Effectiveness of Mobile Application for Adherence to Advice on Diet & Medication among Newly Diagnosed Patients of Type II Diabetes

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ABSTRACT

Background: A healthy diet is an important element among all the lifestyle related management of diabetes, which included diet alone, diet with oral hypoglycaemic drugs, or diet with insulins. This study was conducted to assess the effectiveness of android mobile phone application for adherence to advice on diet and medication among newly diagnosed Type 2 diabetes patients.

Methods: The study was an open-label, parallel-arm, randomized controlled trial. Total of 66 adults (33 in each arm) type 2 diabetes patients were recruited. Study group was getting intervention by using mobile application-based software and control group was through web-based intervention.

Results: In baseline 51.5% knows some risk factors of diabetes and 46.96% patients knew that it can be prevented. Among them 46.97% and 34.85% replied healthy diet and exercise as the best prevention method respectively. Cochrane's Q was significant in recent changes of eating habits both in control and intervention group (P=0.000). Diet advice of doctor was followed among intervention group which was found to be significant (P=0.031). Starch consumption was decreased significantly on both the groups.

Conclusion: Proper treatment with special focus on diet should be given by the healthcare providers in a way to control the disease, reduce the symptoms, and prevent complications.

Key words: Food frequency questionnaire, 72hours recall method, Type 2 DM

INTRODUCTION

Diabetes mellitus (DM) is derived from two words, 'diabetes' Greek word derivative, means siphon - to pass through and the Latin word 'mellitus' means honey or sweet.[1] In the textbook "*The Treatment of Diabetes Mellitus*" by Elliott Joslin described that diet regular exercise could significantly reduce the risk of death in diabetes patients. Health care professionals are using these principles while educating their patients about lifestyle changes for the management of diabetes.[2]

Diabetes is a lifestyle disease which is potentially preventable, and can be significantly decreased with changes in diet, lifestyle and environment. A healthy

diet is one of the major component of lifestyle related management of diabetes which included diet alone, diet with oral hypoglycaemics, or diet with insulin.[3,4,5] The so-called "diabetic diet" is a healthy eating plan ideal for the whole family, which is naturally rich in nutrients and low in fat and calories and sticking to regular meal in time.

Awareness on diabetic diet is necessary to improve dietary habits among diabetes patients. In a study, positive and significant association was found between knowledge of diabetic diet and required calories.[6] Doctors as well as health educators should give emphasis on diabetic education, particularly on dietary management to make the diabetic patients capable enough to manage the disease in a better way.[7] Web-based nutrition management programs support DM patients for improvement of their health and dietary habits. Mobile phone with touchscreen technology may help in delivering diet related information.[8] With this background, the study was conducted among the newly diagnosed Type 2 diabetes patients to enhance their adherence on diet and medication with the use of android mobile phone application.

MATERIALS AND METHODS

The study was designed as an open-label, parallel-arm, randomized controlled trial and was conducted at the department of Endocrinology and Community Medicine of the Medical college. Total of 66 adults (33 in each arm) type 2 diabetes patients were recruited for this two years study. This trial had Institutional ethics committee approval as well as enrolled in Clinical Trial Registry of India.

Selection criteria: Newly diagnosed (within 3months) type 2 diabetes patients aged between 18-60 year. (So as to exclude minors and elderly, assuming to be extremes and less techno-friendly), able to read and write in English and Techno-friendly with smart phones and computers were included in the study. Gestational diabetes patients and those were having serious mental health issues were not included in the study.

Pre-Testing and Data Collection: Initially, the prepared tool for data collection was pre-tested to test the consistency and accuracy of the questionnaire to collect required information. In this randomized controlled trial data collected at every 3-month interval for one year. Socio-demographic profile, knowledge about other risk factors and prevention of diabetes, details on their drug therapy, general diabetes re-

lated dietary habits, food frequency questionnaire through 72hours recall method were included in the interview schedule. Fasting blood sugar (FBS) and post-prandial blood sugar (PPBS) tests were done in baseline and every follow up to see the effect of mobile based dietary intervention on their glucose level.

Intervention: The study consisted of two arms. The block random design method was adopted for selection of patients into different arms. Clinical trial coordinator ensured proper allocation concealment and allotment of cases into the two arms. Study group was getting intervention by using mobile application based software and control group was through web-based intervention. Printed education material and daily intake of 1600 calories diet chat as per the endocrinologist recommendation in both English and local Odia language were provided to both the groups. But an SMS containing some educational tips about diet, drugs etc. was sent every week to the intervention group only.

Statistical Analysis: The response to the questionnaires on dietary information of the study and control group, at the baseline and the follow ups, were analysed using Cochrane Q and continuous data were analysed by Repeated Measure ANOVA. All the analyses were done by using SPSS v 20 licensed to the institute.

RESULTS

Socio-demographic data of 66 participants were collected at baseline of the study. In the newly diagnosed type 2 diabetes patients majority were male (65.2%) with the mean age of 42.29 ± 9.5 years. More than half of the participants (57.6 %) belonged to joint family and among them 86.4% were married. All the respondents were well educated and 51.5% belonged to upper class also. The researchers did not find any difference between the control and study group.

All the study participants (100%) were under the oral anti-diabetic therapy. In baseline assessment, 21.2% participants were on one oral hypoglycemic, 77.3% were on two hypoglycemic and one patient was on three oral hypoglycemic drugs. No patient was on insulin. When asked about the skipping of medications, 86.4% told that they had not skipped medication while 13.6% told that they had skipped medication at least once in a month. One patient told that he had skipped medication 6 times in last month.

Table 1: Change of Treatment in Follow ups

Change of treatment (Dose/medications) in follow up	Control (%)				Intervention (%)			
	1st F/up n=31	2nd F/up n=25	3rd F/up n=22	4th F/up n=20	1st F/up n=29	2nd F/up n=26	3rd F/up n=23	4th F/up n=23
Increased	10 (32.26)	11 (44)	2 (9.09)	4 (20)	11 (37.93)	7 (26.92)	4 (17.39)	1 (4.35)
Decreased	2 (6.45)	0 (0)	0 (0)	0 (0)	3 (10.34)	1 (3.85)	1(4.35)	1 (4.35)
No change	19 (61.29)	14 (56)	20 (90.91)	16 (80)	15 (51.72)	18 (69.23)	18 (78.26)	21(91.30)

Table 2: Eating Habits of Patients

Eating habits	Control (%)						Intervention (%)					
	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	P value	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	P value
Have you made recent changes in eating habits?												
Yes	28 (84.8)	31 (100)	25 (100)	22 (100)	20 (100)	0.000	29 (87.9)	29 (100)	26 (100)	23 (100)	23 (100)	0.000
No	5 (15.2)	0	0	0	0		4 (12.1)	0	0	0	0	
Do you follow doctor's dietary advice?												
Yes	30 (90.9)	28 (90.3)	24 (96)	21 (95.5)	20 (100)	0.637	29 (87.9)	27 (93.1)	26 (100)	23 (100)	23 (100)	0.031
No	3 (9.1)	3 (9.7)	1 (4)	1 (4.5)	0		4 (12.1)	2 (6.9)	0	0	0	
Did you skip any meals last week?												
Yes	6 (18.2)	5 (16.1)	3 (12)	3 (13.6)	1 (5)	0.603	8 (24.2)	4 (13.8)	3 (11.5)	3 (13)	3 (13)	0.894
No	27 (81.8)	26 (83.9)	22 (88)	19 (86.4)	19 (95)		25 (75.8)	25 (86.2)	23 (88.5)	20 (87)	20 (87)	
Did you take everyday food in exact time?												
Yes	30 (90.9)	29 (93.5)	23 (92.0)	18 (81.8)	17 (85)	0.603	26 (78.8)	25 (86.2)	21 (80.8)	19 (82.6)	19 (82.6)	0.984
No	3 (9.1)	2 (6.5)	2 (8.0)	4 (18.2)	3 (15)		7 (21.2)	4 (13.8)	5 (19.2)	4 (17.4)	4 (17.4)	
Did you take artificial sweeteners?												
Yes	17 (51.5)	17 (54.8)	12 (48.0)	15 (68.2)	14 (70)	0.189	14 (42.4)	14 (48.3)	14 (53.8)	13 (56.5)	12 (52.2)	0.155
No	16 (48.5)	14 (45.2)	13 (52.0)	7 (31.8)	6 (30)		19 (57.6)	15 (51.7)	12 (46.2)	10 (43.5)	11 (47.8)	
Did you eat non veg food?												
Yes	29 (87.9)	27 (87.1)	22 (88.0)	18 (81.8)	17 (85.0)	0.406	29 (87.9)	25 (86.2)	23 (88.5)	20 (87.0)	19 (82.6)	0.406
No	4 (12.1)	4 (12.9)	3 (12.0)	4 (18.2)	3 (15)		4 (12.1)	4 (13.8)	3 (11.5)	3 (13.0)	4 (17.4)	
Ate away from home last week												
Yes	12 (36.4)	23 (74.2)	25 (100)	22 (100)	20 (100)	0.000	18 (54.5)	25 (86.2)	26 (100)	23 (100)	23 (100)	0.000
No	21 (63.6)	8 (25.8)	0 (0)	0 (0)	0 (0)	(raised)	15 (45.5)	4 (13.8)	0 (0)	0 (0)	0 (0)	

Table 3: Food Habits of Participants

Food Habits	Control n(%)						Intervention n(%)					
	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	Pvalue	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	Pvalue
Fried food Consumption/ week												
<1	24(72.7)	27(81.8)	21(84.0)	17(77.3)	10(50)	0.008	27(81.8)	22(75.9)	20(76.9)	17(73.9)	19(82.6)	0.569
1-2	9(27.3)	4(12.9)	4(16)	5(22.7)	10(50)	(raised)	6(18.2)	7(24.1)	6(23.1)	6(26.1)	4(17.4)	
Starch serving/ day												
0-1	19(57.6)	31(100)	24(96.0)	22(100)	20(100)	0.000	18(54.5)	29(100)	26(100)	23(100)	23(100)	0.000
2 or more	14(42.4)	0	1(4.0)	0	0		15(45.5)	0	0	0	0	
Sweet servings/ day (sweet foods like cakes, biscuits, lollies and/or chocolate)												
Usuallynone	32(97)	29(93.5)	24(96.0)	22(100)	19(95)	0.809	29(87.9)	29(100)	26(100)	22(95.7)	23(100)	0.017
1-2	1(3)	2(6.5)	1(4.0)	0	1(5)		4(12.1)	0	0	1(4.3)	0	
Sugar consumption (teaspoons)/ day (in hot drinks, added to foods, etc.)												
0-3	33(100)	31(100)	23(95.8)	22(100)	20(100)	0.406	33(100)	29(100)	25(96.2)	23(100)	22(95.7)	0.406
4-6	0	0	1(4.2)	0	0		0	0	1(3.8)	0	1(4.3)	
Fish Consumption/week												
None/rarely	8(24.2)	8(25.8)	4(16.0)	5(22.7)	5(25)	0.820	8(24.2)	7(24.1)	8(30.8)	8(34.8)	7(30.4)	0.866
1-6 times	25(75.8)	23(74.2)	21(84.0)	17(77.3)	17(75)		25(75.8)	22(75.9)	18(69.2)	15(65.2)	16(69.6)	
Fruit servings/day												
Usuallynone	8(24.2)	6(19.4)	3(12.0)	3(13.6)	6(30)	0.513	3(9.1)	3(10.3)	6(23.1)	4(17.4)	4(17.4)	0.287
1->3 piece	25(75.8)	25(80.6)	22(88.0)	19(86.4)	14(70)		30(90.9)	26(89.7)	20(76.9)	19(82.6)	19(82.6)	
Vegetable servings/day (excluding potatoes (1 serve = approximately 1 handful)												
Usuallynone	1(3)	0	0	0	0	0.406	1(3)	0	1(3.8)	1(4.3)	0	0.663
1->4 serves	32(97)	31(100)	25(100)	22(100)	20(100)		32(97)	29(100)	25(96.2)	22(95.7)	23(100)	
Coffee cups/day												
Usuallynone	29(87.9)	31(100)	24(96.0)	22(100)	20(100)	0.255	30(90.9)	28(100)	26(100)	23(100)	23(100)	0.017
1-2	4 (12.1)	0	1 (4.0)	0	0		3(9.1)	0	0	0	0	
Average soft drink consumption/week (ml/week)												
<500	32(97)	32(100)	24(96.0)	23(100)	22(100)	0.406	32(97)	28(100)	26(100)	22(100)	21(100)	0.406
1000-2000	1(3)	0	1(4.0)	0	0		1(3)	0	0	0	0	
Water consumption/day (litres/day)												
>1.5 L	33(100)	31(100)	25(100)	22(100)	20(100)		33(100)	29(100)	26(100)	23(100)	23(100)	-
Total	33	31	25	22	20		33	29	26	23	23	

Table 4: Food Frequency Total Calorie Intake and Food Composition

Food	Control (Mean ± SD)					Intervention (Mean ± SD)				
	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up
Carbohydrate	188.7±37.2	184.4±27.4	192.3±37.1	180.3±32.7	205.0±19.6	180.2±35	179.4±38.2	185.2±36.8	186.1±46.1	204.9±25.4
Protein	43.5±8.5	43.2±8.1	43.6±11.4	42.9±11.6	49.6±10.6	42.3±12.1	42.9±8.3	43.5±11.4	47.2±16.1	44.1±9.1
Fat	27.6±7.5	26.8±7.8	27.9±9.1	23.2±10.5	34.2±7.1	26.5±8.2	28.5±8.8	29.2±13.7	31.4±11.0	31.6±8.4
Fiber	26.9±6.9	25.7±5.6	26.2±6.5	24.1±7.0	27.5±4.7	29.0±17.6	25.2±6.1	25.4±7.2	22.5±7.6	27.7±4.2
Total Calorie	1190.3 ±189.3	1182.6 ±151.7	1232.9 ±181.6	1213.9 ±172.8	1301.8 ±195.9	1170.7 ±207	1162.3 ±224	1193.6 ±248.6	1213.1 ±217.0	1262.3 ±202.8

All the food values are in gram.

Table 5: Blood Glucose Level at Baseline and follow up

Parameter	Control (Mean ± SD)						Intervention (Mean ± SD)					
	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	P value	Baseline	1st F/up	2nd F/up	3rd F/up	4th F/up	P value
FBS	145.9 ±38.4	139.8 ±32.5	135.1 ±28.0	134.6 ±31.1	128.7 ±29.9	0.057	156.5 ±50.1	128.9 ±22.6	128.9 ±25.9	129.7 ±24.1	129.4 ±26	0.148
PPBS	206.7 ±67.5	145.9 ±45.7	167.9 ±56.9	161.9 ±57.8	155.5 ±51.8	0.000	203.7 ±58.6	132.1 ±29.0	152.8 ±37.3	156.5 ±37.2	159.0 ±32.2	0.000

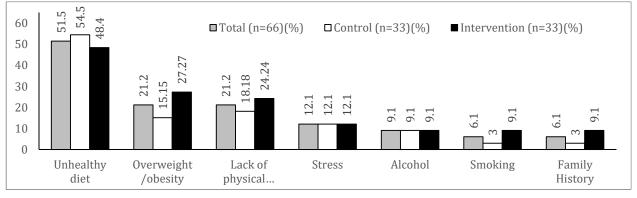FBS=Fasting Blood Sugar; PPBS= Post-Prandial Blood Sugar * Wilks' lambda

Figure 1: Knowledge of Different Risk Factors

During 4th follow up, the dose or no of medications increased among 20% of control group participants while no change was in 80% participants. The change of treatment was proportionately high in control group (20%) than in the intervention group (4.35%) during 4th follow up. It was observed that, the proportion of skipping medications was higher among control group in all follow ups. During last follow up 40% of control group participants skipped their medication, while it was 26.1% in intervention group. (Table 1)

Out of 66 patients, 34 (51.5%) knows some risk factors of diabetes. The knowledge is similar in both control and intervention group. When asked about the knowledge regarding prevention methods of diabetes, out of 66 patients, 31 (46.96%) patients know that diabetes can be prevented. Among them 46.97% answered that healthy diet and 21 (34.85%) responded that exercise is the best prevention method for diabetes. The response was similar in both groups. (Figure 1)

At baseline, Out of total study participants 86.4% had changed their eating habits after diagnosed with diabetes. 89.4% participants followed doctor's dietary advice. 21.2% patients were found to be skipping their meals. 84.8% participants were taking their everyday food in exact time. Almost half (47%) of the whole participants were using artificial sweeteners because of sweet loving nature. 87.9% patients were found to be taking nonveg food items. Out of 66 patients, 30 patients (45.45%) were eating for outside home at least once in a week and 54.55% patients were not eating food outside home.

Cochrane's Q was used to compare categorical variables of eating habits. It was observed that Cochrane's Q was significant in recent changes in eating habits both in control and intervention group (p=0.000). Diet advice of doctor was followed by intervention group which was found to be significant (p=0.031). (Table 2)

Out of total study participants, 77.27% were consuming fried foods less than once in a week and 22.72% one to two times in a week. Starchy foods are being taken by 56.06% patients as one serving per day, 28.78 % two servings per day and 15.15% three servings per day. Majority of the study subjects (92.42%) were not taking sweet foods like cakes, biscuits, lollypops and/or chocolate each day but 7.57% were taking one to two servings per day. All 66 participants (100%) were not consuming sugar or cold drinks. Majority of the participants (69.69%) were eating fish one to two times in a week and 6% were eating fish three to six times in a week. 89.39% patients were not taking coffee at all but 10.6% ware taking coffee one to two times per day. Almost all (98.48%) participants were taking soft drinks less than 500ml per week. All patients were taking more than 1.5liter water in a day.

On analysis of food habits of control and intervention group it was observed that fried food consumption had increased significantly among control group and no significant change was found in intervention group. Starch consumption was decreased significantly on both the groups. There is no significant change of other components of food habits. (Table 3)

From food frequency questionnaire, the mean calorie intake was found to be 1180.51 ± 197.07, carbohydrate was 184.47 ± 36.09, protein was 42.93 ± 10.39, fat was 27.08 ± 7.8 and fiber was 27.99 ± 13.33. When compared between control and intervention group, no difference was found between intervention and control group.

The table 4 represents the composition of food items taken by participants in last 3 days (72 hrs recall method). Carbohydrate, protein, fat, fiber and total calorie was taken in appropriate amount by both control and intervention group. There were no significance changes in dietary composition during follow ups in both control and intervention group. There is no significant change of total calorie intake among control and intervention groups.

Repeated measures ANOVA was conducted to see the significant changes both in control and intervention group. Wilk's lambda was significant for PPBS both in control and intervention group. (Table 5)

DISCUSSION

The study was conducted among newly diagnosed Type 2 diabetes patients with the objective to improve their diabetic diet and proper medication management with the use of android mobile phone application. From the year 2010, 'The Food and Drug Administration' (FDA) has permitted the use of some mobile apps in medical devices for diabetes management.[9] Liang X *et al* in their meta-analysis noticed the impact of mobile app technology on health by directly communicating with diabetic patients and by attending their issues. In a meta-analysis study the result found that through mobile phone intervention, type-2 diabetes patients had significant improvement in glycaemic control and diabetes self-care management.[10] A Randomized controlled trial through telephonic intervention was done in Australia showed that interactive telephone intervention had improved the glycaemic control.[11] Studies reported that decreased risk of diabetes was associated with dietary intake of fruit, vegetables, legumes, nuts, whole grains, and long-chain fats and a lower intake of sugar-sweetened beverages,[12] trans-fat, processed/red meats, and sodium and a moderate alcohol intake.[13] In fact, a diabetes diet is the best eating plan for most everyone. Eating healthily not only helps to control blood sugar levels but also helps in delaying the onset of diabetes-related complications.

In the baseline overall 51.5% participants told that unhealthy diet is an important risk factors of Type 2 diabetes and in both groups 46.97% participants had knowledge on that by modifying daily dietary habits the hazardous effect of diabetes can be prevented, which was similar to a study by Ahmed et al.[14] Another cross-sectional study of Saudi Arabia by Aljoudi and Taha found that Education level was found to be a statistically significant predictive factor for patients' knowledge about DM, and 35.8% of the participants stated that obesity was a significant risk factors for DM and that weight reduction was an effective measure for the prevention of DM.[15] Out of total study participants 86.4% had changed their eating habits after diagnosed with diabetes and 89.4% participants followed doctor's dietary advice which was similar to a study by Ahmed et al.[16] Only 21.2% patients were found to be skipping their meals and

84.8% participants were taking their everyday food in exact time which was showing their healthful eating pattern. In a study it has been suggested that healthy eating habits and behaviour are effective for diabetes management.[17] In the follow ups it was observed that Cochrane's Q was significant in recent changes in eating habits both in control and intervention group (p=0.000). Diet advice of doctor was followed by intervention group which was found to be significant (p=0.031). In the baseline 87.9% patients were found to be taking nonveg food items. The results of many studies found that those who are taking nonveg food items they have the chances of diabetes, obesity, heart disease, etc more than the vegetarians due to the inclusion of meat which is an important contributor towards cholesterol and saturated fat intake in humans.[18,19] But in our study majority of the participants (69.69%) were eating fish one to two times in a week and 6% were eating fish three to six times in a week. And as per research we found that regular fish intake of at least two servings a week, including one serving of oily fish like salmon, mackerel, and trout recommended for cardiovascular risk prevention and diabetes also.[20] Almost half (47%) of the whole participants were using artificial sweeteners because of their sweet loving nature. It's very satisfactory that majority of the study subjects (92.42%) were aware enough and not taking sweet foods like cakes, biscuits, lollypops and/or chocolate each day. All 66 participants (100%) were not consuming sugar or cold drinks which was also a positive step to manage diabetes. Because a recent evidence suggested that the intake of soft drinks with obesity and diabetes, resulting from large amounts of high fructose corn syrup used in the manufacturing of soft drinks, which raises blood glucose levels and BMI to the dangerous levels.[21] On analysis of food habits of control and intervention group it was observed that fried food consumption had increased significantly among control group and no significant change was found in intervention group which was a matter of concern as high intake of fried foods contribute to the increased the risk of insulin resistance and Type 2 diabetes.[22] Starch consumption was decreased significantly on both the groups and all patients were taking more than 1.5 litre water in a day.

Data on dietary consumption of participants was based on 72 hours recall method (3days), the total calorie, protein, fats, fibre and carbohydrates were calculated. Mostly participants were taking odia foods in their four times major meals like breakfast, lunch, evening snacks and dinner. The breakfast dishes were generally pressed rice, puffed rice and local preparation like pitha, upma, etc. Lunch they had rice, dalma, curry, water rice, bhaja, saga, salad, etc. In the evening they consumed light foods like tea, biscuits, puffed rice, baked chana etc. and dinner items were roti, paratha, pitha with santula or curry. A study was conducted in south india region, the participants followed the South-Indian food patterns.[23] Hence, in our study patients were following odia food patterns and the health care providers gave nu-

tritional advises based on their food preferences. From food frequency questionnaire, the mean calorie intake was found to be 1180.51 ± 197.07, carbohydrate was 184.47 ± 36.09, protein was 42.93 ± 10.39, fat was 27.08 ± 7.8 and fiber was 27.99 ± 13.33. In a largest randomised study[24] of Type 2 diabetes revealed that 1200-1800 kcal/day through a low fat diet assisted by liquid meal replacements were helpful to reduce weight and blood glucose level. In this study we also gave emphasis on the quality and quantity of food items and provided 1600 kcal/day diet plan to the Type 2 diabetes patients. The mean FBS and PPBS was measured and found to be 154.5 ±51.78 and 207.21 ±64.15 respectively. Repeated measures ANOVA was conducted to see the significant changes both in control group and intervention group. Wilk's lambda was significant for PPBS both in control and intervention group, which was similar to a study result found that intake of the high amounts of the fiber and low glycaemic foods helps to reduce the blood glucose levels significantly.[24]

CONCLUSION

Type 2 diabetes patients need diabetes education emphasizing on dietary management by health care professionals to enhance self-care and better quality of life. The success of dietary management requires that the health care providers should have an orientation about the cultural beliefs, thoughts, family, and communal networks of the patients. Proper treatment with special focus on diet should be given by healthcare providers in a way to control the disease, reduce the symptoms, and prevent complications. So, cost-effective, simple mobile applications may help in routine clinical practice to encourage the patients for adherence to advice on diet and medication which will further reduce complication of Diabetes.

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