
70-79 yr	Mexican American	115	0.79	0.76	0.81	0.66	0.64	0.69	0.58	0.56	0.6	0.95	0.92	0.98	0.47	0.45	0.5

	Other Hispanic	97	0.78	0.76	0.8	0.66	0.64	0.67	0.59	0.57	0.61	0.94	0.91	0.96	0.48	0.46	0.51
	White	694	0.81	0.8	0.82	0.68	0.67	0.69	0.62	0.61	0.62	0.97	0.96	0.98	0.49	0.48	0.5
	Black	194	0.84	0.82	0.86	0.74	0.72	0.75	0.62	0.6	0.64	1	0.97	1.02	0.53	0.5	0.56
	Other Race	82	0.79	0.76	0.82	0.66	0.62	0.69	0.59	0.57	0.62	0.96	0.92	1	0.47	0.43	0.51
80-85 yr	Mexican American	39	0.74	0.69	0.79	0.61	0.57	0.66	0.54	0.51	0.58	0.89	0.83	0.94	0.42	0.38	0.46
	Other Hispanic	26	0.7	0.66	0.75	0.6	0.57	0.63	0.51	0.47	0.55	0.86	0.79	0.92	0.39	0.35	0.44
	White	517	0.77	0.75	0.78	0.64	0.63	0.65	0.59	0.57	0.6	0.91	0.9	0.92	0.44	0.42	0.45
	Black	69	0.77	0.73	0.81	0.68	0.65	0.72	0.57	0.54	0.6	0.91	0.85	0.96	0.44	0.41	0.47
	Other Race	33	0.78	0.72	0.83	0.65	0.59	0.71	0.59	0.54	0.64	0.93	0.86	0.99	0.44	0.38	0.51

Table 2: Age-specific reference values for femoral Bone Mineral Density (BMD) across race/ethnicity groups.

			Total Spine			L1			L2			L3			L4		
Age	**Race/Ethnicity**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**	
Male		**N**		**L**	**U**		**L**	**U**		**L**	**U**		**L**	**U**		**L**	**U**
20-29 yr	Mexican American	282	1.04	1.03	1.05	0.98	0.97	0.99	1.05	1.04	1.06	1.05	1.04	1.06	1.05	1.04	1.06
	Other Hispanic	89	1.08	1.05	1.11	1.03	1.00	1.06	1.09	1.06	1.12	1.10	1.08	1.13	1.09	1.07	1.12
	White	439	1.06	1.05	1.08	1.00	0.99	1.01	1.08	1.07	1.09	1.09	1.08	1.10	1.07	1.06	1.09
	Black	229	1.11	1.10	1.13	1.04	1.03	1.06	1.13	1.11	1.14	1.14	1.12	1.15	1.13	1.11	1.15
	Other Race	53	1.07	1.04	1.10	1.01	0.98	1.04	1.08	1.05	1.11	1.09	1.06	1.12	1.08	1.04	1.11
30-39 yr	Mexican American	218	1.03	1.01	1.04	0.98	0.96	0.99	1.04	1.03	1.06	1.04	1.02	1.05	1.04	1.03	1.06
	Other Hispanic	96	1.03	1.00	1.05	0.98	0.95	1.00	1.06	1.03	1.08	1.04	1.01	1.06	1.04	1.01	1.06
	White	490	1.04	1.03	1.06	0.99	0.98	1.00	1.07	1.06	1.08	1.06	1.05	1.07	1.05	1.04	1.06
	Black	182	1.10	1.08	1.12	1.03	1.01	1.05	1.11	1.09	1.14	1.12	1.10	1.15	1.12	1.09	1.14
	Other Race	73	1.04	1.01	1.06	0.98	0.96	1.01	1.04	1.02	1.07	1.06	1.03	1.09	1.05	1.02	1.08
40-49 yr	Mexican American	295	1.00	0.98	1.01	0.95	0.93	0.96	1.01	1.00	1.03	1.01	0.99	1.03	1.02	1.00	1.03
	Other Hispanic	131	1.02	1.00	1.05	0.98	0.96	1.00	1.04	1.02	1.07	1.04	1.02	1.06	1.03	1.01	1.06
	White	619	1.05	1.03	1.06	0.99	0.98	1.01	1.06	1.05	1.08	1.06	1.05	1.08	1.06	1.05	1.07
	Black	259	1.11	1.09	1.13	1.06	1.04	1.08	1.12	1.10	1.14	1.13	1.11	1.15	1.13	1.11	1.15
	Other Race	121	1.04	1.01	1.07	1.00	0.97	1.03	1.05	1.02	1.09	1.06	1.02	1.09	1.05	1.02	1.09
50-59 yr	Mexican American	251	1.00	0.98	1.02	0.94	0.93	0.96	1.01	0.99	1.03	1.02	1.00	1.04	1.03	1.01	1.05
	Other Hispanic	134	1.01	0.98	1.03	0.96	0.93	0.98	1.02	1.00	1.05	1.03	1.00	1.06	1.02	0.98	1.05
	White	627	1.04	1.03	1.06	0.98	0.97	1.00	1.05	1.04	1.07	1.06	1.05	1.07	1.07	1.06	1.08
	Black	313	1.11	1.09	1.13	1.05	1.03	1.07	1.11	1.09	1.13	1.13	1.11	1.15	1.15	1.13	1.17
	Other Race	157	0.96	0.93	1.00	0.92	0.88	0.95	0.97	0.93	1.00	0.98	0.94	1.01	0.98	0.94	1.03
60-69 yr	Mexican American	237	1.02	1.01	1.04	0.95	0.93	0.97	1.02	1.00	1.03	1.05	1.03	1.07	1.06	1.04	1.09
	Other Hispanic	152	1.01	0.98	1.04	0.95	0.91	0.99	1.01	0.98	1.04	1.03	0.99	1.06	1.06	1.02	1.09
	White	473	1.06	1.04	1.07	0.98	0.96	1.00	1.06	1.04	1.08	1.08	1.07	1.10	1.09	1.07	1.11
	Black	352	1.09	1.07	1.11	1.00	0.98	1.03	1.09	1.06	1.11	1.11	1.09	1.14	1.14	1.11	1.16
	Other Race	109	1.02	0.98	1.07	0.96	0.92	1.00	1.03	0.98	1.07	1.04	0.99	1.10	1.05	1.00	1.11
70-79 yr	Mexican American	67	1.04	0.99	1.08	0.97	0.92	1.01	1.02	0.98	1.07	1.06	1.00	1.11	1.08	1.03	1.13
	Other Hispanic	46	1.05	1.00	1.09	0.97	0.92	1.02	1.04	1.00	1.09	1.08	1.02	1.13	1.09	1.04	1.15
	White	397	1.05	1.04	1.07	0.98	0.96	0.99	1.05	1.03	1.07	1.08	1.06	1.10	1.10	1.08	1.12
	Black	121	1.14	1.09	1.18	1.03	0.99	1.07	1.12	1.07	1.17	1.17	1.12	1.23	1.20	1.14	1.25
	Other Race	54	1.03	0.95	1.12	0.98	0.91	1.05	1.01	0.93	1.10	1.05	0.97	1.14	1.06	0.96	1.17

80-85 yr	Mexican American	18	1.03	0.95	1.12	0.99	0.92	1.06	1.06	0.97	1.14	1.03	0.94	1.13	1.05	0.95	1.15
	Other Hispanic	11	0.95	0.86	1.03	0.88	0.82	0.95	0.94	0.86	1.01	0.96	0.88	1.05	0.98	0.88	1.08
	White	228	1.07	1.05	1.09	0.99	0.97	1.02	1.07	1.04	1.09	1.10	1.07	1.12	1.11	1.09	1.13
	Black	27	1.09	1.02	1.16	0.99	0.93	1.06	1.08	1.01	1.15	1.12	1.04	1.19	1.13	1.05	1.21
	Other Race	8	1.13	0.97	1.29	1.08	0.95	1.21	1.12	0.96	1.28	1.12	0.94	1.31	1.19	1.01	1.37
Female																	
20-29 yr	Mexican American	221	1.02	1.01	1.04	0.93	0.92	0.94	1.03	1.02	1.04	1.06	1.04	1.07	1.06	1.04	1.07
	Other Hispanic	100	1.05	1.02	1.08	0.95	0.91	0.98	1.06	1.02	1.09	1.09	1.06	1.12	1.08	1.05	1.12
	White	403	1.07	1.06	1.08	0.98	0.97	0.99	1.08	1.07	1.09	1.11	1.10	1.12	1.09	1.08	1.11
	Black	185	1.11	1.09	1.13	1.01	0.98	1.03	1.12	1.10	1.13	1.16	1.14	1.17	1.14	1.12	1.15
	Other Race	52	1.05	1.01	1.08	0.95	0.91	0.98	1.05	1.01	1.08	1.08	1.05	1.12	1.08	1.06	1.11
30-39 yr	Mexican American	224	1.04	1.02	1.06	0.94	0.92	0.95	1.04	1.03	1.06	1.08	1.06	1.09	1.08	1.06	1.10
	Other Hispanic	103	1.06	1.03	1.08	0.96	0.93	0.98	1.06	1.04	1.09	1.10	1.07	1.13	1.08	1.06	1.11
	White	417	1.07	1.07	1.08	0.97	0.96	0.98	1.09	1.08	1.09	1.12	1.11	1.12	1.10	1.09	1.11
	Black	199	1.10	1.08	1.12	0.99	0.98	1.01	1.11	1.09	1.12	1.15	1.13	1.17	1.13	1.11	1.15
	Other Race	49	1.06	1.02	1.09	0.97	0.94	1.01	1.06	1.03	1.10	1.10	1.06	1.13	1.08	1.04	1.12
40-49 yr	Mexican American	301	1.02	1.00	1.03	0.93	0.92	0.95	1.02	1.01	1.04	1.04	1.03	1.06	1.04	1.03	1.06
	Other Hispanic	162	1.02	1.00	1.04	0.94	0.92	0.96	1.02	1.00	1.04	1.06	1.04	1.08	1.04	1.02	1.06
	White	706	1.06	1.05	1.07	0.97	0.96	0.98	1.06	1.05	1.07	1.10	1.09	1.11	1.08	1.07	1.09
	Black	318	1.09	1.07	1.10	1.00	0.98	1.01	1.09	1.08	1.11	1.12	1.11	1.14	1.12	1.10	1.13
	Other Race	142	1.03	1.00	1.06	0.95	0.92	0.98	1.03	1.00	1.06	1.07	1.03	1.10	1.06	1.02	1.09
50-59 yr	Mexican American	242	0.92	0.90	0.94	0.84	0.82	0.86	0.91	0.89	0.93	0.95	0.93	0.97	0.95	0.93	0.97
	Other Hispanic	168	0.94	0.89	1.00	0.85	0.80	0.90	0.95	0.88	1.02	0.98	0.92	1.04	0.97	0.92	1.02
	White	631	0.98	0.97	1.00	0.89	0.87	0.90	0.98	0.97	1.00	1.02	1.01	1.04	1.02	1.01	1.03
	Black	361	1.01	1.00	1.03	0.92	0.90	0.94	1.01	0.99	1.03	1.05	1.04	1.07	1.05	1.04	1.07
	Other Race	185	0.92	0.90	0.95	0.83	0.79	0.86	0.92	0.88	0.95	0.96	0.93	0.99	0.97	0.94	1.00
60-69 yr	Mexican American	277	0.88	0.86	0.90	0.79	0.77	0.81	0.86	0.84	0.89	0.91	0.89	0.93	0.92	0.90	0.94
	Other Hispanic	169	0.88	0.84	0.91	0.78	0.75	0.81	0.87	0.84	0.90	0.91	0.88	0.95	0.92	0.87	0.97
	White	575	0.95	0.93	0.96	0.84	0.82	0.86	0.94	0.92	0.95	0.99	0.98	1.01	0.99	0.98	1.00
	Black	361	0.98	0.96	1.00	0.88	0.85	0.90	0.97	0.94	0.99	1.02	0.99	1.04	1.03	1.01	1.06
	Other Race	122	0.91	0.88	0.94	0.82	0.79	0.85	0.90	0.86	0.93	0.95	0.92	0.98	0.96	0.92	0.99
70-79 yr	Mexican American	82	0.84	0.81	0.88	0.75	0.71	0.78	0.82	0.78	0.86	0.88	0.84	0.91	0.90	0.86	0.94
	Other Hispanic	67	0.85	0.82	0.88	0.75	0.70	0.79	0.83	0.79	0.86	0.89	0.86	0.92	0.90	0.87	0.93
	White	408	0.91	0.89	0.93	0.81	0.79	0.82	0.89	0.88	0.91	0.96	0.94	0.97	0.97	0.95	0.99
	Black	139	0.96	0.93	0.98	0.85	0.82	0.88	0.94	0.91	0.97	0.99	0.96	1.03	1.01	0.98	1.04
	Other Race	59	0.91	0.85	0.97	0.81	0.75	0.87	0.88	0.81	0.94	0.97	0.90	1.03	0.95	0.89	1.01
80-85 yr	Mexican American	16	0.84	0.75	0.93	0.76	0.68	0.84	0.84	0.75	0.92	0.86	0.75	0.96	0.89	0.80	0.99
	Other Hispanic	14	0.83	0.73	0.93	0.68	0.61	0.76	0.81	0.71	0.92	0.91	0.80	1.02	0.88	0.77	1.00
	White	264	0.92	0.90	0.94	0.81	0.79	0.83	0.90	0.88	0.92	0.96	0.94	0.99	0.99	0.96	1.01
	Black	44	0.96	0.88	1.03	0.86	0.78	0.94	0.92	0.85	1.00	1.00	0.93	1.07	1.01	0.93	1.09
	Other Race	16	0.92	0.83	1.01	0.81	0.75	0.87	0.90	0.81	1.00	0.95	0.86	1.05	0.99	0.87	1.11

Table 3: Age-specific reference values for spine Bone Mineral Density (BMD) across race/ethnicity groups.

			Total Femur		Femoral Neck		Trochanter		Intertrochanter		Ward's Triangle	
Age	Race/Ethnicity	N	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change
Male												
20-29 yr	Mexican American	298										
	Other Hispanic	93										
	White	449										
	Black	229										
	Other Race	58										
30-39 yr	Mexican American	230	-0.02	-1.6%	-0.05	-5.1%	-0.02	-2.6%	-0.01	-0.5%	-0.09	-10.4%
	Other Hispanic	106	-0.05	-4.6%	-0.07	-6.9%	-0.05	-6.5%	-0.04	-3.3%	-0.09	-10.6%
	White	531	-0.05	-4.7%	-0.07	-7.4%	-0.04	-4.5%	-0.05	-4.3%	-0.12	-13.9%
	Black	193	-0.04	-3.2%	-0.06	-6.1%	-0.03	-3.7%	-0.04	-2.7%	-0.10	-10.8%
	Other Race	73	-0.09	-8.0%	-0.10	-9.9%	-0.08	-10.2%	-0.09	-7.2%	-0.15	-16.6%
40-49 yr	Mexican American	325	-0.04	-5.1%	-0.05	-10.5%	-0.02	-4.7%	-0.04	-4.0%	-0.09	-20.1%
	Other Hispanic	146	-0.04	-8.2%	-0.07	-14.3%	-0.02	-9.4%	-0.04	-6.6%	-0.12	-23.7%
	White	692	0.00	-5.1%	-0.03	-11.0%	0.00	-4.3%	0.00	-4.3%	-0.08	-22.8%
	Black	286	-0.04	-6.3%	-0.04	-10.2%	-0.03	-6.6%	-0.04	-5.7%	-0.09	-20.4%
	Other Race	132	0.02	-6.1%	-0.01	-11.4%	0.05	-4.1%	0.02	-5.7%	-0.06	-23.9%
50-59 yr	Mexican American	314	-0.01	-6.1%	-0.03	-13.6%	-0.01	-6.1%	-0.01	-4.7%	-0.07	-27.8%
	Other Hispanic	194	-0.02	-9.6%	-0.02	-16.6%	-0.01	-10.4%	-0.01	-7.6%	-0.06	-30.8%
	White	879	-0.02	-7.2%	-0.04	-14.9%	-0.01	-5.8%	-0.02	-6.1%	-0.06	-29.5%
	Black	441	-0.02	-7.7%	-0.03	-13.5%	0.00	-6.7%	-0.02	-7.1%	-0.06	-26.8%
	Other Race	218	-0.06	-11.3%	-0.05	-16.4%	-0.05	-10.5%	-0.06	-10.7%	-0.08	-32.4%
60-69 yr	Mexican American	345	-0.02	-7.8%	-0.03	-16.7%	-0.01	-6.7%	-0.02	-6.1%	-0.04	-32.9%
	Other Hispanic	236	-0.01	-10.6%	-0.02	-18.5%	-0.01	-11.4%	-0.01	-8.6%	-0.03	-33.6%
	White	801	-0.02	-9.2%	-0.02	-17.4%	-0.01	-7.0%	-0.03	-8.2%	-0.06	-36.2%
	Black	617	-0.02	-9.1%	-0.02	-15.4%	-0.01	-8.0%	-0.02	-8.3%	-0.04	-31.3%
	Other Race	186	0.02	-9.9%	-0.02	-18.1%	0.02	-8.6%	0.03	-8.2%	-0.02	-34.8%
70-79 yr	Mexican American	122	-0.05	-12.8%	-0.05	-21.4%	-0.05	-12.7%	-0.06	-11.1%	-0.08	-41.6%
	Other Hispanic	72	-0.03	-13.2%	-0.05	-23.1%	-0.02	-13.9%	-0.03	-10.6%	-0.08	-42.1%
	White	815	-0.02	-10.7%	-0.02	-19.9%	-0.01	-7.7%	-0.02	-9.9%	-0.03	-39.8%
	Black	239	-0.02	-10.8%	-0.02	-17.6%	0.00	-8.3%	-0.03	-10.5%	-0.05	-36.8%
	Other Race	100	-0.03	-12.9%	-0.03	-21.1%	-0.02	-11.1%	-0.05	-12.3%	-0.05	-40.0%
80-85 yr	Mexican American	31	-0.04	-16.8%	-0.05	-26.7%	-0.01	-14.4%	-0.06	-15.8%	-0.07	-50.1%
	Other Hispanic	28	-0.04	-16.6%	-0.05	-28.5%	-0.02	-16.5%	-0.05	-14.3%	-0.05	-47.1%
	White	581	-0.04	-14.5%	-0.03	-23.2%	-0.03	-11.1%	-0.05	-14.0%	-0.04	-44.9%
	Black	67	-0.05	-14.9%	-0.07	-24.3%	-0.04	-13.0%	-0.05	-14.5%	-0.08	-45.1%
	Other Race	27	-0.01	-13.4%	0.00	-20.9%	-0.02	-13.4%	0.00	-11.9%	-0.01	-41.1%
Female												
20-29 yr	Mexican American	233										
	Other Hispanic	113										

	White	449										
	Black	202										
	Other Race	53										
30-39 yr	Mexican American	218	0.00	0.3%	-0.01	-1.6%	0.00	0.3%	0.01	0.6%	-0.04	-4.9%
	Other Hispanic	105	0.00	-0.2%	-0.01	-0.8%	0.00	0.5%	0.00	0.2%	-0.03	-4.2%
	White	457	-0.02	-2.1%	-0.04	-4.2%	-0.01	-1.7%	-0.02	-1.8%	-0.07	-8.5%
	Black	207	-0.03	-3.3%	-0.06	-6.4%	-0.02	-2.7%	-0.03	-2.6%	-0.10	-11.4%
	Other Race	55	-0.03	-2.6%	-0.05	-5.9%	-0.01	-1.2%	-0.03	-3.0%	-0.10	-11.5%
40-49 yr	Mexican American	303	0.00	0.0%	-0.03	-5.2%	0.01	1.1%	0.00	1.0%	-0.06	-12.2%
	Other Hispanic	175	-0.02	-2.3%	-0.05	-6.0%	-0.01	-1.4%	-0.02	-1.6%	-0.09	-15.2%
	White	754	-0.02	-4.4%	-0.04	-8.8%	-0.01	-3.0%	-0.02	-3.8%	-0.08	-17.5%
	Black	309	0.00	-2.8%	0.00	-6.2%	0.01	-1.0%	0.00	-2.3%	-0.03	-14.5%
	Other Race	142	0.01	-1.7%	-0.01	-7.6%	0.01	0.5%	0.02	-1.4%	-0.04	-16.8%
50-59 yr	Mexican American	281	-0.07	-7.4%	-0.07	-13.6%	-0.06	-7.0%	-0.08	-5.8%	-0.11	-26.0%
	Other Hispanic	200	-0.04	-6.5%	-0.06	-13.1%	-0.03	-5.0%	-0.04	-5.2%	-0.09	-25.6%
	White	797	-0.06	-10.6%	-0.07	-16.6%	-0.05	-9.8%	-0.06	-9.4%	-0.10	-29.3%
	Black	418	-0.07	-10.1%	-0.08	-14.6%	-0.06	-8.9%	-0.08	-9.0%	-0.12	-28.1%
	Other Race	237	-0.08	-10.3%	-0.07	-16.1%	-0.07	-9.1%	-0.09	-9.1%	-0.11	-29.7%
60-69 yr	Mexican American	332	-0.06	-13.7%	-0.06	-20.9%	-0.05	-13.4%	-0.07	-11.8%	-0.09	-37.4%
	Other Hispanic	235	-0.06	-13.2%	-0.07	-20.7%	-0.05	-12.1%	-0.07	-11.6%	-0.08	-35.4%
	White	792	-0.04	-14.5%	-0.04	-20.9%	-0.03	-13.4%	-0.04	-13.2%	-0.06	-36.5%
	Black	472	-0.04	-13.9%	-0.04	-18.9%	-0.02	-12.0%	-0.05	-12.8%	-0.07	-35.8%
	Other Race	177	-0.01	-11.1%	-0.02	-18.8%	-0.01	-10.4%	-0.01	-9.6%	-0.03	-33.6%
70-79 yr	Mexican American	115	-0.04	-17.9%	-0.02	-23.7%	-0.03	-17.9%	-0.05	-16.3%	-0.05	-43.0%
	Other Hispanic	97	-0.06	-19.7%	-0.05	-25.8%	-0.05	-18.7%	-0.07	-18.0%	-0.06	-42.0%
	White	694	-0.03	-17.8%	-0.03	-24.2%	-0.02	-16.5%	-0.04	-16.3%	-0.04	-41.7%
	Black	194	-0.04	-18.0%	-0.04	-23.1%	-0.04	-17.6%	-0.04	-16.4%	-0.05	-40.9%
	Other Race	82	-0.06	-17.2%	-0.05	-25.0%	-0.04	-16.2%	-0.06	-15.1%	-0.08	-43.5%
80-85 yr	Mexican American	39	-0.05	-23.0%	-0.05	-29.7%	-0.03	-22.7%	-0.06	-21.6%	-0.05	-49.3%
	Other Hispanic	26	-0.08	-27.6%	-0.06	-32.2%	-0.08	-29.7%	-0.08	-25.0%	-0.09	-53.0%
	White	517	-0.05	-22.5%	-0.04	-28.6%	-0.03	-20.7%	-0.06	-21.5%	-0.05	-48.1%
	Black	69	-0.07	-25.0%	-0.05	-28.4%	-0.05	-24.2%	-0.09	-24.2%	-0.10	-51.5%
	Other Race	33	-0.02	-18.8%	-0.01	-25.8%	0.00	-16.6%	-0.03	-18.0%	-0.03	-47.0%

ΔBMD/10-yr (gm/cm²) was calculated as the difference in mean BMD (g/cm²) between consecutive 10-year age groups (e.g., 30-39 minus 20-29, 40-49 minus 30-39, etc.).

%Change was calculated as (BMDage group−BMD20-29)/BMD20-29×100, representing the percent difference in mean BMD compared with the 20-29-year reference group (peak BMD).

Table 4: Decadal and percentage decline in femoral Bone Mineral Density (BMD) by race/ethnicity.

			Total spine BMD		L1 BMD		L2 BMD		L3 BMD		L4 BMD	
Age	Race/Ethnicity		ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change	ΔBMD/10-yr	% Change
Male		N										
20-29 yr	Mexican American	282										
	Other Hispanic	89										
	White	439										
	Black	229										
	Other Race	53										
30-39 yr	Mexican American	218	-0.01	-1.0%	-0.01	-0.8%	-0.01	-0.9%	-0.01	-1.3%	-0.01	-1.0%
	Other Hispanic	96	-0.05	-4.8%	-0.05	-5.1%	-0.04	-3.4%	-0.07	-6.1%	-0.05	-4.9%
	White	490	-0.02	-1.9%	-0.01	-1.3%	-0.02	-1.5%	-0.03	-2.7%	-0.02	-2.1%
	Black	182	-0.01	-1.1%	-0.01	-1.1%	-0.01	-1.0%	-0.01	-1.1%	-0.01	-1.1%
	Other Race	73	-0.03	-2.9%	-0.03	-2.6%	-0.04	-3.6%	-0.03	-2.9%	-0.03	-2.7%
40-49 yr	Mexican American	295	-0.03	-3.8%	-0.03	-3.8%	-0.03	-3.8%	-0.03	-3.9%	-0.03	-3.6%
	Other Hispanic	131	0.00	-5.1%	0.00	-5.0%	-0.01	-4.5%	0.00	-5.7%	0.00	-5.3%
	White	619	0.00	-1.6%	0.00	-0.9%	0.00	-1.8%	0.01	-2.3%	0.01	-1.2%
	Black	259	0.01	0.0%	0.03	1.3%	0.01	-0.5%	0.00	-0.9%	0.01	0.2%
	Other Race	121	0.01	-2.4%	0.01	-1.4%	0.01	-2.7%	0.00	-3.0%	0.00	-2.4%
50-59 yr	Mexican American	251	0.01	-3.3%	0.00	-3.9%	0.00	-4.2%	0.01	-3.3%	0.02	-2.1%
	Other Hispanic	134	-0.02	-6.6%	-0.02	-7.2%	-0.02	-6.3%	-0.01	-6.9%	-0.01	-6.6%
	White	627	0.00	-1.9%	-0.01	-1.9%	-0.01	-2.8%	0.00	-2.6%	0.01	-0.5%
	Black	313	0.00	0.2%	-0.01	0.5%	-0.01	-1.1%	0.01	-0.3%	0.02	1.5%
	Other Race	157	-0.08	-9.7%	-0.08	-9.5%	-0.09	-10.6%	-0.08	-10.3%	-0.07	-8.6%
60-69 yr	Mexican American	237	0.02	-1.3%	0.00	-3.4%	0.01	-3.4%	0.03	-0.3%	0.03	1.0%
	Other Hispanic	152	0.00	-6.2%	-0.01	-7.7%	-0.02	-7.7%	0.00	-6.8%	0.04	-3.2%
	White	473	0.01	-0.8%	0.00	-2.3%	0.01	-2.3%	0.02	-0.5%	0.02	1.5%
	Black	352	-0.02	-1.9%	-0.04	-3.7%	-0.03	-3.5%	-0.02	-1.9%	-0.01	0.6%
	Other Race	109	0.06	-4.0%	0.05	-5.0%	0.06	-5.3%	0.07	-4.1%	0.07	-2.1%
70-79 yr	Mexican American	67	0.01	-0.2%	0.02	-1.5%	0.01	-2.9%	0.01	0.5%	0.02	2.6%
	Other Hispanic	46	0.04	-2.9%	0.02	-5.8%	0.03	-4.5%	0.05	-2.4%	0.04	0.1%
	White	397	0.00	-1.0%	0.00	-2.6%	-0.01	-3.4%	0.00	-0.9%	0.01	2.4%
	Black	121	0.05	2.3%	0.03	-1.2%	0.04	-0.2%	0.06	3.2%	0.06	6.0%
	Other Race	54	0.01	-3.4%	0.02	-3.2%	-0.01	-6.4%	0.01	-3.1%	0.01	-1.1%
80-85 yr	Mexican American	18	0.00	-0.4%	0.02	0.7%	0.03	0.3%	-0.02	-1.8%	-0.03	-0.4%
	Other Hispanic	11	-0.10	-12.5%	-0.09	-14.2%	-0.11	-14.2%	-0.11	-12.5%	-0.11	-9.7%
	White	228	0.02	0.5%	0.01	-1.1%	0.02	-1.7%	0.02	0.6%	0.01	3.5%
	Black	27	-0.05	-2.2%	-0.04	-4.6%	-0.04	-4.1%	-0.06	-1.7%	-0.07	0.2%
	Other Race	8	0.10	5.9%	0.10	6.9%	0.10	3.1%	0.07	3.1%	0.12	10.3%
Female												
20-29 yr	Mexican American	221										

	Other Hispanic	100										
	White	403										
	Black	185										
	Other Race	52										
30-39 yr	Mexican American	224	0.02	1.6%	0.01	0.8%	0.01	1.4%	0.02	1.9%	0.02	2.1%
	Other Hispanic	103	0.01	0.5%	0.01	1.1%	0.01	0.5%	0.01	0.6%	0.00	-0.2%
	White	417	0.00	0.3%	-0.01	-0.7%	0.00	0.3%	0.00	0.2%	0.01	1.0%
	Black	199	-0.01	-0.7%	-0.01	-1.5%	-0.01	-0.8%	-0.01	-0.7%	0.00	-0.3%
	Other Race	49	0.01	1.1%	0.03	2.8%	0.02	1.4%	0.02	1.4%	0.00	-0.2%
40-49 yr	Mexican American	301	-0.02	-0.8%	0.00	0.6%	-0.02	-0.8%	-0.03	-1.4%	-0.03	-1.0%
	Other Hispanic	162	-0.04	-2.9%	-0.01	-0.4%	-0.04	-3.5%	-0.04	-3.1%	-0.04	-3.7%
	White	706	-0.02	-1.3%	0.00	-1.1%	-0.02	-1.6%	-0.02	-1.5%	-0.02	-1.0%
	Black	318	-0.01	-1.8%	0.00	-1.0%	-0.01	-1.8%	-0.02	-2.7%	-0.02	-1.7%
	Other Race	142	-0.03	-1.6%	-0.02	0.4%	-0.04	-1.9%	-0.03	-1.4%	-0.02	-2.3%
50-59 yr	Mexican American	242	-0.10	-10.4%	-0.10	-9.6%	-0.11	-11.4%	-0.10	-10.4%	-0.09	-9.8%
	Other Hispanic	168	-0.08	-10.3%	-0.09	-10.1%	-0.07	-10.5%	-0.08	-10.4%	-0.07	-10.2%
	White	631	-0.08	-8.3%	-0.08	-9.2%	-0.08	-9.4%	-0.08	-8.3%	-0.07	-6.9%
	Black	361	-0.07	-8.5%	-0.08	-8.6%	-0.09	-9.7%	-0.07	-8.9%	-0.06	-7.1%
	Other Race	185	-0.10	-11.5%	-0.12	-12.6%	-0.11	-12.5%	-0.11	-11.2%	-0.08	-10.1%
60-69 yr	Mexican American	277	-0.04	-14.3%	-0.05	-15.1%	-0.05	-16.1%	-0.03	-13.7%	-0.03	-12.7%
	Other Hispanic	169	-0.07	-16.6%	-0.07	-17.5%	-0.08	-18.0%	-0.07	-16.4%	-0.05	-15.2%
	White	575	-0.04	-11.7%	-0.05	-14.1%	-0.04	-13.3%	-0.03	-11.0%	-0.03	-9.4%
	Black	361	-0.03	-11.6%	-0.04	-12.8%	-0.04	-13.4%	-0.04	-12.1%	-0.02	-8.9%
	Other Race	122	-0.01	-12.8%	0.00	-13.1%	-0.02	-14.3%	-0.01	-12.4%	-0.01	-11.4%
70-79 yr	Mexican American	82	-0.03	-17.6%	-0.04	-19.7%	-0.04	-20.3%	-0.04	-17.3%	-0.02	-14.5%
	Other Hispanic	67	-0.03	-19.2%	-0.03	-21.1%	-0.04	-21.7%	-0.02	-18.6%	-0.02	-16.8%
	White	408	-0.03	-14.9%	-0.03	-17.5%	-0.04	-17.4%	-0.04	-14.2%	-0.02	-11.7%
	Black	139	-0.02	-13.6%	-0.03	-15.4%	-0.02	-15.4%	-0.02	-14.0%	-0.02	-10.7%
	Other Race	59	-0.01	-13.3%	-0.01	-14.2%	-0.02	-16.3%	0.02	-10.8%	-0.01	-12.1%
80-85 yr	Mexican American	16	0.00	-17.8%	0.01	-18.2%	0.01	-18.8%	-0.02	-19.1%	-0.01	-15.5%
	Other Hispanic	14	-0.02	-20.9%	-0.06	-27.5%	-0.02	-23.3%	0.02	-16.7%	-0.02	-18.4%
	White	264	0.01	-14.0%	0.00	-17.5%	0.00	-16.9%	0.01	-13.5%	0.02	-9.6%
	Black	44	0.00	-13.8%	0.01	-14.6%	-0.02	-17.1%	0.00	-13.7%	0.00	-10.9%
	Other Race	16	0.01	-12.0%	0.00	-14.1%	0.03	-13.9%	-0.01	-12.0%	0.04	-8.5%

ΔBMD/10-yr (gm/cm²) was calculated as the difference in mean BMD (g/cm²) between consecutive 10-year age groups (e.g., 30-39 minus 20-29, 40-49 minus 30-39, etc.).

%Change was calculated as (BMDage group−BMD20-29)/BMD20-29×100, representing the percent difference in mean BMD compared with the 20-29-year reference group (peak BMD).

Table 5: Decadal and percentage decline in spine Bone Mineral Density (BMD) by race/ethnicity.

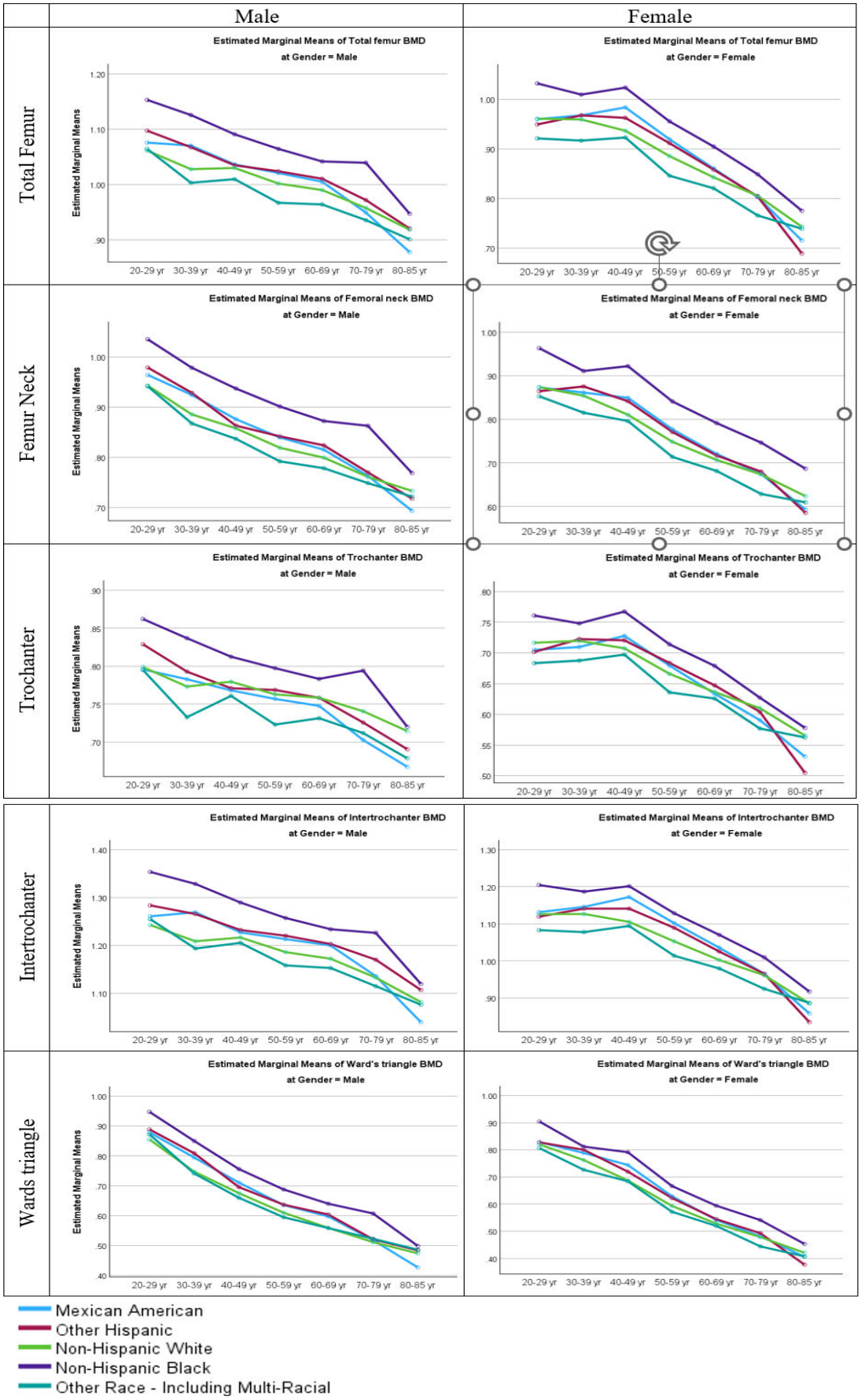

Figure 1: Bone Mineral Density (BMD) of the total femur, neck, trochanter, intertrochanter and Ward's triangle by sex and race/ethnicity.

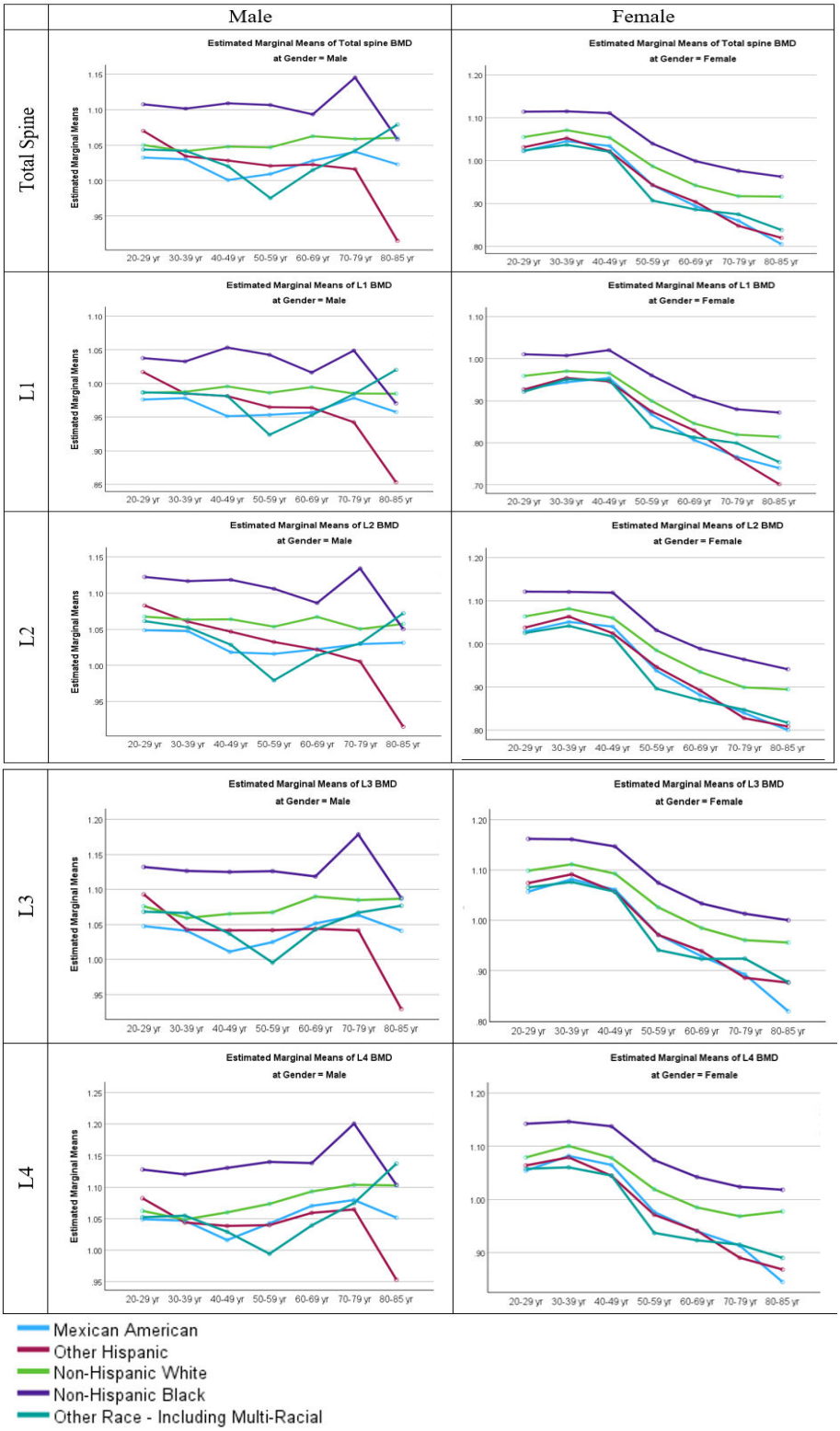

Figure 2: Bone Mineral Density (BMD) of the total lumbar spine and vertebrae L1-L4 by sex and race/ethnicity.

Discussion

BMD plays a central role in determining fracture risk and overall skeletal integrity throughout life. Identifying how BMD patterns vary in the population supports more equitable screening and helps target groups most vulnerable to osteoporosis. This study provided a comprehensive evaluation to date of BMD patterns across adulthood in the U.S. population, integrating femoral and spinal reference values, age-related declines, racial/ethnic disparities, physiologic correlates and osteoporosis prevalence. Using nationally representative NHANES data (ages 20-85+), the analysis demonstrated that BMD peaks in early adulthood and

declines progressively with age, more steeply in women than men and most rapidly at Ward's triangle and the femoral neck. Non-Hispanic Black adults consistently showed the highest BMD and slowest decline, while Non-Hispanic White and Other Race groups exhibited the lowest BMD and highest rates of osteopenia and osteoporosis. Cross-site correlations were strong within femoral and spine regions and moderate between them, while BMI showed weak but positive associations with BMD. Overall, the findings highlight substantial gender and racial/ethnic disparities in skeletal health, establish contemporary normative BMD values across major demographic groups and underscore important targets for osteoporosis prevention and screening.

Compared with earlier population-based studies, our findings align closely with established racial and ethnic patterns in BMD. For the proximal femur, our results are consistent with Looker, et al., who analyzed 14,646 adults from earlier NHANES cycles [16]. Both studies demonstrated that Non-Hispanic Black adults consistently had the highest femoral BMD, followed by Mexican American adults, with Non-Hispanic White adults exhibiting lower values across all femoral sites (total femur, femoral neck, trochanter and intertrochanter). Looker's analysis did not include an "Other Race" category but did report regional differences, noting that Non-Hispanic White adults in the southern United States had slightly lower femur BMD than those in other regions. Our lumbar spine results were also broadly comparable to those of Rondanelli, et al., who examined BMD trajectories in 10,503 adults [15]. While both studies showed similar age-related patterns across adulthood, our findings indicated a steeper decline in lumbar spine BMD among women after age 50, whereas Rondanelli reported a more gradual decline. This discrepancy may reflect differences in population characteristics, geographic context (U.S. vs. Italy) or cohort-specific factors. BMD is influenced by various factors, including genetic variations, dietary habits and lifestyle choices [36-38]. Genetic influences account for a substantial proportion of individual variability; Zhai, et al., estimated that up to 56% of variance in bone loss is heritable [36]. Although many genetic determinants are shared across skeletal sites, site-specific genetic effects (e.g., lumbar spine, femoral neck and total body) tend to be stronger than the common influences [38]. Lifestyle and behavioral factors also play a significant role. Weight-bearing and higher-intensity physical activity are consistently associated with higher BMD, as demonstrated by Whitfield and Kopiczko [37,39]. Lean mass is another key determinant of skeletal strength; Wilkin, highlighted the importance of maintaining adequate muscle mass and recommended resistance training to promote bone health across the lifespan [40]. In contrast, smoking has been identified as a negative predictor of total hip BMD [39]. Dietary patterns also contribute to BMD variation, with several studies linking nutrient intake and eating habits to bone health [41,42]. Integrating genetics, diet, lifestyle and body composition would provide a much deeper, mechanistic explanation of racial/ethnic BMD differences.

In this study, BMI was included as a covariate because higher body mass is known to exert greater mechanical loading on the skeleton and can artificially elevate measured BMD, potentially obscuring true differences across demographic groups. BMI showed weak but consistently positive correlations with all femoral and spinal BMD sites. As expected, adjusting for BMI slightly lowered estimated marginal means in higher-BMI groups and raised them in lower-BMI groups. To assess whether BMI adjustment affected the substantive findings, we compared unadjusted (Model A) and BMI-adjusted (Model B) Complex Samples GLMs. The overall pattern remained unchanged: Non-Hispanic Black adults consistently had the highest total femur BMD, Mexican American and Other Hispanic adults were intermediate and Non-Hispanic White and Other Race groups had the lowest values. Sex and age gradients were also preserved. Differences in estimated marginal means between models were minimal (0.0008-0.0445 gm/cm², typically <0.02 gm/cm²). Although BMI adjustment slightly reduced racial/ethnic contrasts, it did not alter group rankings or interpretation. Both models produced highly consistent conclusions.

Limitations of the Study

There were several limitations in this study. First, although BMI was included as a covariate, we did not adjust for other important determinants of BMD such as body size, lean mass, skeletal geometry, physical activity, nutrition or socioeconomic factors. These unmeasured mediators may partially explain racial and ethnic differences in BMD. Second, BMD is strongly influenced by hormonal factors (e.g., estrogen, testosterone, thyroid and parathyroid function) and chronic health conditions such as hyperthyroidism, diabetes and vitamin D deficiency. These conditions were not incorporated into the analyses and may contribute to unexplained variability in BMD. Third, as a secondary analysis of NHANES data, we were limited to the variables collected and had no control over measurement procedures. Nonetheless, NHANES employs rigorous quality assurance protocols, including extensive technologist training, ongoing field monitoring and standardized DXA phantom scanning procedures that meet Clinical Laboratory Improvement Amendments (CLIA) requirements, ensuring high reliability of the BMD data.

Future Implications

As with any population-based analysis, several considerations emerge when interpreting results and planning future work. Some of the sharp declines in the 80-85+ age group likely reflect small subgroup sample sizes after stratifying by sex and race/ethnicity, which can produce less stable estimates. Future research should prioritize oversampling underrepresented racial/ethnic groups and the oldest adults to improve estimate precision.

Conclusion

In this nationally representative sample of U.S. adults, we established race/ethnicity-specific reference values for femoral and spinal BMD, quantified age-related declines and identified consistent disparities across demographic groups. These findings may improve understanding of skeletal aging patterns and inform targeted screening, prevention and public health strategies to reduce osteoporosis risk and its consequences.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Consent To Participate

The authors certify that they have obtained all appropriate patient consent.

Data Availability and Consent of Patient

Data is available for the journal. Informed consents were not necessary for this paper.

Author's Contribution

All authors contributed equally for this paper.

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Appendix

Correlations	Mexican American									
	Femoral neck	**Trochanter**	**Intertrochanter**	**Ward's triangle**	**Total spine**	**L1**	**L2**	**L3**	**L4**	**BMI**
Total femur BMD	.886	**.941**	**.979**	.755	.665	.675	.659	.611	.588	.294
Femoral neck BMD	1	.827	.827	.883	.629	.609	.616	.580	.553	.223
Trochanter BMD		1	.882	.707	.652	.662	.644	.607	.583	.255
Intertrochanter BMD			1	.700	.629	.641	.624	.577	.558	.295
Ward's triangle BMD				1	.563	.522	.550	.523	.483	.123
Total spine BMD					1	**.923**	**.964**	**.967**	**.928**	.199
L1 BMD						1	**.909**	.848	.791	.208
L2 BMD							1	**.916**	.845	.181
L3 BMD								1	**.912**	.168
L4 BMD									1	.171
	Other Hispanic									
	Femoral neck	Trochanter	Intertrochanter	Ward's triangle	Total spine	L1	L2	L3	L4	BMI
Total femur BMD	.885	**.940**	**.978**	.742	.682	.680	.667	.640	.626	.323
Femoral neck BMD	1	.822	.825	.878	.655	.624	.640	.613	.596	.278
Trochanter BMD		1	.874	.689	.676	.676	.658	.637	.625	.285
Intertrochanter BMD			1	.687	.643	.645	.630	.603	.587	.323
Ward's triangle BMD				1	.578	.512	.557	.542	.511	.130
Total spine BMD					1	**.927**	**.966**	**.970**	**.942**	.226
L1 BMD						1	**.920**	.863	.808	.252
L2 BMD							1	**.932**	.871	.206
L3 BMD								1	**.920**	.190
L4 BMD									1	.184
	Non-Hispanic White									
	Femoral neck	Trochanter	Intertrochanter	Ward's triangle	Total spine	L1	L2	L3	L4	BMI
Total femur BMD	.887	**.937**	**.980**	.740	.687	.676	.675	.627	.591	.356
Femoral neck BMD	1	.810	.834	.867	.640	.607	.624	.587	.546	.280
Trochanter BMD		1	.873	.663	.682	.665	.666	.626	.595	.305
Intertrochanter BMD			1	.695	.651	.643	.641	.592	.557	.363
Ward's triangle BMD				1	.539	.483	.521	.494	.431	.143
Total spine BMD					1	**.922**	**.964**	**.968**	**.934**	.270
L1 BMD						1	**.913**	.852	.778	.292
L2 BMD							1	**.923**	.844	.254
L3 BMD								1	**.909**	.224
L4 BMD									1	.222
	Non-Hispanic Black									
	Femoral neck	Trochanter	Intertrochanter	Ward's triangle	Total spine	L1	L2	L3	L4	BMI
Total femur BMD	.877	**.936**	**.979**	.762	.647	.645	.641	.608	.587	.272
Femoral neck BMD	1	.801	.817	.868	.593	.579	.590	.568	.534	.282

Trochanter BMD		1	.874	.683	.647	.639	.641	.610	.589	.234
Intertrochanter BMD			1	.718	.612	.614	.605	.573	.556	.261
Ward's triangle BMD				1	.499	.469	.496	.482	.426	.201
Total spine BMD					1	**.928**	**.972**	**.975**	**.950**	.194
L1 BMD						1	**.921**	.871	.813	.211
L2 BMD							1	**.939**	.884	.175
L3 BMD								1	**.927**	.158
L4 BMD									1	.144
	Other Race - Including Multi-Racial									
	Femoral neck	Trochanter	Intertrochanter	Ward's triangle	Total spine	L1	L2	L3	L4	BMI
Total femur BMD	.898	**.937**	**.978**	.751	.730	.728	.728	.683	.663	.405
Femoral neck BMD	1	.825	.842	.862	.707	.676	.699	.659	.640	.347
Trochanter BMD		1	.871	.694	.723	.720	.715	.685	.662	.393
Intertrochanter BMD			1	.702	.684	.689	.686	.638	.619	.380
Ward's triangle BMD				1	.599	.552	.592	.557	.524	.199
Total spine BMD					1	**.943**	**.973**	**.978**	**.957**	.345
L1 BMD						1	**.935**	.894	.844	.340
L2 BMD							1	**.943**	.892	.321
L3 BMD								1	**.937**	.296
L4 BMD									1	.297

Appendix 1: Correlation coefficients among femoral BMD, spinal BMD and BMI across race/ethnicity groups.