Bone Mineral Density of Recent African Immigrants in the United States

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Background: Racial/ethnic difference in bone mineral density (BMD) exists. The underlying mechanism is unclear and needs investigation.

Purpose: To determine BMD and its relation to environmental exposure in recent African immigrants.

Methods: BMD in recent sub-Saharan Sudanese immigrants (55 men and 88 premenopausal women) in the United States was measured. Analysis of covariance (ANCOVA) model was performed, with total body, spine and hip BMD as dependent variables; and sex, age, body weight, the length of stay in the United States, and milk intake as independent variables.

Results: BMD Z score in the spine but not total body or hip in the Sudanese immigrants was significantly lower compared with the normative values of African Americans and Caucasians. Total body and hip BMD was positively correlated ($p<0.015$) with their length of stay in the United States. Hip BMD was significantly correlated with milk intake ($p<0.02$) and marginally ($p=0.052$) with their length of stay in the United States, independent of body weight.

Conclusions: Spinal BMD was significantly lower in recent Sudanese immigrants than in African Americans or Caucasians. Their hip and total body BMD was associated with their length of stay in the United States, suggesting a potential role of environmental factors in the ethnic diversity of BMD.

Key words: African immigrants ■ Sudanese ■ bone health ■ environment ■ nutrition

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INTRODUCTION

Osteoporosis occurs in all populations at all ages,[1-7] affecting 25 million people in the United States alone.[1-3] However, there is a remarkable difference in the risks for osteoporosis and fracture among different racial/ethnic groups.[3-7] The risk for fracture is correlated with bone mineral density (BMD). Finkelstein et al. recently reported that Caucasians have lower adjusted femoral neck BMD than African Americans and Asians, which may explain why Caucasians have a higher fracture rate.[8] The underlying mechanisms for the ethnic difference are not well understood. Previous studies show that differences in environmental exposure, including sun exposure, calcium and vitamin-D intakes, nutrition such as protein intake, lifestyle and socioeconomic condition, may play an important role. For example, Wu et al. have shown that peak BMD at the lumbar spine and various sites of the hip were significantly lower in Chinese than in Japanese women. They suggest that the difference is attributable to the difference in milk consumption since the Japanese government provides its citizens with milk free of charge.[9] Also, bone mineral content (BMC) is greater in U.S.-born Japanese than their Japan-born counterparts at several bone sites.[10] Differences between the two Japanese groups in height, weight, exercise, estrogen therapy, and calcium and vitamin-D intake may account for much of the difference in BMC.[10]

BMD is also significantly different among populations of African origin. Melton et al.[11] have shown that lumbar spine and femoral neck BMD are significantly higher in African-American women than in

Somali (East Africa) immigrant women in the United States. Several environmental factors may partly account for the difference. For example, the Somali have experienced famine and war during the past decade,[12] while African Americans tend to ingest more calories than needed,[13] and the prevalence of obesity is high among African Americans.[14] Thus, the racial/ethnic difference in BMD can be in part explained by potential difference in body weight, which is well known to be strongly correlated with BMD. However, the ethnic difference between African-American and Somali women remained significant after adjusting BMD for body weight,[11] suggesting involvement of other factors such as serum vitamin-D levels. The prevalence of hypovitaminosis D is 10-fold higher in African Americans than in Caucasians,[15] which is at least in part attributable to skin color.[16] It may be speculated that the longer the African immigrants have lived in the United States, where the latitude is higher than in Africa, the lower their BMD would be.

In spite of the putatively poor nutrition in the past and lower serum vitamin-D level at present, Somali immigrant women had significantly higher lumbar spine and femoral neck BMD than Caucasian women, while Gambian (West Africa) women had significantly lower lumbar spinal BMD than Caucasian women.[17] On the other hand, black women had similar lumbar spinal BMD and higher femoral BMD than white women in South Africa.[18] It appears that BMD varies among blacks in Africa, depending on the environment (e.g., geographic location, sun exposure, nutrition, etc.), ethnicity or both. It would be of interest to determine whether change in environmental exposure, particularly the duration of environmental exposure, affects BMD.

Because of civil war, many Sudanese from southern sub-Saharan Sudan have migrated to the United States in recent years. Approximately 9,000 of them live in Nebraska, which is the largest Sudanese community in the United States.[19] This provides an opportunity to investigate the effect of change in environmental exposure on BMD, which may in turn provide clues to the mechanisms whereby the racial/ethnic diversity in BMD occurs.

METHODS

Subjects

Recent sub-Saharan immigrants from southern Sudan to the United States were studied. Sudanese individuals and community leaders, particularly Southern Sudan Community Association, First Lutheran Church and the Office of Creighton University Multicultural and Community Affairs, Omaha, NE, assisted in the recruitment. Sudanese subjects were recruited through personal contact by Sudanese community leaders and individuals of African descent, and by word of mouth. Flyers were also distributed at several locations in Omaha. Responders with written consent were recruited. The consent process was conducted by detailed explanation of the purpose, procedure, and potential risk and benefit of the project with the aid of interpreters proficient in both English and Sudanese (mainly the dialect of the Nuer tribe) languages. Approximately 90% of the participants were from the Nuer tribe. Individuals on corticosteroid therapy, evidence of metabolic or inherited bone disease, rheumatoid arthritis, recent major gastrointestinal disease and

Table 1. Characteristics of the Sudanese immigrant subjects

	Women (n=88)					Men (n=55)				
	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
Age (year)	29.8	28.3	6.8	18.4	51.0	31.4	30.4	7.0	20.3	48.2
Height (m)	1.69	1.68	0.07	1.52	1.88	1.81	1.81	0.07	1.68	1.97
Weight (kg)	71.0	71.0	13.0	46.2	121.0	77.3	75.0	14.9	55.5	120.7
Years in United States	4.27	3.35	3.65	0.02	24.8	4.97	4.49	3.2	0.05	11.8
Milk intake (cup)	1.31	1	0.92	0	4	1.24	1.00	1.05	0	4
Milk drinker	83.5%					72.6%				

Table 2. Bone mineral density (g/cm^2) of the Sudanese immigrant subjects

	Women (n=88)					Men (n=55)				
	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
Total body	1.096	1.091	0.073	0.947	1.245	1.183	1.175	0.104	0.980	1.539
Total hip	0.994	0.995	0.101	0.742	1.285	1.109	1.095	0.154	0.767	1.640
Lumbar spine	0.973	0.956	0.118	0.749	1.309	0.984	0.970	0.112	0.769	1.284

conditions known to cause changes in BMD were excluded. Pregnant women were excluded as well. A total of 88 Sudanese women and 55 men were included in this study. Women were all premenopausal with normal menstrual cycle. Creighton University Internal Review Board approved this project.

Assessment of BMD

Total body BMD, lumbar spine (L1–L4) BMD and hip BMD were measured by dual-energy x-ray absorptiometry (DEXA) using a Hologic 4500 densitometer (Hologic, Inc., Waltham, MA). Lumbar spine and hip BMD Z scores and T scores were automatically estimated by the Hologic 4500 with the built-in normative values derived either from African Americans or Caucasian Americans. The DEXA machine was calibrated daily with the same phantom. The coefficient of variation in BMD was <1% and <2% depending on bone site.

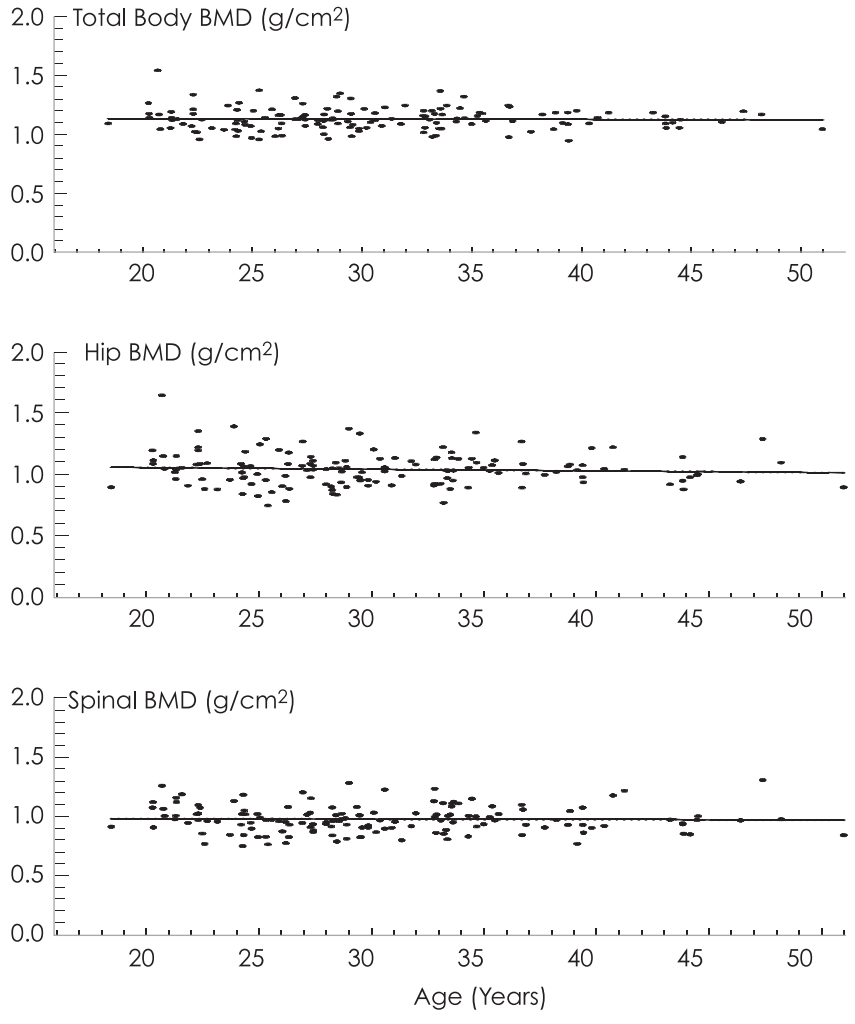
Statistical Analysis

Analysis of covariance (ANCOVA) was performed where BMD of each bone site (hip, total body and spine) was the dependent variable. The independent variables (predictors) included sex, age, body weight, height, milk consumption (cups per day), duration of living in the United States (years), parity and use of contraceptives. To account for type-1 error due to multiple testing, we determined the number of effectively independent tests (for Bonferroni correction) with the method of Camp and Farnham,[20] taking correlation of BMD at different bone sites into account. BMD Z scores of the Sudanese subjects were compared with the normative values of African Americans and Caucasians. The overall type-1 error was always kept at level 0.05.

RESULTS

Anthropometric features, duration of living in the United States and milk consumption are listed in Table 1. Approximately 20% of the women used

Figure 1. The linear relationship between bone mineral density and age

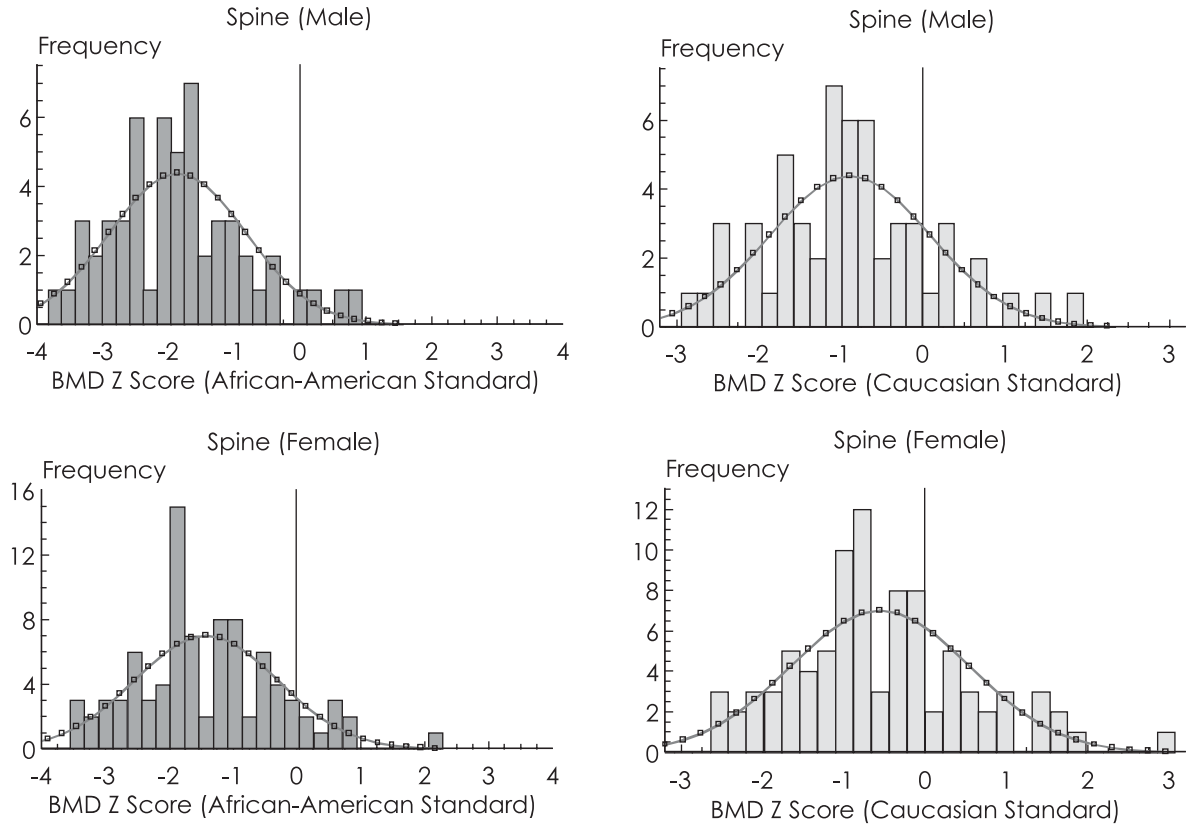


birth control, but none had used it for >6 months before BMD measurement. Obesity (BMI >30 kg/m^2) was observed in 9.1% (eight of 88) of women (five of the eight, or 63% of the obese women had a BMI <31 kg/m^2) and 7.3% (four of 55) of men (all the obese men had a BMI <33 kg/m^2). BMD descriptive statistics are reported in Table 2. Figure 1 shows an apparently linear relationship between age and BMD at these bone sites. BMD Z score in the spine but not total body or hip was significantly lower ($p<0.001$) in the Sudanese immigrants compared with African-American or Caucasian normative val-

Table 3. Summary of ANCOVA

	Total Body Bone Mineral Density			Hip Bone Mineral Density		
	Std. ß	**B Coef. (95% CI)**	**p**	**Std. ß**	**B Coef. (95% CI)**	**p**
Sex	0.434	0.085 (0.054, 0.116)	0.001	0.408	0.113 (0.069, 0.157)	0.001
Age (year)	-0.11	-0.002 (-0.004, 0.001)	0.154	-0.158	-0.003 (-0.006, -0.000)	0.045
Milk (cup/d)	0.141	0.014 (-0.001, 0.030)	0.067	0.181	0.026 (0.004, 0.048)	0.020
Stay in US (y)	0.185	0.006 (0.0013, 0.012)	0.014	0.211	0.010 (0.003, 0.018)	0.005
	Constant=1.01, R^2=0.26, F=10.5			Constant=0.90, R^2=0.26, F=10.8		
After body weight enters in the model						
Sex	0.395	0.078 (0.047, 0.108)	0.000	0.360	0.100 (0.058, 0.142)	0.000
Age (y)	-0.221	-0.003 (-0.005, -0.001)	0.010	-0.291	-0.006 (-0.009, -0.003)	0.001
Milk (cup/d)	0.277	0.013 (-0.002, 0.028)	0.089	0.337	0.024 (0.003, 0.044)	0.027
Stay in US (y)	0.127	0.005 (-0.001, 0.010)	0.086	0.164	0.007 (0.000, 0.014)	0.052
Weight (kg)	0.126	0.002 (0.001, 0.003)	0.003	0.138	0.003 (0.002, 0.005)	0.000
	Constant=0.94, R^2=0.314, F=10.8			Constant=0.78, R^2=0.314, F=12.4		

Figure 2. Lumbar spinal BMD Z scores in the Sudanese compared with African Africans and Caucasians



ues (Figures 2 and 3). If we use African Americans' normative values to derive T scores, then 25.5% of Sudanese men and 21.6% of Sudanese women would have a T score of -2.5 (Figure 4). It appears more appropriate to use Sudanese immigrants' own normative BMD values to derive their T scores for the diagnosis of osteoporosis.

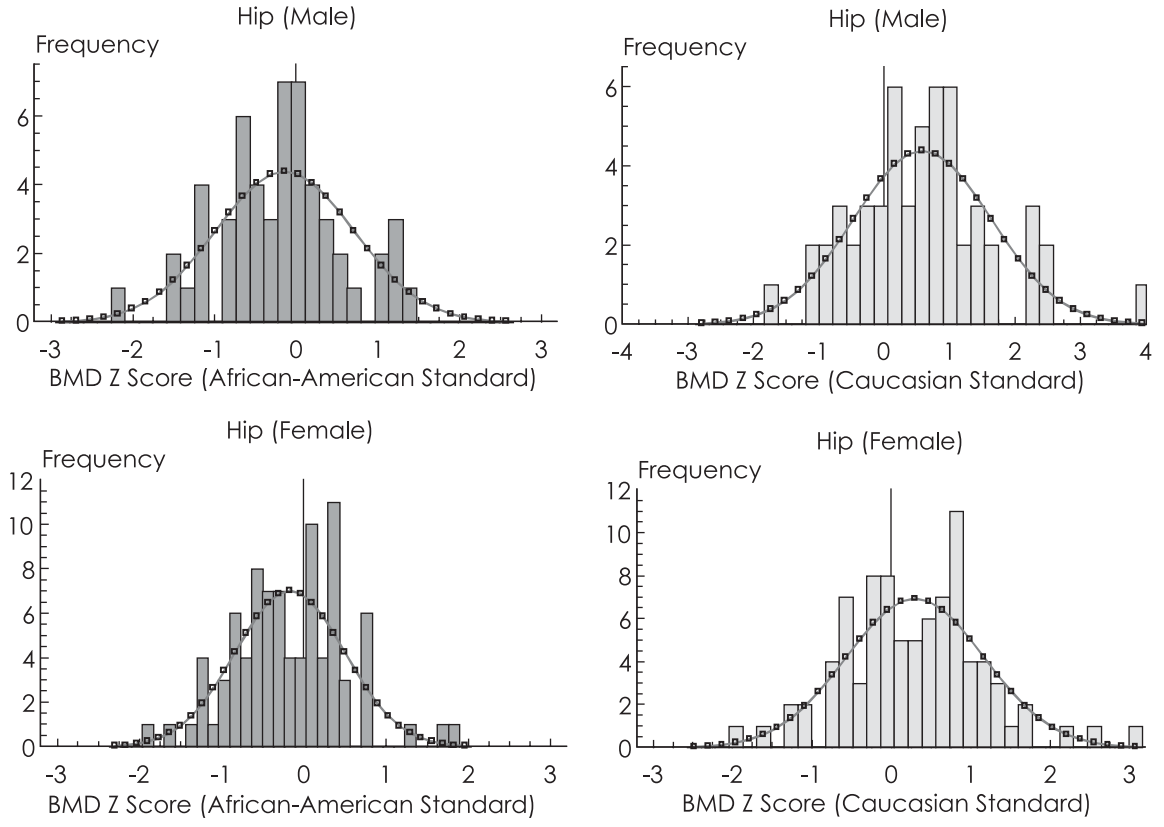
As expected, age, sex and body weight were independently correlated with BMD at all bone sites ($p<0.05$). BMD at these bone sites were significantly correlated with one another ($p<0.0001$). The number of effective and independent tests is equal to 1.73, and the p value=0.0289 was used for determining statistical significance.

Table 3 shows that total body BMD was significantly correlated with the duration in which the Sudanese subjects had lived in the United States. When body weight entered into the ANCOVA model, the effect of the duration of living in the United States was no longer significant (Table 3). Body weight was correlated with the duration of living in the United States ($p=0.027$). Hip BMD was significantly and independently correlated with both milk intake and the duration in which the Sudanese had lived in the United States (Table 3). When body weight entered the ANCOVA model, hip BMD remained significantly ($p<0.02$) correlated with milk intake and marginally ($p=0.052$) with their length of stay in the United States. However, spinal BMD was not significantly correlated with either milk intake or with the length of their stay in the United States ($p>0.05$). BMD was not significantly correlated with either the use of contraceptives (yes or no) or the number of children (as a measure of parity).

Table 4. Variance in bone mineral density (g/cm^2) explained by independent variables (unadjusted R^2)

Site	Sex	Weight (kg)	Stay in United States (Years)	Milk (Cup/Day)	Age (Years)
Total body	0.19863	0.09523	0.05957	0.00801	0.00066
Hip	0.17274	0.11276	0.06629	0.01554	0.00460

Figure 3. Hip bone mineral density Z scores in the Sudanese compared with African Americans and Caucasians



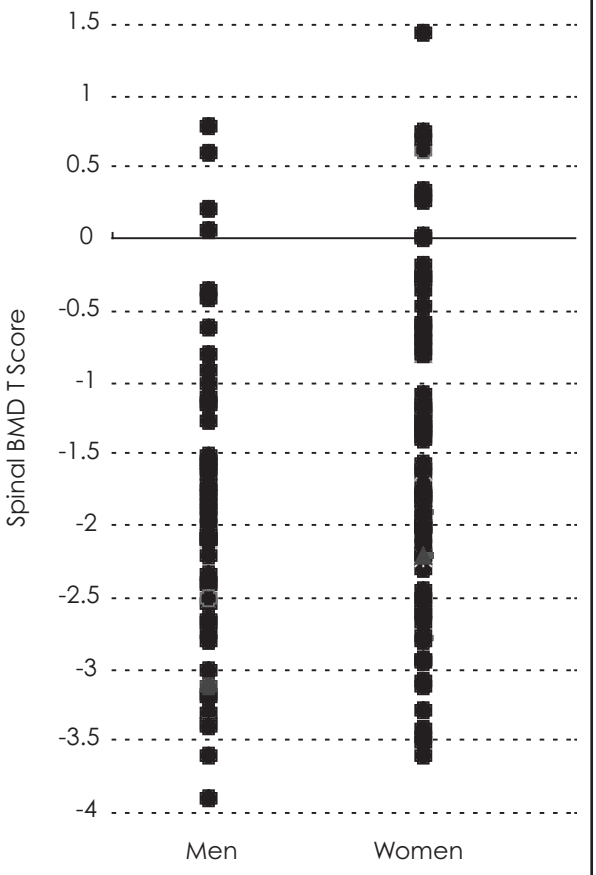
DISCUSSION

This is the first investigation of BMD and its relation with environmental exposure in an immigrant population from sub-Saharan Africa to the United States. Our results show that BMD Z score in the spine but not total body or hip was significantly lower in the Sudanese immigrants as compared with African-American and Caucasian normative values. Currently, there has been no consensus on the densitometric definition of osteoporosis in non-Caucasians.[21] Because of lack of data, it was recommended that a uniform normative database (not adjusted for race) be utilized in the United States for T-score derivation in non-Caucasians.[21] This issue is of practical significance, since >20% of Sudanese men and premenopausal women would have been diagnosed with osteoporosis if native African Americans' normative BMD values were used to derive Z score, which is apparently inappropriate. In addition, normative BMD values derived from the African-American population, where about 50% of women were obese,[22] may be too high for the Sudanese immigrant population, where few were obese. Also, it is questionable whether famine and war would result in widespread "osteoporosis" among individuals who are not in the typical age for the disease, although long-term observation is need for a definitive answer. Therefore, using different BMD normative values for different ethnic groups of African origin for diagnosis should be considered at least for the Sudanese immigrants.

Our studies show that total body and hip BMD was associated with the length of stay in the United States as well as milk intake in the Sudanese immigrants. Notably, when body weight enters the model, the correlation between BMD and the length of stay in the United States was no longer significant, and body weight was correlated with their length of stay in the United States. Thus, the association between BMD and the length of stay in the United States is at least in part attributed to body weight. Several other factors may be responsible for the observed association between BMD and the length of stay in the United States. For example, volunteer bias and small sample size may lead to the observed association by chance. Also, those who came to the United States earlier might happen to have had a higher body weight and BMD before coming to the United States. However, it is more likely that BMD was increased in association with gain in body weight in the U.S. environment (natural or social, e.g., nutrition), because most of them had experienced famine and malnutrition before coming to the United States. Longitudinal studies are indicated to resolve the issue.

It should be noted that the association between hip BMD and milk consumption is commonly observed among all racial/ethnic groups, and it is not unique to the U.S. environment. In addition, the absence of association between spinal BMD and milk intake or their duration of living in the United States may suggest that the lower spinal BMD in the Sudanese immigrants than African Americans is not related to environmental factor. However, it is more likely to be due to their relatively short period of stay (with a mean of five years) in the United States in general, because it is well known that milk intake affects BMD in all these bone sites. Long-term observation is warranted. We did not include postmenopausal women and individuals age >51 years in order to reduce variance and to increase the power with small sample size.

Figure 4. Sudanese immigrants' T scores derived from African-American normative bone mineral density database



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