Original Article

Impact of physical activity and diet counseling on the management of Type-2 Diabetic patients undergoing vitamin D supplementation: A Follow-up Study

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Abstract

Objectives: Aimed to determine the impact of dietary advice and regular physical activities on the blood glucose level among Type-2 diabetic mellitus (T2DM) patients undergoing vitamin D supplementation. **Methodology:** This study was conducted among 124 (Intervention=61, Placebo=63) T2DM patients aged 30-70 years from 2019 to 2020. Socio-demographic characteristics, 24-hour physical activities, 24-hour food recalls, and laboratory analysis of blood Vitamin D, $HbA1_C$ and FBS were estimated at baseline and after 3-month. The impact of vitamin D supplementation, physical activity, and diet counseling on the management of T2DM was measured in multivariable analysis by repeated measure ANOVA. **Results:** The mean age of respondents was 46.4±9.6 years, majority were illiterate 21(34%) with a mean income 31,098.4 BDT; 63.9% have been suffering from T2DM for <5 years and 56% have a strong family history of Diabetes. It was observed that reducing sedentary lifestyles and increasing physical activity increased calorie expenditure across timelines but not between groups (P>0.05). No significant differences were observed for physical activity levels between groups (Intervention and placebo). Consuming less Carbohydrates and increasing physical activity indicated a corresponding lowering of fasting blood glucose levels but not HbA1c. Compliance with physical activity indicated higher total energy expenditure by the intervention group (2448 kcal) than placebo (2364 kcal). The biochemical profile indicated that vitamin D helps to reducing the fasting blood glucose (10.9 to 8.4 mmol/L) levels along with diet restriction and increased physical activity **Conclusion:** Advice on simple carbohydrate restriction and increased walking has an impact on lowering fasting blood glucose level but not HbA1C undergoing vitamin D supplementation.

Keywords: Dietary advice, Physical activity, Carbohydrate restriction, Vitamin D Supplementation, Type-2 Diabetes.

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Introduction

Diabetes is defined as a metabolic disease characterized by persistent hyperglycemia caused by multiple factors including genetics, diet and nutrition, environment, and physical activity. Previously considered a disease of minor significance to health, is now becoming one of the main threats to human health both in developed and developing countries. According to the ninth edition of the IDF Diabetes Atlas in 2019, 488 million adults aged 20–99 years live with diabetes in the world, and the number will reach 578 million by 2030 and 700 million by 2045. It is estimated that 4.2 million adults aged 20–79 years will die of diabetes, which accounts for 11.3% of all deaths and this is equivalent to eight deaths every minute.[1]

The term physical activity denotes the movement of the body produced by the skeletal muscle that requires energy expenditure. As a prevention of T2DM physical mobility acts as a cornerstone. Regular exercise has beneficial effects on overall glycemic control through improved glucose tolerance, lowered insulin requirements, and improved insulin sensitivity. These will help slow down the progress of diabetic complications, ultimately establishing a quality of life. During and after physical activity insulin sensitivity increases, so that when muscle cells contract cells can use any available insulin to take up glucose and use it for energy whether insulin is available or not. In this way exercise can help lower blood sugar and as well as lower $A1_C$.[2] By regular physical activity

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insulin action can be modified both in the liver and within the muscles. The uptake of glucose in the muscle can be enhanced up to fivefold through insulin-independent mechanisms through aerobic exercise. After a long time of exercise, glucose uptake remains elevated by insulin-independent (2 hours) and insulin-dependent (up to 48 hours) mechanisms, which are linked with muscle glycogen repletion.[3] Globally improper dietary habits and lifestyle are responsible for the higher prevalence of Diabetes.[4] Appropriate quality and quantity of diets can modify glucose homeostasis and multiple metabolic processes.[5] So unhealthy food intake habits act as drivers of 'Glucose metabolism disorder' which finally leads to diabetes.[6] Complex carbohydrates have benefits to metabolic control of diabetes and its complications. Furthermore, dietary proteins stimulate insulin secretion which reduces glycemia among normal and diabetic individuals. A diet rich in protein has beneficial effects that significantly increase insulin sensitivity and decrease inflammation.[7] However, the study reported compliance to diet quality improved substantially by only diet counseling.[8] Studies reported even advice-only diet restriction (especially carbohydrate) and counseling on doing physical activity (especially walking) contribute to lowering blood glucose levels among poorly controlled/ uncontrolled T2DM.[9]

On top of that, existing literature showed both promising [10-13] and conflicting results[14] about the contribution of vitamin D on glucose homeostasis. Data suggest that vitamin D may directly or directly prevent/correct high-glucose activation, and that hypovitaminosis D-induced increase in renin-angiotensin system (RAS) activity as evidenced at least by experimental animal studies. [12,13] Thus, given the importance of deliberating advice on diet and physical exercise among T2DM patients undergoing vitamin D supplementation, this study explored how short-term advice during patients' visits to physicians influences glucose homeostasis while undergoing vitamin D intervention.

Materials and Methods

Study population, site, period, and Ethical permission The study was conducted among 124 (Treatment=61, Placebo=63) vitamin D deficient (<50 nmol/L).[15] T2DM patients aged 30-70 years, during January 2019 to January 2020 and participants who were pregnant or lactating were excluded. Respondents were recruited from Z.H Sikder Women's Medical College and Popular Diagnostic Center. Ethical clearance was approved by the ethical review committee of the Faculty of Biological Science, University of Dhaka. Informed consent (both verbal and written) was taken from each of the subjects according to the 'Declaration of Helsinki'.

Vitamin D Intervention Procedure

Tablet D-Rise. ®20000 (Beximco Pharmaceuticals) contains Cholecalciferol (20000 IU) and was supplemented to the 'Treatment group' for every 5th day in a week. The 'control or placebo' group received a placebo (Microcrystalline Cellulose BP) that was supplemented simultaneously with the treatment group.

Counseling on diet and physical activity was performed by the investigator while collecting data during the study period. Counseling (10-15 minutes session per visit) on diet restriction (less simple carbohydrates, more whole grains, fruits, and vegetables) and more physical activity (praying 5 times Salah, less watching TV, sleeping and sitting idle) were advised throughout the study; diet (24-hour recall) and 24-hour physical activities data were collected at baseline and after three months of the study.

Data collection

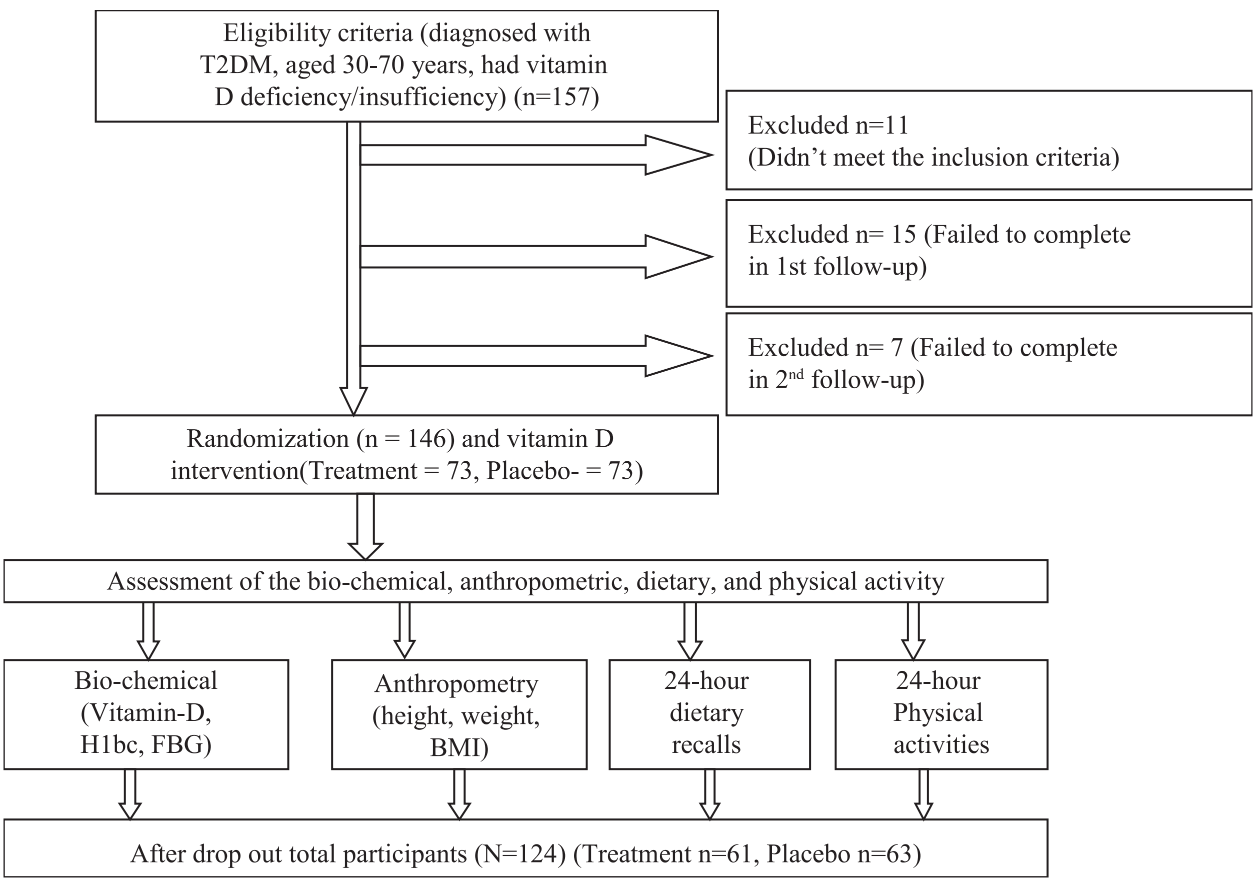
Socio-demographic, anthropometric (BMI kg/m^2), dietary habits (24-hour recall method), physical activity (24-hour activity pattern), and some biochemical parameters like 25 (OH) D, FBS (mmol/L), and HbA1c level (%) were analyzed at baseline and after 12^{th} weeks (end line), and interpreted with the use of statistics. Both baseline and end-line 24-hour physical activities (including sleeping, working, sitting, exercising, and leisure times), 24-hour food recall, BMI (kg/m2) as well as usual dietary habits (if taken more sugar-rich foods/ day, meal frequency/day) were obtained from diabetic patients in a pre-tested semi-structured questionnaire. Data on the dietary intake and physical activity level (PAL) were collected, carefully checked, and recorded, scrutinized data were then entered into the computer. According to WHO the computation of BMI is body weight in Kg divided by body height in $meters^2$. It was categorized as underweight (<18.5kg/m2), normal weight (18.5-24.9kg/m^2), overweight (25-29.9 kg/m^2), and obesity (≥30 kg/m^2).[16]

Assessment of dietary intake

To measure dietary intake quantitatively a one-day 24-hour food recall was performed for all subjects (both treatment and placebo). The names of all foods (traditional, fast foods, and drinks) consumed by the T2DM patients before 24 hours of the interview at home or outside (e.g., restaurants) were recorded. Moreover, investigators displayed 'portion size' to patients to help them recall and estimate the amount of foods they consumed for each meal and the number of meals/day as exactly as possible. Food consumption data were then transformed into grams (g) or volumes (ml) after coding the food items with the help of a 'Food conversion table of Bangladesh'.[17] A special 'Syntax' of statistical package for social science (SPSS) was prepared to endorse all 'Nutrient values' per 100 g according to a serially coded food list. The nutrient composition of the last 24-hour's eaten foods was obtained by running the food analysis through pre-written syntax. The amount of 'Calorie and nutrient values' was transferred into the Microsoft 'Excel sheet' and summed together according to each ID.

Measurement of physical activity : Physical activities reflect the summation of all accumulated physical activities in 24 hours that contribute to the physical activity level (PAL). PAL ratio was estimated through one previous day's '24-hour physical activities' from each respondent, counting through each activity over 1440 minutes. All activities are multiplied by assigned activity codes.[18] and divided by 1440 minutes to get the PAL ratio. There are five types of PAL-ratio Sedentary (little/no exercise), lightly active (light exercise/sports), moderately active (moderate exercise/sports), very active (hard exercise/sports), and extra active (tough exercise/sports/physical job).

Statistical analysis : The normality Test' was performed for all data by Shapiro-Wilk goodness-of-fit. All data (Socio-demographic, anthropometric, dietary, physical activity, and biochemical) were analyzed by the SPSS software package (version 26.0 SPSS Inc, Chicago, IL, USA). The comparison was done 'within group' (across 2-timelines) and between groups (Intervention vs. placebo). Baseline and end-line differences in food intake (carbohydrate, calorie), 25-hydroxy (OH) cholecalciferol, fasting blood sugar, and HbA1c were analyzed by student's t-test. The impact of vitamin D supplementation, physical activity, and diet counseling on the management of T2DM was measured in multivariable analysis by repeated measure ANOVA (across two timelines) using the General linear model (GLM).



Flow Chart: The study flow chart shows the selection criteria and procedure of the study

Results

Background characteristics of the 'treatment' and 'placebo' groups of T2DM were presented in Table 1. No significant (P>0.05) differences between the 'treatment' and 'placebo' groups were observed in variables like ages in years, sex, education, occupation, living area, religion, monthly income (BDT), BMI (kg/m^2), and history and duration of diabetes. The majority of respondents in the treatment (45.9%) and placebo (46.0%) groups were 41-50 years old and were mainly (57% for both groups) female with a mean age of 46.4 years; both groups were illiterate or completed primary education with a mean income of 31,967.7 (±10150.8) taka (P>0.05), most of the T2DM of both groups have been suffering from T2DM for <5 years, and majority of them had strong family history (P>0.05).

Table No. 1: Background characteristics of the Treatment and Placebo Group (n=124)

Characteristics	Total (n=124) n %	Treatment (n=61) n %	Placebo (n=63) n %	P-value
Age in years (Mean± SD)	(46.2±9.9)	(46.4±9.6)	(46.1±10.3)	P=.900
30-40	39 (31.5)	17 (27.9)	22 (34.9)	
41-50	57 (46.0)	28 (45.9)	29 (46.0)	
≥51	28 (22.6)	16 (26.2)	12 (19.0)	P=.861
Sex				
Male	56 (45.2)	26 (42.6)	30 (47.6)	P=.576
Female	68 (54.8)	35 (57.4)	33 (52.4)	
Education				
Illiterate	42 (33.9)	21 (34.4)	21 (33.3)	
Primary (1-5 y)	41 (33.1)	18 (29.5)	23 (36.5)	
Secondary (6-12y)	31 (25.0)	16 (26.2)	15 (23.8)	P=.790
Masters	10 (8.0)	06 (9.9)	4 (6.3)	
Occupation				
Services	45 (36.3)	17 (27.9)	28 (44.4)	
Business	23 (18.5)	10 (16.4)	13 (20.6)	
Housewives	29 (23.4)	18 (29.5)	11 (17.5)	P=.129
Others	27 (21.8)	16 (26.2)	11 (17.5)	
Living area				
Urban	113 (91.1)	54 (88.5)	59 (93.5)	P=.359
Rural	11 (8.9)	07 (11.5)	04 (6.3)	
Income (BDT)(Mean± SD)	(31,967.7 ±10150.8)	(31,098.4 ±10738.9)	(32,809.5 ±9557.7)	P=.350
≤20000	22 (17.7)	11 (18.0)	11 (17.5)	
20001-30000	48 (38.7)	27 (44.3)	21 (33.3)	
≥30001	54 (43.5)	23 (37.7)	31 (49.2)	
BMI (Kg/m^2)				
Normal (18.5-24.9)	45 (36.3)	23 (37.7)	22 (34.9)	
Overweight (25-29.9)	65 (52.4)	32 (52.5)	33 (52.4)	P=.321
Obese (≥30)	14 (11.3)	06 (9.8)	08 (12.7)	
Duration of diabetes				
<5-years	82 (66.1)	39 (63.9)	43 (68.3)	P=.611
≥5-years	42 (33.9)	22 (36.1)	20 (31.7)	
History of family-diabetes				
Yes	77 (62.1)	34 (55.7)	43 (68.3)	P=.151
No	47 (37.9)	27 (44.3)	20 (31.7)	

Per day food and 'calorie consumption patterns' of both T2DM patients by food groups are listed in Table 2 (baseline) and Table 3 (end line/after 3-months vitamin D intervention). By consuming the major food groups like cereals and grains, meat, fish, eggs, milk, lentils, green leafy, non-leafy vegetables and fruits, diabetic patients obtained respectively (total) 2698.4 kcal and 2743.3kcal for treatment and placebo group. Most of the calories came from carbohydrates, especially rice. The treatment and placebo groups consumed respectively total of 134.47±38.3 g and 142.77±49.6g carbohydrate; 407.63±38.9g and 413.33±46.7g protein, and 40.53±15.5g and 38.88±14.52g fat at baseline (Table 2).

Table No. 2: Amount of dietary intake (g/day) at baseline by 'treatment' and 'Placebo' according to the 'food groups' and 'calorie consumption/day'

Food Sources	Treatment (Food weight, g/day) Mean ±SD	Kcal/day	Placebo (Food weight, g/day) Mean ±SD	Kcal/day	P-value
Rice	58.94±16.3	235.8	60.0±17.3	240.0	0.877
Wheat	60.0±30.0	240.0	66.66±36.0	266.6	0.611
Potato	15.53±4.7	62.11	16.11±4.85	64.4	0.763
GLVs	37.89±13.6	151.6	36.66±13.2	146.6	0.595
NLVs	66.84±32.5	267.4	74.44±39.7	297.8	0.929
Fruits	44.21±6.07	176.8	44.44±7.26	177.8	0.737
Total Carbs	134.47±38.3	537.9	142.77±49.6	571.1	0.630
Beef	29.73±8.07	118.9	27.22±3.63	108.9	0.384
Chicken	44.21±15.4	176.8	46.66±15.8	186.6	0.699
Egg	50.0±0.00	200.0	50.00±.00	200.0	0.929
Milk	39.47±14.3	157.9	40.00±15.0	160.0	0.890
Fish	32.63±2.6	130.5	32.77±2.63	131.1	0.828
Lentil	62.63±17.2	250.5	61.11±16.91	244.4	0.823
Total Protein	407.63±38.9	1630.5	413.33±46.7	1653.9	0.756
Plant oil	40.53±15.5	364.74	38.88±14.52	349.9	0.788
Total energy	**-**	**2698.4**	**-**	**2743.3**	**0.933**

It is noticed that the amount of calorie consumption according to food groups was independent (P>0.05) between the two groups for both at baseline (2698.4 kcal verses 2743.3 kcal) (table 2) and end line (2549.5 verses 2575.7 kcal) (table 3). After 3 months periods of diet counseling treatment groups consumed 148.9 kcal less at the end line, and also a significant reduction of carbohydrates than baseline among the treatment group while increments of carb consumption among placebo were observed (Table 3).

Table No. 3: Amount of dietary intake (g/day) at end line by 'treatment' and 'Placebo' according to the 'food groups' and 'calorie consumption /day'

Food Sources	Treatment (Mean weight) (g/day)	Kcal	Placebo (Mean weight) (g/day)	Kcal/day	P-value
Rice	58.02±4.2	232.09	58.59±5.1	234.75	0.575
Wheat	60.6±3.0	242.4	61.13±6.6	245.5	0.635
Potato	15.33±3.6	61.33	16.58±2.9	68.3	0.08
GLVs	38.09±3.4	152.22	38.75±2.9	154.65	0.351
NLVs	65.94±3.7	261.56	66.15±9.9	266.6	0.898
Fruits	45.0±3.1	180.0	45.6±2.7	182.65	0.337
Total Carbs	282.99±5.7	1129.0	286.8±14.6	1139.0	0.109
Beef	30.2±3.2	120.6	29.4±2.2	117.4	0.219
Chicken	45.1±3.1	180.5	45.7±2.4	183.2	0.382
Egg	50.0±3.2	201.1	50.6±2.9	203.4	0.396
Milk	40.0±3.1	160.0	40.9±2.4	164.5	0.123
Fish	32.01±3.2	128.0	34.8±2.41	134.23	0.208
Lentil	62.97±3.0	252.2	63.63±3.06	254.5	0.321
Total Protein	260.3±18.1	1042.5	263.5±10.87	1054.18	0.135
Plant oil	42.0±3.13	378.0	42.5±2.91	382.5	0.449
Total energy	**-**	**2549.5**	**-**	**2575.7**	**0.333**

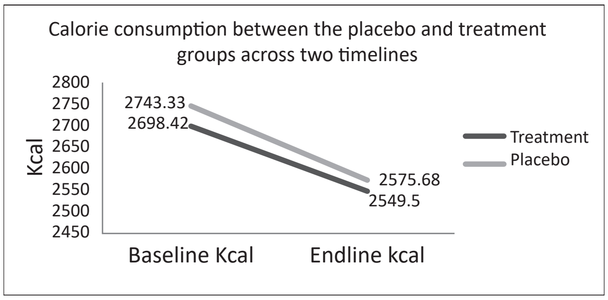


Fig 1: Dietary calorie consumption of the treatment and placebo groups from baseline to the end-line

Fig1: also represents insignificant differences in dietary calorie consumption between the treatment and placebo groups from baseline to the end line.

Table No. 4 and Table 5 respectively represent 'physical activity' levels at baseline and the end line between 'treatment' and 'Placebo' groups. No significant differences were observed for physical activity levels (PALs) between the two groups (P>0.05) both at baseline (2429.0 minutes/1440 minutes= PAL 1.7 verses 2359.2/1440= PAL 1.7) (table 4) and at end line (2488.6/1440= PAL 1.7 verses 2364.5/1440= PAL 1.7) (table 5).

Table No. 4: Physical activity levels performed by 'treatment' and 'Placebo' at baseline

Physical activities at baseline		Treatment (n=61) (Minutes)	values	Minutes* Values	Placebo (n=63) (Minutes)	Values	Minutes* Values
	sleeping	500	1.0	500.0	600	1.0	600.0
	lying	40	1.2	48.0	30	1.2	36.0
	eating	90	1.6	144.0	70	1.6	112.0
Personal	dressing	40	3.3	132.0	20	3.3	66.0
activities	shower	35	1.5	52.5.0	45	1.5	67.5
	recreation	65	1.72	111.8	35	1.72	60.2
	walking	50	3.0	150.0	40	3.0	120.0
	praying/moving/strolling	120	2.5	300.0	90	2.5	225.0
Personal activities total		940 minutes			930 minutes	-	
	Washing dishes	60	1.7	102.0	50	1.7	85.0
ousehold	house cleaning	65	3.0	195.0	90	3.0	270.0
chores	cooking	120	2.0	240.0	115	2.0	230.0
	washing clothes	65	3.0	195.0	75	3.0	225.0
Total Household chores		310 minutes	-		330 minutes	-	
Trips	daily trips	85	1.2	102.0	75	1.2	90.0
	occupational activities	105	1.5	157.5	1.5	1.5	172.5
Total daily trips and occupational activities		ADD	-	102.0		-	90.0
Grand Total		1440	-	2429.8	1440	-	2359.2
Mean PAL value			2429/1440= 1.7			2359.2/1440=1.7	

Table No. 5: Physical activity levels performed by 'treatment' and 'Placebo' at the end line

Physical activities at end line		Treatment (Minutes)	PAL Values	Minutes* Values	Placebo (Minutes)	Values	Minutes* Values
Personal	Sleeping	500	1.1	500	600	1.0	600
Activities	lying	50	1.2	60	40	1.2	48
	Eating	80	1.6	128	60	1.6	96
	Dressing	40	3.3	132	20	3.3	66
	Showering	45	1.5	67.5	55	1.5	82.5
	Recreation	55	1.72	94.6	25	1.72	43
	Walking	60	3.0	180	50	3.0	150
	Praying/moving/ strolling	110	2.5	275	80	2.5	200
Total Personal Activities		940 minutes	-		930 minutes	-	
Household	washing dishes	50	1.7	85	40	1.7	68
chores	House cleaning	75	3.0	225	100	3.0	300
	cooking	110	2.0	220	105	2.0	210
	Washing clothes	75	3.0	225	85	3.0	255
Total household chores		1250	-		1260	-	
Trips	Daily trips	95	1.2	114	80	1.2	96
	Occupational activities	95	1.5	142.5	100	1.5	150
Total Trips & occupational acts		190	-		180	-	
Grand Total (time)		1440	-	2448.6	1400	-	2364.5
Mean PAL Value			2448.6/1440 = 1.7			2364.5/1440 = 1.7	

Table No. 6 outlines the influence of dietary calorie and physical activity levels on fasting blood glucose, HbA_1C, and Vitamin D levels. All biochemical indices especially vitamin D, and FBG were significantly different (P=0.000) in the treatment group while an insignificant increase in vitamin D, and FBG in the placebo group was observed.

Table No. 6: Influence of dietary calorie and physical activity level on fasting blood glucose, HbA_1C, and Vitamin D levels

Parameter tested	Treatment			Placebo			#P-trend (Treatment Vs. Placebo)
	Baseline	End line	P-trend Within groups	Baseline	End line	P-trend (Within two timelines)	
Energy yielded from daily (24-hours) food intake (kcal)	2698.4	2549.5	P<0.05	2743.3	2575.7	P<0.05	P>0.05
(Average of the 2-timelines)		2623.95 kcal			2659.5 kcal		P>0.05
Energy Used by Different Physical Activities of Daily Life (kcal)	2429.0	2448.6	P>0.05	2359.2	2364.5	P>0.05	*P<0.05
(Average of the 2-timelines)		2438.8 kcal			2361.85 kcal		*P<0.05
Vitamin D (ng/ml) (25-hydroxy(OH) cholecalciferol) (Mean ±SD)	14.5±6.1	35.8±7.5	P<0.001	19.4±8.8	20.5±5.2	P>0.05	**P<0.001
(Average of the 2-timelines)		25.2(ng/ml)			19.95(ng/ml)		**P<0.001
HbA_1C (%) (Mean ±SD)	8.97±1.9	8.5±2.6	P=.004	7.9±2.1	7.7±0.60	P=.587	**P<0.001
(Average of the 2-timelines)		8.74%			7.8%		**P<0.001
Fasting Blood Glucose/FBG (mmol/L) (Mean ±SD)	10.9±3.5	8.42±1.7	P<0.001	10.6±2.4	11.5±2.3	P>0.05	**P<0.001
(Average of the 2-timelines)		9.65mmol/l			11.05mmol/l		**P<0.001

PAL = physical activity level, or energy requirement expressed as a multiple of 24-hour BMR

#GLM Model repeated measure ANOVA, Significance *P<0.05, **P<0.001,

Discussion

This study showed that counseling on diet (advised to reduce simple sugar) during the intervention periods (baseline to end line) improved the food habits of both groups as they consumed less energy than baseline, while mean calorie intake between the groups was independent (P>0.05) across timelines (Table No. 6). Contrarily, counseling on physical activity (advised to walk regularly to improve insulin sensitivity) improved energy expenditure through activities in the treatment group as compared to placebo (P<0.05) (Table No. 6), while within timelines both groups did not improve physical activity levels (PAL 1.7 for both groups across two timelines) (Table No. 4 and 5).

Diet and Physical Activity are demanding foci for blood glucose management. In this study, both groups were counseled on a diabetes diet and were also motivated by the enhancement of physical activity. A significant improvement in vitamin D levels and reduction of fasting blood glucose (FBS) levels among the treatment group than placebo was observed. As vitamin D increased in the end-line fasting blood glucose level decreased in treatment groups as well, however, this effect was not effective for glycated hemoglobin (HbA1c) (Table No. 6).

An attempt to consume simple sugar-restricted diets and increase physical activity indicated a corresponding lowering of blood glucose levels. After 3 months of counseling on diet restriction and encouragement to do regular physical activity (especially walking), the calorie intake of T2DM patients was reduced to 2549.5 kcal from 2698.4 kcal which may contributed to a reduction in the fasting blood glucose from 10.9 to 8.42 mmol/L. These findings are somewhat consistent with another study.[11] Notably, Vitamin D plays an important role in immune function and inflammation and physical activity demonstrates a relationship to syntheses of vitamin D, considering to necessary to factors immunologic, environmental and physical. Meta-analysis showed that there was a positive trend between serum 25(OH)D <20 ng/ml and body mass index, vitamin D levels, and high physical activity required sufficient serum levels of 25(OH)D, and physical activity has a stimulating effect on vitamin D synthesis [Mori et al, 2022].[19]

This study showed 25-hydroxyvitamin D levels were significantly higher in the treatment group as compared to placebo after vitamin D supplementation (treatment: 35.8 ±7.5 ng/mL versus placebo: 20.05±5.2 ng/mL, P=0.001) which is obviously for intervention study, while physical activity did not influence vitamin D level as equal PAL value (1.7) was observed across two timelines, and energy intake from food was reduced (P<0.05) in both groups (within effect) only in timelines but was not significant (P>0,05) between treatment and placebo groups. Similarly, diet restriction and walking did not influence HbA1C, except for lowering the fasting blood glucose. Pittas et al (2019)[14] also outlined that vitamin D3 supplementation (4000 IU/day) among persons (not selected for vitamin D insufficiency) at high risk for T2DM, did not result in a significantly lower risk of diabetes than placebo. Notably, Mazahery & von Hurst (2015)the effect on 25(OH[20] reviewed that several demographic/biological factors (baseline 25(OH)D, aging, BMI, body fat percentage, ethnicity, calcium intake, genetics, estrogen use), dietary fat content and composition, some diseases and medications, environment (season), type, dose, and duration of vitamin D supplementation have been associated with vitamin D concentration.

Limitation: Follow-up on the study subjects was hampered due to the COVID-19 Pandemic.

Conclusion: Changes in lifestyle and dietary and physical factors should be focused on for the correction of the rapid increase in the incidence of T2DM. According to the American Diabetes Association, self-dietary management (both type and quantity of food) acts as the key step for diabetics. At regular intervals, meals should be consumed with low fat and high fiber contents including a limited amount of simple carbohydrates/sugar.

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