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Mobile health application based intervention for improvement of quality of life among newly diagnosed type 2 diabetes patients

ABSTRACT

Background. Diabetes and its complications are becoming a major threat to public health. Quality of life among diabetes patients is not optimum.

Objective. To know the usefulness of the mobile health application for improvement of QoL and diabetes self-management activities of the type 2 diabetes patients.

Methods. The present study was conducted in a tertiary care hospital for 2 years from October 2016 to October 2018. In this study, 66 newly diagnosed type 2 diabetes patients, educated, techno-friendly smart phone users, aged between 18–60 years, were included. They were allocated to intervention and control group by block randomization method. Intervention group was allotted to use the android application and control group was allotted to use the website. The data were imported and analyzed by SPSS v 20.

Results. Overall quality of life and general health was 70.26 ± 16.51; for physical health it was 59.52 ± 7.15, for psychological it was 63.38 ± 9.2, for social relations it was 74.87 ± 13.98 and for environment it was 71.87 ± ± 8.38. The score of overall quality of life was increased in both control and intervention group during follow-ups. It was found that there was significant improvement in glucose management, dietary control, physical activity, health care use and sum score. Wilk's lambda was significant for HbA1c both in control and intervention group.

Conclusions. Mobile-based applications with focusing on diabetes self-management education may support to reduce the complications of diabetes and improve the QoL of diabetes patients. (Clin Diabetol 2021; 10; 3: 276–283)

Key words: self-management, mhealth app, diabetes mellitus

Introduction

Diabetes and its complications are becoming a major threat to public health. It is a major cause of blindness, kidney failure, myocardial infarction, stroke and lower limb amputation. Diabetes is growing challenge in India with estimated 8.7% diabetic population in the age group of 20–70 years. The rising prevalence of diabetes and other non-communicable diseases is driven by a combination of factors, i.e. rapid urbanization, sedentary lifestyle, unhealthy diets, tobacco use, and increasing life expectancy [1].

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Apart from the physical problems due to diabetes, people are facing difficulties in their quality of life, which could affect patients' socio-economic status, inter-personal relationships, mental health etc. [2]. According to the World Health Organization, quality of life (QoL) means individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. Quality of life is giving emphasis not only on patients' physical health but also some other aspects of their personal, social and psychological life [3]. Adverse emotional feelings such as feeling alone, irritation, depression are most common in diabetes patients. This lifestyle disease is chronic in nature and difficult to control by doing regular exercises and food restrictions, which increase stress in diabetes patients and affect their QoL. Diabetes related complications raised the medical costs of the patients due to frequent visits to the doctor and other expenses at the time of hospitalization. These financial issues are also a strong reason to disturb the QoL of a diabetes patient [4, 5]. Healthy and proper diet, regular physical activity, daily medication, self-care assessment, and regular check-ups with the health care professionals are the basic requirements for controlling the disease. On the other hand, these lifestyle changes are quite difficult to remember by diabetes patients in their day to day life [6]. Nowadays, health care professionals are implementing many effective treatment and educational interventions to prevent the complications related to QoL in type2 diabetes patients [7].

Diabetes self-management education (DSME) is one of the important aspects in diabetes treatment. The American Diabetic Association has defined self-management education as the process of providing the person with diabetes the knowledge and skills that are needed to perform self-care, manage crises and make life style changes. National standard for self-care management in diabetes has been set by Mensing *et al*. [8]. Through DSME interventions diabetes patients are enhancing their knowledge by exact and authentic information, self-care practice and adopt positive attitude to cope with the disease. Different studies found great impact of DSME interventions on the QoL of diabetes patients [9, 10]. Advances in smartphone technology and wireless networks have resulted in increased adoption and enhanced capability, leading to opportunities for improved diabetes self-management. Mobiles phones are inherently personal communication devices with powerful computing and touch-based user interfaces. That can be used to deliver self-management tools that are embedded into the daily routine of individuals and to facilitate habitual self-monitoring [11]. This study was conducted in a tertiary care hospital of Odisha to obtain basic data pertaining to the usefulness of the application, including whether diabetes self-management activities improved and to what extent the diabetes self-management activities improved the QoL of the type 2 diabetes patients with the smartphone application.

Methods

The present study was conducted with 66 patients diagnosed with type 2 diabetes (within 3 months of diagnosis) in the Department of Endocrinology and Community Medicine in Institute of Medical Sciences & SUM Hospital, Bhubaneswar. The diagnosis was already done by an endocrinologist of the hospital. This Randomized Controlled Trial was fixed for 2 years from 01.10.2016 to 31.10.2018. In this study, educated, techno-friendly smartphone users, aged 18–60 years, type 2 diabetes patients, after giving written consent, were allocated in intervention and control group by block randomization method. Both the groups were counselled with diabetes self-management education (DSME) using printed educational materials. Intervention group was allotted to use the android application and control group was allotted to use the website. Data were collected at baseline and at every 3 months (4 times a year), follow up conducted. Institutional ethics committee approval was taken prior to start of the trial. The trial was registered in Clinical Trial Registry of India.

The study subjects were interviewed using a predesigned, pretested and semi-structured questionnaire. The prospect of this study for improving understanding of diabetes and its complications was explained to the participants. Data were collected to see the changes in their knowledge, attitude and practice to cope with the disease after and before intervention along with age, sex, socioeconomic status, per capita monthly income, family size, duration of diabetes, co-morbidities, etc.

DSMQ. The psychometric properties of the final 16-item version of the Diabetes Self-Management Questionnaire (DSMQ) [12] were assessed in 66 patients of this study. The DSMQ was developed at the Research Institute of the Diabetes Academy Mergentheim. It is the first German instrument targeting diabetes self-care, and was designed to assess behaviors associated with metabolic control within common treatment regimens for T2DM in adult patients [13].

Quality of Life. In this study, WHOQoL-BREF questionnaire was used which consisted of 26 questions. Out of these, two questions related to overall QoL and the remaining 24 questions were divided into four parts, such as physical health, psychological health, social relationships, and environmental health. The

Table 1. Self-management of diabetes (DSMQ) at baseline

	Total (N = 66) Median (IQR)	Control (N = 33) Median (IQR)	Intervention (N = 33) Median (IQR)	Significance
Glucose management	10.0 (8.67–10)	9.33 (8.33–10)	10 (9–10)	0.074
Dietary control	7.5 (6.67–8.33)	8.33 (5.83–8.75)	7.5 (6.67–8.33)	0.658
Physical activity	8.89 (5.28–10)	7.78 (3.33–10)	8.89 (6.11–10)	0.372
Health care use	6.67 (6.67–6.67)	6.67 (6.67–6.67)	6.67 (6.67–6.67)	0.624
Sum score	8.13 (6.46–8.96)	7.71 (6.25–8.85)	8.33 (6.67–8.96)	0.283

answers of each question recorded on a 5-point Likert scale and scored from 1–5. The mean score for various parameters were observed [14] and lineary transformed to a 0–100-scale [15]. Higher scores were associated with a higher QoL.

HbA_{1c} (glycosylated hemoglobin) test. This blood test indicates the average glucose level for the past two to three months. It measures the percentage of blood glucose attached to hemoglobin, the oxygen-carrying protein in red blood cells. HbA1c level of 6.5 percent or higher on two separate tests indicates poor control of diabetes [16].

The data were imported and analyzed by SPSS v 20 licensed to the institute and Cochrane Q test was done for analyzing the categorical data. The significance level was considered as 0.05.

Results

In the current study, 66 respondents with newly diagnosed T2DM were included and 33 randomized into each arms. Most of the participants were male (65.2%) and more than 95% were Hindus. The mean age of the participants was 42.29 ± 9.5 years. Majority of the study participants belonged to general caste (89.4%) followed by socially and educationally backward caste (6%). Around 57.6 % were in joint family and remaining 42.4% were living with nuclear family. As per the marital status of the participants, 86.4% were married. Result showed that 63.7% were graduates and above, 36.4% were educated up to secondary and above secondary level. According to the B G Prasad socioeconomic classification for 2016, it was found that 51.5% belonged to upper class, 34.8% belonged to upper middle class and 13.6% belonged to middle and lower middle class income group. Majority of the participants were professionals (27%) and housewives (27%), with similar distributions in both the groups. There was no difference observed between control and intervention group in socio-demographic characteristics.

It was observed that 74.2% of patients had knowledge about diabetes before diagnosis and 89.4% of patients know that diabetes is affecting more people nowaday. Only 63.1% of patients knew that diabetes affects different body parts and 51.5% of patients were aware of the risk factors of diabetes. The major source of their knowledge is family (31.8%) and friends (30.3%), followed by health professionals (6.1%) and others including media/social media (6%).

The psychometric properties of the final 16-item version of the DSMQ were assessed in 66 patients. The SDSCA served as comparison to assess the quality of our scale. The scoring result showed that median glucose management score was 9.33 for control group while it was 10 for intervention group. Median diet control score for control group was 8.33 and for intervention group it was 7.5. Median physical activity score for control group was 7.78 and for intervention group it was 8.89. The health care use scores for both control and intervention groups were same (6.67). The median sum score for control group was 7.71 and for intervention group it was 8.33. The DSMQ scores were similar in both groups (Table 1).

From Quality of Life (WHOQOL-BRIEF) questionnaire the mean scores for various parameters were observed. For overall quality of life and general health it was 70.26 ± 16.51, for physical health it was 59.52 ± 7.15, for psychological health it was 63.38 ± 9.2, for social relations it was 74.87 ± 13.98 and for environment it was 71.87 ± 8.38. The scores were not different in both groups. When asked about the diabetes-related quality of life, the mean score for diet satisfaction was found to be 1.91 ± 0.63 out of total score of 5, treatment satisfaction was 12.94 ± 2.9 out of total score of 15 and financial worries was 14.83 ± 2.43 out of total score of 20. The scores were not different in both groups (Table 2).

When Repeated Measures ANOVA was done for DSMQ, it was found that there was significant improvement in glucose management, dietary control, physical activity, health care use and sum score across time, but no significant difference of scores across interaction between time and group. There was no significant difference of scores across groups indicating both android application and website had similar effect on

Table 2. Quality of life (WHOQOL-BRIEF) and diabetes-related quality of life at baseline

	Total (N = 66) Mean ± SD	Control (N = 33) Mean ± SD	Intervention (N = 33) Mean ± SD	Significance
Overall quality of life and general health	70.26 ± 16.51	70.07 ± 18.20	70.45 ± 14.92	0.927
Physical health	59.52 ± 7.15	61.03 ± 4.67	58.00 ± 8.79	0.085
Psychological	63.38 ± 9.2	63.25 ± 9.3	63.51 ± 9.20	0.912
Social relations	74.87 ± 13.98	76.01 ± 14.09	73.73 ± 13.99	0.513
Environment	71.87 ± 8.38	71.87 ± 7.81	71.87 ± 9.04	1.000
Diabetes-related quality of life				
Diet satisfaction (total score: 5)	1.91 ± 0.63 (1–3)	1.97 ± 0.73 (1–3)	1.85 ± 0.50 (1–3)	0.436
Treatment satisfaction (total score: 15)	12.94 ± 2.9 (3–15)	13.24 ± 1.99 (6–15)	12.64 ± 3.65 (3–15)	0.405
Financial worries (total score: 20)	14.83 ± 2.43 (4–16)	14.33 ± 3.05 (4–16)	15.33 ± 1.49 (10–16)	0.095

participants. The effect size across time was large but effect size was small across groups. In pairwise comparison it was found that the follow up observations were significantly different from baseline observations ($p < 0.05$) (Table 3).

The score of overall quality of life was increased in both control and intervention group during follow-ups (Table 4).

Diet satisfaction score and treatment satisfaction score was significantly increased both in control and intervention group. There was no change in financial worries (Table 5).

Repeated measures ANOVA was conducted to see the significant changes both in control group and intervention group (Table 6). Wilk's lambda was significant for HbA1c both in control and intervention group.

Discussion

Health care by mobile applications has a great advantage when applied to patients with diabetes; the adherence to self-management activities for diabetes can be improved through mobile applications. Males were higher than females in this study. This may be due to the higher population of male patients in the hospital in comparison with females, which was contradictory to a study by Mohammadi *et al.* [17]. Knowledge on diabetes can help patients to improve their health by taking self-care. In our study, 74.2% patients had knowledge about diabetes before diagnosis and 89.4% patients know that currently diabetes is affecting more people. Some other studies confirmed that knowledge of diabetes patients will be increase if they involved in educational process [18]. Source of information on diabetes for most of patients (62.1%) were family members and friends. But in another study majority respondents gained knowledge on diabetes from the health professionals (73.3%), which was only 6.1% in the present study [16]. Participants' education was an important characteristic in our study. Most of patients (63.7%) were graduates and above, 36.4% were educated up to secondary and above secondary level. As it is obvious that those who are highly educated have greater ability in adopting new technologies, the results of these types of studies based on the use of the app might not be the same if the respondents were less educated. This may be contradictory to a study conducted in Norway. Maximum participants had below high school education but their study result showed significant difference between groups due to their highly digitalized societies [19].

Diabetes self-management includes many others interacting components such as glucose management, dietary control, physical activity, medication, health care use and healthy coping skills. Because of these components of diabetes self-management the use of apps through mHealth intervention is quite multifarious. Hence, the advance design of our app and its use among type 2 diabetes patients gave a clear understanding of the effectiveness of mHealth app in self-management of T2DM. The scoring result showed that median glucose management score was 9.33 for control group while it was 10 for intervention group. Median diet control score for control group was 8.33 and for intervention group it was 7.5. Median physical activity score for control group was 7.78 and for intervention group it was 8.89. The health care use scores for both control and intervention groups were same (6.67). The median sum score for control group was 7.71 and for intervention group it was 8.33. The DSMQ scores were similar in both groups. It was found that there was significant improvement in glucose management, dietary control, physical activity, health care use and sum score across time, but no significant difference of scores across interaction between time and group. There was no significant difference of scores across

Table 3. Self-management of diabetes (DSMQ) at baseline and follow-ups

DSMQ	Control (mean ± SD)						Intervention (mean ± SD)					
	Baseline	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up	Significance	Baseline	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up	Significance
Glucose management	8.88 ± 1.68	9.61 ± 0.86	9.81 ± 0.67	9.79 ± 0.67	9.81 ± 0.67	0.013	9.37± 1.14	9.71 ± 0.94	9.89 ± 0.58	9.83 ± 0.60	9.89 ± 0.58	0.035
Dietary control	7.47 ± 1.98	8.45 ± 1.98	8.73 ± 1.58	8.83 ± 1.38	81.26 ± 0.96	0.008	7.44 ± 1.47	8.48 ± 1.97	8.98 ± 1.03	9.11 ± 1.15	9.14 ± 0.91	0.000
Physical activity	6.7 ± 3.66	8.58 ± 2.78	8.85 ± 2.01	8.75 ± 2.05	8.58 ± 2.71	0.017	7.51 ± 3.4	8.21 ± 2.89	9.15 ± 1.96	9.19 ± 1.94	8.72 ± 2.96	0.011
Health care use	6.46 ± 0.98	6.63 ± 0.85	9.15 ± 1.47	9.15 ± 1.47	6.66 ± 0.48	0.000	6.63 ± 0.81	6.7 ± 0.7	9.29 ± 1.26	9.15 ± 1.33	6.76 ± 0.32	0.000
Sum score	7.51 ± 1.47	8.48 ± 1.28	9.14 ± 1.02	9.14 ± 0.99	8.66 ± 1.00	0.000	7.89 ± 1.29	8.47 ± 1.16	9.33 ± 0.79	9.33 ± 0.85	8.82 ± 0.81	0.000

Table 4. Quality of life of participants at baseline and follow-ups

QoL	Control (mean ± SD)					Intervention (mean ± SD)				
	Baseline	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up	Baseline	1st Follow-up	2nd Follow-up	3rd Follow-up	4th Follow-up
Overall quality of life and general health	70.07 ± 18.2	73.10 ± 14.69	73.10 ± 8.33	72.75 ± 6.54	73.10 ± 5.52	70.45 ± 14.92	72.72 ± 12.67	73.86 ± 10.98	73.18 ± 7.73	73.10 ± 8.90
Physical health	61.03 ± 4.67	58.98 ± 4.10	59.52 ± 3.64	61.06 ± 2.76	60.06 ± 3.62	58.07 ± 8.79	58.33 ± 6.77	58.22 ± 4.67	58.78 ± 5.41	58.43 ± 5.03
Psychological health	63.25 ± 9.20	60.85 ± 8.39	59.72 ± 4.95	60.93 ± 8.01	58.33 ± 7.51	63.51 ± 9.20	60.85 ± 8.39	59.72 ± 4.95	60.93 ± 8.01	58.33 ± 7.51
Social relations	70.01 ± 14.09	71.71 ± 10.19	72.72 ± 10.05	62.96 ± 10.9	72.97 ± 8.34	73.73 ± 13.99	72.22 ± 12.26	71.46 ± 9.77	63.75 ± 8.38	70.96 ± 11.04
Environment	71.87 ± 7.81	72.06 ± 6.34	72.72 ± 4.70	79.15 ± 6.64	73.67 ± 5.18	71.87 ± 9.04	72.72 ± 7.34	72.06 ± 5.78	77.81 ± 9.10	71.68 ± 5.99

QoL — quality of life

Table 5. Diabetes related quality of life at baseline and follow-ups

Diabetes related QoL	Control (Mean ± SD)						Intervention (Mean ± SD)					
	Baseline	1st	2nd	3rd	4th	Significance	Baseline	1st	2nd	3rd	4th	Significance
Diet satisfaction (total score: 5)	1.97 ± 0.73	1.67 ± 0.64	1.61 ± 0.70	2.91 ± 1.18	2.91 ± 1.18	0.000	1.85 ± 0.50	1.82 ± 0.88	1.61± 0.55	3.21 ± 1.02	3.21 ± 1.02	0.000
Treatment satisfaction (total score: 15)	13.24 ± 1.97	14.15 ± 1.34	14.42 ± 1.17	13.48 ± 1.00	13.09 ± 1.01	0.002	12.63 ± 3.65	14.27 ± 1.30	14.45 ± 1.17	13.09 ± 1.01	13.09 ± 1.01	0.001
Financial worries (total score: 20)	14.33 ± 3.05	15.48 ± 1.12	15.36 ± 1.14	15.33 ± 1.16	15.33 ± 1.16	0.247	15.33 ± 1.49	15.64 ± 0.82	15.52 ± 0.87	15.54 ± 0.83	15.54 ± 0.83	0.586

QoL — quality of life

Table 6.

HbA_{1c}	Baseline	1st follow-up	2nd follow-up	3rd follow-up	4th Follow-up	Significance (Wilks' lambda)
Control	9.15 ± 2.15	7.53 ± 1.40	7.30 ± 1.24	7.07 ± 1.29	6.99 ± 1.32	0.001
Intervention	9.77 ± 2.26	7.43 ± 1.21	7.16 ± 1.16	7.06 ±1.17	7.11 ± 1.17	0.000

groups indicating both android application and website had similar effect on participants. In pairwise comparison it was found that the follow up observations were significantly different from baseline observations ($P < 0.05$). The results from a meta-analysis suggest that self-monitoring can be delivered by smartphones, with increasing use of smartphones by people from different socioeconomic conditions. The use of such devices can still be considered complex and potentially a barrier to access among elderly patients. However, in the medium term, population aging will include almost all in a highly connected and digitalized society [20]. A study by Skinner *et al.* [21] on 236 newly diagnosed type 2 diabetes patients who attended the structured self-management education session with 97% and 64% completing baseline and 3 months follow-up. At the follow-up patients better understood their diabetes and the hazardous impact of the disease. After getting self-management education respondents were capable to manage their glucose level in the 3 months follow-up ($r = 0.24$; $P = 0.05$) [21]. Some other previous studies primarily assessed the effectiveness of mHealth apps for enhancing diabetes health outcomes [23, 24] and a systematic review also focused on understanding how mHealth apps might influence self-management of T2DM [25].

In this study, QoL of diabetes patients was measured by using WHOQOL-BREF questionnaire. The overall quality of life and general health it was 70.26 ± 16.51, for physical health it was 59.52 ± 7.15, for psychological it was 63.38 ± 9.2, for social relations it was 74.87 ± 13.98 and for environment it was 71.87 ± 8.38. The scores were not different in both groups. But after intervention the score of overall quality of life was increased in both control and intervention group during follow-ups. These findings were similar to previous studies in which educational interventions had an effect on QoL [26, 27]. A qualitative study by using digital health interventions on T2DM patients found that the patients' experiences of the health care services varied; there was agreement that even the best services were unable to meet all users' needs to support the emotional regulation, psychological adjustment, and behavioral changes needed for successful self-management [28]. Some other studies found positive and statistically significant results in QoL and satisfaction with treatment in the intervention group. Health improvements reported by participants with the app were the perception of hyperglycemia episodes, social relationships, decreased fear of hypoglycemia, perception that the apps aid treatment, and healthier dietary habits [29, 30]. Findings of another study also indicated that there were significant differences found between the groups in mean scores of physical, psychological, and social domains of QoL after intervention ($P < 0.001$) [16].

When asked about the diabetes-related quality of life, the mean score for diet satisfaction was found to be 1.91± 0.63 out of total score of 5, treatment satisfaction was 12.94 ± 2.9 out of total score of 15 and financial worries was 14.83 ± 2.43 out of total score of 20. The scores were not different in both groups. Diet satisfaction score and treatment satisfaction score were significantly increased both in control and intervention group. There was no change in financial worries. In this study researchers gave website access to the control group for their diabetes self-care management and they used that digital platform which was almost equal to the mobile app to enrich their health care practice towards diabetes. So, the result showed that in some variables scores were significantly high in both control and intervention group. According to the findings of this study, it was recommended that given information should be used in health education to improve the effectiveness of educational programs in the personal and social dimensions in investigations on QoL.

The mean HbA1C was found to be 9.49 ± 2.27, indicating uncontrolled diabetes and overall poor control of diabetes among the study population. But in the follow-ups highly significant difference was found in HbA1c levels both in control and intervention groups. These findings of the study were similar to some extent to some other studies [16, 31, 32]. Reduction of HbA1c observed continuously during follow-ups was possible for the technical interventions in both the groups and decreased HbA1c levels will also helpful for reducing the associated complications of type 2 diabetes.

Conclusion

Mobile applications are an important tool to address the problem of diabetes management among type 2 diabetes patients. Mobile-based applications

focusing on diabetes self-management education reduce prevalence of complications of diabetes and improve the QoL of diabetes patients. The application also strengthens the perception of self-care by providing better information and health education to the patients. App features consisting blood sugar data, daily diet, regular physical activity, drug therapy and advice by health care professionals contributed to the awareness of diabetes patients.

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Conflicts of interest

There are no conflicts of interest.

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