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RESEARCH ARTICLE

Vitamin D level and body mass index in patients with type II diabetes mellitus

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ABSTRACT

Background: There are many evidence suggesting an association between Vitamin D and diabetes mellitus. Low Vitamin D levels, development of diabetes mellitus, and metabolic syndrome have all been interrelated. Interestingly, obesity and sedentary lifestyle are risk factors common to both Vitamin D deficiency and diabetes mellitus. **Aims and Objectives:** The study was carried out to determine the correlation of Vitamin D levels and body mass index (BMI) in patients with type 2 diabetes mellitus (T2DM). **Materials and Methods:** A case-controlled study was carried out at Shree Balaji Medical College and Hospital, Chrompet, Chennai, a tertiary care teaching institute. A total of 48 patients with T2DM (cases) and 43 non-diabetics healthy individuals (controls) were included in this study. The controls were age and sex matched with the cases. The demographic data and other relevant information were recorded in case record form. 5 mL blood was collected from all persons in the fasting state and analyzed for plasma blood glucose levels and Vitamin D. Plasma glucose levels were determined by glucose oxidase- peroxidase method. Vitamin D levels were determined by ELISA method. **Results:** An inverse correlation has been found between Vitamin D and BMI in diabetics. ANOVA single factor done for diabetics and non-diabetics both cases F statistical value >F critical value and $P < 0.05$ proving statistical significance. As Vitamin D levels decreased, there was an increase in plasma blood glucose levels. **Conclusion:** It was thus concluded that Vitamin D supplementation can help in efficient control of blood glucose levels in diabetes as well as prevent early onset of diabetes in obese individuals.

KEY WORDS: Type 2 Diabetes Mellitus; Vitamin D; Body Mass Index; Hypovitaminosis D

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a growing as pandemic by affecting almost 170 million people worldwide that might double to 370 million by another 30 years.[1] Obesity, sedentary lifestyle, decreased physical activity, and unhealthy eating habits are the risk factors for T2DM.[2]

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There are many evidence suggesting an association between Vitamin D and diabetes mellitus. Low Vitamin D levels, development of diabetes mellitus, and metabolic syndrome have all been interrelated.[3] Interestingly, obesity and sedentary lifestyle are the risk factors common to both Vitamin D deficiency and diabetes mellitus.[4] In one of the studies, it was found that a majority (80%) of the patients with T2DM were Vitamin D deficient.[3] It was also found that supplementation of Vitamin D in individuals with Vitamin D deficiency can decrease insulin resistance and hence may modify the risk factor development of T2DM, especially more in obese person.[5-7] Initially, it was believed that the individuals living in areas with less exposure to sunlight were more chances for the development of Vitamin D deficiency. Now, it has been proven that even individuals living in areas with more exposure to sunlight can also have Vitamin D deficiency.[5-8]

It has been projected that approximately 300 million people worldwide will be affected by T2DM by the year 2025. Only in India, about 50.9 million people are suffering from T2DM, and this figure is likely to increase up to 80 million by the year 2025, making India the "diabetes capital" of the world.[9] Despite adequate exposure to sunlight throughout the year, Vitamin D deficiency is common in Indian population of all age groups and both gender in urban as well as rural areas.[10] There are Indian studies, in which Vitamin D deficiency has been identified as an independent adjunctive risk factor for T2DM.[10-13]

With this background, the present study was carried out to determine the correlation of Vitamin D levels and body mass index (BMI) in patients with T2DM.

MATERIALS AND METHODS

A case-controlled study was carried out at Shree Balaji Medical College and Hospital, Chrompet, Chennai, a tertiary care teaching institute. Ethical permission was obtained from the Institutional Ethical Committee (Ref. no.: 002/SBMC/IHEC/2013-94). After obtaining informed written consent, 48 patients with T2DM (cases) and 43 non-diabetics healthy individuals (controls) were included in this study. For both the groups, individuals of both gender and age between 18 and 35 years were included in the study. The controls were age and sex matched with the cases. Individuals taking calcium and Vitamin D supplements, anticonvulsants, and those suffering from osteoporosis, renal disease, asthma, and hypertension were excluded from the study. The demographic data and other relevant information were recorded in case record form. 5 mL blood was collected from all persons in the fasting state and analyzed for plasma blood glucose levels and Vitamin D. Plasma glucose levels were determined by glucose oxidase-peroxidase (GOD-POD) method. Vitamin D levels were determined by ELISA method.

Plasma Glucose Level Estimated by GOD-POD Method

GOD oxidizes glucose into hydrogen peroxide and gluconate. In the presence of POD, hydrogen peroxide that was produced in the previous step is coupled oxidatively to phenol and 4-aminoantipyrine to yield a dye called quinonimine that is red in color. It is then measured at 505 nm. The amount of glucose present in the sample is directly proportional to the absorbance at 505 nm. The reference range for plasma glucose for the present study was 70–110 mg/dl.

$$\text{Glucose} + O_2 + H_2O \xrightarrow{\text{Glucose oxidase}} \text{Gluconate} + H_2O$$

$$H_2O_2 + \text{4aminoantipyrine} + \text{Phenol} \xrightarrow{\text{Peroxidase}} \text{Red quinoneimine dye} + H_2O$$

Serum Vitamin D Levels Estimated by Immunoenzymetric Assay (ELISA)

The DIA source 25-hydroxy Vitamin D total ELISA was used. It is carried out on microtiter plates. After incubation lasting 2 h Vitamin D present in calibrators, samples and controls are separated from serum proteins and made to bind with specific monoclonal antibody. The plates are washed after which biotin-labeled 25OH Vitamin D in the presence of horseradish peroxidase is made to compete with unlabeled 25hydroxy Vitamin D2 and 25hydroxy Vitamin D3 present bound to the monoclonal antibody. The plates are incubated for 30 min after which they are washed. This stops the competition reaction. It is then again incubated for 15 min after addition of chromogenic solution. Stop solution is added and microtiter plate read at an appropriate wavelength. The absorbance is inversely proportional to the amount of Vitamin D. Reference range for serum Vitamin D for the present study was 30–150 ng/dl.

BMI was calculated by the following formula:

$$\text{BMI}(\text{kg}/\text{m}^2) = \frac{\text{Weight(kg)}}{(\text{Height [m]})^2}$$

BMI was classified in the following categories: (i) Underweight: BMI <18.5 kg/m^2; (ii) normal: BMI - 18.5–24.9 kg/m^2; (iii) overweight: BMI - 25.0–29.9 kg/m^2; and (iv) obesity: BMI >30.0 kg/m^2.

Statistical Analysis

Data were analyzed using Microsoft Excel and presented in number, frequency, and percentage. Data were analyzed by ANOVA single factor in diabetics and non-diabetics using Microsoft Excel. $P < 0.05$ denotes that the difference is statistically significant.

RESULTS

A total of 48 patients with T2DM and 43 non-diabetics healthy individuals (controls) were included in this study. Mean age of cases was 39.56 ± 15.67 years, while of controls was 41.87 ± 17.88 years. Mean BMI value in cases was 24.52 ± 15.38 kg/m^2, while of controls was 23.88 ± 12.88 kg/m^2. A majority of the individuals are suffering from Vitamin D deficiency in both the groups (cases: 40 and controls: 38) [Table 1].

In this study, an inverse correlation has been found between Vitamin D and BMI in diabetics. ANOVA single factor done for diabetics and non-diabetics both cases F statistical value >F critical value and $P < 0.05$ proving statistical significance. As Vitamin D levels decreased, there was an increase in plasma blood glucose levels [Tables 2-5].

DISCUSSION

There is worldwide deficiency of Vitamin D among people of all age groups. Major contributing factors for the deficiency of Vitamin D are reduced exposure to sunlight and decreased dairy intake of Vitamin D.[14] In western countries, the lack of exposure to sunlight hampers the cutaneous synthesis of Vitamin D and leads to a deficiency of Vitamin D among residing people.[14,15] Deficiency of Vitamin D is also found among the residents of desert area despite abundant exposure to sunlight throughout the year. The reason for this is still under research. Vitamin D has been shown to be associated with the development of various disorders such as rickets, osteoporosis, cardiovascular disease, diabetes mellitus, metabolic syndrome, anemia, and cancer and infections such as tuberculosis in India.[16-18]

Table 1: Comparison of cases and controls

Parameters	Cases	Controls
n	48	43
Age in years (mean±SD)	39.56±15.67	41.87±17.88
Gender (*n*, %)		
Males	31 (64.58)	29 (67.44)
Females	17 (36.42)	14 (32.56)
BMI in kg/m^2 (mean±SD)	24.52±15.38	23.88±12.88
Number of individuals with different BMI (*n*, %)		
<18.5	4 (8.33)	3 (6.98)
18.5–24.9	26 (54.17)	25 (58.14)
25.0–29.9	14 (29.17)	11 (25.58)
>30.0	4 (8.33)	4 (9.30)
Plasma glucose in mg/dl (mean±SD)	159.31±35.24	112.16±28.90
Number of individuals		
<70	2 (4.17)	0
With different plasma		
70–110	14 (29.17)	26 (60.47)
Glucose level (*n*, %)		
>110	32 (66.66)	17 (39.53)
Serum Vitamin D in ng/dl (mean±SD)	20.88±12.43	18.21±10.19
Number of individuals with different serum Vitamin D levels (*n*, %)		
<30 mg/dl	40 (83.33)	38 (88.37)
30–150 mg/dl	8 (16.67)	5 (11.63)

BMI: Body mass index, SD: Standard deviation

A majority of the individuals are suffering from Vitamin D deficiency in both the groups (cases: 40 [83.33%] and controls: 38 [88.37%]) in the present study. Widespread Vitamin D deficiency has been found in all over India. The estimated prevalence of different studies is 70–100% in the general population of India.[18] The reasons behind this deficiency are nutritional; food items such as dairy products which are rarely fortified with Vitamin D; and lack of adequate sunlight exposure due to Indian socioreligious and cultural practices. Subclinical Vitamin D deficiency is highly prevalent in urban as well as in rural areas and across all socioeconomic and geographic strata.[18]

In our study, we found Vitamin D levels to be decreased among diabetics which were consistent with the findings of studies done by Holick *et al*.[19-21] In a meta-analysis of observational studies, an inverse relation of Vitamin D levels and calcium status with insulin resistance and hyperglycemia has been found. In this meta-analysis, it was also found that combined supplementation of Vitamin D and calcium showed benefit in optimizing glucose levels.[6] In a study done by Agrawal *et al*. regarding the association of serum hydroxy Vitamin D with markers of insulin resistance among postmenopausal women, an inverse correlation was found between Vitamin D and BMI.[22] In another Indian study by Dutta *et al*., statistically significant inverse correlation of Vitamin D with insulin resistance and positive correlation with insulin sensitivity were found. People with severe deficiency had highest and positive correlation with insulin sensitivity. The study also reported worsening of and positive correlation with insulin sensitivity in Indians with prediabetes.[13] 18% annual risk of the progression of prediabetes to diabetes has been reported in Indian Diabetes Prevention Program-1.[23]

In the present study, Vitamin D and BMI in diabetics were negatively correlated. That is as Vitamin D levels decreased, BMI increased and vice versa. Vitamin D was found to be related to obesity that is Vitamin D deficiency was seen to be present among obese individuals.[24] According to studies done till now, it has been postulated that Vitamin D levels are low in obese individuals as this vitamin gets collected

Table 2: Correlation between Vitamin D and body mass index in non-diabetics

Variables	Vitamin D level (ng/ml)	Age	Height	Weight	BMI
Vitamin D level (ng/ml)	1	-	-	-	-
Age	0.319968904	1	-	-	-
Height	−0.061176453	−0.080140328	1	-	-
Weight	−0.038756754	−0.048149456	0.394650601	1	-
BMI	−0.002354727	0.034169456	−0.550225056	0.529653586	1

BMI: Body mass index

Table 3: Correlation between Vitamin D and body mass index in diabetics

Variables	Vitamin D level (ng/ml)	Age	Height	Weight	BMI
Vitamin D level (ng/ml)	1	-	-	-	-
Age	0.21934116	1	-	-	-
Height	−0.165395797	0.066018	1	1	-
Weight	−0.277573209	−0.04085	0.442003	-	1
BMI	−0.167954393	−0.12401	−0.28128	0.725213	1

BMI: Body mass index

Table 4: ANOVA: Single factor for non-diabetics

Source of variation	SS	Df	MS	F	*P* value	F crit
Between groups	238460.7642	2	119230.3821	211.4175644	5.47652E-41	3.068100269
Within groups	71058.56205	126	563.9568416	-	-	-
Total	309519.3263	128	-	-	-	-

Table 5: ANOVA: Single factor for diabetics

Source of variation	SS	Df	MS	F	*P* value	F crit
Between groups	597532.4515	2	298766.2257	191.7486168	5.9986E-41	3.060291772
Within groups	219694.0897	141	1558.114112	-	-	-
Total	817226.5412	143	-	-	-	-

in fat tissue and its release from this adipose tissue is low. Small quantities of this vitamin are present circulating within the body. Besides, the enzymes such as 1-hydroxylase and 25-hydroxylase that are involved in formation of an active form of this vitamin are low in persons with high BMI.[24] Obese people have lower quantities of active metabolites of Vitamin D.[24]

Concurrent epidemics of T2DM and hypovitaminosis D are prevalent in India due to rapid and disorganized urbanization and industrialization.[10] Well-defined upper and lower range of values, however, have to be established which takes into consideration of BMI and other factors such as race, ethnicity, and physiological needs for optimal working conditions of the body. Further research is necessary to evaluate Vitamin D requirements before doctors make recommendations to their patients.

CONCLUSION

It is a great concern and matter of serious discussion whether obesity is a cause for the deficiency of this vitamin or whether the deficiency of Vitamin D is a cause for increased BMI. Obesity and deficiency of Vitamin D are modifiable risk factors for numerous diseases such as diabetes mellitus. Studies have to be carried out regarding whether supplementation of Vitamin D can prevent ill effects of various diseases. If the causal relationship can be established between Vitamin D deficiency and obesity, Vitamin D supplementation can prove to be a cost-effective measure to cure obesity and control diabetes mellitus.

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