International Journal of Food and Nutritional Science

ISSN: 2377-0619

Research Article

OMMEGA Publishers

OPEN ACCESS

DOI: 10.15436/2377-0619.20.2716

Advice-only Diet Restriction and Physical Activity: Influence on Blood Glucose Level of Poorly controlled Type 2 Diabetic Patients

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Abstract

Background: Diabetes Mellitus (DM) is a chronic medical condition associated with abnormally high levels of glucose in the blood linked with unhealthy and poor dietary habit and sedentary modern lifestyle.

Objectives: This article describes the influence of advice-only diet restriction and physical activity on the blood glucose levels of type-2 diabetic (T2DM) patients.

Methods: This follow up study was conducted on sixty poorly controlled/uncontrolled T2DM patients, who were recruited from Gazipur Diabetic Center, Bangladesh. Patients were counseled (30-45 minutes session/week for 3-months) on simple carbohydrate restriction and advised to perform more physical activity (e.g. walking) and not being in sedentary state. Both baseline and end line fasting blood glucose, HbA1C%, 24-hour food recall and 24-hour physical activity were estimated and analyzed by statistical software package.

Results: Overall compliance to dietary counseling indicated by lesser intake of carbohydrate (421 to 245 g) and more green leafy vegetables (25 to 50 g) intake within ≥4 meal-frequency in end line as compared to baseline. Compliance to physical activity indicated by higher proportion of moderately active (end line: 66.7% vs. baseline: 31.7%) and lower proportion of sedentary active (33.3% vs. 68.3%) T2DM patients in end line than baseline and higher total energy expenditure in end line (2433 kcal) than baseline (2180 kcal). Biochemical profile indicated that both diet restriction and physical activity contributed to reduce the fasting blood glucose (15.5 to 9.4 mmol/L) and HbA1C (12.5% to10.9%) levels of type-2 diabetic patients ($P<0.05$).

Conclusion: Advice-only physical activity and carbohydrate restriction contribute on lowering blood glucose level and maintain glucose homeostasis.

Keywords: Diet restriction; Physical activity; Blood glucose; HbA1C; Type 2 Diabetic patients

Introduction

Diabetes Mellitus (DM) is a stress induced metabolic disorder and a chronic public health problem Worldwide. World prevalence of diabetes was 9.3% in 2019, is projected to increase by 25% in 2030 and 51% by 2045. The prevalence is higher in urban areas (10.8%) and high-income countries (10.4%)[1-3]. More than 80% of the people with type-2 diabetes mellitus (T2DM) currently live in low and middle-income countries like Bangladesh, is estimated to be more than 150% in South Asia between 2000 and 2035 because of irreversible phenotype/genotype factors and reversible risk factors e.g. diet, physical inactivity and metabolic syndromes [3-5]. Globally it is associated with rapid cultural transforms, dietary changes, unhealthy and sedentary lifestyle[6-8].

Received Date: March 27, 2020
Accepted Date: July 06, 2020
Published Date: July 10, 2020

Citation: Nasrin, S., et al. Advice-only Diet Restriction and Physical Activity: Influence on Blood Glucose Level of Poorly controlled Type 2 Diabetic Patients. (2020) J Food Nutr Sci 7(1): 51-56.

The prevalence of type 2 diabetes showed an increasing trend in both urban and rural population of Bangladesh[9] and placed a substantial burden on overstretched healthcare services of resource-poor settings. Older age, higher socioeconomic status, higher educational attainment, hypertension, and obesity were found to be significant correlates of type 2 diabetes[10] and low levels of diabetes knowledge were also reported among T2DM patients[11]. Studies showed physical exercise[12-14] and nutritional control[15-17] are the key approaches for the management of type-2 diabetes. Physical activity helps the body cells to take up glucose and thus lower blood glucose levels. It activates human organs, muscles, bones, arteries to be more efficient, and thus, reduce chances of getting illness or disease[14]. In order to provide adequate calorie, diabetic patients need nutritionally balanced diet in spaced time interval[15]. Given the importance of taking carbohydrate restricted diet and performing more physical activity for T2DM patients, present study counseled urban T2DM patients on food restriction and more walking and less sedentary activities for three months, aimed to appraise the influence of simple carbohydrate restricted diet practice and change in physical activity on blood glucose level in urban setting. To the best of our knowledge, no study in Bangladesh advised on diet restriction and physical activity and followed up for three months period among urban T2DM patients.

Materials and Methods

Subjects

This follow up study was conducted on sixty poorly controlled/ uncontrolled type-2 diabetic (T2DM) patients attending at Gazipur Diabetic Centre, Bangladesh. They neither received any type of counselling on diet nor physical activity before. Exclusion criteria included the presence of major diabetes complications (i.e. retinopathy, stroke or myocardial infarction and renal disease). At first, 186 patients were enrolled but after 3 months only 60 T2DM patients were available for end line data collection. Informed consent was taken from each of the subject who willing to participate in this study. The study protocol was approved by the Ethical Board of the Faculty of Biological Science, University of Dhaka.

Procedure

Counseling (30-45 minutes session per week) on diet restriction[17] (less simple carbohydrate, more whole grains and vegetables) and more physical activity (less watching TV, sleeping, sitting idle) were advised and followed up to three months[18]. Data were collected and recorded in pretested questionnaire. Twenty-four hour food recall and seven days food frequency questionnaire (FFQ) was used to record the dietary habit (types, amount & frequency of food intake) and 24-hour physical activity was recorded to monitor the physical activity level[18-20]. Both baseline and end line fasting blood glucose (FBG), HbA1C% levels were estimated and dietary habit and 24-hour physical activities were recorded. Fasting blood glucose and HbA1C levels were estimated by Glucose oxidase[21] and Nyco Card Test method[22] respectively. Calorie and nutrient intake was estimated from food Conversion table[23].

Data analysis

Data were checked and used for entry into computer program. SPSS software package (version 23.0 SPSS Inc. Chicago, IL, USA) was used to analyze the data. Descriptive statistics were employed to analyze all variables. Values were expressed as frequency, percentage, mean and standard deviation as and where necessary. Association of carbohydrate intake with HbA1C level (%) was enumerated by chi-square test; differences of baseline and end line energy expenditure and fasting blood glucose were analyzed by student's t test.

Results

Diabetic patients consuming the major nutrients–carbohydrate, protein, and fat from different food groups obtained 3124.7 kcal (mostly from 421.2 g carbohydrate). After diet counseling on less simple carbohydrate (especially rice) consumption, calorie consumption was reduced to 2455.0 kcal (carbohydrate 245 g). This amount of calories was required for the maintenance of normal lifestyle and physical activity. Most (55.0%) of the T2DM patients took <4 meals in a day in baseline while nearly two third of them (65.0%) used to take ≥ 4 meal after diet counseling (Table 1). Table 2 shows their physical activity comprising personal activities, household chores, and occupational involvement. It was also observed that reducing sedentary lifestyle, such as sleeping, lying, sitting and increasing physical activity like exercise, walking, prayer increase total calorie expenditure. Compliance to physical activity indicated by higher total energy expenditure in end line (2433 kcal) than baseline (2180 kcal). Table 3 enumerated influences of dietary consumption of calorie and different physical activity level (PAL) of T2DM patients on their baseline and end line fasting blood sugar (mmol/L). More T2DM patients (68.3%) showed sedentary activity in baseline, on the contrary, higher proportion of T2DM patients (66.7%) were moderately active in end line. Attempt of consuming simple sugar-restricted diets and increasing physical activity as well energy expenditure indicated lowering of blood glucose level (Table 3). The HbA1C did not lower in the same way (Table 4). After 3 months of dietary restriction, less carbohydrate consumption was found to be associated with lower HbA1C% level (P=0.035), but calorie consumption did not show any relation with HbA1C%.

Table 1: Food Consumption Patterns of type-2 Diabetic Patients by Food Groups and Nutrient sources

Nutrients (Food groups)	Nutrient sources	Food names	Baseline consumption (Before diet counseling)		End line consumption (after 3 months)	
			Food weight (g) Mean ± SD	Calorie consumed Kcal	Food weight (g) Mean ± SD	Calorie consumed Kcal
Carbohydrate (cereals/ grain/tubers)	Plant	Rice	277.0 ± 11.2	1108	100.0 ± 0.8	400
		Red Wheat	90.1 ± 5.0	360.4	80.0 ± 0.6	320
		Potato	54.1 ± 5.0	216.4	65.0 ± 1.8	300
		Total	**421.2 ± 21.2**	**1684.8**	**245.0 ± 3.2**	**1020**
Protein, vitamins and minerals (Meat/fish/ eggs/milk/ Lentils/[a]GLV/ NLVs/fruits)	Animal and plant	Beef	07.2 ± 0.1	28.8	05.0 ± 0.2	20
		Chicken/Duck	15.2 ± 0.7	60.8	10.0 ± 0.7	40
		Eggs	10.1 ± 0.8	40.4	10.0 ± 0.8	40
		Fish	65.2 ± 0.5	360.8	60.0 ± 0.5	240
		Milk & milk products	10.2 ± 0.8	40.8	15.0 ± 0.8	80
		Lentil	19.4. ± 0.4	77.6	10.0 ± 0.4	40
		GLV	25.2 ± 0.2	100.8	50.0 ± 0.2	400
		NLV	110.1 ± 1.1	440.4	150.0 ± 1.1	600
		Fruits	25.0 ± 0.9	100	25.0 ± 0.4	102
		Total protein	**287.6 ± 5.4**	**-**	**335.0 ± 5.1**	**-**
Fat	Plant and Animal	Plant Oil	15.3 ± 1.5	137.7	10.0 ± 3.9	90
		Animal fat	10.2 ± 7.3	91.8	5.0 ± 5.0	45
		Total Fat	**25.5 ± 8.8**	**229.5**	**15.0 ± 8.9**	**135**
Miscellaneous foods			**10.0 ± 0.1**		**10.0 ± 0.1**	
Total foods (g) and calorie consumption (Kcal)			824.6 ± 32.5 (g)	3124.7 ± 453.43	603.0 ± 4.8 (g)	2455.0 ± 145.36
Frequency of meal/day			**Baseline % n**		**End line % n**	**Statistics**
<4			55.0 (33)		35.0 (21)	χ^2=3.61
≥ 4			45.0 (27)		65.0 (39)	P=0.035

[a]GLV= Green leafy vegetables, NLV=Non leafy vegetables

Table 2: Energy used by Different Physical Activities of Daily Life (1440 minutes/24 hours) by type-2 diabetic patients

Physical activities[a] (n)	PAR or Energy costb	Baseline		End line	
		Time allocation (minutes)	Time x Energy cost[b] (Kcal used)	Time allocation (minutes)	Time x Energy cost[b] (Kcal used)
Personal activities /care					
Sleeping (n=60)	1	600	600x1.0=600.0	515	515x1.0=515.0
Lying, sitting quietly (n=45)	1.2	58	58x1.2=69.6	60	90x1.2=108.0
Eating, drinking (n=60)	1.6	60	60x1.6=96.0	120	120x1.6=192.0
Dressing (n=60)	1.3	35	35x 1.3=45.5	30	35x 1.3=45.5
Shower, Washing (n=60)	1.5	62	62x1.5=93.0	60	60x1.5=90.0
Recreation (n=40)	1.72	130	130x1.72=223.9	60	60x1.72=103.2
Walking, sports (n=60)	3	60	60x3.0=180.0	120	120x3.0=360.0
Prayer, moving, strolling (n=38)	2.5	30	30x2.5=75.0	90	90x2.5=225.0
Total time used		**1035m ~17.25 h**	**1382.7**	**1035m ~17.25 h**	**1638.7**
Household chores					
Washing dishes (n=35)	1.7	30	30x1.7=78.2	30	30x1.7=78.2
House cleaning (n=40)	3	55	55x3.0=160.0	55	55x3.0=160.0
Cooking (n=35)	2	120	120x2.0=240.0	120	120x2.0=240.0
Washing clothes (n=45)	3	20	20x3.0=60.0	20	20x3.0=60.0
Total times		**225 m ~ 3.75 h**	**538.2**	**225 m ~ 3.75 h**	**538.2**
Daily trips (n=22)	1.2	60	60x1.2=72.0	60	60x1.2=72.0

Occupational activities (n=22)	1.5	125	125x1.5=187.4	123	123x1.5=184.5
Total times		**180 m ~ 3 hours**	**259.5**	**180 ~ 3 hours**	**256.5**
Grand total		**1440 m ~24 hours**	**2180.4 ± 112.4**	**1440 m ~ 24 hours**	**2433.4 ± 125.4**

[a] PAL = physical activity level, or energy requirement expressed as a multiple of 24-hour BMR
[b]Energy costs (or PAR/physical activity ratio) of activities, expressed as multiples of BMR (basal metabolic rate) [19]

Table 3: Influence of Dietary Calorie intake and Physical Activity Level on Fasting Blood Glucose of type-2 diabetic patients

Parameter tested				**Base line (Mean ± SD)**	**End line (Mean ± SD)**	**Statistics**
Energy (Kcal) yielded from daily (24-hours) food intake				3124.7 ± 453.43	2455.0 ± 145.36	P=.000*
Fasting blood glucose/FBS (mmol/L)				15.5 ± 4.7	9.4 ± 1.7	P=.000*
Energy (Kcal) used by Different Physical Activities of Daily Life				2180.4 ± 112.4	2433.4 ± 125.4	P=.000*
Fasting blood glucose/FBS (mmol/L)				15.5 ± 4.7	9.4 ± 1.7	P=.000*
Overall Energy (Kcal) used for 2 different physical activity levels (PALs) by type 2 diabetic patients						
PAL *(Baseline vs. End line) (% n)*						
Sedentary activity	68.3 (41)	33.3 (20)	χ^2=4.05	2439.2 ± 131.5	3060.8 ± 390.1	P=.000*
Moderate activity	31.7 (19)	66.7 (40)	P=0.04	2462.5 ± 196.5	3154.4 ± 525.9	P=.000*
Mean energy used for 2 types of PAL Corresponding mean FBS (mmol/L)				**2450.85 ± 164.0** 15.5 ± 4.7	**3107.6 ± 458.0** 9.4 ± 1.7	P=.000*

*Significance p<0.01

Table 4: Influence of Dietary carbohydrate and Calorie intake on HbA1C% of type-2 diabetic patients

Nutrient consumption	**Baseline HbA1c (%)** Mean ± SD (12.5 ± 2.5) **% (n)**			**End line HbA1c (%)** Mean ± SD (10.9 ± 1.9) **% (n)**		
	≤10.5	**>10.6**	**Total**	**≤10.5**	**>10.6**	**Total**
Carbohydrate ((g)						
≤300	6.2 (01)	27.3 (12)	21.7 (13)	66.7 (18)	39.4 (13)	51.7 (31)
>300	93.8 (15)	72.7 (32)	78.3 (47)	33.3 (09)	60.6 (20)	48.3 (29)
Total	100 (16)	100 (44)	100 (60)	100 (27)	100 (33)	100 (60)
Statistics	$\varkappa^2$=1.422	P=0.153		$\varkappa^2$=4.423	P=0.035*	
Calorie (Kcal)						
≤1900	25.0 (04)	43.2 (19)	38.3 (23)	92.6 (25)	84.8 (28)	88.3 (53)
>1900	75.0 (12)	56.8 (25)	61.7 (37)	7.4 (02)	15.2 (05)	11.7 (7)
Total	100 (16)	100 (44)	100 (60)	100 (27)	100 (33)	100 (60)
Statistics	$\varkappa^2$=1.614	P=.200		$\varkappa^2$=.864	P=.442	

*Significance p<0.05

Discussion

This study outlined that advice-only diet restriction and physical activity can alter fasting blood glucose levels of poorly controlled type-2 diabetic patients. Umpierre et al.[24] showed Advice-only physical activity worked on blood sugar if diet is also restricted simultaneously. However, compliance to diet quality improved substantially by only diet counseling reported by another study[25]. Diet should reduce oxidative stress and insulin resistance, therefore, antioxidant rich (green-yellow fruits and vegetables), low glycemic index and high fiber complex carbohydrate content diets (whole grains) have been suggested to maintain glucose homeostasis[26]. In T2DM patients, physical activity improves insulin sensitivity, prevents impaired glucose tolerance and delays onset of diabetes complications through a synergistic effect with insulin by enhancing glucose uptake into the cells and subsequent increasing blood flow in the muscle[27-29]. Present study indicated that diet restriction and physical activity significantly reduce the fasting blood glucose (FBG) and glycated hemoglobin levels (HbA1C %) (Table 3 and 4). Balaji et al.[30] also reported that physical exercise (even brisk walking and yoga exercises) has significant insulin like effect on FBG and HbA1C%. In this study, after 3 months of counseling on diet restriction and encouragement of doing regular physical activity (especially walking), calorie intake of T2DM patients was reduced to 2455 from 3124 kcal including reduction of rice intake (from 277 g to 100 g) and more green leafy vegetables intake

(25 to 50 g) within ≥4 meal frequencies than baseline (Table 1) which contributed to reduce the fasting blood glucose from 15.5 to 9.4 mmol/L (Table 3). These findings are somewhat consistent with another study[31]. Moreover, lower carbohydrate intake was associated with significant reduction of end line HbA1C% among T2DM patients which is echoed with that of Meng et al.[32]. Educational intervention had significant positive effect on type-2 diabetic self-care behaviors and reduction of HbA1C% also reported in a recent Iranian study[33].

Reducing sedentary lifestyle, such as sleeping, lying, sitting and increasing physical activities like sporting, walking, prayer etc. increase the expenditure of calories (Table 2) which have an effect on lowering the fasting blood glucose of T2DM patients of this study (Table 3). As mentioned before, large number of studies [26-29] have reported that physical activity plays an important role on glycemic control. A recent 27-years follow up study reported that moderate-to-vigorous physical activity of any duration, compared to none, associated with the lower risk of type-2 diabetes incident and reduced all-cause mortality[34]. However, Omar et al showed no contribution of physical activity on the fasting blood glucose level among housewives [35].

Conclusion

Shifting of some daily sedentary activities (e.g. sitting, excess sleeping and watching TV) to more performing activities (e.g. walking, praying and sporting) and simultaneous simple sugar restriction contribute on lowering blood glucose level and thus maintaining glucose homeostasis among urban T2DM patients.

Acknowledgement
Authors thank the Gazipur Diabetic Centre (Samity), Gazipur, Bangladesh for supporting and facilitating the recruitment of diabetic patients and also thankful to the subjects of this study for assisting and keep patience in the collection of blood samples, dietary and physical activity information. Authors are grateful to Praveen Begum, PhD, Consultant Nutritionist at Gulshan Ma O Shishu Shasto kendro and Shah Muhammad Anayetullah Siddiqui, Principle Scientific Officer of Institute of Nutrition and Food Science (INFS), University of Dhaka, for helping in delivering lecture, data and blood collection during the study.

Conflict of Interests: Authors have declared no conflict of interest.

Funding: No funding was received for this study.

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