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Vitamin D intakes of children differ by race/ethnicity, sex, age, and income in the United States, 2007 to 2010☆

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ABSTRACT

The 2007-2010 National Health and Nutrition Examination Survey was used to estimate vitamin D intakes of children 1 to 18 years old in the United States by race/ethnicity, sex, age, and family using 24-hour dietary intake recalls and dietary supplement use questionnaires. We hypothesized that total, dietary, and supplemental vitamin D intakes of children would differ by race/ethnicity, sex, age, and income. Statistical analyses of weighted data were performed using Statistical Analysis Software (V 9.2) to estimate means ± SE. Race and ethnic intake differences controlling for poverty income ratio (PIR), sex, and age were assessed by analysis of covariance. Total (dietary and supplement) vitamin D intake was greater in the high (7.9 ± 0.3 μg/d) vs the medium (6.5 ± 0.3 μg/d) income group, but not the low (7.2 ± 0.2 μg/d) PIR group. Total vitamin D intake of non-Hispanic (NH) white children (8.1 ± 0.2 μg/d) was greater than Hispanic (7.0 ± 0.2 μg/d) and NH black (5.9 ± 0.2 μg/d) children. Total vitamin D intake declined with age, and intake by boys was higher than girls. Only 17.4% of the children consumed supplements containing vitamin D. Overall, mean intake of vitamin D by all children in each age and ethnic group was lower than the estimated average requirement for vitamin D. Public health efforts should encourage consumption of foods high in vitamin D, expand the number of foods fortified, and target health messages to parents to increase use of vitamin D supplements by children.

1. Introduction

Vitamin D status has become a public health concern in the United States, and in 2010, Dietary Guidelines for Americans identified low vitamin D intake as a public health concern [1]. Over the last several years, vitamin D deficiency has been reported among many children [2] and adults [3], and especially for certain ethnic groups [4]. Non-Hispanic (NH) black and Hispanic children were more likely to have suboptimal levels of vitamin D than NH white children in the US [2]. Multiple factors likely contributed to race/ethnic vitamin D differences including economic status, reduced

Abbreviations: BMI, body mass index; EAR, estimated average requirement; IU, international unit; NH, non-Hispanic; NHANES, National Health and Nutrition Examination Survey; PIR, poverty income ratio; RDA, recommended dietary allowance; US, United States; UV, ultraviolet; SAS, Statistical Analysis Software; SE, standard error; SR, standard reference; 25(OH)D, 25-hydroxyvitamin D.

☆ Note: The study was not registered at ClinicalTrial.gov because data were publically available.

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nutrient intake, and skin pigmentation [5–9]. Minority groups are more likely to have lower incomes compared to white [10], and access to nutritious food may be too expensive or limited, therefore contributing to nutrient health disparities [11]. Furthermore, increased skin pigmentation may reduce cutaneous synthesis of vitamin D and increase the risk of a deficiency [12,13]. Vitamin D is produced endogenously through exposure of skin to ultraviolet (UV) light, which stimulates conversion of the precursor, 7-dehydrocholesterol, to previtamin D_3 that is rapidly converted to D_3[14].

Although vitamin D plays an important role in the optimal rate of bone accretion and in maintaining strong bones and teeth throughout childhood, identification of vitamin D receptors in most tissues indicates an expanded role of vitamin D. Adequate vitamin D status may provide a protective effect against the development of chronic conditions during childhood including asthma, cystic fibrosis, inflammatory bowel disease, and tuberculosis [15]. Later in life, vitamin D may provide protection against the future development of cardiovascular disease and cancer [16]. Among adult populations, high 25-hydroxyvitamin D [25(OH)D] levels are associated with a substantial decrease in prevalence of cardiovascular disease, type 2 diabetes, and the metabolic syndrome [17]. In 2010, the Institute of Medicine revised dietary reference intakes for vitamin D and established the estimated average requirements (EARs) as 10 μg/d to meet the needs of half of the children aged 1 to 18 years [18]. The recommended dietary allowance (RDA) was also established as 15 μg/d to meet the needs of 97.5% of children aged 1 to 18 years [18].

The two major forms of vitamin D are ergocalciferol (vitamin D_2) and cholecalciferol (vitamin D_3). Cholecalciferol occurs naturally in very few foods (oily fish, meat, and egg yolks) and is added to some foods (milk, milk products, calcium-fortified juices, and fortified breakfast cereals). Ergocalciferol is produced in mushrooms exposed to UV light. Likewise, irradiation of yeast produces ergocalciferol, which is used in fortification of foods such as soy milk. In the United States, fortified foods represent the primary dietary source of vitamin D [19], and between 2003 and 2006, fortified milk (60.4%) and milk drinks (8.3%) provided the major source of dietary vitamin D for children aged 2 to 19 years [20].

The vitamin D content of foods was included for the first time in the National Nutrient Database for standard reference (SR) in 1991 based on some analytical data, processed food label declarations, and calculated values from ingredient composition [21]. In 2008, using high-pressure liquid chromatography and UV spectroscopic methods, vitamin D_2 and vitamin D_3 concentrations were added to SR22 and used to estimated vitamin D intakes for the National Health and Nutrition Examination Survey (NHANES) 2005-2006 cycle [22–24]. As vitamin D–fortified products (yogurts, margarine brands, cereal bars, etc.) enter the marketplace [25], vitamin D content is now routinely measured and incorporated into SR updates.

Given the increased interest in the role of vitamin D in children's health, the continuing vitamin D analytical updates of the food supply, the establishment of the vitamin D EAR and RDA for children, and interest in economic and race/ethnic factors that may contribute to health disparities, we estimated vitamin D intake in the United States for children during 2007-2010. We hypothesized that total, dietary, and supplemental vitamin D intakes of children would differ by race/ethnicity, sex, age, and income. Earlier studies estimating vitamin D intake of children typically had grouped children and adolescents into wider age categories [2,26] or used arbitrary income ranges that did not account for family size [27]. Furthermore, previous comparisons of milk intake, the major source of vitamin D in the United States, of boys and girls revealed sex differences [28]. Therefore, we compared total, dietary, and supplemental vitamin D intake of children during 2007-2010 by race/ethnicity, sex, age, and family poverty income ratio (PIR). By helping to identify subgroups of children particularly at risk for low vitamin D intake, enhanced awareness of these health disparities may lead to increased vitamin D fortification of foods and use of supplements by children in the United States.

2. Methods and materials

2.1. *Survey design and source of data*

The NHANES is a nationally representative, cross-sectional survey of US residents that may be used for the examination of the relationship between diet, nutrition, and health [29]. The survey uses a complex multistage probability sampling design with oversampling of certain races/ethnicities and age groups to select a sample representative of the noninstitutionalized US civilian population [30]. A detailed description of the survey design, content, operations, and procedures can be found elsewhere [31].

To increase the study sample size, NHANES 2007-2008 and 2009-1010 were combined to provide a final total of 8214 children age less than 19 years for analysis. The study measures obtained from the NHANES demographic file included race/ethnicity, sex, age, and PIR. From the initial 8214 children, participants less than 1 year of age (n = 598) were excluded or when 24-hour dietary recall data the Food Surveys Research Group was judged to be incomplete or unreliable (n = 897) [32].

Ethnicity and race were derived from self-reported or parental information obtained in the screener and the household interviews [33]. For our analyses, groups were categorized into the following: NH whites, NH blacks, Hispanics, and other ethnic groups. Hispanics were composed of Mexican American and other Hispanic combined into one Hispanic group to increase sample size for analysis. Statistical results for the other ethnic group (n = 493) were not included because of the small sample size and wide variation within the group, which made meaningful interpretation difficult. Therefore, the final sample size of the study equaled 6226 children.

Participants were classified as boys or girls based on self-reported or parental data. Children were grouped by body mass index (BMI; kg/m^2) percentiles, with <85th percentile defined as normal weight and underweight, ≥85th to <95th percentile as overweight, and ≥ 95th percentile as obese. Participants were categorized into income groups by PIR, which was determined by the US Census Bureau method of dividing family income by poverty threshold specific to a family size [34]. Children were classified by parental PIR into low income (≤131% below the poverty level), medium income (131.01%-185% of the poverty level), or high income (>185% the poverty level).