Published in final edited form as:
Bone. 2008 July ; 43(1): 156–161.

Correlates of Bone Mineral Density among Postmenopausal Women of African Caribbean Ancestry: Tobago Women's Health Study

Deanna D. Hill¹, Jane A. Cauley¹, Clareann H. Bunker¹, Carol E. Baker², Alan L. Patrick³, Gloria L. A. Beckles⁴, Victor W. Wheeler³, and Joseph M. Zmuda¹

¹Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania 15261, USA

²Office of Measurement and Evaluation, University of Pittsburgh, Pittsburgh, Pennsylvania 15261, USA

³Tobago Health Studies Office, Scarborough, Tobago, Trinidad and Tobago

⁴Division of Diabetes Translation, Epidemiology and Statistics Branch, National Center for Chronic Disease Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia, 30341, USA

Abstract

Population dynamics predict a drastic growth in the number of older minority women, and resultant increases in the number of fractures. Low bone mineral density (**BMD**) is an important risk factor for fracture. Many studies have identified the lifestyle and health related factors that correlate with BMD in Whites. Few studies have focused on non-Whites. The objective of the current analyses is to examine the lifestyle, anthropometric and health related factors that are correlated with BMD in a population based cohort of Caribbean women of West African ancestry. We enrolled 340 postmenopausal women residing on the Caribbean Island of Tobago. Participants completed a questionnaire and had anthropometric measures taken. Hip BMD was measured by DXA. We estimated volumetric BMD by calculating bone mineral apparent density (BMAD). BMD was 10% and 20% higher across all age groups in Tobagonian women compared to US non-Hispanic Black and White women, respectively. In multiple linear regression models, 35–36% of the variability in femoral neck and total hip BMD respectively was predicted. Each 16 kilogram (one standard deviation (SD)) increase in weight was associated with 7% higher BMD; and weight explained over 10% of the variability of BMD. Each eight year (1 SD) increase in age was associated with 6% lower BMD. Current use of both thiazide diuretics and oral hypoglycemic medication were associated with 4–5% higher BMD. For femoral neck BMAD, 26% of the variability was explained by a multiple linear regression model. Current statin use was associated with 5% higher BMAD and a history of breast feeding or coronary heart disease were associated with 1–1.5% of higher BMAD. In conclusion, African Caribbean women have the highest BMD on a population level reported to date for women. This may reflect low European admixture. Correlates of BMD among Caribbean women of West African ancestry were similar to those reported for U.S. Black and White women.

Corresponding Author, Jane A. Cauley, DrPH, University of Pittsburgh, Department of Epidemiology, 130 DeSoto Street, Pittsburgh, PA 15261, Tele: 412-624-3057, Fax: 412-624-7397, Email: jcauley@edc.pitt.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

Osteoporosis; epidemiology; African ancestry continental group; bone densitometry; women

Introduction

Bone mineral density (BMD) is one of the strongest predictors of future fracture risk among Whites [1] and Blacks [2]. It is well established that Black Americans have greater BMD across the entire life span compared to White Americans [3–7], which maybe due in part to higher peak bone mass, body size, and slower rates of bone loss [3,8–11]. Although Black American women have considerably higher BMD than White American women, this is not the case for all women of African ancestry. Aspray and colleagues established that among older West African women, BMD was considerably lower than British women [12]. Similarly, Dibba et al. did not observe any ethnic differences in BMD among Gambians compared to British women [13], suggesting that among women of African ancestry, BMD was comparable to or even lower than Whites [12,13]. However, despite their similar and sometimes lower BMD than White women, the risk of fracture is not higher among African women [12,14].

Lifestyle and health-related factors influence BMD and subsequent fracture risk [1,8,15–17]. Studies have evaluated risk factors associated with lower BMD among postmenopausal White women but few studies have evaluated risk factors associated with lower BMD among Blacks [9,16]. Risk factors correlated with BMD among Black women appear to be similar to those observed for White women and include sedentary lifestyle, low BMI, and personal or parental history of osteoporotic fractures [8,9,16,18,19]. Whether these modifiable risk factors are applicable to women of West African ancestry in other countries is not known.

Osteoporosis is a serious public health concern for older women, regardless of ethnicity. Population dynamics predict a drastic growth in the number of older minorities, possibly resulting in steep increases in number of fractures among postmenopausal women [20]. More research is needed to evaluate the role of race and ethnicity, in conjunction with lifestyle and health-related factors, to better understand ethnic differences in BMD and subsequent fracture risk.

To better understand the interrelationships between bone health and demographic, lifestyle, anthropometric, and health-related factors, we conducted a cross-sectional analysis of postmenopausal women on the Caribbean island of Tobago to identify correlates of BMD. Our objectives were: (1) to compare BMD measured at the total hip and femoral neck subregion among postmenopausal Tobagonian women to U.S. non-Hispanic Black and non-Hispanic White women of the same age [4]; (2) to identify the demographic, anthropometric, health-related, lifestyle, and reproductive factors that were correlated with BMD; and (3) to identify the best subset of independent predictors of BMD.

Methods

Trinidad & Tobago is a twin-island nation situated at the southern end of the Caribbean chain of islands. Our study focused solely on Tobago. The majority of the Tobagonian population (94%) was reported to be of West African ancestry with very little European or Indian admixture [21]. The Institutional Review Boards of University of Pittsburgh and the Tobago Ministry of Health and Social Services approved this study.

To increase awareness about the Tobago Women's Health Study, recruitment flyers were posted near the Tobago Health Studies Office in downtown Scarborough, Tobago. Recruitment

efforts also included word-of-mouth referral by research staff and male participants in the Tobago Prostate Cancer Survey Study [22]. Potential study participants were women aged 50 years and older, postmenopausal, ambulatory, willing to provide informed consent, and residents of the Caribbean Island of Tobago. Postmenopausal status was defined as cessation of menses at least 12 months prior to study enrollment. Ethnicity was self-reported and participants provided detailed information on the ethnic origin of their parents and grandparents. A total of 350 women were recruited to participate in the Tobago Women's Health Study between October 2002 and December 2002. In this cross-sectional analysis, we excluded ten women who were not of West African ancestry based on their grandparents' ethnic origin, resulting in a sample of 340 women.

Trained interviewers and nurses administered questionnaires to participants. Questionnaires gathered information pertaining to demographic characteristics, medical history, medication use, and lifestyle variables. We focused on potential correlates of BMD based on the literature [1,8,16,18,19,23]. Physical activity was measured as a continuous variable by the number of hours walked per week. Other lifestyle characteristics and health-related questions were measured as dichotomous variables. Medical history was based on self-report. Parental history of hip fracture was also ascertained at baseline. Any mention of joint pain, regardless of joint site or type of arthritis, was considered arthritis. Information was collected on alcohol consumption and smoking history. **Smoking status was categorized as current, ever, or never.** Women who smoked cigarettes for less than six months were considered to have never smoked.

Participants were asked to bring all prescription and nonprescription medications to the interview for verification by trained study personnel. Prescription medication names were cross-referenced with a drug handbook to identify drug class[24]. All medications recorded were considered as current use and selected over-the-counter medication that was used at least three-times per week was considered regular use.

Fasting blood glucose was measured by nursing staff using standard techniques with glucometers (Accu-Chek: Roche Diagnostics or Prestige: Home Diagnostics) Using a calibrated balance beam scale, body weight was measured in kilograms with participants wearing indoor clothing and their shoes removed. Standing height without shoes was measured in centimeters with a wall-mounted stadiometer. We calculated average standing height based on two repeated measurements recorded to the nearest tenth. Body mass index (BMI) was calculated by dividing weight (in kilograms) by standing height (in meters squared). Handgrip strength was measured in kilograms for the dominant hand using an adjustable hydraulic dynamometer (Preston Grip Dynamometer, JA Preston Corp). We calculated average grip strength based on two repeated measurements.

Participants received a DXA examination during the study period (QDR 4500W, Hologic, Inc). For all participants, the same scanner was used and DXA scans were completed using the array beam mode. Standardized positioning and utilization of QDR software was based on the manufacturer's recommended protocol. Scans were analyzed with QDR software version 8.26a. The left hip was scanned to obtain areal BMD measures at the total hip and the femoral neck subregion. Since areal BMD may be confounded by body size (i.e., height), we calculated an estimate of volumetric bone mineral apparent density (BMAD, g/cm^3) from the formula $\text{BMC}_{\text{femoral neck}} / (\text{area}^2_{\text{femoral neck}})$ [25]. Body composition measures (bone mineral-free lean mass and fat mass), were assessed by whole body scans. To ensure consistency, a spine phantom was scanned daily and quality control whole body air scan was completed weekly, prior to completing any scans. Synarc, Inc. monitored spine phantom data, reviewed DXA scans, and flagged scans if positioning errors occurred.

Data Analysis

We compared mean BMD measured at the hip and femoral neck subregion to a nationally representative sample of U.S. non-Hispanic Black and non-Hispanic White women from the National Health and Nutrition Examination Survey (NHANES) III (1988–1994), stratified by 10-year age categories [4]. To identify variables that were correlated with hip BMD, predictor variables were analyzed using age-adjusted models. The strength of the association is expressed as percent change in units of change chosen to approximate one standard deviation in the distribution for each continuous variable and yes (1) or no (0) for dichotomous variables. The formula used to calculate the percent difference in BMD per unit change of the independent variable (β) = (unstandardized $\beta \times$ unit change in independent variable) $\times$ 100. The corresponding 95% confidence intervals were calculated using: $\beta \times$ unit change $\pm 1.96 \times$ standard error of β . This approach is similar to published studies in White women [18,19] and men [8].

To limit the number of predictors tested, only variables with a p-value less than 0.10 in age-adjusted models were considered in multiple linear regression analyses. Multiple linear regression analyses were performed using the stepwise approach to identify correlates of hip and the femoral neck subregion in separate models. Age was forced into models for both the total hip and femoral neck subregion. The final model only included variables significantly associated with BMD at $p < 0.05$.

Multicollinearity was assessed with the variance inflation factor (VIF), which suggests that a VIF greater than 10 for any one variable or the mean of VIFs substantially larger than 1 represents collinearity among the variables [26]. In some instances, our data captured information from multiple variables that measured the same characteristic and we selected the variable that was most correlated with BMD. BMI and components of body weight (lean and fat mass) were significantly associated with higher BMD in age-adjusted models, but to a lesser extent than body weight, so we did not consider BMI or lean and fat mass in multiple linear regression models. Similarly, diabetes mellitus was identified using three variables: (1) self-report of physician diagnosed diabetes; (2) fasting blood glucose; and (3) diabetes medication. Diabetes medication was most strongly correlated with BMD, so this variable was used as a potential predictor in the multiple regression models. No one in the study reported use of insulin.

Potential interactions were derived from extant literature and initial review of the multiple linear regression models. We tested for interactions including age and weight, and weight and history of using thyroid hormone medication. None of the interactions tested were significant ($p < 0.05$) in models for the hip or femoral neck subregion (data not shown). Data were analyzed using SAS software version 8.2 (SAS Institute, Cary, NC).

Results

Of the 340 participants, average age was 63.9 ± 8.0 years (ranged 50 to 94 years) at baseline; women aged 50–69 years accounted for more than 77% of the study sample. Mean total hip BMD was 0.98 ± 0.16 g/cm² and mean femoral neck BMD was 0.88 ± 0.15 g/cm². Compared to NHANES III data, age-specific total hip BMD among Tobagonian women was 10–18% higher than non-Hispanic Black women and 29–30% higher than non-Hispanic White women (Figure 1). The direction and magnitude of ethnic group comparisons in BMD was similar at the femoral neck subregion (data not shown). The declined in slopes for total hip and femoral neck across age-groups appeared similar in Tobagonian and U.S. women.

Correlates of total hip and femoral neck BMD, adjusted for age, are shown in Table 1. BMD decreased 6% for every standard deviation increase (eight additional years) in age. Each 16 kg

(one standard deviation) increase in body weight accounted for 5–6% higher BMD at the femoral neck subregion and hip, respectively, after adjusting for age. Each 5.8 kg/m² increase in BMI was associated with 6% higher hip and 5% higher femoral neck BMD in age-adjusted models.

Lifestyle Characteristics

In age-adjusted models, women who reported a fall in the past 12 months had 3% higher total hip BMD compared to those who did not fall. Among women who reported recent back pain, hip and femoral neck BMD was 4–6% higher after age adjustment. Personal history of a broken or fractured bone walking, or consumption of alcohol containing was not significantly associated with total hip or femoral neck BMD after age-adjustment.

Medical History and Medication Use

Self-report of thyroid disease was associated with 2% lower femoral neck BMD and 6% lower total hip BMD in age-adjusted models. Current thiazide diuretic use was associated with 5–6% higher BMD at both sites, after adjustment for the effects of age. Similarly, diabetes medication was associated with a 5–7% higher BMD at both sites. Current use of prescription and over-the-counter nonsteroidal anti-inflammatory drugs (NSAIDs) was associated with higher hip and femoral neck BMD. Women who were taking beta-blockers had 6–7% lower femoral neck and hip BMD, respectively. Parity and breast-feeding were each associated with a 5% increase in BMD in age-adjusted models.

Multiple Linear Regression Models

Complete data were available for 339 participants in the total hip regression model, 340 in the femoral neck regression model, and 339 for the calculated femoral neck BMAD model (Table 2). Models derived from stepwise regression analyses explained 36% of the total variance (R^2) in total hip BMD and 35% of the variability in femoral neck BMD. Each standard deviation unit increase in body weight (16 kg) was associated with 5% higher BMD; and every additional eight years in age was associated with 5% lower BMD. Self-reported thyroid disease was associated with almost 8% lower total hip BMD but was not associated with femoral neck BMD. Current use of diabetes medication was associated with 4–5% higher BMD while use of beta blockers was associated with lower BMD at each site. Parental history of hip fracture was associated with a 9% lower total hip BMD. Regular use of aspirin was associated with higher femoral neck BMD. Finally, self report of back pain was independently associated with higher total hip BMD.

The amount of variability explained by correlates in femoral neck BMAD model was somewhat lower than the areal BMD models ($R^2 = 26\%$). Some variables associated with femoral neck BMD in the multiple linear regression models were also significant in the BMAD model (weight, aspirin use, beta blocker use, and parental history of hip fracture), but to a lesser magnitude but the direction remained unchanged. Coronary heart disease, current statin use, and history of breast feeding were positively correlated with BMAD, whereas these variables were not significant correlates of areal BMD.

Discussion

To our knowledge, this analysis is one of few studies that identified correlates of BMD among postmenopausal women of West African ancestry residing outside the U.S. Of importance, Tobagonian women had 10–18% and 29% higher BMD compared to non-Hispanic Black and White women in the U.S., respectively [4]. To our knowledge, these African Caribbean women have the highest BMD on a population level reported to date for women.

It is well established that BMD is significantly higher among U.S. Black women compared to White women. Greater skeletal size and bone size (depth) may partially explain the higher BMD that was observed among postmenopausal Tobagonian women compared to U.S. women of similar age. Areal BMD accounts for only bone length and width, not bone depth [25]. Reference data did not allow for direct comparison of volumetric BMD [4], which takes bone depth into consideration, between Tobagonian and U.S. women. Research suggests that people of African ancestry may have genetic potential for higher BMD compared to people of European ancestry [7,27]. This high BMD potential may not be realized among native Africans due to nutritional and lifestyle factors [12]. It is reasonable to consider that the lower levels of genetic European and East Indian admixture among Tobagonian women, in the context of better nutrition and lifestyle factors, may be a possible reason for the higher BMD that we observed in this analysis compared to American Blacks, where European admixture is more prevalent [7,21,27,28].

Correlates explained 35% and 36% of the variability in areal BMD measured at the femoral neck subregion and total hip, respectively. The amount of variability accounted for in this analysis is slightly higher than other studies of American Whites, Blacks and Asians where only 20–30% of the variability in hip BMD was explained by risk factors [16,18,29]. A recent study by Robbins et al. investigated the association between BMD and demographic, health-related, and functional status variables for Black men and women, aged 67–96 years, in the Cardiovascular Health Study [16]. The model that best predicted BMD in Black women included weight, age, and income group, which accounted for 28% of the variability in hip BMD. Weight was the strongest correlate of BMD, explaining 21% of the variability in BMD. Our results confirm these observations and extends the findings to a slightly younger study population of African Caribbean women [16]. Wang et al. reported that anthropometric, lifestyle, and medical factors accounted for 12–32% of the variability in BMD for the Tobago Family Health Study [7].

Low BMI and cigarette smoking were identified as risk factors for low BMD among U.S. non-Hispanic Black women based on data from NHANES III [30]. In this analysis, we were unable to demonstrate an association between BMD and smoking, which is probably due to the low prevalence of current smoking (0.3%) or ever smoking (2.7% - data not shown). Similarly, statin use has been commonly associated with higher BMD and we observed a positive correlation between statin use and BMD but the effect was not significant after age-adjustment, likely reflecting low power. Current statin use was only significant in the femoral neck BMAD multiple linear regression model.

We confirmed the findings of previous studies that thiazide diuretics use [31,32], aspirin use [31,33], and history of diabetes [34,35] were significant predictors of higher BMD. The association between diabetes and higher BMD was independent of body weight and thus, other factors may contribute. For example, insulin and insulin-like growth factors have been shown to have an anabolic effect on bone [36] and Type 2 diabetics have hyperinsulinemia. Lower BMD was associated with increasing age [16,30], history of thyroid disease [37], hip of fracture [38,39], and use of beta-blockers. The predominance of medication use in our final model is novel. We limited our analyses to current use which was verified against medication bottles. It is also possible that medication use is a surrogate for the severity of the disease and we had greater power to detect associations with medications because prevalence of use, especially thiazide diuretics and beta blockers, was quite high. This high prevalence contrasts with the low prevalence of smoking, alcohol consumption, and previous fracture.

A major strength of our study was the focus on a unique homogeneous group of women of Western African descent. We examined a large number of possible correlates that have previously been linked to BMD in other studies. Our results add to the body of literature

examining the epidemiologic correlates of BMD in White women [40], White men [41], and Asian men [42]. There are, however, several limitations. Ethnicity was based on self-report and represents a crude surrogate for biological, environmental, cultural and behavioral differences among individuals. However, this would have less impact on our study because of the homogeneous nature of the Tobago population. We had no information on possible biological correlates of BMD including sex steroids, biochemical markers of bone turnover and Vitamin D levels. Self-reported data are subject to inaccurate recall, resulting in possible biased estimates of measures of association. Due to the lack of automated medical history data, we were unable to verify medical history. Research has shown, however, that self-reported medical history tends to be consistent with medical records [43,44]. We attempted to partially correct for any dependence of areal BMD on the volume of bone (i.e., bone size) by calculating femoral neck BMAD, an estimate of volumetric density. Finally, this study focused on a rural, community-based sample of postmenopausal women and our correlates of BMD may not be generalizable to other postmenopausal women of African ancestry.

In conclusion, African Caribbean women have the highest BMD on a population level reported to date for women. This may reflect low European admixture. Correlates of BMD among Caribbean women of West African ancestry were similar to those reported for U.S. Black and White women. Our findings provide support for heterogeneity in BMD among persons of West African ancestry. We observed that body weight was a strong predictor of BMD in African Caribbean women. The amount of variability in BMD explained by these correlates was considerably greater than other studies of White and Black women [16,18,19]. We believe our findings contribute to the limited research that has been completed on etiology of fracture risk among women of West African ancestry.

Acknowledgements

The authors would like to thank the staff of the Tobago Health Studies Office for their assistance with this research.

Dr. Hill is an employee of GlaxoSmithKline. Dr. Cauley has research grants from Merck and Co. and Eli Lilly and Co., Pfizer Pharmaceuticals and Novartis Pharmaceuticals. She has received honorarium from Merck, Eli Lilly and Co. and Novartis. She is on the Speaker's Bureau for Merck and Co.

The Tobago Women's Health Study was supported, in part, by funding or in-kind services from the Division of Health and Social Services, Tobago House of Assembly and grant 01AR049747, the National Institute of Arthritis and Musculoskeletal Diseases.

References

1. Barrett-Connor E, Siris ES, Wehren LE, Miller PD, Abbott TA, Berger ML, Santora AC, Sherwood LM. Osteoporosis and fracture risk in women of different ethnic groups. *Journal of Bone & Mineral Research* 2005;20:185–194. [PubMed: 15647811]
2. Cauley JA, Lui LY, Ensrud KE, Zmuda JM, Stone KL, Hochberg MC, Cummings SR. Bone mineral density and the risk of incident nonspinal fractures in black and white women. *JAMA* 2005;293:2102–2108. [PubMed: 15870413]
3. Ettinger B, Sidney S, Cummings SR, Libanati C, Bikle DD, Tekawa IS, Tolan K, Steiger P. Racial differences in bone density between young adult black and white subjects persist after adjustment for anthropometric, lifestyle, and biochemical differences. *Journal of Clinical Endocrinology & Metabolism* 1997;82:429–434. [PubMed: 9024231]
4. Looker AC, Wahner HW, Dunn WL, Calvo MS, Harris TB, Heyse SP, Johnston CC Jr, Lindsay R. Updated data on proximal femur bone mineral levels of US adults. *Osteoporosis International* 1998;8:468–489. [PubMed: 9850356]
5. Bachrach LK, Hastie T, Wang MC, Narasimhan B, Marcus R. Bone mineral acquisition in healthy Asian, Hispanic, black, and Caucasian youth: a longitudinal study. *Journal of Clinical Endocrinology & Metabolism* 1999;84:4702–4712. [PubMed: 10599739]

6. Finkelstein JS, Lee ML, Sowers M, Ettinger B, Neer RM, Kelsey JL, Cauley JA, Huang MH, Greendale GA. Ethnic variation in bone density in premenopausal and early perimenopausal women: effects of anthropometric and lifestyle factors. *Journal of Clinical Endocrinology & Metabolism* 2002;87:3057–3067. [PubMed: 12107201][see comment]
7. Wang X, Kammerer CM, Wheeler VW, Patrick AL, Bunker CH, Zmuda JM. Genetic and environmental determinants of volumetric and areal BMD in multi-generational families of African ancestry: the Tobago Family Health Study. *Journal of Bone & Mineral Research* 2007;22:527–536. [PubMed: 17227221]
8. Cauley JA, Lui L-Y, Ensrud KE, Zmuda JM, Stone KL, Hochberg MC, Cummings SR. Bone mineral density and the risk of incident nonspinal fractures in black and white women. *JAMA* 2005;293:2102–2108. [PubMed: 15870413][see comment]
9. Cauley JA, Lui L-Y, Stone KL, Hillier TA, Zmuda JM, Hochberg M, Beck TJ, Ensrud KE. Longitudinal Study of Changes in Hip Bone Mineral Density in Caucasian and African-American Women. *J Am Geriatr Soc* 2005;53:183–189. [PubMed: 15673339]
10. Luckey MM, Wallenstein S, Lapinski R, Meier DE. A prospective study of bone loss in African-American and white women—a clinical research center study. *Journal of Clinical Endocrinology & Metabolism* 1996;81:2948–2956. [PubMed: 8768857]
11. Finkelstein JS, Sowers M, Greendale GA, Lee ML, Neer RM, Cauley JA, Ettinger B. Ethnic variation in bone turnover in pre- and early perimenopausal women: effects of anthropometric and lifestyle factors. *Journal of Clinical Endocrinology & Metabolism* 2002;87:3051–3056. [PubMed: 12107200][see comment]
12. Aspray TJ, Prentice A, Cole TJ, Sawo Y, Reeve J, Francis RM. Low bone mineral content is common but osteoporotic fractures are rare in elderly rural Gambian women. *J Bone Miner Res* 1996;11:1019–1025. [PubMed: 8797124]
13. Dibba B, Prentice A, Laskey MA, Stirling DM, Cole TJ. An investigation of ethnic differences in bone mineral, hip axis length, calcium metabolism and bone turnover between West African and Caucasian adults living in the United Kingdom. *Annals of Human Biology* 1999;26:229–242. [PubMed: 10355494]
14. Adebajo AO, Cooper C, Evans JG. Fractures of the hip and distal forearm in West Africa and the United Kingdom. *Age Ageing* 1991;20:435–438. [PubMed: 1776593]
15. Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley CJ, Black D, Vogt TM. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. *New England Journal of Medicine* 1995;332:767–773. [PubMed: 7862179][see comment]
16. Robbins J, Hirsch C, Cauley J. Associates of bone mineral density in older African Americans. *Journal of the National Medical Association* 2004;96:1609–1615. [PubMed: 15622691]
17. Bohannon AD, Hanlon JT, Landerman R, Gold DT. Association of race and other potential risk factors with nonvertebral fractures in community-dwelling elderly women. *American Journal of Epidemiology* 1999;149:1002–1009. [PubMed: 10355375]
18. Bauer DC, Browner WS, Cauley JA, Orwoll ES, Scott JC, Black DM, Tao JL, Cummings SR. The Study of Osteoporotic Fractures Research Group. Factors associated with appendicular bone mass in older women. *Ann Intern Med* 1993;118:657–665. [PubMed: 8460853]
19. Orwoll ES, Bauer DC, Vogt TM, Fox KM. Study of Osteoporotic Fractures Research Group. Axial bone mass in older women. *Annals of Internal Medicine* 1996;124:187–196. [PubMed: 8533993]
20. Kenny AM, Prestwood KM. Osteoporosis. Pathogenesis, diagnosis, and treatment in older adults. *Rheumatic Diseases Clinics of North America* 2000;26:569–591. [PubMed: 10989513]
21. Miljkovic-Gacic I, Ferrell RE, Patrick AL, Kammerer CM, Bunker CH. Estimates of African, European and Native American ancestry in Afro-Caribbean men on the island of Tobago. *Hum Hered* 2005;60:129–133. [PubMed: 16282694]
22. Bunker CH, Patrick AL, Konety BR, Dhir R, Brufsky AM, Vivas CA, Becich MJ, Trump DL, Kuller LH. High prevalence of screening-detected prostate cancer among Afro-Caribbeans: the Tobago Prostate Cancer Survey. *Cancer Epidemiology, Biomarkers & Prevention* 2002;11:726–729.
23. Taaffe DR, Cauley JA, Danielson M, Nevitt MC, Lang TF, Bauer DC, Harris TB. Race and sex effects on the association between muscle strength, soft tissue, and bone mineral density in healthy elders:

- the Health, Aging, and Body Composition Study. *J Bone Miner Res* 2001;16:1343–1352. [PubMed: 11450711]
24. Wilkins CH, Goldfeder JS. Osteoporosis screening is unjustifiably low in older African-American women. *J Natl Med Assoc* 2004;96:461–467. [PubMed: 15101666]
 25. Katzman DK, Bachrach LK, Carter DR, Marcus R. Clinical and anthropometric correlates of bone mineral acquisition in healthy adolescent girls. *J Clin Endocrinol Metab* 1991;73:1332–1339. [PubMed: 1955516]
 26. Glantz, SA.; Slinker, BK. *Primer of applied regression and analysis of variance*. New York: McGraw-Hill, Inc.; 2001.
 27. Shaffer JR, Kammerer CM, Reich D, McDonald G, Patterson N, Goodpaster B, Bauer DC, Li J, Newman AB, Cauley JA, Harris TB, Tyllavsky F, Ferrell RE, Zmuda JM. Genetic markers for ancestry are correlated with body composition traits in older African Americans. *Osteoporos Int* 2007;18:733–741. [PubMed: 17235662]
 28. Parra EJ, Marcini A, Akey J, Martinson J, Batzer MA, Cooper R, Forrester T, Allison DB, Deka R, Ferrell RE, Shriver MD. Estimating African American admixture proportions by use of population-specific alleles. *American Journal of Human Genetics* 1998;63:1839–1851. [PubMed: 9837836]
 29. Walker MD, Babbar R, Opatowsky A, McMahon DJ, Liu G, Bilezikian JP. Determinants of bone mineral density in Chinese-American women. *Osteoporosis International* 2007;18:471–478. [PubMed: 17120181]
 30. Broussard DL, Magnus JH. Risk assessment and screening for low bone mineral density in a multi-ethnic population of women and men: does one approach fit all? *Osteoporosis International* 2004;15:349–360. [PubMed: 14676991]
 31. Carbone LD, Tyllavsky FA, Cauley JA, Harris TB, Lang TF, Bauer DC, Barrow KD, Kritchevsky SB. Association between bone mineral density and the use of nonsteroidal anti-inflammatory drugs and aspirin: impact of cyclooxygenase selectivity. *J Bone Miner Res* 2003;18:1795–1802. [PubMed: 14584890]
 32. Reid IR, Ames RW, Orr-Walker BJ, Clearwater JM, Horne AM, Evans MC, Murray MA, McNeil AR, Gamble GD. Hydrochlorothiazide reduces loss of cortical bone in normal postmenopausal women: a randomized controlled trial. *American Journal of Medicine* 2000;109:362–370. [PubMed: 11020392][see comment]
 33. Bauer DC, Orwoll ES, Fox KM, Vogt TM, Lane NE, Hochberg MC, Stone K, Nevitt MC. Study of Osteoporotic Fractures Research Group. Aspirin and NSAID use in older women: effect on bone mineral density and fracture risk. *Journal of Bone & Mineral Research* 1996;11:29–35. [PubMed: 8770694]
 34. van Daele PL, Stolk RP, Burger H, Algra D, Grobbee DE, Hofman A, Birkenhager JC, Pols HA. Bone density in non-insulin-dependent diabetes mellitus. The Rotterdam Study. *Annals of Internal Medicine* 1995;122:409–414. [PubMed: 7856988][see comment]
 35. Strotmeyer ES, Cauley JA, Schwartz AV, Nevitt MC, Resnick HE, Zmuda JM, Bauer DC, Tyllavsky FA, de Rekeneire N, Harris TB, Newman AB, Health ABCS. Diabetes is associated independently of body composition with BMD and bone volume in older white and black men and women: The Health, Aging, and Body Composition Study. *Journal of Bone & Mineral Research* 2004;19:1084–1091. [PubMed: 15176990]
 36. Heinze E, Vetter U, Voigt KH. Insulin stimulates skeletal growth in vivo and in vitro--comparison with growth hormone in rats. *Diabetologia* 1989;32:198–202. [PubMed: 2666211]
 37. Ross DS, Neer RM, Ridgway EC, Daniels GH. Subclinical hyperthyroidism and reduced bone density as a possible result of prolonged suppression of the pituitary-thyroid axis with L-thyroxine. *American Journal of Medicine* 1987;82:1167–1170. [PubMed: 3605133]
 38. Siris ES, Miller PD, Barrett-Connor E, Faulkner KG, Wehren LE, Abbott TA, Berger ML, Santora AC, Sherwood LM. Identification and fracture outcomes of undiagnosed low bone mineral density in postmenopausal women: results from the National Osteoporosis Risk Assessment. *Jama* 2001;286:2815–2822. [PubMed: 11735756]
 39. Grainger DJ, Percival J, Chiano M, Spector TD. The role of serum TGF-beta isoforms as potential markers of osteoporosis. *Osteoporos Int* 1999;9:398–404. [PubMed: 10550458]

40. Orwoll ES, Bauer DC, Vogt TM, Fox KM. Study of Osteoporotic Fractures Research Group. Axial bone mass in older women. *Ann Intern Med* 1996;124:187–196. [PubMed: 8533993]
41. Cauley JA, Fullman RL, Stone KL, Zmuda JM, Bauer DC, Barrett-Connor E, Ensrud K, Lau EM, Orwoll ES. Factors associated with the lumbar spine and proximal femur bone mineral density in older men. *Osteoporos Int*. 2005
42. Lau EM, Leung PC, Kwok T, Woo J, Lynn H, Orwoll E, Cummings S, Cauley J. The determinants of bone mineral density in Chinese men--results from Mr. Os (Hong Kong), the first cohort study on osteoporosis in Asian men. *Osteoporos Int* 2006;17:297–303. [PubMed: 16175311]
43. Nevitt MC, Cummings SR, Browner WS, Seeley DG, Cauley JA, Vogt TM, Black DM. The accuracy of self-report of fractures in elderly women: evidence from a prospective study. *American Journal of Epidemiology* 1992;135:490–499. [PubMed: 1570815]
44. Bergmann MM, Byers T, Freedman DS, Mokdad A. Validity of self-reported diagnoses leading to hospitalization: a comparison of self-reports with hospital records in a prospective study of American adults. *American Journal of Epidemiology* 1998;147:969–977. [PubMed: 9596475]

Figure 1.

Mean total hip BMD (g/cm^2) for Tobagonian women (TWHs, 2002) compared to non-Hispanic Black and non-Hispanic White women, NHANES III, U.S. 1988–1994.

Looker, AC et al. Updated data on proximal femur bone mineral levels of US adults 1998; 8:468–489. *Osteoporos Int.*

Table 1

Correlates of Total Hip and Femoral Neck Bone Mineral Density in Age-Adjusted Bivariate Models (N=340)

Characteristics	Mean $\pm$ SD or Prevalence (%)	Age-Adjusted Percent Difference in BMD per Unit Change (95% CI) [†]	Age-Adjusted Percent Difference in BMD per Unit Change (95% CI) [†]
Demographics			
Age (years)	63.9 $\pm$ 8.0	-5.97 (-7.54, -4.40) ^b	-6.25 (-7.67, -4.82) ^b
High school graduate	116 (34.1)	-2.48 (-5.88, 0.91)	-2.92 (-6.00, 0.16)
Physical & Anthropometric Measures			
Weight (kg)	80.6 $\pm$ 16.1	6.04 (4.53, 7.54) ^b	5.23 (3.85, 6.61) ^b
Standing height (cm)	162.9 $\pm$ 6.2	0.07 (-1.59, 1.74)	0.74 (-0.77, 2.24)
Body mass index (kg/m ²)	30.4 $\pm$ 5.8	5.99 (4.52, 7.45) ^b	4.93 (3.58, 6.28) ^b
Average grip strength (kg)	27.6 $\pm$ 6.8	1.31 (-0.46, 3.09)	0.89 (-0.71, 2.49)
Lean mass (kg)	46.7 $\pm$ 7.2	5.49 (3.93, 7.04) ^b	4.52 (3.10, 5.95) ^b
Fat mass (kg)	29.8 $\pm$ 9.4	5.31 (3.80, 6.82) ^b	4.66 (3.29, 6.04) ^b
Personal/Family History			
Fallen in past 12 mos	115 (33.8)	3.40 (0.10, 6.69) ^a	1.89 (-1.12, 4.90)
Recent back pain	112 (33.0)	5.59 (2.29, 8.88) ^a	4.36 (1.35, 7.36) ^a
Ever fractured or broken bone	47 (14.0)	-0.46 (-5.04, 4.12)	-1.28 (-5.43, 2.87)
Parental history of hip fracture	8 (2.4)	-5.03 (-15.37, 5.31)	-2.98 (-12.40, 6.43)
Lifestyle characteristics			
Current smoker	1 (0.3)	14.64 (-14.31, 43.59)	21.65 (-4.62, 47.92)
Ever smoker	9 (2.7)	1.82 (-7.96, 11.59)	3.94 (-4.95, 12.82)
Hours walked per week	18.3 $\pm$ 16.8	0.25 (-1.33, 1.83)	0.55 (-0.89, 1.99)
1 or more alcohol drinks/week in past 12 mos	20 (5.9)	-1.62 (-8.41, 5.18)	-4.84 (-11.00, 1.32)
Self-Reported Medical History			
Hypertension	191 (56.2)	3.08 (-0.11, 6.27)	2.31 (-0.60, 5.22)
Coronary heart disease	26 (7.7)	5.73 (-0.15, 11.61)	5.29 (-0.06, 10.64)
Diabetes	69 (20.3)	5.51 (1.62, 9.40) ^a	4.58 (1.03, 8.12) ^a
Arthritis	147 (43.2)	5.32 (2.19, 8.44) ^a	3.35 (0.48, 6.22) ^a
Osteoporosis	8 (2.4)	-2.93 (-13.28, 7.42)	-0.53 (-9.95, 8.89)
Thyroid disease	28 (8.2)	-5.88 (-11.56, -0.20) ^a	-1.99 (-7.18, 3.20)
Reproductive History			
Ever pregnant	317 (93.2)	8.91 (2.73, 15.09) ^a	6.49 (0.84, 12.13) ^a
Ever breast fed child	283 (83.2)	4.90 (0.72, 9.07) ^a	4.66 (0.86, 8.45) ^a
Hysterectomy	100 (29.4)	-2.90 (-6.34, 0.53)	-2.80 (-5.92, 0.33)
Oophorectomy	53 (15.6)	-2.47 (-6.84, 1.89)	-3.14 (-7.10, 0.83)
Current Medications			
Hormone therapy (estrogen or progestin)	7 (2.1)	-3.55 (-14.60, 7.50)	-0.18 (-10.24, 9.88)
Thiazide diuretics	52 (15.3)	6.73 (2.40, 11.05) ^a	5.98 (2.05, 9.92) ^a
Diabetes medication	60 (17.7)	7.43 (3.36, 11.50) ^a	6.01 (2.29, 9.73) ^a
Beta blockers	27 (7.9)	-7.30 (-13.05, -1.54) ^a	-6.22 (-11.46, -0.98) ^a
NSAIDs	51 (15.0)	5.60 (1.23, 9.97) ^a	4.81 (0.83, 8.78) ^a
Statins	2 (0.6)	21.24 (0.81, 41.67) ^a	19.08 (0.50, 37.66)
Regular aspirin use	62 (18.2)	6.09 (2.07, 10.11) ^a	4.50 (1.06, 7.93) ^a

[†] Indicates percent change in bone mass in g/cm² per indicated unit or 1 standard deviation^a p < 0.05^b p < 0.0001

Table 2

Correlates of Hip BMD in Stepwise Multiple Linear Regression Analyses

Variable	Percent Difference (95% CI) Total Hip BMD	Percent Difference (95% CI) Femoral Neck BMD	Percent Difference (95% CI) Femoral Neck BMAD
N	339	340	339
Age (years)	-4.81 (-6.27, -3.35) ^b	-5.39 (-6.75, -4.02) ^b	-1.12 (-1.48, -0.76) ^b
Weight (kg)	5.72 (4.25, 7.19) ^b	4.72 (3.36, 6.07) ^b	0.67 (0.30, 1.04) ^b
Current diabetes medication (yes)	5.21 (1.52, 8.90) ^a	3.77 (0.32, 7.21) ^a	--
Self-reported thyroid disease (yes)	-7.70 (-12.84, -2.56) ^a	--	-2.27 (-3.98, -0.57) ^a
Recent back pain (yes)	3.53 (0.56, 6.50) ^a	--	--
Current thiazide diuretic use (yes)	5.16 (1.24, 9.08) ^a	4.38 (0.70, 8.05) ^a	--
Current use of beta-blockers (yes)	-6.93 (-12.11, -1.75) ^a	-7.18 (-12.02, -2.33) ^a	-1.85 (-3.18, -0.52) ^a
Parental history of hip fracture (yes)	-9.46 (-18.60, -0.31) ^a	--	-3.01 (-5.29, -0.72) ^a
Regular aspirin use (yes)	--	4.42 (1.00, 7.85) ^a	1.57 (0.65, 2.50) ^a
Coronary heart disease (yes)	--	--	1.46 (0.13, 2.79) ^a
Current statin use (yes)	--	--	5.39 (0.84, 9.95) ^a
Breast fed child (yes)	--	--	1.06 (0.11, 2.01) ^a
Model R ²	0.36	0.35	0.26

Other possible predictors tested but not entered to explain variability in total hip BMD using $p < 0.05$ as the criterion for entry in the model include: any type of arthritis, parity, breast fed child, regular aspirin use, NSAIDs. Other possible predictors tested but not entered to explain variability in femoral neck BMD using $p < 0.05$ as the criterion for entry in the model include: thyroid disease, recent back pain, family history of fracture, any type of arthritis, parity, breast fed child, aspirin use, nonsteroidal anti-inflammatory drugs. Other possible predictors tested but not entered to explain variability in femoral neck BMAD (g/cm^3) using $p < 0.05$ as the criterion for entry in the model include: recent back pain, current diabetes medication use, and current thiazide diuretic use. Regular aspirin use defined as self-report of use three or more times per week.

^a $p < 0.05$

^b $p < 0.0001$