Relation of Vitamin D Intake and Sun Exposure to Respiratory Conditions in Hispanics

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Abstract

Background: Low vitamin D status could predispose individuals to higher risk of respiratory conditions.

Objective: To assess if vitamin D intake and sun exposure is associated with respiratory conditions in a group of Hispanic adults in Puerto Rico.

Methods: Hundred adults completed a questionnaire about respiratory conditions (asthma, allergies and respiratory infections). Vitamin D intake and sun exposure were estimated using validated questionnaires. An index score was created combining data from both questionnaires, which ranged from 0-6 points. Associations between the combined index score (< 3 or ≥ 3) and respiratory conditions were determined using Chi-square/Fisher’s exact tests.

Results: Mean age was 45 ± 9 y and most were overweight/obese (75%). Those with a combined vitamin D intake and sun exposure index score ≥ 3 had less allergies and any respiratory condition/symptom compared to an index < 3 (p < 0.05).

Conclusions: In this group of adults in Puerto Rico, a high combined vitamin D intake and sun exposure index score was significantly associated with fewer respiratory conditions and symptoms.

Keywords: Vitamin D Intake, Sun Exposure, Asthma, Allergy, Respiratory Infections; Puerto Rico

Abbreviations

CDC: Center of Disease Control; WHO: World Health Organization; BMI: Body Mass Index; IU: International Units; 25(OH)D: 25-hydroxyvitamin D; FFQ: Food Frequency Questionnaire.

Introduction

The monitoring of vitamin D status has gained recent relevance due to its effect on the immune response [1]. Vitamin D status is best assessed by measuring serum 25(OH)D levels, which reflect the contributions from both the cutaneous synthesis and total intake (foods and supplements) [2]. The Institute of Medicine has established that serum 25(OH)D levels < 30 nmol/L are considered deficient while levels 50 nmol/L or greater are considered sufficient [2]. Studies have found a relationship between vitamin D deficiency and higher prevalence of respiratory infections [3,4], allergies and asthma [5,6]. However, not all studies have shown consistent results.

Vitamin D deficiency is a worldwide public health problem, including in countries with sun exposure all year round and in countries with vitamin D fortified foods [7]. This high prevalence of vitamin D deficiency may be due to several factors, such as the increased rate of obesity, low vitamin D intake and indoor lifestyles and dark skin [1]. In the US and Europe, vitamin D deficiency and insufficiency has been estimated in 30-50% of the population [8]. Hispanics are particularly at high risk of low vitamin D status [9].

Puerto Rico is not an exemption; a study using a large sample size (> 4090 of individuals) found vitamin D deficiency in 24.9% and vitamin D insufficiency in 43.6% [10]. Such high prevalence of low vitamin D status is present even though Puerto Rico is situated near the Equator, with sun exposure all year around and minimal seasonal changes.

Asthma and respiratory infections are conditions highly prevalent in most populations. In the US, the prevalence of asthma is about 8.2%, as reported in 2009 by the Center of Disease Control (CDC) [11]. This report also showed a higher prevalence among females, children, non-Hispanic blacks and Puerto Ricans. With respect to influenza, the World Health Organization (WHO) has estimated 250,000 to 500,000 deaths annually attributable to this condition [12]. Others infections such as acute respiratory infections has been estimated globally as the third cause of death, with 4.6 million of deaths on 2004 [13]. A common observation among different investigators is the high prevalence of these infections during the months of less sun exposure.

These conditions have an impact in the quality of life of individuals and also have important economic consequences. One such impact is the number of days absent from work due to the symptoms caused by these conditions. The CDC has reported that the absentees due to asthma were estimated in 11.8 million workdays per year [11]. The Asthma and Allergy Foundation have estimated that 27,000 adults are missing work days due to asthma and 4,700 people are visiting the emergency room due to asthma attacks per day [14]. With respect to respiratory infections and allergies, a study in 8267 employees at 47 employer’s locations found that allergic rhinitis was the most prevalent condition with 3.6 days of absenteeism and the cost of lost productivity was estimated in 4.9 million dollars per year [15].

Given the impact of respiratory conditions on quality of life and in the economy, it is of great importance to find factors associated with these conditions. Low vitamin D status, vitamin D intake or sun exposure appears to be associated with an increase risk of respiratory conditions but more studies are needed to clarify the inconsistent results found between available studies. Therefore, the objective of the proposed study was to assess if vitamin D intake and sun exposure was associated with asthma, allergies, or upper respiratory infections or their symptoms in a group of adults in Puerto Rico.

Methods

This cross-sectional study was conducted among employees of a pharmaceutical company (non-nutritionally related) located in the northern area of Puerto Rico. For this study, participants completed a questionnaire about respiratory conditions. Vitamin D intake and sun exposure were estimated using validated questionnaires. All participants signed a consent form approved by Investigation

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Review Board of the Medical Sciences Campus in the University of Puerto Rico and by the pharmaceutical company. The study was conducted from November 2014 to January 2015.

**Study Population**

All employees (n = 340) over 21 years were invited to participate in the study using the internal company’s email and by posting the invitation at the nursing department of the company.

**Measures**

Participants completed a questionnaire with the following information:

**Socio-demographics:** Which included sex, age (years), and education level (high school, technical grade, bachelor degree or higher).

**Anthropometrics:** Participants self-reported their weight (pounds) and height (inches). These were transformed into kilograms (kg) and meters (m), respectively. Body mass index (BMI) was calculated as: kg/m². Subjects were classified using the WHO cut-off points as: healthy weight if BMI was 18.5-24.9 kg/m²; or as obese if BMI was ≥ 30 kg/m² (16).

**Vitamin D intake:** A previously validated semi-quantitative food frequency questionnaire (FFQ) of foods and supplements rich in vitamin D was used (17). This FFQ was composed of 22 items that were considered potential sources of vitamin D, such as milk and other dairy products, fish, margarine, fortified foods (breakfast cereals and juices) and supplements. It also included an open-ended question regarding the type of such products consumed and the approximate serving size for each. The frequency of each food item was assessed for the last month, ranging from three or more servings per day to rarely or never. The frequency was converted into frequency per day; for this, when participants chose a monthly frequency of consumption (e.g. one per month), this was divided by 30; when it was a weekly consumption (e.g. one per week), this was divided by seven. To estimate vitamin D consumption from foods, we multiplied the frequency (in days) by the serving size specified by the participant. Then, this was multiplied by the amount of vitamin D in that food (expressed in International Units) based on the serving size specified to obtain the vitamin D content per food per serving per day. This was done for each food and then summed to obtain the total vitamin D content from foods per day. Vitamin D content of each food was recorded from the US Department of Agriculture National Nutrient Database for Standard Reference [18]. For supplements, participants were asked to provide the name, brand and dose used. To estimate vitamin D intake from supplements, the dose was multiplied by the frequency of use for each supplement containing vitamin D. The total vitamin D intake was obtained by adding the amount from foods and supplements and categorized as: < 200, 200-400, 401-600, > 600 International Units (IU)/d based on the current vitamin D recommendation of 600 IU/d (2).

**Sun exposure:** A previously validated sun exposure questionnaire and sun exposure index was used (17). Briefly, this sun exposure index was calculated by assigning scores to each premise included in the questionnaire as follows: frequency in which participants were outside more than 15 min (range score 0 “never” to 7 “daily”), the time of day they were outdoors (range score 0 “no sun use” to 8 “between” 11 am - 3 pm), the type of clothing worn when outdoors (range score 0 “arms, legs, face and neck covered” to 3 “arms, legs, face and neck uncovered”), the frequency of sunscreen used (range score 0 “daily” to 3 “never”), the level of sun protection factor used (range score 0 “>30 SPF” to 3 “No use”), the anatomical sites protected with sunscreen (range score 0 “use in arms, legs, face and neck” to 6 “no use”), and their ability to tan and tendency to burn after sun exposure (range score 0 “never burns or tans or deeply pigmented skin” to 6 “tans and burns easily or very lightly pigmented skin”). This index ranged from 0 (no sun exposure, high use of clothing and sunscreen when outdoors and never burns/tans or deeply pigmented skin) to 600 (high sun exposure, no sunscreen and light clothing when outdoors and burns easily, tans deeply or very lightly pigmented skin).

An index score was constructed combining the results from the assessment of vitamin D intake and the results of the sun exposure index.

The sun exposure index was assigned the following points:

- 0 points if a participant had a sun exposure index ranging from 0 to 8;
- 1 point if a participant had a sun exposure index ranging from 9 to 17 or;
- 2 points if a participant had a sun exposure index ranging from 18 to 25; and
- 3 points if a participant had a sun exposure index > 25.

Vitamin D intake was assigned the following points:

- 0 points if vitamin D consumption was < 200 IU/d;
- 1 point if vitamin D consumption ranged from 200 to 400 IU/d;
- 2 points if vitamin D consumption ranged from 401 to 600 IU/d; and
- 3 points if vitamin D consumption was > 600 IU/d.

The points were added to obtain a total combined index score ranging from 0 to 6.

**Respiratory related conditions and symptoms:** Participants were asked questions related to the frequency of having the following conditions in last six months: allergy, asthma, and respiratory infections (such as Respiratory syncytial virus, Influenza, bronchitis, and pulmonary disease). Also, they were asked about the following symptoms in last six months: chest whistle, short breath, phlegm, runny nose and swelling eyes.

**Statistics**

Baseline characteristics were summarized using descriptive statistics (location and dispersion statistics) for continuous variables and frequency distributions for categorical variables. The combined vitamin D intake and sun exposure index score was associated with the respiratory conditions using Chi-square test or Fisher’s exact test. The numerical values for combined vitamin D intake and sun exposure index score were divided into two categories using the median of three in the analyses. Data analyses were performed using the Stata: Data Analysis and Statistical Software version 13 software (StataCorp LP. College Station, TX). The significance level was set at p < 0.05.

**Results**

Table 1 shows the general characteristics of the sample. Our response rate was 30% (n = 100 participants). Mean age was 45 ± 9 years with approximately equal number of males and females. Most had a bachelor’s degree or higher level of education (75%) and most were overweight (43%) or obese (32%) (data not shown in table).
Vitamin D intake from foods, supplements and total intake and sun exposure in the total sample is shown in Table 2. There were no differences by sex (results not shown). In general, vitamin D intake from foods was low (200 ± 120 IU/d) and supplements increased total vitamin D intake to 1000 ± 1900 IU/d. The sun exposure index was 19 ± 5, out from a range of 0-36. Table 2 also shows the re-categorized scores for vitamin D and sun exposure and the combined vitamin D intake and sun exposure index scores. Similar scores were obtained for both variables with a combined average score of 3.2 out of a range of 0-6.

Table 3 shows the prevalence of respiratory conditions in the total sample. The highest prevalence was found for allergies (37%), followed by respiratory infections (9%). The symptoms with the highest prevalence were runny nose and swelling eyes (29%) and phlegm (17%).

The associations between the combined sun exposure and vitamin D intake index score and respiratory conditions and their symptoms are shown in Table 4. Those with a combined vitamin D intake and sun exposure index score < 3 were more likely to have allergies (44%) and runny nose and swelling eyes (40%) compared to those with an index score ≥ 3 (allergies 24% and with runny nose and swelling eyes 11%; \( p < 0.05 \)). Also, those with a combined vitamin D intake and sun exposure index score < 3 were more likely to have any respiratory condition or symptom (51%) compared to those with an index ≥ 3 (16%; \( p < 0.05 \)).

**Discussion**

In this cross-sectional study among employees from a northern pharmaceutical company in Puerto Rico, we found that a high combined vitamin D intake and sun exposure index score was significantly associated with lower prevalence of respiratory conditions and symptoms.
Prevalence of asthma found in the present study (9%) was similar to reports in the US (8.2%) [11], although somewhat lower than other reports among Puerto Ricans (15.7%) [19]. With respect to allergies and related symptoms (runny nose and swollen eyes), we found a prevalence of 37%, which is somewhat similar to the prevalence in the US (30%) [20]. Therefore, our sample was not composed of at-risk individuals, as reported in most studies, which allowed associating these two variables in the general population.

A handful of studies have assessed the association between vitamin D intake or sun exposure with respiratory conditions. A study in Sweden conducted among 799 adolescents found no association between allergy and total daily intake of vitamin D [21]. Another study conducted in Norway found no significant association between fish consumption (main source of vitamin D), use of fish oil supplement (rich in vitamin D) or any other supplement or sun exposure with respiratory tract infections [22]. In young children, a study found that those with acute lower respiratory infections had lower vitamin D intake compared with controls [23]. Furthermore, among pregnant women, vitamin D intake was found to be independently positively associated with the prevalence of asthma throughout pregnancy [24]. Among studies assessing vitamin D by serum 25(OH)D levels, some have found inverse associations between vitamin D status and allergy [1], infections [4], asthma [6,25], while others have not [22,26]. Among intervention trials investigating the effects of vitamin D supplementation on respiratory conditions, inconsistent results have been found [27-30]. These inconsistencies could be explained by differences in vitamin D doses and regimens used, using populations with different vitamin D status, age, skin color, etc., differences in latitude and seasons, and differences in methods for measuring serum 25(OH)D levels, among others.

The main mechanism proposed to explain the role of vitamin D in preventing respiratory conditions is its immunomodulation role [31]. There are several immune pathways that are affected by vitamin D. Vitamin D could enhance innate immunity by up-regulating the expression and secretion of antimicrobial peptides, such as defensin [32] and peptide LL-37 [33], which boosts mucosal defenses. At the same time, vitamin D also prevents excessive inflammation by modulating the expression and secretion of pro-inflammatory cytokines and chemokine [34]. However, these effects depend on the disease state studied, as some conditions promote more inflammation than others, and also on the vitamin D status of the individuals tested [35].

There are a few limitations to address in this study, such as not assessing vitamin D status through serum 25(OH)D level, the small sample of Hispanic participants employees of a pharmaceutical company in Puerto Rico, and the cross-sectional nature of our study. Also, we did not assess past and current smoking, an important factor contributing to the development of respiratory conditions. In addition, we did not include other foods that could also contribute to total vitamin D intake, such as meats (beef, poultry or pork). However, we used validated instruments to assess vitamin D intake and sun exposure; although some recall bias could be present. In addition, we included a population with similar prevalence of respiratory conditions as in the general population.

In conclusion, a high combined vitamin D intake and sun exposure improve sun exposure through participation in outdoor activities as part of their lifestyles during sun hours (without overexposure to prevent other serious health conditions such as skin cancer) and increasing intake of vitamin D rich foods such as fatty fish and fortified foods (milk, orange juice, etc.) or use of vitamin D supplements in those who have low serum 25(OH)D levels.

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