Original article

The association of vitamin D deficiency and glucose control among diabetic patients

Mansour S Almetwazi [a,b,*], Ahmad O Noor [c], Diena M Almasri [c], Ioana Popovici [d], Tariq Alhawassi [a,b], Khalid A Alburikan [a], Catherine A Harrington [d]

[a] Clinical Pharmacy Department, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia
[b] Medication Safety Research Chair, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia
[c] Clinical Pharmacy Department, College of Pharmacy, King Abdulaziz University, Saudi Arabia
[d] Department of Sociobehavioral and Administrative Pharmacy, College of Pharmacy, Nova Southeastern University, Fort Lauderdale, FL, USA

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ABSTRACT

Objective: To evaluate the association between the level of vitamin D and glycemic control among patients with diabetes.

Research design and method: We analyzed data collected from NHANES 2003–2006. We included only non-pregnant adult diabetic persons 18 years or older. Participants who had vitamin D level less than 20 ng/ml were considered as having vitamin D deficiency. Participants were considered to have a glucose control if the HbA_{1c} level was less than 7% [53 mmol/L]. We used student's *t* test to compare the difference in HbA_{1c} means between people with Diabetes with and without a vitamin D deficiency. We used a multivariate logistic regression model to predict the relationship between glucose control and vitamin D deficiency. We used race/ethnicity, BMI, age, gender, type of diabetic medication used, having health insurance or not, and comorbid conditions (hypertension, anemia, cholesterol, liver disease, and kidney disease) as control variables.

Results: The study population included a total of 929 non-institutionalized, non-pregnant, diabetic adult persons. About 57% of patients with diabetes had a vitamin D deficiency. Blacks (non-Hispanic patients) with diabetes had the highest rate of vitamin D deficiency (79%). The unadjusted means of HbA_{1c} were significantly different between diabetic patients with no vitamin D deficiency and those with a vitamin D deficiency (7.06% [54 mmol/L], 7.56 % [59 mmol/L], respectively, P < 0.0001). Multivariate adjustment showed a small but not significant, increase in odds (11%) of having uncontrolled diabetes in patients with a vitamin D deficiency after adjustment for other factors.

Conclusion: Vitamin D deficiency is very common in patients with diabetes. We found no significant association between vitamin D level and glycemic control in patients with diabetes after adjustment for control variables.

1. Introduction

Vitamin D has many roles in the regulation of the mineral homeostasis as well as other non-skeletal functions. Of these roles, increasing insulin secretion and insulin sensitivity (Sung et al., 2012). Studies have shown that a low serum level of vitamin D increases the risk of developing diabetes (Afzal et al., 2013; Schöttker et al., 2013; Tsur et al., 2013). Other studies have found that vitamin D deficiency is associated with complications of diabetes such as neuropathy and retinopathy (Patrick et al., 2012). However, little is known about the strength of the association between Vitamin D levels and glucose control.

Only a few studies have examined the association between vitamin D levels and diabetic control. A study conducted in Iran evaluated the effect of vitamin D on insulin resistance in patients with Type 2 diabetes. Researchers found that raising the level of vitamin D improved the fasting plasma glucose and reduced insulin

* Corresponding author at: King Saud University, College of Pharmacy, Riyadh, Saudi Arabia.
E-mail address: mmetwazi@ksu.edu.sa (M.S Almetwazi).

resistance in these patients (Talaei et al., 2013). Another study that was conducted in Saudi Arabia found that vitamin D supplementation significantly improved their insulin resistance and lipid profile (Al-Daghri et al., 2012). A couple of studies used HbA_{1c} as an outcome, which might had a better estimation of diabetes control over fasting blood glucose (FBG) (Jorde and Figenschau, 2009; Ljunghall et al., 1987; Mohamad et al., 2016). However, no studies were found to determine the association between vitamin D and glycemic control in diabetic patients in the U.S.

Based on the Institute of Medicine (IOM), there are four categories of vitamin D status: (1) risk of deficiency: if the level of serum 25-hydroxyvitamin D (25OHD) is less than 12 ng/ml, (2) risk of inadequacy: if the level of 25OHD is between 12 to less than 20 ng/ml, (3) sufficiency: if the level of 25OHD is between 20 to 50 ng/ml, (4) and possibly harmful: if the level of 25OHD is more than 50 ng/ml (Ross et al., 2011). In 2011, a report claimed that about 32% of United States population had a level of vitamin D of less than sufficiency (Looker et al., 2011).

The purpose of this retrospective cross-sectional study was to examine the relationship between levels of vitamin D and diabetes control among patients with diabetes (both Type 1 and 2 but not gestational) drawn from National Health and Nutrition Examination Survey (NHANES) 2003–2006. We also explored the association between HbA_{1c} levels and serum vitamin D status (deficiency or non-deficiency) in patients with diabetes in the U.S.

Patients with diabetes are more susceptible to have serious health complications such as cerebrovascular disease, retinopathy, coronary heart disease, nephropathy and neuropathy. From this study we will be able to know the effect of vitamin D level on the HbA_{1c} that may help to reduce the complications of diabetes. Moreover, the study will describe the vitamin D status among the patients with diabetes.

2. Materials and methods

2.1. Design

Secondary database analysis using data collected in NHANES that used a cross-sectional design.

2.2. Data source

NHANES is a program of studies designed to assess the health and nutritional status of adults and children in the United States. It is implemented by the US National Center for Health Statistics, part of the Centers for Disease Control and Prevention. NHANES uses a multistage stratified sampling design to collect data from the non-institutionalized civilian US population. The survey is unique in that it combines interviews, physical examinations, and laboratory tests.

The analysis sample consists of non-pregnant diabetic persons 18 years or older selected from the NHANES 2003–2006 cross-sections. We used the data from 2003 to 2006 because the measurement technique was changed after 2006 in the dataset, and the vitamin D level was not available at the time of analysis. A participant was excluded if HbA_{1c} or serum vitamin D level data was missing. The participants were defined as having diabetes if they answer yes to the question, "they have ever been told by a doctor or health professional that they have diabetes or sugar diabetes" in the NHANES questionnaire.

2.2.1. Dependent variable
2.2.1.1. HbA1c and diabetes control
According to the American Diabetic Association (ADA), the goal for HbA_{1c} for non-pregnant adults is less than 7% [53 mmol/L].

Therefore, participants who had HbA_{1c} less than 7% [53 mmol/L] were considered to have glucose control (American Diabetes Association, 2017).

2.2.2. Independent variable
2.2.2.1. Serum vitamin D deficiency
From the categories of vitamin D levels, we classified the participants into two groups. The first group consisted of participants with serum vitamin D $\geq$ 20 ng/ml (non-vitamin D deficiency). The second group consisted of participants with serum vitamin D < 20 ng/ml (vitamin D deficiency).

2.2.3. Control variables
The analysis included the following additional covariates: age (young adults, aged 18–44, middle age adults, ages 45–64, and elderly, 65 years or older), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), gender, body mass index (BMI), having health insurance or not, type of diabetic medications used, and co-morbid conditions (i.e., hypertension, anemia, cholesterol, liver disease, and kidney disease). Diabetic patients were characterized into four groups based on Body Mass Index (i.e., underweight if the BMI was <18.5, normal weight if the BMI was between 18.5 and 24.9, overweight if the BMI was between 25 and 29.9, and obese if the BMI was $\geq$30). In regard to the type of diabetic medications, the precipitants were also classified into one of four groups (i.e., not using medications, using insulin only, using oral medication only, or using both insulin and oral medications).

2.3. Statistical analysis

Statistical analysis was performed using STATA® 11.0 statistical package. Data were weighted to represent the U.S. non-pregnant diabetic adults aged $\geq$18 years. Descriptive analyses were conducted to characterize the participant and to examine demographic differences between patients by Vitamin D deficiency category. Student's t test was used to compare the difference in HbA_{1c} means between diabetic patients with and without a vitamin D deficiency. A multivariate logistic regression model was used to predict the relationship between glucose control (HbA_{1c} <7% [53 mmol/L]) and vitamin D deficiency. Adjusted odds ratios, 95% confidence intervals were used to present the results, and the significance was set at P < 0.05.

Table 1
Demographic characteristics of diabetic patients, 2003–2006, U.S.

Characteristic	Number (%)
Gender	
Male	465 (50.1)
Female	464 (49.9)
Age	
Young adults (18–44 year)	104 (11.2)
Middle age adults (45–64	368 (39.6)
Elderly (≥65 year)	457 (49.2)
Race/ethnicity	
Hispanic	264 (28.4)
Non-Hispanic White	382 (41.1)
Non-Hispanic Black	246 (26.5)
Other	37 (4.0)
Body mass index	
Under weight	4 (0.4)
Normal weight	141 (15.2)
Over weight	285 (30.7)
Obese	499 (53.7)