Original Research

Racial/Ethnic Differences in Bone Mineral Density of Young Adults

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ABSTRACT

Int J Exerc Sci 3(4) : 197-205, 2010. An estimated 1.5 million people suffer a bone disease-related fracture every year. Most work investigating bone mineral density (BMD) focuses on post-menopausal females but a report from the Surgeon General in 2004 stated that of particular concern are men, racial and ethnic minorities, poor individuals, individuals with disabilities, and individuals living in rural areas. The purpose of this study was to examine the racial/ethnic differences in bone mineral density of young adults and to investigate any correlations with variables suggested to influence BMD. BMD was assessed at a younger age than most studies based on the assumption that osteoporosis is a pediatric disorder that manifests in old age. Whole-body BMD, percent body fat (BF), fat mass (FM), and lean mass (LM) of 103 college-aged Blacks, Whites, and Hispanics (18 – 34 years of age) were measured using a Lunar Prodigy Dual Energy X-ray Absorptiometry (DEXA). Blacks and Whites were taller than Hispanics. Blacks had higher BMD than Whites and Hispanics. Blacks and Whites had higher t-scores than Hispanics. Weight and LM correlated with BMD for all three groups. Height correlated with BMD for Blacks only. FM correlated with BMD for Hispanics only. In conclusion, BMD is suggested to be higher in Blacks than Whites and Hispanics. LM is suggested to be an important component of bone health. It is important to stress resistance training for building and maintaining bone health throughout life.

KEY WORDS: Osteoporosis, Lean Mass, Fat Mass, Percent Body Fat

INTRODUCTION

According to Bone Health and Osteoporosis: A Report of the Surgeon General, "fractures due to bone disease are common, costly, and often become a chronic burden on individuals and society" (19). An estimated 1.5 million people suffer a fracture every year related to bone disease. One in two females and one in four males over the age of 50 years will have an osteoporosis related fracture in their remaining lifetime (6). In addition, roughly 10 million individuals over the age of 50 years in the United States have osteoporosis of the hip and an additional 33.6 million have low bone mass or osteopenia. The National Osteoporosis Foundation reports that in 2005 about 293,000 Americans (≥ 45 years) were admitted to hospitals with hip fractures and were diagnosed with osteoporosis as the underlying cause of most of the injuries (6).

In 2007, Rizzoli et al. (13) suggested that the measurement of bone mass is the difference between the accumulation of bone mass at the end of skeletal growth (peak bone mass) and the subsequent loss of bone mass over time. Rizzoli et al. (13) continued to suggest that peak bone mass is a predictor of future risk of osteoporosis and fracture. Although research varies on the age at which peak bone mineral density (BMD) is reached, most suggest peak is reached somewhere between the ages of 20 and 30 years. Some investigators suggest that 95% of peak bone mineral density is reached by age 17 years for females and two to three years later for males (11), while others suggest peak bone mass is reached by age 30 years for most bone sites (3,15). BMD is operationally defined for the purposes of this research as the amount of bone mineral normalized to the unit of area (g/cm^2). It has been further suggested that osteoporosis is a pediatric disorder that manifests in old age (9).

Furthermore, females can lose up to 20 percent of their bone mass in the five to seven years following menopause, making them more susceptible to osteoporosis (6). The direct care expenditures for osteoporotic fractures alone ranges from $12.2 to $17.9 billion each year, as measured in 2002 dollars (18). The National Osteoporosis Foundation suggests that this cost is expected to exceed $25.3 billion each year by the year 2025. This increase in cost is related to the increase in the number of individuals at risk for osteoporosis as the “baby boomers” reach retirement age.

Most would agree that exercise is a good non-pharmacological approach for maximizing BMD but the most efficacious prescription for exercise is unknown (16). However, according to the Centers for Disease Control and Prevention (CDC) 2005 data, only 57.4% of those 18 - 24 years of age and 51.0% of those 25 – 34 years of age were meeting the national average for sustaining physical activity at the recommended dosage. Of the 18 - 24 year old group, 20.7% participate in no leisure-time physical activity and of the 25 – 34 year old group, 22.0% participate in no leisure-time physical activity.

A report from the Surgeon General in 2004 states that there is a gap between what we know about prevention and treatment of osteoporosis and how the knowledge is applied to the community. According to the report, of particular concern are men, racial and ethnic minorities, poor individuals, individuals with disabilities, and individuals living in rural areas. Most work investigating BMD focuses on post-menopausal females as a greater percentage of females are diagnosed with osteoporosis than males.

Previous studies have examined the racial/ethnic differences in BMD of either females or males with ages ranging from 2-87 years (1,2,4,5,7,10,12,17,21). Most of these studies have determined that Blacks have higher BMD than Whites. A review by Wagner et al. in 2000 (20) examined the biological differences in body composition including BMD between Blacks and Whites. Wagner et al. stated that in general, Blacks have a greater BMD and whole body protein content than do Whites, resulting in a greater fat-free body density.

The purpose of this study was to examine the racial/ethnic differences in BMD of a diverse group of young adults and to investigate any correlations with variables (risk factors) suggested to influence BMD.

This approach is in agreement with the Surgeon General's Bone Health and Osteoporosis report (19) which suggests that more research needs to be conducted examining racial and ethnic minorities. In addition, due to the lack of adequate physical activity in young adults based on the CDC data, the level of physical activity and the nutritional status of the participants were also examined to investigate any possible correlations with BMD. According to the National Osteoporosis Foundation Osteoporosis Fast Facts (6), risk factors include: being female, older age, family history, being small and thin, certain race/ethnicities, history of broken bones, low sex hormones, diet, inactive lifestyle, smoking, alcohol abuse, certain medications and certain diseases and conditions that interfere with bone health.

METHODS

Participants

A convenience sample of 103 racially diverse, young adult participants was recruited from a variety of classes at one university during the summer session. All participants had their BMD assessed at a younger age (average age 23.56 ± 3.72 years) than most studies (typically postmenopausal females) based on the assumption that osteoporosis is a pediatric disorder that manifests with increasing age. Participants were excluded if they had any medical conditions that interfere with bone metabolism and/or if they were taking any prescribed medications known to interfere with bone metabolism. All female participants that were pregnant or were suspected to be pregnant were also excluded. Participants self-identified their ethnic group from the categories available from the Dual Energy X-ray Absorptiometry (DEXA) software. The categories included White, Black, Hispanic, Asian, and Other. A total of 41 Whites, 26 Blacks, 36 Hispanics ranging in age from 18 to 34 years volunteered for the study. This study was approved by the Institutional Review Board.

After signing an informed consent, all participants were weighed and height was measured using an eye-level physician's scale with pounds and metric and a height rod (Depecto®, Webb City, MO). Participants were interviewed by the same two investigators to recall their 24 hour food intake. Pictures and models of serving sizes were used to assist participants with the accuracy of their recall. Food intake was then analyzed by Nutritionist Pro™ Software a product of Axxya Systems. The software package includes over 35,000 foods, recipes and ingredients. Participants were then interviewed by trained interviewers using a seven-day activity recall to assess their physical activity level (14). More than fourteen studies have

Table 1. Descriptive Data (means ± SD).

	Blacks (n = 26) Min - Max	Whites (n = 41) Min - Max	Hispanics (n = 36) Min - Max	All (n = 103) Min – Max
Age (yrs)	22.92 ± 2.30 18.00 – 28.00	24.41 ± 3.54 19.00 – 33.00	23.06 ± 4.57 18.00 – 34.00	23.56 ± 3.72 18.00 – 34.00
Height (cm)	170.74 ± 8.42[b] 157.48 – 187.00	171.15 ± 9.43[b] 152.40 – 188.00	166.09 ± 8.28 152.00 – 184.15	169.28 ± 9.02 152.00 – 188.00
Body Mass (kg)	80.09 ± 16.92 53.18 – 121.59	76.51 ± 17.17 41.36 – 120.00	75.89 ± 17.70 51.40 – 113.18	77.19 ± 17.21 41.36 – 121.59
Body fat (%)	31.17 ± 12.47 8.00 – 56.00	33.78 ± 11.31 7.00 – 55.00	36.07 ± 10.38 14.00 – 53.00	33.92 ± 11.35 7.00 – 56.00
Fat mass (kg)	24.43 ± 12.08 4.63 – 49.90	25.02 ± 11.13 4.14 – 55.39	26.62 ± 11.76 8.60 – 57.31	25.43 ± 11.52 4.14 – 57.31
Lean mass (kg)	51.96 ± 12.88[a] 32.59 – 75.55	48.05 ± 12.43 28.17 – 77.84	45.81 ± 10.91 30.60 – 67.26	48.26 ± 12.16 28.17 – 77.84
Activity level (kcal/kg/wk)	291.82 ± 46.54 228.65 – 404.43	296.97 ± 68.33 223.00 – 578.50	302.55 ± 63.62 220.32 – 561.15	297.62 ± 61.39 220.32 - 578.50

[a] Blacks > Hispanics (p = .031); [b] Blacks (p = .021) and Whites (p = .006) > Hispanics

examined the reliability of the seven-day physical activity recall instrument. The *r* values ranged from 0.12 to 0.99. This tool was originally developed for use in the Stanford Five-City Project in the 1980's and is currently widely used in epidemiologic, clinical, and behavior change studies.

Whole body measurement using a Lunar Prodigy DEXA (enCORE 2007, software version 11.20.068; General Electric (GE) Medical Systems, Madison, WI) was used to assess percent body fat (BF), fat mass (FM), lean mass (LM), and BMD. All assessments were conducted according to the protocol as stated by the manufacturer. The DEXA was calibrated at the beginning of each day with an anthropometric phantom supplied by the manufacturer.

T-scores were calculated based on the data from the DEXA scan. This data is typically used in a clinical setting to compare BMD for diagnostic purposes. Unlike other clinical measurements such as blood pressure or cholesterol, the normal values of BMD are not generally known. The *t-score* is calculated by subtracting BMD from the young normal value, divided by the population standard deviation (SD). *T-scores* were calculated using the National Health and Nutrition Examination Survey III (NHANES III) reference data for 20 to 30 year-olds (young normal value), as it is suggested that the bones of adults are their healthiest between 20 and 30 years of age. A *t-score* between 1 and 2.5 SD below the mean indicates that an individual may have osteopenia, or some bone loss. With a score ≥ 2.5 SD below the mean, the individual is considered to have osteoporosis. If a person is under the age of 20 years, a *z-score* is reported and they are compared with others of their same age and sex.

Statistic Analysis

Data were examined using the Statistical Package for the Social Sciences (SPSS) Version 16.0 (SPSS Inc., Chicago, IL). Descriptive statistics including the mean (±SD) of the continuous variables were calculated. A Pearson's Product Moment correlation was computed to determine the existence of any correlations between BMD and the other variables examined. A Multivariate Analysis of Variance (MANOVA) was used to determine the differences between the racial/ethnic groups. An alpha level of .05 was set to determine statistical significance.

Table 2. Nutritional Data (means ± SD).

	Blacks (n = 26) Min - Max	Whites (n = 41) Min – Max	Hispanics (n = 36) Min - Max	All (n = 103) Min – Max
Total calories (kcals/day)	2722.65 ± 1342.81 735.37 – 6470.00	2623.05 ± 1467.98 884.69 – 7840.00	2298.89 ± 855.91 891.80 – 4816.16	2534.89 ± 1253.06 735.37 – 7840.00
Fat (kcals/day)	666.65 ± 530.36 34.50 – 1534.62	834.77 ± 618.84 196.24 – 3072.81	761.40 ± 355.63 197.84 – 1701.08	766.69 ± 512.06 34.50 – 3072.81
Protein (kcals/day)	332.05 ± 126.19 49.36 – 599.72	351.18 ± 193.63 130.24 – 1059.08	333.54 ± 21.03 153.36 – 605.80	337.66 ± 159.12 49.36 – 1059.08
CHO (kcals/day)	1501.88 ± 1026.23 276.00 – 4419.68	1408.99 ± 818.16 414.04 – 4297.44	1222.52 ± 543.87 406.32 – 2679.44	1367.26 ± 796.77 276.00 – 4419.68
Calcium (mg/day)	682.84 ± 311.67 165.34 – 1395.10	919.12 ± 599.40 114.12 – 2547.07	785.96 ± 455.89 153.33 – 2352.89	812.94 ± 498.27 114.12 – 2547.07

There were no differences between groups.

RESULTS

A total of 103 participants were used for data analyses. Descriptive data are

Table 3. BMD Data (means ± SD).

	Blacks (n = 26) Min - Max	Whites (n = 41) Min - Max	Hispanics (n = 36) Min - Max	All (n = 103) Min – Max
t-scores	1.49 ± 1.36[a,b] -1.60 – 3.80 n = 22	0.72 ± 1.07[a] -2.80 – 3.00 n = 39	0.04 ± 0.99 -1.60 – 2.70 n = 28	0.70 ± 1.25 -2.80 – 3.80 n = 89
z-scores	-0.28 ± 1.13 -1.30 – 1.30 n = 4	-0.05 ± 0.07 -0.10 – 0.00 n = 2	0.89 ± 1.41 -1.50 – 3.20 n = 8	0.42 – 1.30 -1.50 – 3.20 n = 14
BMD (g/cm^2)	1.27 ± 0.12[c] 0.99 – 1.52	1.22 ± 0.11[d] 0.90 – 1.46	1.18 ± 0.08 1.03 – 1.43	1.22 ± 0.11 0.90 – 1.52

[a] Blacks (p = .000) and Whites (p = .002) > Hispanics; [b] Blacks (p = .010) > Whites;

[c] Blacks > Whites (p = .015) and Hispanics (p = .000); [d] Whites (p = .044) > Hispanics

Note: A *t*-score between -1.0 and -2.5 suggests osteopenia. A *t*-score -2.5 or lower suggests osteoporosis presented in Table 1. Blacks had greater LM than Hispanics. Whites and Blacks were taller than the Hispanics. There were no differences between the groups in physical activity level as assessed by the 7-day activity recall instrument. Nutritional data are presented in table 2. There were no nutritional differences between the groups. Blacks and Whites had higher *t-scores* than Hispanics (Table 3). However, Blacks also had higher *t*-scores than Whites. BMD was higher in Blacks when compared with Whites and Hispanics. BMD was also higher in Whites than Hispanics (see table 3).

Pearson's Product Moment correlations are presented in table 4 for the Blacks, table 5 for the Whites and table 6 for the Hispanics. BMD was correlated with weight and LM for all three groups. For Blacks, height also correlated with BMD. There were relatively weak correlations for total calories with BMD for Blacks and Whites. Total protein intake and height weakly correlated with BMD for Whites. Fat mass weakly correlated with BMD for Hispanics.

Table 4. Correlation table for the Blacks.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. BMD (g/cm^2)	-	.392*	.754**	.736**	-.153	.727**	.206	.415*	.347	.333	.314	.296	.326
2. Age (yrs)	-	-	.164	.326	.036	.236	.180	.143	-.100	.066	.213	-.174	-.281
3. Height (cm)	-	-	-	.532**	-.488*	.830**	-.174	.206	.326	.076	.146	.576**	.466*
4. Body Mass (kg)	-	-	-	-	.204	.685**	.630**	.334	.367	.310	.228	.347	.233
5. %Body Fat	-	-	-	-	-	-.565**	.878**	.134	-.189	.332	.180	-.369	-.249
6. Lean Mass (kg)	-	-	-	-	-	-	-.133	.205	.447**	.045	.087	.569**	.410*
7. Fat Mass (kg)	-	-	-	-	-	-	-	-.245	.219	.378	.219	-.118	-.115
8. Total kcals/day	-	-	-	-	-	-	-	-	.554**	.633**	.932**	.181	.322
9. Protein kcals/day	-	-	-	-	-	-	-	-	-	.344	.313	.574**	.408*
10. Fat kcals/day	-	-	-	-	-	-	-	-	-	-	.469*	-.071	.433*
11. CHO kcals/day	-	-	-	-	-	-	-	-	-	-	-	.081	.144
12. Calcium (mg/day)	-	-	-	-	-	-	-	-	-	-	-	-	.379
13. Activity level (kcal/kg/wk)	-	-	-	-	-	-	-	-	-	-	-	-	-

Pearson Correlation Blacks * $p \leq 0.05$ ** $p \leq 0.01$

Table 5. Correlation table for the Whites.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. BMD (g/cm^2)	-	.049	.689**	.700**	-.222	.777**	.183	.324*	.346*	.313*	.233	.070	-.127
2. Age (yrs)	-	-	.077	.209	.153	.068	.237	.076	.089	.281	-.027	-.013	.035
3. Height (cm)	-	-	-	.729**	-.226	.798**	.194	.273	.235	.233	.233	-.053	-.009
4. Body Mass (kg)	-	-	-	-	.203	.733**	.675**	.206	.165	.229	.136	-.010	-.254
5. %Body Fat	-	-	-	-	-	-.505**	.845**	-.300	-.363*	-.123	-.355*	-.237	-.215
6. Lean Mass (kg)	-	-	-	-	-	-	-.005	.386*	.402**	.292	.360*	.162	-.116
7. Fat Mass (kg)	-	-	-	-	-	-	-	-.121	-.204	.015	-.194	-.186	-.259
8. Total kcals/day	-	-	-	-	-	-	-	-	.852**	.871**	.923**	.543**	-.289
9. Protein kcals/day	-	-	-	-	-	-	-	-	-	.823**	.702**	.687**	-.232
10. Fat kcals/day	-	-	-	-	-	-	-	-	-	-	.655**	.490**	-.266
11. CHO kcals/day	-	-	-	-	-	-	-	-	-	-	-	.463**	-.312*
12. Calcium (mg/day)	-	-	-	-	-	-	-	-	-	-	-	-	-.298
13. Activity level (kcal/kg/wk)	-	-	-	-	-	-	-	-	-	-	-	-	-

Pearson Correlation Whites * $p \leq 0.05$; ** $p \leq 0.01$

Table 6. Correlation table for the Hispanics.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. BMD (g/cm^2)	-	.137	.125	.620**	.079	.521**	.425**	.053	-.150	-.085	.166	.014	-.092
2. Age (yrs)	-	-	-.023	-.100	-.020	-.044	-.111	.084	-.056	-.057	.158	.194	-.038
3. Height (cm)	-	-	-	.406*	-.332*	.662**	-.014	.389*	.170	.235	.431**	-.103	-.120
4. Body Mass (kg)	-	-	-	-	.308	.735**	.790**	-.090	-.016	-.164	-.033	-.115	-.090
5. %Body Fat	-	-	-	-	-	-.407*	.814**	-.521**	-.392*	-307	-.525**	-.359*	-.185
6. Lean Mass (kg)	-	-	-	-	-	-	.167	.308	.261	.083	.367*	.159	.056
7. Fat Mass (kg)	-	-	-	-	-	-	-	-.420*	-.258	-.321	-.393*	-.312	-.177
8. Total kcals/day	-	-	-	-	-	-	-	-	.713**	.782**	.917**	.366*	-.115
9. Protein kcals/day	-	-	-	-	-	-	-	-	-	.589**	.529**	.329	-.047
10. Fat kcals/day	-	-	-	-	-	-	-	-	-	-	.496**	-.001	-.127
11. CHO kcals/day	-	-	-	-	-	-	-	-	-	-	-	.477**	-.080
12. Calcium (mg/day)	-	-	-	-	-	-	-	-	-	-	-	-	-.064
13. Activity level (kcal/kg/wk)	-	-	-	-	-	-	-	-	-	-	-	-	-

Pearson Correlation Hispanics * $p \leq 0.05$ ** $p \leq 0.01$

DISCUSSION

The primary finding of this study was that Blacks have a higher BMD than Whites and Hispanics, is in agreement with most of the work that has been published with regard to BMD and racial/ethnic differences. Most studies have found that Blacks have a higher BMD than Whites (1,2,4,8,10,12,17,20,21).

As expected, LM correlated with BMD for all three racial/ethnic groups. This is in agreement with other studies that found LM correlated with BMD for Blacks and Whites (2,5). In addition, weight correlated with BMD for all three racial/ethnic groups and FM correlated with BMD for the Hispanics. The correlation of FM with BMD for the Hispanics was r = .425. While it was statistically significant, the correlation only explains 18% of the variability of BMD. While statistically significant, it is likely not clinically significant.

Height and body mass were correlated with BMD for the Blacks and Whites. A weaker correlation was found for body mass for the Hispanics. Greater height and a larger body mass would indicate a larger person and that would be a positive influence on BMD. Most work investigating BMD and examining other variables that impact BMD, control for height and body mass to rule out those variables as the influence. When controlling for these variables, the differences found in BMD remained the same.

Both physical activity level and nutritional status were evaluated. There were no differences between the three groups on physical activity level or nutritional status. The seven-day activity recall was used to analyze physical activity and the level of activity was not different between the groups. A 24-hour dietary recall was utilized to analyze food intake and there were no differences between the groups on food intake levels. These findings might suggest at this point in life these factors are not a major influence on BMD.

In 1997, Ettinger et al. (5) examined the racial differences in BMD of young adult Black and White participants. Similarly this study examined BMD of young adults including Hispanics as well as Blacks and Whites. However, the participants in the Ettinger et al. study were older (Ettinger et al. 25 – 36 years with an average age approximately 31 years versus this study 18 – 34 years with an average age approximately 23 years). Both studies found greater BMD in Blacks compared with Whites and both also found LM greater in Blacks than Whites.

A study by Barondess et al. in 1997 (2) found correlations between BMD and LM (Blacks, r = .51; Whites, r = *.58)*, weight (Blacks, r = .59; Whites, r = .58), and FM (Blacks, r = .60; Whites, r = .35) in Black and White men. Although data were not examined by sex in this study, similar results were found with LM (Blacks, r = .73; Whites, r = .78; Hispanics, r = .52) and weight correlating with BMD in all three groups (Blacks, r = .74; Whites, r = .70; Hispanics, r = *.62)*. However, when correlations between FM and BMD were examined, Barondess et al. found FM to be more strongly correlated with bone mass in Blacks (r = .60*)* compared with Whites (r = .35), while this study shows a correlation of FM and BMD only occurred in Hispanics (r = .43). Again, the clinical significance of these correlations should be questioned.

Since the report from the Surgeon General in 2004 states that of particular concern are men, racial and ethnic minorities, poor individuals, individuals with disabilities, and individuals living in rural areas, this study examined a diverse population of women and men. An interesting finding of this study was that 3 out of 15 young Hispanic males had *t-scores* that suggested osteopenia or some bone loss. Overall the *t*-scores of the Hispanics, while not statistically different, were somewhat lower than the Blacks and Whites. This finding might suggest that the Surgeon General may be correct, that the focus of this type of work should be on men and minorities.

In conclusion, BMD is suggested to be higher in Blacks than Whites and Hispanics. Snow-Harter et al. (16) suggest that BMD is higher in active people and may be associated with a lower rate of age-related bone loss. While this study did not find any difference between the three groups on physical activity level, the Snow-Harter et al. review (16) suggests that most studies lend strong support to a positive relationship between physical activity and BMD. Also, LM is suggested to be an important component of our bodies that plays a large role in BMD. As fitness professionals and instructors of fitness professionals, it is important to stress a level of resistance training consistent with building and maintaining LM. While it is important to stress increasing LM for females as they tend to not want to build large muscles, it is apparent that both sexes need to spend more time on this aspect of their overall fitness in an attempt to maintain good bone health throughout life.

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