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Research Article

Vitamin D and Iron Nutritional Status of Black/African American College Students

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Abstract

Purpose: To determine students' vitamin D and iron nutritional status in a Historically Black Colleges and Universities (HBCU) institution based on their blood levels of 25-hydroxyvitamin D and ferritin.

Methods: In this cross-sectional study, 100 students were recruited by announcements at the Morgan State University websites, bulletin boards, and face-to-face classes. Each student made an appointment and came in to complete a health and nutrition questionnaire, a food frequency questionnaire for fruit and vegetable intake, anthropometrics, and a blood draw. Blood samples used in this study were drawn during the months of January to May (winter/spring) for a parent study, and plasma was analyzed for 25-hydroxy vitamin D (for vitamin D nutritional status) and ferritin (for iron nutritional status). Descriptive analysis determined the number and percentage of vitamin D and iron-deficient individuals.

Results: Plasma 25-hydroxy vitamin D among males (N = 32) was 21.6 ± 7.0 ng/ml (Mean ± SD), and among females (N = 67) was 19.7 ± 12.2. Based on plasma 25-hydroxy vitamin D ≤ 20 ng/ml (cut point for deficiency), 37.5% of males and 58.2% of females were considered deficient in vitamin D, respectively. Plasma ferritin among males (N = 32) was 32.8 ± 16.9 ng/ml, and among females (N = 67) was 19.0 ± 13.8 ng/ml. Based on plasma ferritin ≤ 25 ng/ml (cut point for deficiency), 25.0% of males and 50.7% of females were considered deficient in iron, respectively.

Conclusion: Many participants detected low or deficient levels of vitamin D and iron. It is important to emphasize the essential role of these two micronutrients in health and well-being and help college-aged students improve their nutritional status by teaching them in introductory nutrition courses and through on-campus communication. At Morgan State University, we offer an Introduction to Nutrition course as a general education course, which is also very popular among students (400 - 500 students enrolled in several sections each semester) from all majors, including health-related fields of study.

Keywords: Vitamin D Status; Iron Status; College Students; Blacks/African Americans

Introduction

The "vitamin D hormone" is not a typical vitamin because it is made in the body. Usually, vitamins are not synthesized in the human body, and they must be supplied by the food/beverages consumed or by vitamin supplements. Under the skin, cholesterol is converted to 7-dehydro cholesterol, then to vitamin D under sunlight/ultraviolet light. Newly synthesized vitamin D under the skin is then moved in the bloodstream to the liver and then to the kidneys to undergo two-stage activation and become active vitamin D. Except for some foods, such as fish, mushrooms, eggs, and some vitamin D-fortified foods and beverages, such as cereals, milk, and orange juice, there are few dietary sources of vitamin D, and humans rely on vitamin D synthesis under the skin in the sun. Synthesis under the skin is lower in black/African Americans because of skin pigmentation, especially if they are living at high altitudes during cold winter months when there may not be enough sunshine [1].

A well-known function of vitamin D is its important role in calcium and bone metabolism. Additionally, the vitamin D hormone controls the activity of thousands of genes needed for protein synthesis; thus, optimal levels may be important for health. An adequate amount of vitamin D is important in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis [2]. Vitamin D deficiency, as defined by serum 25-hydroxy vitamin D concentrations ≤ 20 ng/ml (50 nmol/L), is common among the U.S. population and especially among minorities such as blacks and Hispanics [3]. According to Ames., *et al*. [4], evidence suggests that high 25-hydroxyvitamin D levels and/or vitamin D supplementation reduce the risk for many adverse health outcomes, and they question the high prevalence of vitamin D deficiency in African Americans as a contributor to health disparities.

Further, Pittas., *et al*. [5], did a systematic review and meta-analysis of individual participant data from three randomized clinical trials and concluded that in adults with prediabetes, vitamin D supplementation reduced the risk of diabetes, in some cases by 76%. Epidemiological studies indicate an association between vitamin D deficiency and schizophrenia; however, the authors urge caution in any causal interpretation of results because patients with schizophrenia tend to have poorer general health and diets, are less active and outgoing, and have an increased risk of other medical conditions, all of which reduce circulating vitamin D levels in blood [6].

Iron is an essential trace element crucial for various metabolic processes in the human body. The primary function of iron is the transportation of oxygen throughout the body via hemoglobin, a protein in red blood cells. Iron is also a component of myoglobin, a protein found in muscles, which facilitates oxygen storage and release for muscle contraction. Iron also plays an essential role in cellular energy production as a cofactor for enzymes involved in the electron transport chain, a key process in generating adenosine triphosphate (ATP), the body's primary energy currency. Moreover, iron is vital for the synthesis of neurotransmitters such as dopamine, which are crucial for brain function and mood regulation [7]. Iron deficiency is the most prevalent micronutrient deficiency in the world and can lead to various health complications, including anemia, impaired cognitive function, and a weakened immune response [8]. Iron deficiency anemia and depleted iron stores are prevalent among African American adolescents, as reported by investigators at the Johns Hopkins Bloomberg School of Public Health in Baltimore, MD [9]. Children up to the age of 5 years, women of childbearing age, and pregnant women are at increased risk of iron deficiency [10]. There is growing evidence that nonanemic iron deficiency and iron deficiency anemia are health disparities among minority groups in high-income countries [11]. Maintaining adequate iron levels through dietary sources or supplementation is essential for overall health and well-being.

Finally, iron and vitamin D interact in various ways in the human body, and one example is that vitamin D regulates the absorption, tissue distribution, and extracellular concentration of iron in the body by increasing the expression of proteins involved in iron transport [12].

Based on reports of low levels of vitamin D and iron in black/African Americans and the importance of these micronutrients for health, blood levels of 25-hydroxy vitamin D (as indicators of vitamin D nutritional status) and ferritin (as indicators of iron nutritional status) were measured in plasma samples obtained from the parent study outlined below.

Materials and Methods

Overview of parent study and participants

The data were drawn from a parent study [13], which was designed to validate the results from an instrument called Veggie Meter. The instrument measures skin carotenoids via reflection spectroscopy as a biomarker of fruit and vegetable intake by scanning a fingertip and reading the amounts of carotenoids under the skin. Carotenoids are found only in fruits and vegetables and are not synthesized in the human body; thus, their levels can indicate fruit and vegetable intake, which is an important issue in nutritional recommendations. To validate the results of the Veggie Meter, we also needed to draw blood samples, measure the amount of carotenoids in the participants' blood, and correlate that with Veggie Meter readings. We piggybacked on the parent study, added 25-hydroxy vitamin D and ferritin assays in the blood samples, and included everything in the consent form, which the Institutional Review Board (IRB) approved for Human Subjects of Morgan State University. For 99 non-fasting participants, a 7-ml blood sample was collected from an arm vein into a glass vacutainer tube with ethylenediaminetetraacetic acid (EDTA) as the anticoagulant and centrifuged to separate the plasma. Two aliquots of approximately 200 μL were collected in polypropylene centrifuge tubes, placed on dry ice protected from light, and then frozen at -80°C until analysis for 25-hydroxy vitamin D and ferritin. Blood samples were collected from January through May in Baltimore, Maryland, USA.

Analyses of plasma 25-hydroxyvitamin D and ferritin

The plasma 25-hydroxyvitamin D concentration was assayed via an enzyme-linked immunosorbent assay (ELISA) kit from Eagle Biosciences, Inc. (20A Northwest Blvd., Suite 112, Nashua, NH 03063). For quality control, 40% of the samples were analyzed in duplicate, and the results were reasonably close, within 10% of the mean of the duplicate values. Plasma ferritin was assayed via a Human Ferritin ELISA Kit (FLT) (ab200018) from Abcam (https//:abcam.com/human-ferritin-elisa-kit-flt-ab200018.html). Twenty-two percent of the samples were assayed in duplicate, and the results were within 10% of the mean of the duplicates.

Results

The results are presented in table 1.

	Age Mean ± SD*	Plasma 25-hydroxy Vitamin D (ng/ml) Mean ± SD	Number Deficient	Percent Deficient	Plasma Ferritin (ng/ml) Mean ± SD	Number Deficient	Percent Deficient
Male	20.7 ± 2.4	21.6 ± 7.0	12	37.5	32.8 ± 16.9	8	25
N	32	32			32		
Female	20.7 ± 2.5	19.7 ± 12.2	39	58.2	19.0 ± 13.8	34	50.7
N	68	67			67		
Total	20.7 ± 2.4	20.3 ± 10.8	51	51.5	23.4 ± 16.1	42	42.4
N	100	99			99		

Table 1

*Mean ± standard deviation.

**Based on plasma 25-hydroxy vitamin D ≤ 20 ng/ml and plasma ferritin ≤ 25 ng/ml.

Overall, the mean plasma 25-hydroxy vitamin D level was 20.3 ± 10.8 ng/ml (Mean ± SD) (N = 99), and the mean ferritin was 23.4 ± 16.1 ng/ml (N = 99). Using plasma 25-hydroxy vitamin D ≤ 20 ng/ml, the cut point for deficiency, 51.5% of total participants were deficient in vitamin D. Applying the cut point plasma ferritin levels of ≤ 25 ng/ml, 42.4% of the participants were considered lacking in iron (Table 1).

In terms of male and female students, plasma 25-hydroxy vitamin D among males (N = 32) was 21.6 ± 7.0 ng/ml (Mean ± SD), and among females (N = 67) was 19.7 ± 12.2. Based on plasma 25-hydroxy vitamin D ≤ 20 ng/ml (cut point for deficiency), 37.5% of males and 58.2% of females were considered deficient in vitamin D, respectively. Plasma ferritin among males (N = 32) was 32.8 ± 16.9 ng/ml, and among females (N = 67) was 19.0 ± 13.8 ng/ml. Based on plasma ferritin ≤ 25 ng/ml (cut point for deficiency), 25.0% of males and 50.7% of females were considered deficient in iron, respectively.

Discussion

The prevalence of vitamin D deficiency was lower in the current study than in the results reported by [3]. (82.1% vs. 51.5%). Compared with males, females had a greater prevalence of vitamin D deficiency (Table 1). Among 12- to 21-year-old US females between 2003 and 2020, iron deficiency (ferritin levels ≤ 25 ng/ml) affected almost 40% [14], in comparison to the current survey of 50.7% among females. Among 3490 females in the Weyand., [14] study who used the National Health and Nutrition Examination Survey (NHANES), 188 were premenarchal, which may explain the lower prevalence of iron deficiency in that group.

There is evidence that high levels of 25-hydroxyvitamin D in the blood and/or vitamin D supplementation are protective against many adverse health outcomes, including all-cause mortality, adverse pregnancy and birth outcomes, cancer, diabetes mellitus, Alzheimer's disease and dementia, multiple sclerosis, COVID-19, asthma exacerbations, acute respiratory tract infections, rickets, and osteomalacia. African Americans have a 15- to 20-fold greater prevalence of severe vitamin D deficiency due to melanin in the skin, which blocks the synthesis of vitamin D and is exacerbated at high latitudes because of the combination of dark skin color with lower UVB radiation levels at higher altitudes. Ames and coworkers [4] consider this a health disparity and recommend that people with low vitamin D status and their health care providers consider taking vitamin D3 supplements to increase their serum 25-hydroxyvitamin D levels to 30 ng/mL (75 nmol/L) or possibly higher. There is also the "Vitamin D Paradox in Black Americans" [15], where it is proposed that despite markedly low (or "deficient") measures of vitamin D status in Black Americans, the incidence of falls, fractures, or osteopenia is significantly lower (better bone health) than that in their White American counterparts with similar vitamin D status.

In a recent Invited Commentary, Tang and Sholzberg [16] look at the definition of iron deficiency as an issue of health equity. [11] emphasized the importance of applying evidence-based definitions for iron deficiency, especially among black and Indigenous women. Both nonanemic iron deficiency (NAID) and iron deficiency anemia are associated with morbidity and mortality, and they are preventable and treatable with proper diagnosis. The current cutoff point of serum ferritin less than 25 ng/ml (National Health and Nutrition Examination Survey [NHANES] definition) is associated with white male mortality, morbidity, and decreased productivity. It is time to raise the scale and enhance the early detection of NAID in all women. Other authors [17] have proposed to increase the ferritin cutoff point to 50 ng/ml to prevent underdiagnosis.

A limitation of this study was the small number of participants, which was drawn from the parent study mentioned above [13]. Another limitation was the lack of dietary intake of vitamin D and iron. In the parent study, the participants' fruit and vegetable intake was measured via a food frequency questionnaire, which was not reported here because fruits and vegetables are not significant vitamin D and iron sources.

Conclusion

Many participants have detected low or deficient levels of vitamin D and iron. It is important to emphasize the essential role of these two micronutrients in health and well-being and help college-aged students improve their nutritional status by teaching them in introductory nutrition courses and through on-campus communication. Females in this age group require special attention concerning iron intake.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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