Research Paper

Impact of Short Message System Education on Blood Sugar Control and Treatment Adherence in Patients With Type 2 Diabetes

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ABSTRACT

Objectives: Considering the need of diabetic patients for accessing the care system and the role of modern media in health education and culture, we aimed to determine the effectiveness of educating via mobile SMS in controlling blood sugar. Moreover, the adherence to drug treatment of patients with type 2 diabetes was assessed.

Methods: This quasi-experimental study was conducted in Isfahan City, Iran in 2018. A total of 100 diabetic patients participated in the case (intervention) and control groups. The control group underwent conventional therapies and training. SMS training was applied for the intervention group in addition to the conventional therapies. Collecting the information and data to assess adherence to patients' treatment was done using a researcher-made 18-item questionnaire. Analyzing data was performed in SPSS software, version 20 through the employment of the independent t test, paired t test, and multivariate analysis of covariance.

Results: Based on the independent t test results, no significant difference was detected between the two study groups at any time points (P>0.05) in terms of the mean fasting blood sugar. However, by analysis of covariance and adjusting the fasting blood sugar level before the intervention in the studied groups, the mean fasting blood sugar was recognized to be significantly lower in the intervention group compared to the control group in the second month (P=0.048) and the third month after the intervention (P=0.008).

Discussion: There is an association between SMS education and fasting blood sugar control and adherence to treatment in the studied patients. In the field of health care education, it is possible to use patient communication techniques and short message services to control follow-up and monitor interventions.

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Highlights

• A significant difference was detected between the two groups based on the mean score of adherence to treatment, physical activity, and healthy nutrition after the intervention.

• The mean fasting blood sugar was remarkably lower in the intervention group compared to the control group in the second and third months after the intervention.

• After the intervention, significantly lower mean hemoglobin A1C values were detected in the intervention group compared to the control group.

Plain Language Summary

Diabetes is a common disease in Iran and its incidence is increasing day by day. Numerous studies emphasize the difficult clinical management of this disease, and few people understand the risk factors and take action to reduce them. Our findings in the present study revealed that the SMS system in the form of an educational medium along with conventional diabetes treatment could be effective in enhancing blood sugar control and positively affecting other aspects of diabetes care.

1. Introduction

Diabetes is the most common disease caused by metabolic disorders. The disease is very costly from the view of treatment and disability and is one of the most important health problems in the world [1]. The global prevalence of diabetes in 2017 was approximately 425 million people, which is approximately 8.5% of the world's adult population and is expected to be doubled by 2045 [2].

World Diabetes Federation has ranked Iran as the third regarding the highest number of adults (5.4 million) suffering from diabetes among the 20 countries in the Middle East and North Africa region. In Iran, its prevalence in the adult population was 4.4% in 2014, and based on estimations, the number of Iranian patients with diabetes will be 9.2 million by 2030 [3, 4].

Diabetes is on the rise worldwide, especially in developing countries, and affects society in terms of public health and social well-being in various ways [4]. The complications of diabetes impose a heavy economic burden and diminish the quality of life of the patients and their families [5]. In other words, diabetes is a growing threat to world health, as World Health Organization (WHO) has been calling on all countries to fight the disease since 1993. Serious disabilities such as heart, eye, and kidney diseases are complications of uncontrolled diabetes [6].

Regarding the prevalence of diabetes in Iran, the statistics are different. Azizi reported the prevalence of diabetes in adults between 2% and 10%, the Ministry of Health and Medical Education 2.3% and according to the Endocrine Research Center of Isfahan 2% to 3% of the total population and 7.3% of individuals over 30 years of age [3, 7, 8]. According to the statistics of the World Diabetes Federation, 4.5 million people are currently diagnosed with diabetes in Iran [3]. However, despite the prominence of this disease and the extensive measures taken to provide care and health services to people in the community, there are still shortcomings in the quality of services [9]. Providing services in the field of public health in most countries of the world, including Iran, faces significant challenges, the main reasons for which can be problems related to education to people and patients with chronic diseases, increase in demand for health care due to the growing population with chronic diseases, increase in demand for access to care and ease of education, the need to reduce the financial costs of health care, and unfair distribution of health care [10-14].

Therefore, in this regard, there is a basic need to educate people in the community and attract their active participation in health care for preventing and controlling diseases, especially diabetes [15]. The purpose of educational programs is to raise awareness, create a positive attitude and maintain proper performance in proper health and healthcare-oriented behaviors. As opposed to traditional health education models, which emphasize individual and routine aspects, health education programs' new approaches place more emphasis on active, experiential learning because it is a social and participatory process that emphasizes empowerment [16].

Regarding the health of people with diabetes, education, medication, exercise, and diet are important. For the effectiveness of treatment, the patient should know the nature of the disease well and take positive steps to deal with it [17]. Education in diabetes is an imperative aspect of disease management and the main part of care [13, 18].

On the other hand, it should be noted that health care has changed so many changes, especially in recent decades. So that in the process of sustainable development, one of the important factors in advancing the goals and remaining in the field of global competition is the effective use of scientific resources and new technologies [19, 20]. Diabetics face many challenges, one of which is learning how to live with diabetes and controlling blood sugar [21, 22].

The results of the research also show that by using information and communication technology (ICT), information can be provided to people at an understandable level and in a simple, fast, and explicit way. One of the most important areas of ICT usage is electronic health. In the meantime, e-health is a term that is defined as providing e-learning using ICT, to provide the required health and support services when the two groups of service recipients and service providers are far from each other [23-25].

In recent years, mobile technology like other communication technologies has entered the field of education, health, and treatment and has been introduced as mobile-based education. It has exhibited the potential to alter the traditional method of face-to-face education and offer an innovative explanation of education. It has also provided learners with a time and place to learn at home, at work, and while traveling, and has overcome many drawbacks and inefficiencies. The use of mobile phones in the daily lives of people and now in the field of health care is increasing dramatically [24, 25].

In the field of health care education, it is also possible to use mobile communication techniques and increase patients' awareness about their disease and related treatments [26]. One of the easy and low-cost communication methods is using a short message service (SMS). This system can be used for follow-up interventions such as reminding and monitoring patients. Necessary knowledge to prevent and reduce this disease in society requires cooperation based on public knowledge. Therefore, broadcasting TV teasers, controlling patients' blood sugar by receiving and sending text messages [22], sending monthly educational text messages to patients, educating health care providers in schools, educating health center staff, educational animations for children, virtual diabetes clinic, preparing brochures and educational pamphlets and booklets can successfully contribute to preventing and reducing this disease [11, 27, 28].

Finally, due to the lack of similar research on education through SMS in diabetes control and also the need of diabetic patients for an accessible care system, and the role of modern media as a leading tool in health education and culture, this study was conducted to identify the effectiveness of educating via mobile SMS on blood sugar control and adherence to drug treatment scores of patients with type 2 diabetes.

2. Materials and Methods

In this quasi-experimental study, diabetic patients (type 2) who visited the Khansarak Health Center located in Flowerjan City, Iran from January 2017 to March 2017 were included. After considering the inclusion and exclusion criteria for eligible patients, 100 patients were selected. Using the table of random numbers, one control group (50 people) and one intervention group (50 people) were defined for the completion of the study.

The inclusion criteria were as follows: patients with type 2 diabetes diagnosed by a physician, regular visits to Khansarak 2 health center in the last 6 months, having a minimum literacy, having a mobile phone, the ability to use the phone, and reading SMS with the Persian text. Considering the limitations of the need for the Internet, the lack of access to a smartphone for all people, and the higher cost of using educational clips, images, and multimedia, it can be said that sending SMS is a relatively cheap and very accessible technology for more people.

The patients should also be eager to participate in the study and provide informed written consent to participate in the study.

The exclusion criteria were as follows: reluctance to participate in the study at any time during the study, failure to receive text messages more than three times in a row, change of medication regimen for medical reasons and hospitalization, and failure to receive training from other sources.

We studied the effect of SMS on fasting blood sugar control in patients with diabetes mellitus type 2 and patients' adherence to treatment, therefore both groups were under routine system care. The intervention group received text messages with educational and motivation-

al content. The contents of the sources were also used to prepare the texts of the sent SMS. The content of this training included self-care, lifestyle changes, and the correct way of taking drugs. To prepare the texts of the sent SMS, the contents of authentic medical books in the field of diabetes have been used.

Before the intervention, the demographic characteristics of patients, i.e., sex, age, level of education, occupation as well as blood sugar level were recorded. To evaluate the adherence to patients' treatment by studying scientific texts, a researcher-made questionnaire of 18 questions was prepared. Domestic and foreign studies in the field related to the present study were examined, the questionnaires used in these studies were localized and according to the needs of the present study and the local conditions, a new questionnaire was designed by the researchers for the study.

The questions of this questionnaire included items in the field of adherence to treatment and observing important points for disease control. A qualitative method was employed to define the face and content validity. The questionnaire was given to 10 faculty members, internal medicine physicians, and endocrinologists, and after receiving their comments, corrections were made to the questionnaire. Then the questionnaire was given to 30 patients and was confirmed using the test-retest method with the Cronbach alpha coefficient of 0.76 [29].

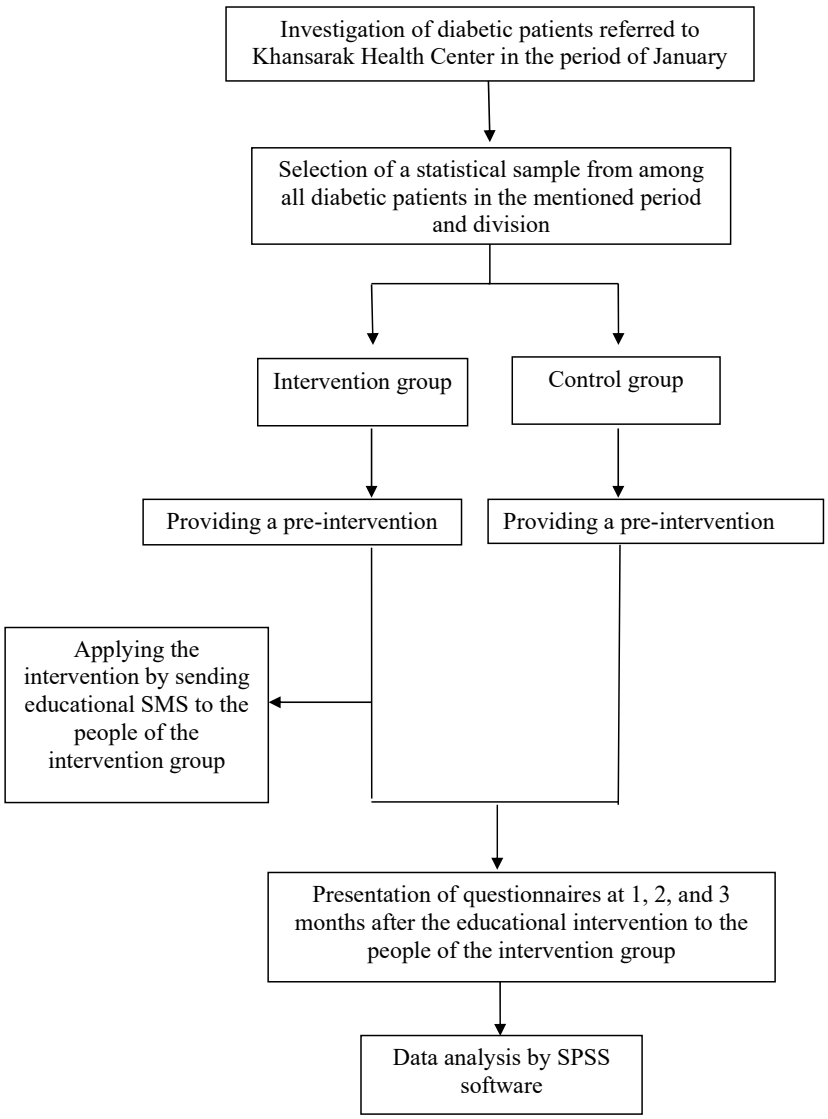

Figure 1. CONSORT (the consolidated standards of reporting trials) flowchart

The questions of the treatment adherence questionnaire were scored on a 5-point Likert scale (a maximum score of 50 and a minimum of 10. During the study, both intervention and control groups had the same face-to-face or group training by the health care provider according to the diabetes care instructions. In addition to the above training, the intervention group received Persian short messages every day for three months through an online SMS panel regularly at a specific time of day. The educational text was about the definition of diabetes, its symptoms and complications, methods of controlling it, teaching lifestyle modification, and the correct use of medications. A glucometer was used to measure blood sugar. Fasting blood sugar was measured for all participants at the beginning of the intervention, and then at the end of the first, second, and third months of the intervention. Hemoglobin A1C was also measured in all patients before and immediately after the intervention. The treatment adherence questionnaire was also completed for all patients at the beginning and immediately after the intervention. This study was triple-blind to prevent bias. Individuals who were responsible for measuring blood sugar, distributing and completing a questionnaire, and analyzing data were blind to the study groups. Finally, for statistical data analysis, related statistical tests such as the independent t test, dependent t test, and multivariate analyses of covariance were performed using SPSS and the results were extracted (Figure 1).

3. Results

This clinical randomized trial was conducted to assess the effect of SMS education on fasting blood sugar control and adherence to drug therapy in our evaluated patients. The age range of studied subjects in the intervention group was 42 to 75 years (mean age: 58.5±7.6 years) and in the control group 42 to 78 years (mean age: 60.6±8.3 years) (Table 1).

The independent t-test disclosed no remarkable difference in the mean age of the two groups (P=0.18). Meanwhile, in each of the two groups, 36 patients (72%) were female and 14 (28%) were male.

According to the independent t test, the mean scores of adherence to treatment before the intervention were comparable between the two groups (P=0.93). However, after the intervention, significantly higher values for mentioned factor were detected in the intervention group compared to the control group (P<0.001).

The paired t test showed that the mean score of adherence to treatment in the control group was not significantly different before and after the intervention

Table 1. Demographic variables

Variables	Intervention Stage	Mean±SD	
		Intervention	Control
Adherence to treatment	Before	65.4±15.8	65.6±14.8
	After	87.4±2.7	66.1±4.03
Physical activity	Before	63.1±19	59±18.04
	After	88.5±12.6	59.5±18.8
Healthy nutrition	Before	53.9±14	57.5±12.3
	After	77.2±3.9	57.4±12
Hemoglobin A1C	Before	8.4±2.1	7.9±2.0
	After	7.8±1.5	8.0±1.9
Fasting blood sugar	Before	168.6±50.5	164.6±50.6
	First month	163.7±37.4	161.1±52.9
	Second month	154.4±28.8	159.9±51.3
	Third month	150.2±27.2	160.6±49.1

Table 2. Mean scores of adherence to treatment in the two groups before and after the intervention

Stages	Mean±SD		P
	Intervention	Control	
Before the intervention	65.4±15.8	65.6±14.8	0.93
After the intervention	87.4±2.7	66.1±4.03	<0.001
P	<0.001	0.17	--------

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(P=0.17). Nevertheless, in the intervention, and after the intervention, the adherence score was significantly greater than before the intervention (P<0.001) (Table 2).

The independent t test results revealed a significant difference between the two groups (P=0.27) in terms of the mean score of physical activity before the intervention. However, after the intervention, significantly higher values were diagnosed in the intervention group compared to the control group (P<0.001). The paired t test disclosed no significant difference between before and after the intervention (P=0.32) in terms of the mean score of physical activity in the control group; however, the values in the experimental group after the intervention were significantly higher compared to before the intervention (P<0.001) (Table 3).

Considering the independent t test results, we could not see a significant difference between the two groups (P=0.17) in terms of the mean score of healthy nutrition before the intervention. Nevertheless, applying intervention in the intervention group was associated with significant enhancement in its values compared to the control group (P<0.001). The paired t test revealed no significant difference in the control group in terms of the mean scores of healthy nutrition before and after the intervention (P=0.57); however, applying intervention in the experimental group led to significantly higher values after the intervention compared to before the intervention (P<0.001) (Table 4).

The independent t-test disclosed no significant difference between the two groups at any time points (P>0.05) in terms of the mean fasting blood sugar, but the analysis of covariance by adjusting the fasting blood sugar level

Table 3. Mean scores of physical activity in the two groups before and after the intervention

Intervention Stage	Mean±SD		P
	Intervention	Control	
Before the intervention	63.1±19	59±18.04	0.27
After the intervention	88.5±12.6	59.5±18.8	<0.001
P	<0.001	0.32	--------

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Table 4. Mean scores of healthy nutrition in the two groups before and after the intervention

Intervention Stage	Mean±SD		P
	Intervention	Control	
Before the intervention	53.9±14	57.5±12.3	0.17
After the intervention	77.2±3.9	57.4±12	<0.001
P	<0.001	0.57	--------

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Table 5. Mean fasting blood sugar in the two groups at different time points

Stages	Mean±SD		P (Independent t-test)	P (Analysis of Covariance)
	Intervention	Control		
Before the intervention	168.6±50.5	164.6±50.6	0.69	-------
The first month after the start of the intervention	163.7±37.4	161.1±52.9	0.78	0.84
The second month after the start of the intervention	154.4±28.8	159.9±51.3	0.51	0.048
The third month after the start of the intervention	150.2±27.2	160.6±49.1	0.19	0.008
P (Analysis of variance with repeated measures)	0.003	0.38	--------	-------

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before the intervention in the two groups was indicative of significantly lower mean fasting blood sugar in the second month (P=0.048) and the third month after the intervention (P=0.008) in the intervention group compared to the control group.

Analysis of variance with repeated measures revealed that the mean fasting blood sugar in the control group did not differ significantly between the 4 time points (P=0.38), but for the intervention group, a significant difference between the different time points (P=0.003) was detectable (Table 5).

The least significant difference (LSD) post hoc test presented a remarkable difference between before the intervention and the first month after the intervention (P=0.15) in the intervention group in terms of the mean fasting blood sugar. However, in the second and third months after the intervention, significant decreases, compared to before the intervention and the first month after the intervention (P<0.05), were detected in the values of mean fasting blood sugar. Moreover, no significant difference between the second and third months after the intervention (P=0.07) was found (Figure 2).

The Independent t test disclosed no substantial difference between the two groups in terms of mean HbA1C before (P=0.35) and after the intervention (P=0.69).

However, analysis of covariance by adjusting the HbA1C values before the intervention in both groups revealed that intervention could remarkably lower mean HbA1C in the intervention group compared to the control group.

Moreover, considering the paired t test, in the control group, a significant difference was not detected in mean HbA1C before and after the intervention (P=0.94) while applying intervention was effective in the experimental group so that it led to significantly lower values compared to before the intervention (P=0.001) (Table 6).

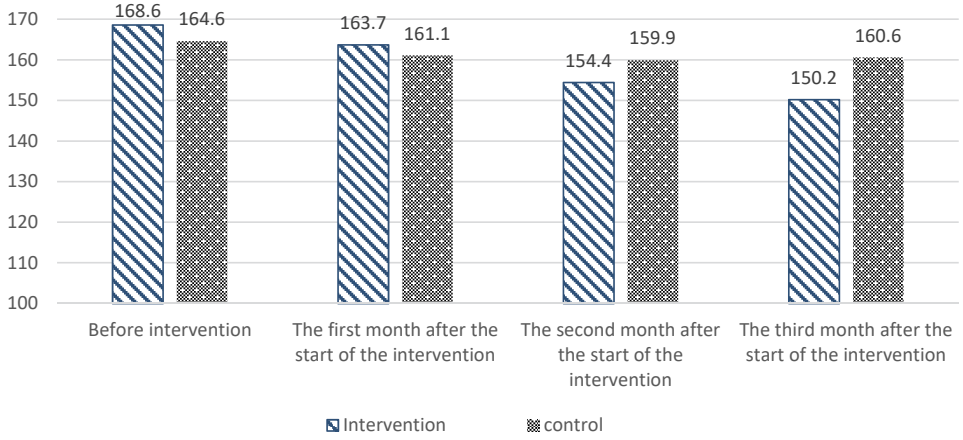

Figure 2. Mean fasting blood sugar in two groups at different time points

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Table 6. Mean HbA1C in the two groups before and after the intervention

Intervention Stage	Mean±SD		P
	Intervention	Control	
Before the intervention	8.4±2.1	7.9±2.0	0.35
After the intervention	7.8±1.5	8.0±1.9	0.69
P	<0.001	0.94	--------

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Table 7. One-way analysis of variance test results (n=50)

Group	Intervention Stage	Mean±SD	t	P
FBS intervention	Before the intervention	168.6±50.5	2.691	0.012
	The 1st month after the intervention	163.7±37.4		
	The 2nd month after the intervention	154.4±28.8		
	The 3rd month after the intervention	150.2±27.2		
FBS control	Before the intervention	164.6±50.6	1.083	0.045
	The 1st month after the intervention	161.1±52.9		
	The 2nd month after the intervention	159.9±51.3		
	The 3rd month after the intervention	160.6±49.1		

FBS: fasting blood sugar

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The 1-way analysis of variance test shows that the average fasting blood sugar in the four recorded times in the intervention group was reported to be significant (P=0.012) as well as the average fasting blood sugar in the four measured times. It was statistically significant in the control group (P=0.045) (Table 7).

4. Discussion

Information can be provided to people at an understandable level and in a simple, fast, and explicit way by using health information and communication technology (ICT). In recent years, mobile technology has represented an ability to alter the traditional method of face-to-face education and offer an innovative definition of education; it also makes it possible to learn at home, at work, and on trips, both temporally and spatially. It overcomes many limitations and inefficiencies. The use of mobile phones in the daily lives of people and now in the field of health care is increasing dramatically [25].

Healthcare education is possible by using mobile communication techniques and increasing patients' awareness about their disease and related treatments; because by using this system, interventions can be followed up by reminding and monitoring patients [22].

This part of the results was consistent with the findings of other researchers which shows the effectiveness of SMS training in the field of control and diabetes has been cured by raising awareness [15, 26, 30, 31].

The independent t test and paired t test were utilized to check drug adherence. In both tests, the mean score of adherence to treatment in the control group was not significantly different between before and after the intervention, but in the intervention group, after the intervention was significantly higher than before the intervention.

The results of the paired t test showed insignificant differences in the control group between before and after the intervention in terms of the mean physical activity score, but in the experimental group, a remarkable development in its value was detected after the intervention, which shows the effectiveness of our intervention training. This part of the findings also agrees with Shamsi et al. findings [32].

According to the results, in terms of mean healthy nutrition score, a detectable difference was not observed between the two groups before the intervention, but after the intervention, for the intervention group, significantly higher values of the mentioned parameter were recognized compared to the control group. Therefore, our finding shows the positive effect of the intervention in improving the nutritional status of diabetic patients in the experimental group. These results are in line with the findings of Baraz et al. and Shamsi et al. [32, 33]. In explaining this research finding, it can be said that providing appropriate education in the field of prevention, improvement, and treatment of diabetes by raising awareness and knowledge can improve general health and healthy nutrition of patients and thus increase better blood sugar control in diabetics. On the other hand, according to the paired t test results, before and after the intervention, the mean hemoglobin A1C had no remarkable difference in the control group. However, in the experimental group, applying the intervention was associated with a significant reduction in its values compared to before the intervention. This finding indicates the positive effect of the intervention in controlling the mean hemoglobin A1C of diabetic patients in the experimental group. These findings were similar to the study of other researchers [26, 30, 34].

These results showed that in the previous stage of the educational intervention, the studied samples did not have the desired control of the metabolic indicators of diabetes; however, education through SMS has improved the metabolic control of diabetes and by making such changes, good clinical results can be expected for them. Considering the independent t test results, a significant difference could not be detected between the two groups at any time points in terms of the mean fasting blood sugar, but the analysis of covariance by adjusting the fasting blood sugar level before the intervention in the two groups revealed that the mean fasting blood sugar in the second and third months after the intervention, was significantly less the intervention group compared to the control group. Analysis of variance with repeated measures exhibited that the mean fasting blood sugar in the control group was not significantly different between time points but in the intervention group, noteworthy differences were observed between different time points. Considering the LSD post hoc test, before the intervention and in the first month after the intervention, the mean fasting blood sugar could not be recognized in the intervention group, but a significant reduction in its values could be detectable in the second and third months after the intervention. However, the difference was not significant between the second and third months after the intervention. This part of the findings exhibited consistency with the reports of Goodarzi et al. and Kim et al. [26, 34].

In justifying this part of the findings, it can be said that the use of the mobile phone is effective in providing health services and managing chronic diseases. Perhaps further studies in this field will lead to planning to use new methods and meet the educational needs of patients in our country.

On the other hand, the educational methods that have been used so far and in most of the research are lectures, question and answer sessions, face-to-face training, group discussion, and the use of slides, pamphlets, and training.

5. Conclusions

In this study, we sought to explore the effectiveness of education via Persian text on blood sugar control and adherence to drug treatment of patients with type 2 diabetes, which if effective that used in health centers implementing the family physician plan.

The results indicated no significant difference between the two defined groups in terms of the mean score of adherence to treatment before the intervention. However, after applying the intervention, it was detected to be significantly higher in the intervention group compared to the control group, which shows the positive effect of the intervention in improving treatment adherence in the experimental group. Finally, based on our results, it can be summarized that the SMS system in the form of an educational medium along with the common treatment of diabetes, can improve blood sugar control and have a positive effect on other aspects of diabetes care.

The use of such educational methods can target the beliefs that guide patients' behavior. Healthcare personnel who take care of diabetic patients can make more effective interventions to avoid or postpone the complications of diabetes. This educational method can lead to providing services to patients regardless of time and place. Therefore, the length of hospitalization of patients decreases, and the independence and self-management of patients increase and ultimately leading to the improvement of medical care and reduction of health costs.

Study limitations

These training methods, in addition to the need for health workers, time, and money, for study patients, which are often between the ages of old and very old, are not convenient. The limitations of this research include the small sample size and the unwillingness of some people to participate in the research. Also, for obtaining

more reliable and generalizable results, we recommend that this study be conducted over a longer time with a larger number of participants. Therefore, it is suggested that future studies do longer-term follow-ups. Long-term follow-up evaluation can help in understanding the long-term effects of this method on diabetics.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences (Ethical Code: IR.MUI.REC.1396.30856).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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