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25-Hydroxyvitamin D Levels in African American and Nigerian Women

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Abstract

Objectives—African Americans have substantially lower levels of circulating 25(OH)D than whites. We compared population-based samples of 25(OH)D in women of African descent from Nigeria and metropolitan Chicago.

Methods—100 Women of Yoruba ethnicity from southwest Nigeria and 94 African American women from metropolitan Chicago were recruited and compared using a standardized survey protocol and the same laboratory assay for 25(OH)D.

Results—Mean 25(OH)D levels were 64 nmol/L among the Nigerians and 29 nmol/L among the African Americans. Only 10% of the values were shared in common between the groups, and 76% of the Nigerians were above the currently defined threshold for adequate circulating 25(OH)D compared to 5% of the African Americans. Modest associations were seen between 25(OH)D and measures of obesity, although adjustment for these traits did not materially affect the group differences.

Conclusion—These data support the presumption that skin color is an adaptive trait which has evolved in part to regulate 25(OH)D. It remains undetermined, however, whether lower values observed in African Americans have negative health consequences.

Keywords

vitamin D; African American; Nigerian; obesity

Objectives

The health consequences of variation in circulating 25-hydroxyvitamin D (25(OH)D) levels are currently the subject of major controversy, as reflected in a recent Institute of Medicine (IOM) report (Ross and others 2011). One out of 3 Americans has a 25(OH)D serum level < 20 ng/mL (Looker and others 2011), which is currently considered the threshold for risk of vitamin D inadequacy (Ross and others 2011). Light skin facilitates formation of 25(OH)D and, consequently, only 17% of US blacks have “optimal” levels, with very low levels (< 12 ng/mL) found in 32% of blacks, compared to 3% of whites and 9% of Mexican Americans (Looker and others 2011). Concern exists, therefore, that low serum levels of 25(OH)D may contribute to the disproportionately higher risk for some chronic diseases in US blacks (e.g.,

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obesity, hypertension and cardiovascular disease) (Melamed and others 2009; Michos 2009; Pilz and others 2009; Wang and others 2008). Although vitamin D deficiency has been linked to several chronic diseases (Melamed and others 2009; Michos 2009; Reis and others 2005) and increased risk of mortality (Durazo-Arvizu and others 2010; Melamed and others 2008) in observational studies, the IOM report concluded that current epidemiologic evidence was insufficient to warrant a call for population-wide supplementation (Ross and others 2011).

We present descriptive data from African Americans (AA) and West Africans which highlight the context within which skin color has evolved as an adaptive trait to help regulate 25(OH)D levels over the course of the historical migration of humans out of Africa.

Methods

Women of African descent, between 18–59 years and resident in either metropolitan Chicago (latitude 40° N) or from a rural area of Yoruba-speakers in southwest Nigeria (6° N) were evaluated. The parent study was an epidemiologic cohort study examining the relationship of energy expenditure to weight change (Luke and others 2009).

Participants were in general good health and not pregnant or lactating at the time of enrollment. A standardized examination protocol was used in both Nigeria and the US, including anthropometry, phlebotomy, as well as medical and social history.

The primary occupation of the women in Nigeria was market trading (43%), followed by subsistence farming (21%). In contrast, women in the US were employed in a wide variety of occupations, with the most common being certified nurse assistant (8%), followed by customer service representative (6%) with approximately 40% unemployed.

The protocol was approved by the Institutional Review Board of Loyola University School of Medicine and the Ethics Committee of University College Hospital, University of Ibadan. Written informed consent was obtained from all participants and all relevant documents including the consent form were translated into Yoruba for use at the Nigerian site.

A detailed description of methods employed has been previously published (Ebersole and others 2008). In brief, at both sites weight was measured to the nearest 0.1 kg using a calibrated electronic scale (Health-o-meter, Bridgeview, IL); height was measured to the nearest 0.1 cm using a stadiometer (Seca Corp., San Jose, CA); body mass index (BMI) was calculated as weight (in kg)/height² (in m); waist circumference was measured to the nearest 0.1 cm. All participants were asked about their medical and social history and the season was recorded. In Nigeria, the wet season was determined to be from the beginning of April to the end of October, and the dry season from the beginning of November to the end of March. A similar delineation of the seasons was used for the US cohort, with examinations conducted between November to April designated as winter and those between May and October as summer.

Fasting blood samples were collected, processed and stored at –80C in the US and at –20C in Nigeria until the samples could be shipped to Loyola. Serum 25(OH)D was measured by a radioreceptor assay from DiaSorin, Inc. (Stillwater, MN). The minimal limit of detection is 3.75 nmol/L and the maximal is 250 nmol/L. The intraassay precision (coefficient of variation) for the mean of 21.5 nmol/L is 11.7% and for the mean of 122.5 nmol/liter is 12.5%. The overall intraassay variability in our laboratory is 4.1%, and interassay variability is 7.0%. Our laboratory participates in Vitamin D External Quality Assessment Scheme (DEQAS), an external quality control program (Carter and others 2004).

Descriptive characteristics were expressed as means $\pm$ SD or percent. Statistical analyses and frequency distributions of 25(OH)D levels were performed using STATA 12.1 (STATA, College Station, TX).

Results

Descriptive characteristics of the study participants are presented in Table 1. The samples were relatively matched in age, through design, and the Nigerians were substantially leaner than the AA (BMI 23 vs. 30 kg/m², respectively). As a consequence of the variation in degree of adiposity, components of the metabolic syndrome, including insulin and glucose, were also much more favorable among the Nigerian women, and blood pressures were lower (data not presented). Mean levels of 25(OH)D among the Nigerians exceeded those of AA by 120%, 64 and 29 nmol/L, respectively. Adjustment for age did not significantly change the mean values, i.e. 65 nmol/L for the Nigerian women and 28 nmol/L for the AA women.

Among the US participants only 5% had circulating 25(OH)D at or above the level defined as adequate by recent guidelines (i.e., > 50 nmol/L), while fully three-quarters of the Nigerians met this criterion, and none of the Nigerians were at risk of deficiency (Table 1). The majority of tests were conducted in the rainy season in Nigeria (82%) and during summer months in the US (68%). There were no significant differences in mean 25(OH)D concentrations between the seasons in either site (data not presented).

Inter-relations among 25(OH)D and anthropometric biochemical traits were examined through correlation coefficients. Measures of adiposity had a tendency to be negatively associated with 25(OH)D, particularly among the AA, but the relationships were only modestly significant. The frequency distributions of 25(OH)D were widely offset (Figure 1), intersecting at about the 90th percentile for AA and 10th percentile for Nigerians.

Discussion

In the standardized comparison between AA and Nigerians presented here the non-overlapping distributions of 25(OH)D demonstrate that the physiologic set-point for vitamin D conversion is severely constrained at higher latitudes by the melanin content typical of West Africans. Nutritional sources of vitamin D – such as fatty fish, dairy products or supplemented foods – are virtually absent from the diet of the Nigerians we studied, while some increased intake is likely in AA; this contrast in serum levels therefore cannot be confounded by diet. An urban lifestyle with limited sun exposure – in addition to latitude could also contribute to lower levels in AA. Molecular genetic data have demonstrated that skin color is under strong recent selection by two separate pathways in Europe and Asia, presumably as a response to ultraviolet B (UVB) exposure (Pilz and others 2009; Reis and others 2005; Wang and others 2008). It has been suggested on the basis of admixture analysis that genes other than those influencing skin color might account in part for lower 25(OH)D in AA (Signorello and others 2010); the data presented here would suggest that these variants play at most a minor role. Thus, while 25(OH)D levels are low in US blacks, in West Africans they are similar to US whites, and these levels are presumably the current best estimate of the “norm”, if not “normal”, for human populations. Unlike sickle cell, however, it is clear that darker skin color is not under sufficiently strong negative selective pressure to have altered gene frequencies in the 400 years that persons of African descent have lived in North America.

25(OH)D has regulatory functions in numerous physiologic systems which could have driven positive selection for light skin color. The health consequences of low 25(OH)D levels in pre-historic eras are unknown, although rickets and pelvic dysplasia could have

played a role, along with other potential effects such as immune function (Schwalfenberg 2011). Paradoxically, while US blacks have relatively low serum 25(OH)D, they have higher bone mineral density and lower fracture rates compared to whites, suggesting important variation in metabolic set points across populations (Aloia 2008). Unfortunately, we do not have information on downstream effects of bone mineral metabolism that could permit a test of this question. However, it is not known whether US blacks are at increased risk from the non-skeletal effects of low 25(OH)D. Public health recommendations for the US must therefore confront the dilemma of whether or not to set population-specific guidelines for light vs. dark skinned groups. A better understanding of the physiology of 25(OH)D is therefore required before public health recommendations regarding health-promoting levels can be made on a secure basis.

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RD, AL and RC designed the research, RD, AL, BT and LD conducted the research, JA, AMB and JY conducted the laboratory analysis, RC, JA, RD and AL did the interpretation and RD, JA, LD, BT, DS, RC and AL prepared the manuscript. RD had primary responsibility for the final content and all authors read and approved the final manuscript.

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Figure 1.
Distributions of Serum 25-Hydroxyvitamin D in Nigerians and African Americans

Table 1

Participant Characteristics by Study Location – mean (SD)

	Nigeria	N	US	N	Total	N
Age (y) *	30.5 (11)	100	35.2 (10.4)	95	32.8 (11)	195
Weight (kg) *	57.9 (11.5)	100	81.1 (14.7)	95	69.2 (17.5)	195
Height (cm) *	159.2 (6.2)	100	164.3 (5.8)	95	161.7 (6.5)	195
BMI (kg/m ²) *	23.1 (5.2)	100	30 (5)	95	26.5 (6.2)	195
Waist Circumference (cm) *	78 (9.7)	98	89.6 (13.2)	95	83.7 (12.9)	193
25(OH)D (nmol/L) *	64.4 (17.4)	100	29.1 (12.7)	95	47.2 (23.4)	195
% Increased risk of deficiency \$	0	0	58.9	56	28.7	195
% Increased risk of insufficiency \$\$	24.0	24	35.8	34	29.7	195
% Adequacy \$\$\$	76.0	76	5.3	5	41.5	195

* p < 0.01

\$ (< 30nmol/L),

\$\$ (< 50 30 nmol/L),

\$\$\$ (> 50 nmol/L), all based on Cut-points based on Dietary Reference Intakes (Ross and others 2011)