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Predictors of Bone Mineral Density in African-American and Caucasian College-Aged Women

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ABSTRACT

Background: Research regarding risk factors and prevalence of low bone mineral density (BMD) among African-American and Caucasian college-aged women are limited. The objective of this cross-sectional study was to determine if selected predictors of BMD in African-American and Caucasian college-aged women differ by race.
Methods: A total of 101 local African-American (n=50) and Caucasian (n=51) females, ages 18 to 30 years, were in this study. All data were collected in the Bone Density and Body Composition Laboratory. BMD was measured using DXA technology. Race, family history of osteoporosis, BMI, current physical activity, osteoporosis knowledge, length of time on oral contraceptives, age at menarche and calcium intake were included in the multiple regression analyses with spinal and femoral BMD as dependent variables.
Results: Overall, 38.6% had low spinal BMD and 7.9% had low femoral BMD. BMI (β=0.073, R^2 = .148, P = .001, 95% CI [0.030, 0.116]) and current physical activity (β=0.071, R^2 = .148, P = .017, 95% CI [0.013, 0.129]) were the only variables that were statistically significant in predicting spinal BMD. BMI (β=0.056, R^2 = .13, P = .010, 95% CI [0.014, 0.098]) and current physical activity (β=0.078, R^2 = .13, P = .007, 95% CI [0.022, 0.134]) were also the only variables that were statistically significant in predicting femoral BMD. Race was not a significant predictor of spinal or femoral BMD.
Conclusion: It is imperative for both African-American and Caucasian women to engage in osteoporosis-preventive behaviors.

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Introduction

Researchers estimate that 10 million Americans have osteoporosis, while 44 million adults over the age of 50 year are at risk for this disease.[1] By the year 2020, osteoporosis will affect approximately 14 million adults over the age of 50 yr.[2] Women account for 80% of those affected by osteoporosis; and, men account for the remaining 20%.[3] Because females are at a greater risk for os-

teoporosis than males, only females were included in this study. Because of the higher prevalence of osteoporosis in women, their risk of hip fractures is equal to their risk of breast, uterine and ovarian cancers combined.[1]

Osteoporosis is a skeletal disease that is characterized by low bone mass and degradation of bone tissue.[4] The utilization of t-scores and z-scores to express bone mineral density (BMD) is typical. The t-score is based on comparison of an individual's bone density to the bone density of a 25 to 30-year-old of similar gender and race/ethnicity.[5] The World Health Organization (WHO) uses a threshold of 2.5 standard deviations below the mean BMD of young adult women and a threshold of 1 to 2.5 standard deviations below the mean BMD of young adult women as the criterion for a diagnosis of osteoporosis and osteopenia, respecti-vely.[6] African-American women fracture at a lower rate when compared to Caucasians with the same BMD. However, when African-American fracture bone, they have higher mortality and morbidity rates.[7] With an increasing aging population and increasing longevity of minority groups, osteoporosis is an increasing public health concern.[8]

Risk factors for osteoporosis include estrogen deficiency, age, being female, genetic factors, personal history of fractures in the absence of trauma, thin/small frame, diet low in calcium, vitamin D deficiency and reaching menopause either naturally or surgically before the age of 45.[9] Being overweight, however, has been shown to be protective against osteoporosis due to the additional mechanical loading and the endocrine-like properties of adipocytes.[3] Other risk factors include the use of certain drugs such as glucocorticoids and antiepileptics and lifestyle behaviors such as excessive alcohol consumption, smoking and physical inactivity.[9] However, high-impact physical activity has been protective against osteoporosis and even improves bone mineral density.[10] Some factors that are linked to low BMD in premenopausal women include conditions that require the use of glucocorticoids and anticonvulsants and the eating disorder, anorexia nervosa.[11] Other factors linked to low BMD in premenopausal women are delayed menarche and amenorrhea.[12] Moreover, Depo-Provera, a contraceptive injected intramuscularly, can cause a decline in femoral and spinal BMD.[13,14] Additionally, young women tend to lack knowledge regarding osteoporosis and its risk factors.[15]

The primary aim of this research was to determine if selected predictors of BMD in African-American and Caucasian college-aged women differ by race.

Materials and Methods

Participants and Procedures

This was a prospective cohort study. African-American and Caucasian females were recruited by email, advertisement in university classrooms and campus bulletin boards as well as in doctors' offices, local churches, and local newspapers on a rolling basis beginning in August of 2009. All data were collected in the Bone Density and Body Composition Laboratory at a Mississippi university. Participants were required to come to the laboratory on two separate occasions with there being a weekend separating the two visits. Participants were included if they were between the ages of 18 and 30 years, and did not have any conditions that would place them at apparent risk (celiac disease, corticosteroid use, and amenorrhea) for low BMD. Since recruitment was mostly based around the university, this sample was considered a convenient sample.

Based on existing literature, eight factors were selected to determine the role and magnitude in predicting spinal and femoral BMD.[9] The selected factors were race, family history of osteoporosis, body mass index (BMI), current physical activity, osteoporosis knowledge, length of time on oral contraceptives, age at menarche and calcium intake.

Anthropometric Assessment

Height and weight of all participants were measured using a balance scale (Detecto, Webb City, MO) on their very first visit. Body mass index (BMI) was calculated as a ratio of the participant's weight (kg) to her height (m^2). For the purpose of this study, participants were stratified into three weight categories: 1) low weight if BMI ≤

20.4 kg/m^2, 2) normal weight if 20.5 ≤ BMI kg/m^2 ≤ 24.4 kg/m^2 and 3) high weight if BMI ≥ 24.5 kg/m^2. Participants were stratified in this way to closely emulate the BMI cutoffs set by WHO. The WHO's cutoffs are as follows: 1) underweight if BMI < 18.5 kg/m^2, 2) normal weight if 18.5 kg/m^2 ≤ BMI ≤ 24.9 kg/m^2, and 3) overweight if BMI ≥ 25 kg/m^2.[16]

Race, Family history of osteoporosis, Osteoporosis knowledge, Current physical activity, Age at menarche, Calcium, and Oral contraceptives

During the recruitment process, potential participants were asked to select their race. Only participants who self-identified themselves as Caucasian or African-American were eligible to participate in the study. Family history of osteoporosis was established by asking participants, "Do you have a family history of osteoporosis?" The answer choices included, "Yes," "No," and "Don't Know."

During the first visit, osteoporosis knowledge was assessed using the Osteoporosis Knowledge Test (OKT).[17] The 24-item, self-administered, multiple-choice questionnaire has two subscales: OKT calcium and OKT exercise with reliability coefficients for internal consistency of 0.72 and 0.69, respectively.

Current physical activity was also assessed on the participants' first visit using a 7-day Physical Activity Recall Questionnaire.[18] Participants identified each day of the week that they exercised at least 30 minutes. The physical activity variable was scored on a scale of 0 – 7 days. If a participant's total was ≥ 5 days, then she was considered to have met the physical activity requirement, which is a primary guideline set forth by the American College of Sports Medicine and the American Heart Association for adults aged 18 to 65 years.[19]

Each participant's age at menarche was subtracted from his or her current age to determine cumulative exposure to endogenous estrogen. During their initial visit, each participant was given instructions on how to record their food intake over the next 4 days, which would consist of two-week days and two weekend days. Licensed technicians entered food records into the Nutrition Data System for Research (NDS-R, version 4.01). The NDS-R, which calculates nutrient intake, is a dietary analysis program developed by the Nutrition Coordinating Center at the University of Minnesota in 1998. This program was used to determine each participant's calcium intake.

Length of time of oral contraceptives was determined by asking participants, "Have you ever taken oral contraceptives"? If participants answered, "Yes", then they were asked, "How long did you take oral contraceptives"?

Bone Mineral Density Assessment

During participants' first visit, BMD was measured using the dual energy x-ray absorptiometry (DXA) Hologic Delphi-W (Hologic, Waltham, MA) and was expressed as t-scores. Individuals were classified as having low spinal BMD if their t-score was ≤ -1.0. Participants with a t-score ≤ -1.0 of the spine or femur were classified as having low BMD whereas a t-score > -1.0 was indicative of normal BMD. For the present study, t-scores were utilized for four reasons: 1) t-scores and z-scores are relatively equal for individuals between the ages of 19 and 30 years, 2) the densitometer utilized for this study contains an African-American database, 3) t-scores rather than z-scores are utilized by the WHO for diagnostic criteria, and 4) z-scores are not available on the densitometer used in this study for individuals younger than 20 years of age.

Statistical Analysis

Sample size and power were determined using the statistical software package G*Power (3.1.9.2). Data were presented using means (SD) for quantitative variables and frequency (%) for qualitative variables. ANOVA and independent samples t-tests were conducted to examine the association between each of the outcome variables (femoral and spinal BMD) with the selected risk factors: age, physical activity, calcium intake, oral contraceptive use, family history of osteoporosis, BMI, and race.

Multiple linear regression was performed to determine which risk factors were statistically signifi-

cant in predicting femoral and spinal BMD. Statistical significance was set as a *P*-value = 0.05.

Ethical Considerations

There was a fair and equitable participant selection process in accordance with the aims of this study. This study also has scientific value. Lastly, the benefits of this study far outweighed the risks involved. After reviewing these ethical considerations, this study was approved by the university's Institutional Review Board.

Results

Description of the Sample

A total of 101 participants (49.5% African-Americans and 50.5% Caucasians) were included in this study. African-American and Caucasian women were similar with respect to their mean age, anthropometric measures, and BMD scores (Table 1).

Table 1: Characteristics by Race and Overall

Characteristics	Overall (*n* =101)*	African American (*n* = 50)*	Caucasian (*n* = 51)*
Age (yr)	21.3 ± 2.2	21.0 ± 1.8	21.6 ± 2.6
Body Mass Index	23.4 ± 4.4	23.8 ± 4.9	23.0 ± 3.8
Spinal BMD (t-score)	-0.5 ± 1.0	-0.6 ± 1.0	-0.4 ± 1.0
Femoral BMD (t-score)	0.4 ± 0.98	0.3 ± 0.9	0.5 ± 1.1
Hours of Physical Activity	5.5 ± 6.5	3.4 ± 4.4	7.7 ± 7.5
Grams of Calcium	0.9 ± 0.4	0.8 ± 0.3	0.98 ± 0.4
Oral Contraception Duration (months)	24.5 ± 28.2	19.0 ± 25.0	29.8 ± 30.4

*Mean ± SD

Table 2 shows a summary of the responses on physical activity requirements, smoking habits, and oral contraceptive use, as well as Depo-Provera use. African-Americans were less likely to be a current smoker compared to Caucasians but they were also more likely to have used Depo-Provera in comparison to Caucasians. Caucasians were more likely to meet physical activity requirements in comparison to African-Americans.

Table 2: Percentage of participants that met physical activity requirements, reported smoking, used oral contraceptive and used Depo Provera

Items	African-Americans *n* (%)	Caucasians *n* (%)
Met physical activity requirements	14.0	29.4
Current smoker	2.0	9.8
Oral contraceptive use	62.0	76.5
Depo-Provera use	18.0	2.0

Bone Mineral Density

Results for spinal and femoral BMD by the weight categories are shown in Table 3. The mean spinal BMD was higher in participants who had a high weight compared to those in the low weight category. Similar to the mean spinal BMD, the mean femoral BMD was higher in individuals belonging to the high weight category in comparison to the low weight category. Among the 31 low-weight participants, nearly 55% also had low spinal BMD. In addition, 17.9% of those of a high weight also had low spinal BMD. Participants in this study had a higher prevalence of low spinal BMD (38.6%) than low femoral BMD (7.9%).

Participants with a low weight were more than four times as likely to have low femoral BMD in comparison to those who had a normal or high weight.

Table 3: Weight categories by Spinal and Femoral BMD

Weight	Spinal BMD			Femoral BMD		
	Low *n* (%)	Normal *n* (%)	Total *n* (%)	Low *n* (%)	Normal *n* (%)	Total *n* (%)
Low	17 (43.6)	14 (22.6)	31 (30.7)	6 (75)	25 (26.9)	31 (30.7)
Normal	15 (38.5)	16 (25.8)	31 (30.7)	1 (12.5)	30 (32.3)	31 (30.7)
High	7 (17.9)	32 (51.6)	39 (38.6)	1 (12.5)	38 (40.9)	39 (38.6)
Total	39 (38.6)	62 (61.4)	101	8 (7.9)	93 (92.1)	101

Food Intake Assessment, Osteoporosis Knowledge, and Physical Activity

Table 4 shows the percentage of participants meeting the Recommended Dietary Allowance (RDA) for calcium, vitamin D, iron, zinc, and magnesium. Calcium is the main nutrient that was focused on for this study. Caucasian women were more than twice as likely as African-American women to meet the RDA for calcium and Caucasians were also more than four times as likely to meet the RDA for magnesium.

Table 4: Percentage Meeting RDA for Calcium, Vitamin D, Iron, Zinc, and Magnesium

Nutrients	African American (%) (*n* = 50)	Caucasian (%) (*n* = 51)	Total (%) (*n* = 101)
Calcium	16.0	37.3	26.7
Vitamin D	46.0	56.9	51.5
Iron	32.0	39.2	35.6
Zinc	72.0	66.7	69.3
Magnesium	6.0	27.5	16.8

The items included in the OKT and the percentage of correct answers for African-Americans and Caucasians are reported in Table 5. Based on the responses to Question 6, more than 70% of Caucasian participants and over 60% of African-American participants did not realize that being a White woman with fair skin increases osteoporosis risk. Based on the results to Question 22, more than 90% of African-Americans and 87% of Caucasians did not know the recommended milligrams of calcium intake for adults.

Findings for time spent engaging in physical activity are reported in Table 1. For the purpose of this study, the time spent engaging in moderate and vigorous physical activities were combined. Only 21.8% of the participants met physical activity requirements (Table 2). Caucasian participants were more likely to engage in the recommended amount of physical activity than African-American participants were. There was also a statistically significant difference (P = 0.001) between Caucasian and African-American participants regarding total hours of physical activity with Caucasians spending more time engaged in physical activity than African-Americans.

Linear Regression Findings

The results from the linear regression analysis for femoral BMD are presented in Table 6, yielding a final model (R^2=13%; P = 0.001) of Y = -1.11 + 0.079 (hours of physical activity) + 0.056 (BMI). Race, family history of osteoporosis, osteoporosis knowledge, length of time on oral contraceptives, age at menarche, and calcium intake were not statistically significant (P> 0.05) predictors of femoral BMD.

Table 5: Percentage of Correct Responses on Osteoporosis Knowledge Test for Each Race and Overall

Items	African American (%) (n = 50)	Caucasian (%) (n = 51)	Total (%) (n = 101)
1. Eating a diet low in milk products	84.0	98.0	91.1
2. Being menopausal: "change of life"	48.0	92.2	70.3
3. Having big bones	30.0	31.4	30.7
4. Eating a diet high in dark green leafy vegetables	52.0	70.6	61.4
5. Having a mother or grandmother who has osteoporosis	84.0	98.0	91.1
6. Being a white woman with fair skin	38.0	27.5	32.7
7. Having ovaries surgically removed	18.0	37.3	27.7
8. Taking cortisone (steroids, e.g., Prednisone) for long time	54.0	51.0	52.5
9. Exercising on a regular basis	88.0	100.0	94.1
10. Which of the following exercises is the best way to reduce a person's chance of getting osteoporosis?	44.0	33.3	38.6
11. Which of the following exercises is the best way to reduce a person's chance of getting osteoporosis?	48.0	43.1	45.5
12. How many days a week do you think a person should exercise to strengthen their bones?	76.0	84.3	80.2
13. What is the least amount of time a person should exercise on each occasion to strengthen their bones?	78.0	84.3	81.2
14. Exercise makes bones strong, but it must be hard enough to make breathing:	52.0	52.9	52.5
15. Which of the following exercises is the best way to reduce a person's chance of getting osteoporosis	92.0	84.3	88.1
16. Which of the following exercises is the best way to reduce a person's chance of getting osteoporosis?	88.0	84.3	86.1
17. Which of these is a good source of calcium?(cheese)	90.0	100.0	95.0
18. Which of these is a good source of calcium?(canned sardines)	22.0	25.5	23.8
19. Which of these is a good source of calcium?(chicken)	78.0	66.7	72.3
20. Which of these is a good source of calcium?(yogurt)	84.0	100.0	92.1
21. Which of these is a good source of calcium?(ice cream)	52.0	76.5	64.4
22. Which of the following is the recommended amount of calcium intake for an adult?	10.0	13.7	11.9
23. How much milk must an adult drink to meet the recommended amount of calcium?	50.0	56.9	53.5
24. Which of the following is the best reason for taking a calcium supplement?	76.0	82.4	79.2

Multiple regression results indicate that BMI and total hours of physical activity are significant predictors of femoral BMD, as well as, spinal BMD. The results from the linear regression analysis for spinal BMD are presented in Table 6. Accordingly, the final linear regression model (R^2=14.8%; P=0.0004) for spinal BMD was Y = -2.4 + 0.073 (BMI) + 0.071 (hours of physical activity). Race, family history of osteoporosis, body mass index (BMI), current physical activity, osteoporosis knowledge, length of time on oral contraceptives, age at menarche and calcium intake were not statistically significant (P > 0.05) in predicting spinal BMD.

Table 6: Multiple Regression Results for Femoral and Spinal BMD

Type of Bone	variables	Parameter Estimate	Standard Error	*P* value
Femoral	Exercise	0.079	0.028	0.007
	BMI (weight)	0.056	0.021	0.010
Spinal	Exercise	0.071	0.029	0.017
	BMI (weight)	0.073	0.022	0.001

Discussion

A previous study reported that approximately 15% of premenopausal women have low BMD.[20] In this study of premenopausal women, 38.6% had low spinal BMD; and 7.9% had low femoral BMD. Finding no racial differences were an unprecedented finding because numerous studies indicate that African-American women consistently have higher BMDs when compared to their Caucasian counterparts.[21] Due to prior research findings, one would expect that African-American women would consistently have higher BMDs than Caucasian women would across each weight category. This, however, is not what was found in the present study. It is probable that the higher prevalence of past and present use of Depo-Provera among African-American participants eliminated the racial differences that would typically be seen in this age group. Depo-Provera, a contraceptive which is injected intramuscularly, can cause a decline in femoral and spinal BMD.[13, 14] In the present study, 18% of African-Americans reported past or current Depo-Provera use in comparison to 2% of Caucasian participants.

Weight status affects BMD.[22,23] In the current study, 43.6% of individuals who were classified as having a low weight also had low spinal BMD; and 75% of those who had a low weight had low femoral BMD. Being thin and/or having a small frame is listed as one of the risk factors for low bone mass, meaning that a larger frame or higher weight would be associated with a higher bone density.[6,9] We were unable to recruit successfully underweight African American participants in accordance with the WHO criteria. Consequently, for the purpose of this study, both African American and Caucasian women were considered underweight if they had a BMI of ≤ 20.4 kg/m^2. Weight was a significant predictor of both spinal and femoral BMD. Furthermore, participants in the low weight category had significantly different mean femoral BMDs than individuals in the high weight category; and participants in the low and normal weight categories had significantly different mean spinal BMDs than individuals in the high weight category. The proportion of lean mass to fat mass has an effect on BMD.[23]

One of the limitations of the present study was not distinguishing between fat mass and lean mass. Weight (BMI) was used rather than fat and lean mass to give physicians and the public a more convenient way of determining risk for low BMD.

A previous study examined risk factors for low BMD in Caucasian women ages 22 to 44 and reported that current physical activity is not related to BMD.[24] When participants in the present study were categorized into two groups; those who met the physical activity requirements and those who did not, t-test results showed no statistically significant difference in spinal or femoral BMDs between the two groups. However, when total hours of physical activity were included in the linear regression model for spinal and femoral BMD, it was a significant predictor. This finding is consistent with an earlier study that included 157 women, aged 18 to 39.[25] They found that current physical activity was significantly associated with spinal BMD ($P = 0.004$).

The American College of Sports Medicine and The American Heart Association recommends at least 30 minutes of exercise on not less than five days of the week for adults aged 18 to 65 years.[19] Less than one-quarter (21.8%) of the participants in this study met these requirements. Furthermore, one-third (33.7%) of this sample reported no physical activity. The latter finding is in accordance with the findings of Wallace, who found no

physical activity reported in 30% of the subjects in a similar age group to that of the present study.[26] Total hours of physical activity were significantly different between Caucasians and African-Americans. Caucasians were more likely to meet physical activity requirements in comparison to African-Americans. The lack of physical activity is a possible reason why low spinal BMD was so prevalent in this sample.

It is clear from the number of participants in the study who are affected by low BMD that programs need to be established to encourage young women to engage in behaviors that will maximize their bone densities. Premenopausal women should be encouraged to modify their lifestyles to improve their BMD.[27] Physical activity, particularly weight-bearing exercises, and helps to improve BMD. Since physical activity was significant in predicting BMD in this study, programs that specifically target increasing physical activity among young women, especially African-Americans, should be established; seeing that African-Americans are less likely to meet physical activity requirements in comparison to other racial groups.[19]

After including variables to explain BMD, only weight and physical activity were significant in predicting spinal and femoral BMD. These two significant predictors only accounted for 14.9% and 13.1% of the variance in spinal and femoral BMD, respectively. It is possible that genetics accounts for, in part, the remaining unexplained variance. An earlier study reported that up to 80% of the differences seen in peak BMD can be attributed to genetic factors.[28] Other variables that we did not measure could also accounts for the unexplained variance.

Early menarche has been shown to result in higher BMD in premenopausal women just as late menarche results in lower BMD and increased risk of fracture in postmenopausal women.[29] These findings are due to the differences in duration of exposure to endogenous estrogen.[29] For the purposes of this study, each participant's age at menarche was subtracted from their current age to determine cumulative exposure to endogenous estrogen. Age at menarche was not a significant predictor of spinal or femoral BMD.

The restrictions in this sample cannot be discounted as attributing to the lack of a substantial amount of variance in BMD being found. Since this sample was restricted regarding age and factors that place women at apparent risk for low BMD, the amount of variability was reduced. Thus, it is difficult for the current study to account for a substantial amount of variance due to the research design limiting the variability of the sample. Another limitation of the study was the use of a convenience sample. With the use of a convenience sample, there is a chance that these results cannot be applied to the general population.

Since physical activity was a significant predictor of spinal and femoral BMD for this study, future studies can examine time participants spent engaging in endurance exercise versus resistance exercise to see which type exhibits the greatest effect on BMD. Additionally, because of the limited knowledge about osteoporosis, a future study could include an osteoporosis-knowledge intervention.

Practical Implications

As noted earlier, weight (BMI) rather than percent body fat was used in this study to make it easier for practitioners to readily assess the risk for low bone density in young women. The National Osteoporosis Foundation (NOF) does not recommend women get a DXA scan until the age of 65 year; however, the bone density of women begins to decline years before that age. It is imperative that practitioners recognize the early risk factors in young women for the development of osteoporosis later in life. This study shows that a healthy body weight and physical activity can affect BMD.

Conclusion

Race was not a significant predictor of spinal or femoral BMD; therefore, it is vital for both African-American and Caucasian women alike to engage in osteoporosis-preventive behaviors. If women between the ages of 18 and 30 are made

aware of their low-BMD status, they can begin bone-building activities before them reach peak bone mass. This provides an opportunity to decrease risk for osteoporosis and related fractures later in life. Weight and physical activity were significant predictors of spinal and femoral BMD. Women between the ages of 18 and 30 should be encouraged to maintain a healthy body weight as well as participate in weight-bearing physical activity, which will increase their spinal and femoral BMD.

Conflict of Interest

The authors declare no financial or personal conflict of interests.

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