INTRODUCTION

Vitamin D deficiency, as reflected by circulating 25-hydroxyvitamin D (25(OH)D) levels <20 ng/ml, is prevalent in as many as one-half of middle-aged to elderly adults in developed countries.\(^1\)\(^2\) The ubiquitous distribution of Vitamin D receptors in the body, controlled by nearly 3000 genes,\(^3\)\(^4\) suggest that a deficiency could have widespread health consequences. Thus, understanding the characteristics that promote Vitamin D deficiency in the general population has important clinical implications. Vitamin D deficiency is estimated to affect over 1 billion people worldwide,\(^4\) and its prevalence is increasing in conjunction with Type 2 diabetes (T2D), obesity, and derangements in metabolic traits. Recent studies have examined the physiological functions of Vitamin D beyond its well-established role in musculoskeletal health.\(^5\) In addition to findings of oncologic\(^6\) and immunologic\(^7\) associations, Vitamin D deficiency is associated with metabolic derangements and T2D.\(^6\)\(^7\)\(^8\) Although 1, 25(OH)D is the active form of Vitamin D, it is not suitable for measuring Vitamin D serum level. 25(OH)D has a longer half-life and it can more precisely show the food intake and skin production of Vitamin D. A serum level of <20 ng/ml (50 nmol/L) 25(OH)D is considered as Vitamin D deficiency, between 20 and 30 ng/ml as its insufficient level and higher than 30 ng/ml as its desirable or sufficient level.\(^9\)\(^11\)
Vitamin D status is known to be poor among Indians, however, limited data exists to assess the implications of T2D on Vitamin D status and metabolic traits in Indians. This study was conducted to assess the correlation of Vitamin D deficiency with T2D and metabolic risk factors in the Indian population.

**Aims and objectives**

- To evaluate the association of Vitamin D deficiency and T2D
- To examine the association of Vitamin D deficiency and metabolic traits.

**METHODS**

This prospective study was conducted in D. Y. Patil University, School of Medicine over a period of 1-year. Institutional Ethics Committee approval was obtained before starting the study. The study procedure was explained to the patients who volunteered and fulfilled the eligibility criteria. Informed consent was taken from the subjects before starting the study.

**Study procedure**

Out of the screened patients, those fulfilling the eligibility criteria were invited into the study. After explaining them the details of the study, written informed consent was taken from each of the participants. For the assessment of all the required parameters of the study, 10 ml of blood was collected after a fasting period of 12 hrs from both the groups, i.e., from diabetic and non-diabetic patients and the following tests were assessed:

- Fasting blood glucose
- Serum 25(OH)D levels
- Lipid profile, i.e., triglyceride, cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), very LDL (VLDL).

A detailed history regarding age, sex, smoking habits, alcohol consumption, blood pressure, diet, body mass index (BMI), waist circumference, and waist to hip ratio was noted down, and patients were also asked whether they were on any Vitamin D supplements.

**Duration:** 1 year.

**Sample size:** 144 patients (74 diabetic patients and 70 normoglycemic controls).

**Eligibility criteria**

**Inclusion criteria**

1. Either gender 18 years and above who have Vitamin D deficiency with serum 25(OH)D <20 ng/ml
2. T2D
3. Sign written informed consent.

**Exclusion criteria**

1. Impaired fasting glucose or impaired glucose tolerance test
2. Type 1 diabetes or secondary diabetes
3. Subjects taking Vitamin D supplementation
4. Pregnant and nursing mothers.

**Statistical analyzes**

Data for anthropometric and metabolic characteristics of the study subjects was expressed as mean±standard deviation or n (%). Student’s t-test was used for comparison of parameters in two groups. Regression analysis was applied to assess the impact of Vitamin D status on T2D and metabolic traits.

**RESULTS**

**Demographic and laboratory data**

25(OH)D was quantified in a total of 144 patients with a mean age of 55.95±10.95 in the diabetic patients and 44.42±16.79 in the non-diabetic patients. Among the participants, 52.7% were males in the diabetic group and 54.2% were males in the non-diabetic group. Furthermore, 51.38% had T2D while 48.61% were non-diabetics (Table 1).

**Prevalence of Vitamin D deficiency**

Levels of 25(OH)D as assessed in 144 patients showed that more number of patients in the non-diabetic group were Vitamin D deficient as compared to the diabetic group (Table 2).

**Association of Vitamin D deficiency with metabolic traits**

Analyzes were performed to assess the impact of Vitamin D status on T2D, and the related metabolic traits (Table 3). p<0.05 was considered as significant.

**DISCUSSION**

Vitamin D levels and its association with various factors such as T2D mellitus and other metabolic traits are gaining interest in upcoming research fields. Its levels prove to be important factors governing various health implications. In this study, a trend of Vitamin D deficiency in both diabetics and non-diabetics was observed, with 13.51% diabetics found to be Vitamin D deficient and 28.57% of non-diabetics as deficient in Vitamin D. Thus, more participants in non-diabetic group were deficient in Vitamin D which contrary to the outcome in other study which showed that out of the total 1765 participants, the T2D cases (50.2%) had a significantly
Vitamin D and lipid profile and statistically significant association of serum 25(OH)D with T2D, FBS, and the lipid profile parameters.

There is an inverse correlation between 25(OH)D and fasting blood sugar (FBS), serum triglycerides, HDL, and VLDL; however, the values were not statistically significant which is similar to the findings of the study conducted by Braun et al. in 2012 which reported a highly significant, inverse association of serum 25(OH)D with T2D, FBS, and the lipid profile parameters. A total of 13.51% patients in the diabetic group and 47.14% patients in the non-diabetic group had sufficient (≥30 ng/dl) Vitamin D levels. It can be observed that number of patients are having sufficient Vitamin D levels as Vitamin D deficient (≤20 ng/dl). Around 55.4% patients in the diabetic group while 28.57% patients in the non-diabetic group were classified higher prevalence of Vitamin D deficiency (83.5%) when compared to non-diabetic patients (68%). There was an inverse correlation between 25(OH)D and fasting blood sugar (FBS), serum triglycerides, HDL, and VLDL; however, the values were not statistically significant which is similar to the findings of the study conducted by Braun et al. in 2012 which reported a highly significant, inverse association of serum 25(OH)D with T2D, FBS, and the lipid profile parameters.

Table 1: Demographic data and laboratory results in diabetic and non-diabetic patients.

| Parameters     | Diabetics (n=74) | Non-diabetics (n=70) |
|----------------|------------------|----------------------|
| Age            | 55.95±10.95      | 44.42±16.79          |
| Males          | 39                | 38                   |
| Females        | 35                | 32                   |
| FBS (mg/dl)    | 160.88±69.75     | 92.95±10.22          |
| Total cholesterol (mg/dl) | 193.13±50.85      | 171.67±34.47         |
| Triglycerides (mg/dl) | 163.48±86.73      | 110.34±65.55         |
| HDL (mg/dl)    | 40.40±11.87      | 38.98±9.49           |
| LDL (mg/dl)    | 117.91±48.24     | 107.35±29.23         |
| VLDL (mg/dl)   | 32.09±17.55      | 22.03±13.16          |
| BMI (kg/m²)    | 25±4.63          | 24±4.12              |
| Waist circumference (cm) | 95.64±9.9       | 89.62±12.25          |

Table 2: Vitamin D levels in diabetic and non-diabetic patients.

| Vitamin D levels (ng/dl) | Diabetics n=74 (%) | Non-diabetics n=70 (%) |
|--------------------------|--------------------|------------------------|
| ≤20 (deficient)          | 10 (13.51)         | 20 (28.57)             |
| 21-29 (insufficient)     | 23 (31.08)         | 17 (24.28)             |
| ≥30 (sufficient)         | 41 (55.40)         | 33 (47.14)             |

Table 3: Correlation between 25(OH)D and biochemical parameters.

| Biochemical parameter | Pearson’s correlation coefficient (r) |
|-----------------------|--------------------------------------|
| Fasting blood glucose | -0.1897 0.0789                       |
| p value               | 0.51 (NS) 0.10 (NS)                  |
| Total cholesterol     | -0.2790 -0.0538                      |
| p value               | 0.01* 0.65 (NS)                      |
| Serum triglycerides   | -0.12691 -0.0935                     |
| p value               | 0.28 (NS) 0.44 (NS)                  |
| HDL                   | 0.079536 0.1379                      |
| p value               | 0.50 (NS) 0.25 (NS)                  |
| LDL                   | -0.2971 0.0207                       |
| p value               | 0.01* 0.86 (NS)                      |
| VLDL                  | -0.1292 -0.0911                      |
| p value               | 0.27 (NS) 0.45 (NS)                  |

A negative (p<0.05) association was found between Vitamin D and total cholesterol and between Vitamin D and LDL. Thus, our study shows that diabetic patients had higher levels of total cholesterol, triglycerides, and LDL as compared to the non-diabetic group. This coincides with the findings of a study conducted by Simonen et al. in 2011. A negative correlation was found between Vitamin D levels and blood sugar levels, i.e., more number of diabetic patients had higher levels of Vitamin D.

We did not consider blood pressure measurements, which could have helped in a better correlation between Vitamin D levels and diabetes. Another limitation of this study was a small sample size.

Assessment of levels of Vitamin D can thus be a useful predictor for the occurrence of derangements in the metabolic traits in a particular population. Proper treatment of Vitamin D deficiency can thus help in improving metabolic traits and the diabetic status of the patients. It can be provided by Vitamin D supplementation by fortifying staple foods with Vitamin D and it is the most viable population based strategy to achieve Vitamin D sufficiency.

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