Study On Vitamin D And Calcium Deficiency In Patients With Type II Diabetes Mellitus And Non - Diabetic Population

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Abstract :

INTRODUCTION : Type II Diabetes Mellitus is a metabolic disorder increasing rapidly among individuals and researches have shown low Vitamin D and Calcium to be associated with the development of Type - II Diabetes Mellitus.

PURPOSE AND OBJECTIVES ; The purpose and objective of the study was to find out the differences in incidence of Vitamin D and Calcium deficiency in both the groups.

METHODS : Total of 150 subjects (75 diabetic and 75 non diabetic) were chosen. A pretested questionnaire regarding personal history, medical history, clinical examination, nutritional assessment, biochemical parameters, food frequency questionnaire (FFQ) and 24 hour dietary recall was used as a tool to collect data. The result was statistically analysed using standard statistical methods.

RESULTS : The study showed that in experimental group, 16% (n = 12) were vitamin D deficient while in control group, 9.3% (n = 7) were deficient. There was significant association ($p<0.05$) between Vitamin D status ($p = 0.021$) of both the groups. About 38.7% (n = 29) were hypocalcemic in experimental group while in control group, 72% (n = 54) were hypocalcemic. There was significant association ($p<0.05$) between calcium status ($p = 0.000$) of both the groups.

CONCLUSION : The study concluded that the incidence of vitamin D deficiency was higher in diabetic patients as compared to non – diabetic population while calcium deficiency rate was lower in diabetic population. This shows that vitamin D deficiency is more prevalent in Type II Diabetic patients and has a role to play in glucose metabolism. With various factors leading to Vitamin D deficiency, such as lack of sunlight exposure, inadequate intake of Vitamin D rich food sources, etc; the need on awareness of vitamin D in the management of diabetes through educational programs and workshops is important. Also, the importance of vitamin D and the risk factors associated with its deficiency should be made an important aspect in the overall management of Type II diabetes mellitus.

Keywords : Type II Diabetes Mellitus, Vitamin D Deficiency, Calcium, Sun Exposure, Body Composition Analysis, Nutritional Assessment, Biochemical Parameters.

Introduction : Type 2 Diabetes Mellitus is a metabolic disorder characterised by rise in blood sugar levels i.e Hyperglycaemia. It is due to insulin resistance and lack of insulin regulation in the body. The population of India is undergoing changes in lifestyle and reduced physical activity that have led to increased prevalence of obesity which is related to type – diabetes mellitus, hyperlipidemia and cardiovascular diseases. Recently researches have shown low vitamin D and calcium to be associated with the development of Type - II Diabetes Mellitus. It has led to the hypothesis that insufficiency of these correlates positively with insulin resistance and cardiovascular risk in obese adolescents and that 25-OH Vitamin D and Calcium supplementation improves insulin resistance and cardiovascular risk factors in this population.

Increasing evidence has suggested a protective role of vitamin D on metabolic syndrome (MetS). A study was conducted that examined the association of serum 25-hydroxyvitamin D (25(OH)D) status with MetS, and the potential effect modification by calcium intake in a Japanese working population. Study subjects were 1790 workers, ages 18 to 69 years, who participated in a health survey at the time of periodic checkup. The results suggested that higher circulating vitamin D is associated with decreased likelihood of having MetS among Japanese adults. (1)

A study was conducted that investigated the association between vitamin D levels and 5-year changes in blood pressure, lipid profile and incidence of metabolic syndrome, hypertension and hypercholesterolemia. The study concluded that an optimal vitamin D status may influence cardiovascular health by changing lipid profile in a favorable direction and decreasing the incidence of metabolic syndrome (2)

Up until recently, vitamin D deficiency was considered rare in those parts of the world that had plenty of sunshine all year round but WHO now estimates that globally one billion people have vitamin D deficiency or insufficiency. There have been many recent studies implicating the role of vitamin D in cardiovascular disease prevention, cancer prevention, inhibiting parathyroid hormone secretion, promoting insulin secretion, high risk of fractures. etc.

A prospective case-control study was performed whereby serum Vitamin D levels and corresponding PTH levels were measured. The purpose of the present study was to characterize the extent of Vitamin D inadequacy and parathyroid hormone (PTH) levels among patients presenting for fracture management. The study concluded the prevalence of vitamin D deficiency and rise of PTH and that body is an independent risk factor for increased incidence of fracture. (3)

Aim and Objectives : To evaluate the incidence of vitamin d and calcium deficiency in diabetic patients and non – diabetic population. To statistically analyse and highlight the differences in association between the diabetic patients and the non-diabetic population.

Methods and Material : The study was conducted on 150 subjects in total (75 diabetic and 75 non – diabetic). Data on the Experimental group (diabetic subjects) was collected from Lifespan Diabetes Clinic, Malad West, Mumbai; while data for the control group (non – diabetic subjects) was taken from Hill Park Tower, Jogeshwari West, Mumbai. The diabetic subjects with recent glycated haemoglobin of more than 6 (either currently on oral hypoglycemic agents or insulin) with no age criteria were included in the study. Subjects suffering from type - I diabetes mellitus, gestational diabetes or with chronic diseases like cancer. etc. were completely excluded from the study. Non - diabetic subjects will be those with no history of type II diabetes mellitus with no age criteria. The subjects fulfilling the above mentioned criteria were selected after informing them about the study and their demographic data pertaining to their medical history or present illness. Anthropometric measurements [weight, height, ideal body weight (IBW), body mass index (BMI), waist circumference, hip circumference, waist to hip ratio] along with body composition analysis (BCA) test to analyse total body fat, visceral fat, subcutaneous fat, skeletal mass and body age were performed on the subjects. Biochemical parameter like 25-hydroxy vitamin D levels and Calcium levels were compulsorily performed and identified in all the subjects of both the groups, while their blood sugar test, lipid profile, kidney function test and liver function test were also taken into consideration and inadequate or above normal levels were identified for the purpose of the study. A pretested oral questionnaire regarding personal history, medical history, clinical examination, nutritional assessment and biochemical parameters was used as a tool to collect required data. Questionnaire consisted of food frequency questionnaire (FFQ) and one day 24 hour dietary recall to understand the eating pattern and food choices of the subjects. Awareness of both the groups regarding sun exposure, calcium, vitamin D absorption and sunscreen were also taken into consideration along with their physical activity levels at present. Once data was collected, data was statistically analysed using Statistical Package for Social Science (SPSS) software (Version 20, SPSS, Inc., Chicago, IL, USA). All the data were expressed as mean ± standard deviation (SD) along with 95% confidence interval (CI). Descriptive statistics such as mean, standard deviation, frequency distribution and range values were computed for quantitative variables. Chi – square test and student *t* – test was done to analyse the incidence of Vitamin D and Calcium deficiency in patients with Type 2 Diabetes Mellitus and non – diabetic population.

Results and Discussion : The following are the results for the study :

I. Anthropometric Measurements

Anthropometric measurements included were height, weight, ideal body weight (IBW), body mass index (BMI), waist circumference, hip circumference and waist-to-hip ratio. These measurements were performed to assess the body size and to determine the prevalence of obesity and its relation with Type II Diabetes, Vitamin D and Calcium deficiency in both the groups.

Table 1.1. Anthropometric Measurements of the Study Population

Anthropometric Measurements	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	t value	p value
Height (cms)	164.64 ± 6.96	159.83 ± 14.06	2.658	0.009*
Weight (kg)	75.20 ± 14.07	68.21 ± 13.83	3.069	0.003*
Ideal Body Weight (IBW) (kg)	62.71 ± 8.49	57.03 ± 8.38	4.122	0.000*
Body Mass Index (BMI) [kg/m2]	28.05 ± 4.35	26.23 ± 5.28	2.302	0.023*
Waist Circumference (cms)	95.16 ± 12.55	89.51 ± 10.27	3.018	0.003*
Hip Circumference (cms)	99.27 ± 9.26	93.38 ± 13.81	3.070	0.003*
Waist : Hip Ratio	0.98 ± 0.13	1.07 ± 1.04	0.701	0.484

Data presented as Mean ± Standard Deviation

$*p<0.05$

According to Table 1.1, the mean height, weight, ideal body weight (IBW), body mass index (BMI), waist circumference and hip circumference of the experimental group are significantly higher than that of the control group.
There was significant association ($p<0.05$) between height (p = 0.009), weight (p = 0.003), ideal body weight (p = 0.000), body mass index (p = 0.023), waist circumference (p = 0.003) and hip circumference (p = 0.003) while there was no significant association ($p>0.05$) seen between waist to hip ratios (p = 0.484) of both the groups.
A study was conducted to investigate the association between body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR), and the incidence risk of type 2 diabetes mellitus (T2DM). In total, 20,194 participants ≥18 years old were selected randomly by cluster sampling from two township of the county in Henan province from July to August of 2007 and July to August of 2008 and the investigation included questionnaires, anthropometric measurements, fasting plasma glucose, and lipid profile examination were performed; 17,236 participants were enrolled in this cohort study. 14,720 were followed up from July to August 2013 and July to October 2014. The study concluded that BMI, WC, and WHtR were associated with increased T2DM risk. The more abnormal aggregation of BMI, WC, and WHtR presents, the higher T2DM risk could be decreased when abnormal WC or WHtR reversed to normal. (4)

II. Body Composition Analysis

Body composition analysis test was performed on the subjects of both experimental and control group which included percentage of total fat, visceral fat, subcutaneous fat, skeletal mass and body age in years. This was performed to evaluate the body composition of the subjects and observe its association in both the groups.

Table 2.1. Body Composition Analysis of the Study Population

Body Composition Parameters	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	t value	p value
Total Fat (%)	32.22 ± 7.08	30.56 ± 6.92	1.450	0.149
Visceral Fat (%)	12.22 ± 4.59	12.43 ± 3.17	0.327	0.744
Subcutaneous Fat (%)	28.43 ± 6.84	27.36 ± 5.87	1.026	0.307
Skeletal Mass (%)	23.39 ± 4.21	25.18 ± 4.43	- 2.543	0.012*
Body Age (years)	59.21 ± 13.18	38.52 ± 15.39	8.846	0.000*

Data presented as Mean ± Standard Deviation

***p<0.05**

According to Table 2.1, the mean total fat, subcutaneous fat and body age of the experimental group was significantly higher than that of the control group. Similarly, the mean visceral fat and skeletal mass of the experimental group was significantly lower than that of the control group.
There was significant association ($p<0.05$) between skeletal mass ($p = 0.012$) and body age ($p = 0.000$) of both the groups while there was no significant association ($p>0.05$) found between total fat (p – 0.149), visceral fat ($p = 0.744$) and subcutaneous fat ($p = 307$) of both the groups.
A study was conducted that evaluated the possible risk factors associated with type 2 diabetes (T2DM) in adult subjects during a five-year prospective cohort study. A total of 1160 subjects were recruited who underwent oral glucose tolerance test, anthropometric measurements, and body composition and body fat distribution analysis at a baseline visit and again at follow-up after approximately five years. The conclusions of the study were based on observation of 219 subjects who attended both the first and follow-up visits. T2DM was diagnosed in 7.4% of participants, impaired fasting glucose in 37.7%, and impaired glucose tolerance in 9.3%. The results showed the correlation between the %loss of muscle mass and T2DM development in adults, independent of changes in insulin resistance while changes in glucose concentration, visceral fat tissue content, insulin resistance, and % loss of muscle mass were chosen as the potential predictors for T2DM development. (5)

III. Medical History

Medical history of Diabetes and its complications, Blood Pressure, Cardiovascular diseases, other health issues were included to analyse since how many years they have the history of the same. Also, medical history of Vitamin D status along with its duration and calcium status was taken into consideration along with subject's current oral medications if they were consuming. Their duration of medical history were mentioned in years like for example 1 – 2 years, 3 – 5 years, more than 5 years or if they did not suffer from any disease or deficiency at all. This was done to observe association of these medical history in both the groups.

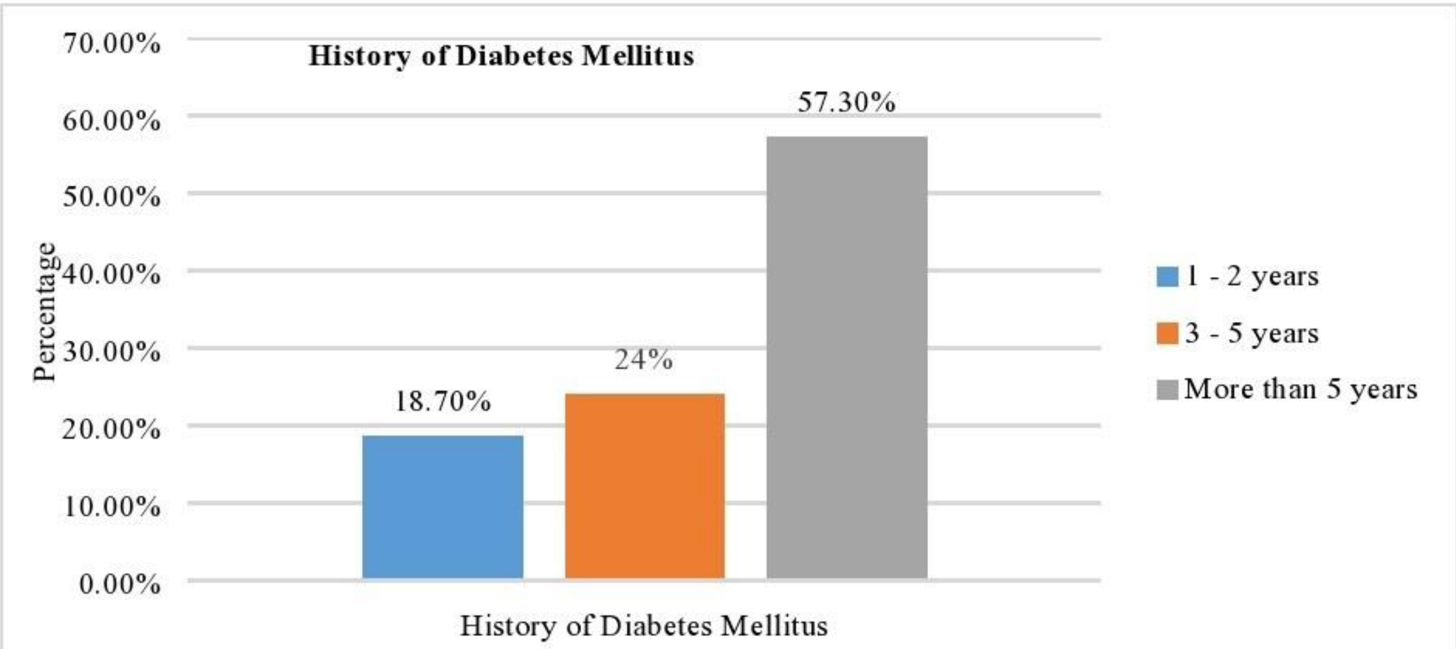

Figure. 3.1. Medical History of Diabetes of the Experimental group

Figure 3.1 shows the duration of medical history of Type II Diabetes Mellitus of the experimental group. Among 75 subjects, highest of all i.e. about 57.3% (n = 43) of experimental group had the medical history of Type II diabetes for more than 5 years. The statistical analysis showed that about 24% (n = 18) had the medical history of Type II Diabetes since 3 – 5 years while 18.7% (n = 14) since 1 – 2 years. There was no significant association found and the value obtained was constant.

Table 3.1. Calcium and Vitamin D Status along with its Duration and Oral Medications.

Vitamin D Status	Experimental Group % (n)	Control Group % (n)	x^2	p value
Deficiency	16% (12)	9.3% (7)		
Insufficiency	46.7% (35)	30.7% (23)	7.757	.021*
Normal	37.3% (28)	60% (45)		
Years Of Vitamin D Deficiency				
1 – 2 years	17.3% (13)	17.3% (13)		
3 – 5 years	37.3% (28)	18.7% (14)	12.024	.007*
More than 5 years	10.7% (8)	4% (3)		
Calcium Status				
Hypocalcemic	38.7% (29)	72% (54)		
Normal	61.3% (46)	28% (21)	16.858	.000*
Hypercalcemic	0% (0)	0% (0)		
Subjects On Medications				
Yes	100% (75)	24% (18)	91.935	.000*
No	0% (0)	76% (57)		

$*p<0.05$

Table 3.1 shows the Calcium and Vitamin D status along with its duration and oral medications. Among experimental group, highest of all i.e. about 46.7% (n = 35) were under insufficiency range of Vitamin D status while 37.3% (n = 28) under normal range and 16% (n = 12) under range of deficiency. Among control group, highest of all i.e. about 60% (n = 45) were under normal range of Vitamin D status while 30.7% (n = 23) under insufficiency range and 9.3% (n = 7) under range of deficiency. There was significant association ($p<0.05$) between Vitamin D status (p = 0.021) of both the groups.

Among experimental group, highest of all i.e. about 37.3% (n = 28) had Vitamin D deficiency since 3 – 5 years, 17.3% (n = 13) had Vitamin D deficiency since 1 – 2 years while 10.7% (n = 8) since more than 5 years. Among control group, about 18.7% (n = 14) had Vitamin D deficiency since 3 – 5 years, 17.3% (n = 13) had Vitamin D deficiency since 1 – 2 years while 4% (n = 3) since more than 5 years. There was significant association ($p<0.05$) between history of vitamin D deficiency (p = 0.007) of both the groups.

A cross sectional study was conducted that aimed to assess the vitamin D status and investigate the factors affecting vitamin D distribution among Saudi males at the King Saud University Medical City from December 2015 to August 2016. Data were collected on the current and past health status along with biochemical investigations for total 25-hydroxyvitamin D (25OHD), blood sugar, and cholesterol. Majority of the participants (76.1%) had vitamin D deficiency. Blood sugar level, age, and cholesterol level were the most significant factors associated with vitamin D status. The highest percentage of deficiency was observed in the youngest age group (30-40 years). This study concluded that Vitamin D screening, supplementations, and vitamin D-fortified foods should be provided especially for these groups. (6)

A study was carried out to explain the potential relationship between vitamin D status and metabolic control in patients with type 2 diabetes mellitus (T2DM). The aim of the study was to evaluate the relationship between the serum 25-hydroxyvitamin D [25(OH)D] level and various parameters in patients with T2DM. The study was done on 276 Korean patients with T2DM whose serum 25(OH)D level was measured in hospital. 160 Non diabetic healthy subjects who visited the hospital for health screening were selected as the control group. The study results showed that in comparison to control subjects, patients with T2DM had a lower serum 25(OH)D level. Eleven percent of T2DM patients were Vitamin D insufficient (20-29 ng/ml) and 87% of the patients were Vitamin D deficient. The serum 25(OH)D level was significantly related to serum fibrinogen, triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), ferritin, the urine albumin creatinine ratio, and hemoglobin A1C (HbA1C). The study finally concluded that Vitamin D status has some impact on the pathophysiology and progression of T2DM and its complications and it is necessary to evaluate the relationship between serum 25(OH)D and various metabolic and clinical parameters in patients with T2DM. (7)

Among experimental group, highest of all i.e. about 61.3% (n = 46) were under normal range of calcium status while 38.7% (n = 29) under hypocalcemic range denoting deficiency of calcium in body. Among control group, highest of all i.e. about 72% (n = 54) were under hypocalcemic range while 28% (n = 21) under normal range of calcium status. There was significant association ($p<0.05$) between calcium status (p = 0.000) of both the groups.

Among experimental group, all the subjects were on medications hence comprising of 100% population, while in control group; about 24% (n = 18) of total population were on medications and the remaining 76% (n = 57) were not on any kind of medications. There was significant association ($p<0.05$) between subjects that are medications (p = 0.000) of both the groups.

IV. Awareness On Vitamin D And Calcium

The subjects of the study group that were on Vitamin D and calcium supplements were analysed to evaluate association in both the groups. This helped in understanding the relation between the percentage of subjects consuming vitamin D and calcium supplement and the percentage of subjects having deficiency of these nutrients.

Table 4.1. Intake of Vitamin D and Calcium supplement in Study Population

Calcium supplement	Experimental Group % (n)	Control Group % (n)	x^2	p value
Yes	25.3% (19)	28% (21)	.136	.712
No	74.7% (56)	72% (54)		
Vitamin D supplement				
Yes	53.3% (40)	17.3% (13)	21.796	.000*
No	46.7% (35)	82.6% (62)		

*p<0.05

Table 4.1 shows the analysis on intake of calcium supplement of subjects in experimental and control groups. Among experimental group, about 25.3% (n = 56) of total population consumed calcium supplement; while in control group, about 28% (n = 21) consumed calcium supplement. There was no significant association (p>0.05) between the intake of calcium supplements (p = 0.712) of both the groups.

Among experimental group, about 53.3% (n = 40) of total population takes Vitamin D supplement; while in control group, about 17.3% (n = 13) of the total population takes Vitamin D supplement. There was significant association (p<0.05) between the intake of Vitamin D supplements (p = 0.000) of both the groups.

Vitamin D inadequacy is associated with a wide range of diseases. A study was conducted to test the hypotheses that relevant sun exposure or oral vitamin D supplementation would significantly increase serum 25-hydroxyvitamin D (25OHD) concentrations compared with placebo, secondly, sun exposure and supplementary vitamin D would be similar in serum 25OHD increase, and thirdly if the two interventions may have different effects on cardio-metabolic markers. The study concluded that enhanced sun exposure and 500 IU/d of oral vitamin D3 supplementation significantly increased serum 25OHD concentrations. However, our protocol for sun exposure was not as effective as 500 IU/d of oral vitamin D3 supplementation. (8)

Another study was conducted to examine the relationship between obesity and the increase in serum 25(OH)D levels in response to vitamin D supplementation among adults with baseline serum 25(OH)D levels<50 nmol/L, and relatively long average treatment duration and large average daily cholecalciferol. The computerized database of the Clalit Health Services in Israel was retrospectively searched for all subjects aged ≥20 years who performed serum 25(OH)D test in 2011. The study concluded that BMI is inversely associated with the increase in serum 25(OH)D levels in response to vitamin D supplementation. (9)

A randomized controlled trial was also conducted to evaluate the effects of vitamin D supplementation on circulating levels of magnesium and selenium in patients with type 2 diabetes mellitus (T2DM). A total of 126 adult Saudi patients (55 men and 71 women) with controlled T2DM were recruited for the study. All subjects were given vitamin D3 tablets (2000 IU/day) for six months. Follow-up mean concentrations of serum 25-hydroxyvitamin D [25-(OH) vitamin D] significantly increased while levels of parathyroid hormone (PTH) decreased significantly in both men and women. In addition, there was a significant increase in serum levels of selenium and magnesium in men and women after follow-up. In women, a significant correlation was observed between serum magnesium versus high-density lipoprotein (HDL)-cholesterol and fasting glucose. In men, there was a significant correlation between serum selenium and triglycerides (r=0.32, p=0.04). The study concluded that vitamin D supplementation improved serum concentrations of magnesium and selenium in a gender-dependent manner, which in turn could affect several cardiometabolic parameters such as glucose and lipids. (10)

The analysis was done on subject's belief on calcium as important nutrient in availability of Vitamin D. There was no statistical significance found and the value obtained was constant.

V. Awareness On Sunlight Exposure

To understand the awareness and beliefs of the subjects regarding sunlight exposure, opinion of the subjects on various aspects were taken into consideration like their belief on sunlight being a good source of Vitamin D, their frequency of exposing themselves to sunlight, what according to them was the correct time and duration for sunlight exposure, if the type of clothing matters for sunlight exposure, what SPF value sunscreen they used and if according to them application of sunscreen affect vitamin D absorption.

Table 5.1. Awareness of Study Population on Sunlight Exposure

Frequency of sunlight exposure	Experimental Group % (n)	Control Group % (n)	x^2	p value
Everyday	33.3% (25)	70.7% (53)	21.210	.000*
Thrice a week or more	44% (33)	21.3% (16)		
Never	22.7% (17)	8% (6)		
Time for sunlight exposure				
8am – 11am	98.7% (74)	98.7% (74)	.000	1.000
10am – 3pm	1.3% (1)	1.3% (1)		
12pm – 4pm	0% (0)	0% (0)		
Any other time	0% (0)	0% (0)		
Duration of sunlight exposure				
5 – 10 mins	42.7% (32)	50.7% (38)	2.135a	.344
10 – 15 mins	57.3% (43)	48% (36)		
More than 20 mins	0% (0)	1.3% (1)		
Significance of type of clothes for sunlight exposure				
Yes	89.3% (67)	89.3% (67)	.000	1.000
No	10.7% (8)	10.7% (8)		
Effects of sunscreen in Vitamin D absorption				
Yes	49.3% (37)	40% (30)	1.322	.250
No	50.7% (38)	60% (45)		

***p<0.05**

Table 5.1 shows the analysis on awareness of study population on sunlight exposure. Among experimental group, about 33.3% (n = 25) exposed themselves to sunlight on daily basis, while 44% (n = 33) exposed themselves thrice a week or more while 22.70% (n = 17) does not exposed themselves to sunlight at all. In control group, highest of all i.e. about 70.7% (n = 53) exposed themselves to sunlight on daily basis, while 21% (n = 16) exposed themselves thrice a week or more while 8% (n = 6) does not exposed themselves to sunlight at all. There was significant association ($p<0.05$) between frequency of sunlight exposure ($p = 0.000$) of both the groups.

In both the groups, 98.7% (n = 74) agreed on 8am – 11am being the correct time for sunlight exposure while 1.3% (n = 1) agreed on 10am – 3 pm. There was no significant association ($p>0.05$) between subject's belief on correct duration for sunlight exposure ($p = 1.000$) of both the groups.

In experimental group, highest of all i.e about 57.3% (n = 43) agreed on 10 – 15mins, while about 42.7% (n = 32) agreed on 5 – 10 mins to be the correct duration for sunlight exposure. In control group, about 50.7% (n = 38) agreed on 5 – 10mins, while about 48% (n = 36) agreed on 5 – 10 mins and 1.3% (n = 1) agreed to more than 20 mins to be the correct duration for sunlight exposure. There was no significant association ($p>0.05$) between subject's belief on correct duration for sunlight exposure ($p = 0.344$) of both the groups.

In both the groups, highest of all i.e about 89.3% (n = 67) agreed on the same while about 10.7 % (n = 8) denied. There was no significant association ($p>0.05$) between subject's belief on whether types of clothing matters for sunlight exposure ($p = 1.000$) in both the groups.

An in - vitro study was conducted to analyse the effect of clothing varieties on solar photosynthesis of previtamin D3. Fifteen different fabric samples were tested for their effect on the efficiency of the in - vitro solar conversion of 7-dehydrocholesterol (7-DHC) to vitamin D3. The study concluded that clothing plays an important role in attenuating sunlight, thus leading to diminished vitamin D3 production to an extent that would require dietary compensation. (11)

In experimental group, highest of all i.e about 50.70% (n = 38) denied on sunscreen affecting vitamin D absorption while 49.3% (n = 37) agreed. In control group, highest of all i.e about 60% (n = 45) denied while 40% (n = 30) agreed. There was no significant association ($p>0.05$) between subject's belief on affect of sunscreen in Vitamin D absorption ($p = 0.250$) in both the groups.

A study was conducted that investigated the effect of sunscreen on cutaneous vitamin D production and circulating 25(OH)D3 levels, according to different body surface areas (BSA). Vitamin D and 25(OH)D3 levels were measured in 4 groups exposed to a single nbUVB exposure on 9% (group I: head and hands), 23% (group II: head, hands and arms), 50% (group III: head, hands, arms and legs) and 96% (group IV: total body) of the body surface without and with a 50+ sun protection factor sunscreen. The study concluded that although a 50+ sunscreen decreases significantly cutaneous vitamin D production following a single nbUVB exposure, the circulating 25(OH)D3 levels were only minimally affected. Short-term sunscreen use probably does not affect circulating vitamin D levels. (12)

The subject's belief on sunlight being a good source of Vitamin D in experimental and control group were analysed. In both the groups, 100% (n = 75) of the total population agreed on sunlight being a good source of Vitamin D. There was no statistical significance found and the value obtained was constant.

The application of sunscreen was analysed in experimental and control group. In both the groups, 100% (n = 75) of the total population does not apply sunscreen of any SPF in their daily routine. There was no statistical significance found and the value obtained was constant.

VI. Biochemical Parameters

Biochemical parameters like fasting blood sugar (FBS), Post prandial blood sugar (PPBS), HbA1c (glycated haemoglobin), BUN, creatinine, sodium, potassium, chloride, uric acid, calcium, vitamin D, phosphorus, total protein, albumin, globulin, A/G ratio, total bilirubin, SGOT, SGPT, alkaline phosphatase, total cholesterol, triglycerides, HDL, LDL and VLDL cholesterol were analysed. This helped to evaluate the blood compositions and deficiencies in the subjects and in observing their association in both the groups.

Table 6.1. Biochemical Parameters of the Study Population

Biochemical Parameters	Units	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	t value	p value
FBS (Fasting blood sugar)	mg/dl	155.47 ± 49.23 (n = 72)	100.64 ± 6.15 (n = 22)	5.193	.000*
PPBS (Post Prandial Blood Sugar)	mg/dl	210.13 ± 65.82 (n = 55)	111.29 ± 48.75 (n = 7)	3.829	.000*
HbA1c (glycated haemoglobin)	%	7.82 ± 1.21 (n = 38)	5.92 ± 0.28 (n =24)	7.570	.000*
Creatinine	mg/dl	1.26 ± 1.04 (n = 35)	1.00 ± 0.00 (n = 17)	1.015	.315
Sodium	meq/L	137.90 □2.69 (n = 20)	137.25 ± 1.50 (n = 4)	.463	.648
Potassium	meq/L	4.30 ± 0.47 (n = 20)	4.00 ± 0.00 (n = 4)	1.254	.223
Chloride	meq/L	102.61 ± 4.97 (n = 18)	102.00 ± 0.82 (n = 4)	.241	.241
Uric Acid	mg/dl	4.00 ± 1.73 (n = 3)	4.17 ± 0.41 (n = 6)	-.239	.818
Calcium	mg/dl	10.24 ± 0.96 (n = 75)	11.17 ± 1.29 (n = 75)	-5.039	.000*
Vitamin D	ng/ml	26.35 ± 10.76 (n = 75)	32.49 ± 10.75 (n = 75)	-3.499	.001*
SGOT (Serum Glutamic Oxaloacetic Transaminase)	u/L	31.29 ± 12.9 (n = 14)	28.30 ± 3.47 (n = 10)	.708	.487
SGPT (Serum Glutamic Pyruvic Transaminase)	u/L	29.93 ± 15.93 (n = 15)	30.82 ± 4.05 (n = 11)	-179	.859
Alkaline PO4	u/L	76.00 ± 34.66 (n = 4)	28 (n = 1)	1.239	.304
Total Cholesterol	mg/dl	187.81 ± 36.39 (n = 21)	180.57 ± 28.14 (n = 14)	.628	.534
Triglyceride	mg/dl	170.29 ± 58.81 (n = 21)	150.36 ± 29.70 (n = 14)	1.168	.251
HDL (High Density Lipoprotein)	mg/dl	42.38 ± 7.28 (n = 21)	45.00 ± 8.27 (n = 14)	-.988	.330
LDL (Low Density Lipoprotein)	mg/dl	96.14 ± 26.41 (n = 21)	98.29 ± 12.89 (n = 14)	-.281	.780

Data presented as Mean ± Standard Deviation

$^*p<0.05$

Table 6.1 shows that the mean fasting blood sugar (FBS), post prandial sugars (PPBS), glycated haemoglobin (HbA1c), creatinine, sodium, potassium, chloride, SGOT, alkaline phosphatase, total cholesterol and triglycerides of the experimental group were significantly higher than that of the control group. On the other hand, the mean uric acid, calcium, vitamin D, SGPT, HDL and LDL of the experimental group were significantly lower than the control group.

There was significant association ($p<0.05$) between fasting blood sugar ($p = 0.000$), post prandial sugars ($p = 0.000$), glycated haemoglobin ($p = 0.000$), calcium ($p = 0.000$) and vitamin D ($p = 0.001$) in both the groups.

There was no significant association ($p>0.05$) between creatinine ($p = 0.315$), sodium ($p = 0.648$), potassium ($p = 0.223$), chloride ($p = 0.241$), uric acid ($p = 0.818$), SGOT ($p = 0.487$), SGPT ($p = 0.859$), alkaline phosphatase ($p = 0.304$), total cholesterol ($p = 0.534$), triglycerides ($p = 0.251$), HDL ($p = 0.330$) and LDL (0.780) in both the groups.

In parameters like BUN, phosphorus, total protein, albumin, globulin, A/G ratio, total bilirubin and VLDL, there was no statistical association found and the value obtained was constant.

A study was conducted that aimed to assess whether vitamin D supplementation improves glucose metabolism in adults with type 2 diabetes. PubMed and Cochrane database were searched up to July 1st 2016 for randomized controlled trials that assessed the relationship between vitamin D supplementation and glucose metabolism (change in hemoglobin A1C (HbA1C) and fasting blood glucose (FBG)) among adults with type 2 diabetes. Twenty nine trials (3324 participants) were included in the systematic review. The study concluded a modest reduction of HbA1C after vitamin D treatment in adults with type 2 diabetes albeit with substantial heterogeneity between studies and no difference in Fasting Blood Glucose.

A study was conducted that focuses on the relationship between vitamin D intervention and glycaemic control in subjects with Type 2 Diabetes. Available randomized controlled trials (RCTs) studies were reviewed from the establishment time of each database to March 31, 2018. Finally, a total of 19 RCT studies involving 747 intervention subjects and 627 placebo controls were included in this meta-analysis. Meta-analysis showed that compared with the control group, the short-term vitamin D supplementation group had a decline in hemoglobin A1c (HbA1c), insulin resistance, and insulin. The study concluded that vitamin D supplementation in type 2 diabetes patients can improve HbA1c, insulin resistance, and insulin in short-term intervention, suggesting that vitamin D can be considered as a therapeutic agent along with the other treatments for type 2 diabetes. (13)

Another study was conducted that aimed to determine whether vitamin D deficiency is associated with increased risk of metabolic syndrome (MetS) among Chinese type 2 diabetes mellitus (T2DM) patients aged over 50 years. The study concluded that serum 25(OH)D deficiency may be a risk factor of MetS among Chinese type 2 diabetic patients, especially in the T2DM with BMI≥24 kg/m2 and the challenge is to determine the mechanisms of vitamin D action for recommendation of vitamin D supplementation that reduces the risks of MetS and progression to T2DM. (14)

VII. ONE DAY 24 HOUR DIETARY RECALL

Dietary recall of 24 hours involves total calories consumed and intake of carbohydrate, protein and fat along with calcium and vitamin D^2. This helped to understand the subjects total dietary intake of macronutrients and micronutrients a day.

Table 7.1. 24 Hour Questionnaire of the Study Population

Nutrients	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	t value	p value
Energy (Kcal)	1567.05 ± 143.946	1620.63 ± 127.03	-2.417	.017*
Carbohydrate (gm)	201.75 ± 27.095	215.16 ± 30.43	-4.154	.000*
Protein (gm)	54.21 ± 8.788	61.68 ± 11.267	-4.525	.000*
Fat (gm)	58.15 ± 5.260	54.93 ± 5.59	3.625	.000*
Fiber (gm)	26.55 ± 4.335	29.84 ± 4.07	-4.794	.000*
Calcium (mg)	754.09 ± 67.280	738.57 ± 81.08	2.098	.038*
Vitamin D^2 (mcg)	27.08 ± 4.106	28.85 ± 5.94	-2.127	.035*

Data presented as Mean ± Standard Deviation

***p<0.05**

Table 7.1 shows that the mean energy, mean intake of carbohydrate, protein, fiber and vitamin D^2 of the experimental group were significantly lower than that of the control group. Similarly, the mean fat and calcium of the experimental group were significantly higher than that of the control group.

There was significant association ($p<0.05$) between total calories ($p = 0.017$) consumed, intake of all the macronutrients and micronutrients like carbohydrate ($p = 0.000$), protein ($p = 0.000$), fat ($p = 0.000$), fiber ($p = 0.000$), calcium ($p = 0.038$) and vitamin D^2 of both the groups.

A study was conducted to examine a low-carbohydrate, high-fat diet with detailed physiological assessments of insulin sensitivity, glycemic control, and risk factors for cardiovascular disease. Fourteen obese patients with type 2 diabetes were recruited for an "Atkins"-type low-carbohydrate diet. Measurements were made at 0, 12, and 24 weeks of weight, insulin sensitivity, HbA1c, lipids, and blood pressure. Glycemic control significantly improved with reductions in hypoglycemic medication. Fasting glucose, homeostasis model assessment

(HOMA), and area under the curve (AUC) glucose were significantly reduced with non - significant improvements in insulin sensitivity. Systolic blood pressure, ratio of total: HDL cholesterol and triglycerides reduced while mean high-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol all increased. The study concluded that low-carbohydrate diet was well tolerated and achieved weight loss over 24 weeks in subjects with diabetes. Glycemic control improved with a reduction in requirements for hypoglycemic agents. (15)

Summary and Conclusion : The study concluded that the incidence of vitamin D deficiency was higher in diabetic patients as compared to non – diabetic population while calcium deficiency rate was lower in diabetic population. This shows that vitamin D deficiency is more prevalent in Type II Diabetic patients and has a role to play in glucose metabolism. With various factors leading to Vitamin D deficiency, such as lack of sunlight exposure, inadequate intake of Vitamin D rich food sources, etc; the need on awareness of vitamin D in the management of diabetes through educational programs and workshops is important. Also, the importance of vitamin D and the risk factors associated with its deficiency should be made an important aspect in the overall management of Type II diabetes mellitus.

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