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Applied nutritional investigation

Vitamin D deficiency and inadequacy in a correctional population

Elizabeth T. Jacobs Ph.D. [a,b,*], Charles J. Mullany M.B., M.S. [c,d]

[a] Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, Arizona
[b] University of Arizona Cancer Center, Tucson, Arizona
[c] Maricopa Correctional Health Services, Phoenix, Arizona
[d] Emeritus Professor of Surgery, Mayo College of Medicine, Rochester, MN

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ABSTRACT

Objectives: Adequate nutrition among inmates at correctional facilities may prevent a variety of diseases and conditions. Vitamin D is a nutrient of particular interest to incarcerated populations; however, research in this area is sparse. Therefore, the aim of this study was to assess vitamin D status among inmates in a prison in southern Arizona, a sun-replete region of the United States.
Methods: We conducted a cross-sectional study of circulating concentrations of 25-hydroxycholecalciferol [25(OH)D] among short-term (group 1; <6 wk; n = 29) and long-term (group 2; >1 y; n = 30) inmates at The Fourth Avenue Jail in Maricopa County (Phoenix) Arizona.
Results: The long-term inmates in group 2 had statistically significantly lower levels of 25(OH)D (13.9 ± 6.3 ng/mL) compared with group 1 (25.9 ± 12.4; $P < 0.0001$). Defining vitamin D deficiency as circulating concentrations of 25(OH)D < 20 ng/mL, 37.9% of inmates in group 1 and 90% of those in group 2 were deficient. After adjusting for body mass index and age, the odds ratio (95% confidence interval) for deficiency in group 2 was 18.7 (4.1–84.9) compared with group 1.
Conclusions: This study demonstrates the presence of vitamin D deficiency at the Fourth Avenue Jail in Maricopa County, Arizona, particularly among inmates who have been housed at the facility for >1 y. Because marked vitamin D deficiency is associated with a myriad of adverse health outcomes, consideration should be given to providing dietary or supplemental vitamin D to inmates at correctional facilities.

Introduction

Vitamin D has traditionally been recognized for its key role in bone health [1]; however, recent evidence has implicated the hormone with a variety of diseases and conditions including diabetes [2], cardiovascular disease [3], cancer [4], infectious disease [5], immune function [6], metabolic dysregulation [7], and mental health disorders [8], including depression [9]. Therefore, the risks associated with long-term vitamin D insufficiency are potentially severe. For adults under the age of 70 y, the current Institute of Medicine recommendation for adequate intake of vitamin D is 600 IU/d [10]. The primary source of vitamin D in the United States is dairy products; however, 1 cup or 8 oz of vitamin D-fortified milk contains only 115 to 124 IU of vitamin D [11]. Additionally, although this nutrient may be consumed through the diet, endogenous synthesis is a major contributor to overall vitamin D status [10]. Therefore, populations with limited sun exposure, such as inmates in correctional facilities, are at increased risk for vitamin D inadequacy or deficiency.

In the United States, more than 2.2 million individuals are incarcerated at the state and federal levels [12]. Of these, more than 40,000 are housed in the state of Arizona [13], and approximately a quarter of Arizona inmates are housed in Maricopa County [14], which encompasses Phoenix, the largest city in the state. Incarcerated populations comprise a substantial area of interest to stakeholders regarding health care funding. For example, the cost per capita for health care among Arizona inmates was reported to be $4005 in 2001 and $4523 in 2008 after adjustment for inflation; this represents an increase of 12.9% in health care spending during that time period [15]. Therefore, it is

ETJ and CJM were equally responsible for formulation of the research question and designing the study. CJM was responsible for carrying out the study within the Maricopa County Fourth Avenue Jail. ETJ was primarily responsible for data analysis and preparation of the manuscript. The authors have no conflicts of interest to report.

* Corresponding author. Tel.: +1 520 626 0341; fax: +1 520 626 9275.
E-mail address: Jacobse@email.arizona.edu (E. T. Jacobs).

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important to explore comparatively low-cost interventions for maintaining the health of correctional populations, and one such potential area of interest is nutrition.

Adequate nutrition has been identified by the United Nations as a basic human right [16]; however, adherence to recommended dietary guidelines by correctional facilities does not fall under the aegis of federal regulations and is largely at the discretion of jail or prison officials [17]. Poor nutrition is associated with a myriad of adverse chronic and infectious disease outcomes that are common within incarcerated populations and range from overweight and obesity to infectious diseases such as tuberculosis [18,19]. Due to potentially reduced ultraviolet (UV) exposure, one nutrient of particular interest to the health of correctional populations is vitamin D.

Prior studies have demonstrated that intake of vitamin D in correctional facilities is lower than recommended guidelines [17,20,21]. However, due to the major contribution of cutaneous synthesis to vitamin D status, studies of the vitamin D metabolite 25-hydroxycholecalciferol [25(OH)D] among inmates are required to fully elucidate vitamin D adequacy. To date, only one study conducted in a Massachusetts correctional population has employed this biomarker to assess vitamin D status [22], and whether the findings of that study are applicable to inmates in a sun-replete geographic location is unknown. Therefore, the objectives of this study were to evaluate the vitamin D status of inmates at the Fourth Avenue Jail in Maricopa County (Phoenix), Arizona using measurements of blood 25(OH)D levels; and to compare the concentrations of 25(OH)D between inmates who were incarcerated for <6 wk compared with those incarcerated for >1 y.

Methods

Study population

The population of the present study consisted of 59 inmates incarcerated at the Fourth Avenue Maricopa County Jail. All male inmates between the ages of 20 and 41 y who were able to read and write in English were eligible for study inclusion. Because one of our a priori hypotheses was to compare circulating 25(OH)D concentrations of those who were newly incarcerated with those who had been at the Fourth Avenue Jail for at least 1 y, we employed two main procedures for study recruitment. For the newly incarcerated group (group 1), men within the eligible age range who presented for a health assessment within 2 mo of incarceration were approached for participation in the study by Maricopa County Correctional Health Services (MCCHS) staff. For those incarcerated >1 y (group 2), any eligible inmate who presented for, or requested, a medical assessment or examination was invited to join the study. When inmates from either group agreed to participate, the consent process was completed.

Ethics

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the University of Arizona Institutional Review Board (Protocol 13-0439) and the MCCHS. Written informed consent was obtained from all participants. Because the proposed study was conducted within a population categorized as vulnerable by the Code of Federal Regulations, we followed all additional procedures required by the University of Arizona Human Subjects Protection Program. We addressed each of criteria outlined in 45 CFR §46.305, and thereafter the study and all related procedures were approved by the university's Institutional Review Board (Protocol 13-0439) and the MCCHS.

Data collection and study procedures

After the informed consent process was completed, including obtaining written informed consent from all participants, data regarding age, race, height and weight, and time of incarceration were collected from each study participant. Additionally, a single blood draw of 10 cc was obtained from each inmate. These samples were collected at the initial health assessment for newly incarcerated inmates, and at the health examination of those inmates who had been in the jail for >1 y. Samples were immediately shipped for analysis of 25(OH)D using the methods described here.

Analysis of vitamin D metabolite levels

Deidentified serum samples from study participants were shipped to Bio-Reference Laboratories, Incorporated (Elmwood Park, NJ, USA) for analysis of 25(OH)D concentrations using a chemiluminescent immunoassay. Bio-Reference Laboratories is a standard commercial laboratory and employs several quality assurance and quality control measures to monitor analytical precision and to identify possible laboratory shifts over time. The laboratory currently holds licenses for testing in New York City, New Jersey, and New York state, as well as an interstate license issued by the U.S. Health Care Financing Administration (HCFA). The laboratory did not retain any data related to this study, and all analyses were conducted in a blinded fashion.

Statistical analyses

Descriptive data for study population characteristics overall and in groups 1 and 2 were calculated with means and SDs for the continuous variables and frequencies and percentages for the categorical variables. For comparisons of participant characteristics and concentrations of 25(OH)D by group, a Student's *t* test, with log-transformation of 25(OH)D levels, was used; χ^2 analyses were employed to compare categorical variables by group. Analysis of variance was used for statistical tests of differences in 25(OH)D concentrations by population characteristics with more than two categories. Additionally, we categorized study participants using the criteria for vitamin D deficiency and inadequacy established by the Endocrine Society [23]. Deficiency was defined as circulating 25(OH)D concentrations <20 ng/mL; inadequacy included those with 25(OH)D levels >20 and <30 ng/mL. Participants with 25(OH)D levels ≥30 ng/mL were classified as adequate. Unconditional logistic regression modeling was used to evaluate the odds ratios (95% confidence intervals [CI]) for risk for vitamin D deficiency or inadequacy in group 2 compared with group 1. Adjusted models included age and body mass index (BMI) to control for potentially confounding variables. Other variables including race and season of blood draw were not confounders in the present analysis. All analyses were conducted using the STATA statistical software package (version 9.0, Stata Corporation, College Station, TX, USA).

Results

Data were obtained from 59 inmates at the Fourth Avenue Maricopa County Jail, including 29 in the newly incarcerated group (group 1), and 30 who had been incarcerated for >1 y (group 2). As shown in Table 1, there were no significant differences between the groups for age, BMI, race, or season of blood draw, which occurred exclusively in the fall and winter seasons. As expected, there was a significant difference in length of incarceration between the two groups, with inmates in group 1 having a mean of 0.7 (SD = ±2) mo and those in group 2 having been incarcerated for a mean of 27.2 (SD = ±16) mo. Table 2

Table 1
Characteristics of study participants, by incarceration group

Characteristic	Total (N = 59)	Group 1* (n = 29)	Group 2† (n = 30)	*P*-value‡
Age, y (mean ± SD)	31.0 ± 6.1	29.9 ± 6.3	32.0 ± 5.8	0.20
BMI, kg/m^2 (mean ± SD)	27.9 ± 6.0	28.0 ± 6.9	27.8 ± 5.1	0.93
Time incarcerated, mo (mean ± SD)	14.1 ± 17.6	0.7 ± 2.0	27.2 ± 16.0	<0.0001
Race, n (%)				
White	20 (34.5)	7 (24.1)	13 (44.8)	
Black or Hispanic	33 (56.9)	18 (62.1)	15 (51.7)	
Other	5 (8.6)	4 (13.8)	1 (3.5)	0.14
Season of blood draw, n (%)				
Fall	27 (45.8)	14 (48.3)	13 (43.3)	
Winter	32 (54.2)	15 (51.7)	17 (56.7)	0.70

BMI, body mass index
* Group 1 incarcerated at Fourth Avenue Maricopa County Jail <6 wk.
† Group 2 incarcerated at Fourth Avenue Maricopa County Jail >1 y.
‡ *P*-value for group 1 versus group 2 calculated using Student's *t* test for continuous variables and χ^2 analysis for categorical variables.