

Effect of Diabetes Self-Management Education on Glycaemic Control in Sudanese Adults with Type 2 Diabetes

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Abstract

Research Background: The high prevalence of diabetes in Sudan, estimated at 16%, highlights the importance of effective health education in diabetes management. Diabetes self-management education has been identified as a crucial tool in enhancing the knowledge, attitudes, and abilities necessary for self-management among individuals with diabetes. **Aim:** To assess the impact of diabetes self-management education on medication adherence and glycaemic control in Sudanese adults with type 2 diabetes before and 3 months after the DSME intervention. **Method:** The study was conducted in Sudan between September 2022 and March 2023, it was an interventional, one-group, pre- and post-test study that aimed to assess the impact of diabetes self-management education (DSME) on medication adherence and diabetes control in Sudanese adults with type 2 diabetes. The research was conducted in primary health care centers in six cities in Sudan and involved 244 participants. The data entry and statistical analysis were conducted using the Statistical Package for Social Sciences version 27.0. A paired *t* test was used for analysis. **Results:**



The study included 244 participants, 67% of whom were males. The age mean \pm SD was 48.6 ± 9.3 years, and 85.3% of participants were married. Age at onset of diabetes mean \pm SD was 40.60 ± 7.81 years; 44.6% had diabetes for less than 5 years; and 84.1% had a positive family history of diabetes mellitus. The levels of poor, low, and partial adherence to medication decreased by 8.2%, 4%, and 20.6%, respectively, after the intervention. The levels of good and high medication regime adherence increased by 13% and 19.8%, respectively; BMI decreased by 1.1 ± 0.73 kg/m² ($p = 0.005$). The fasting blood sugar decreased by 69 ± 32.9 mg/dl ($p = 0.049$), and the glycated hemoglobin decreased by $1.21 \pm 0.28\%$ ($p = 0.001$). **Conclusions:** The findings of this study reinforce the importance of patient education in improving glycemic control and enhancing self-management behaviors. Patient education plays a critical role in enhancing glycemic control and self-management behaviors. It is essential for healthcare providers to adopt a patient-centered approach, taking into account the individual's beliefs, attitudes, and knowledge about their illness and treatment. Overcoming these challenges necessitates a comprehensive approach, including enhancing healthcare professionals' knowledge and communication skills, offering accessible and culturally sensitive diabetes education programs, and addressing barriers to resources and support for self-management.

Keywords

Sudan, Adherence, Intervention, Education, Self-Management, Diabetes

1. Introduction

Diabetes mellitus (DM) is a chronic disease characterized by high blood glucose levels due to abnormal β -cell function and insulin action. It can lead to long-term damage and dysfunction in various organs, including the eyes, kidneys, nerves, heart, and blood vessels. The development of diabetes involves multiple pathogenic processes [1].

1.1. Diabetes as a Public Health Burden

The prevalence of diabetes is rising at a faster rate in low- and middle-income countries (LMICs) than in high-income countries. The Lancet Commission on Diabetes issued a report [2] emphasizing the unequal burden of the disease on people in LMICs, noting that 80% of diabetes cases worldwide occur in these countries. The prevalence of diabetes in Sudan is estimated to be 16%, or 3,526,600 cases [3].

1.2. Benefits of Lifestyle Interventions

A healthy lifestyle can prevent or delay complications caused by type 2 diabetes mellitus (T2DM). Large prevention trials show that the risk of type 2 diabetes is reduced by approximately 50% in high-risk populations by lifestyle modification [4]. A healthy lifestyle includes maintaining a nutritious diet, engaging in regular

physical activity, maintaining a healthy body weight, and avoiding tobacco use [5]. Both the American Diabetes Association and the United Kingdom's National Institute of Health and Care Excellence (NICE) recommend that patients with diabetes refrain from or quit smoking cigarettes [6].

Health education plays a crucial role in diabetes management, as it helps individuals understand the disease, make informed decisions about their lifestyle and treatment, and develop self-care skills. Planning nutritious meals, making changes in lifestyle, engaging in physical activity, and developing healthy habits are all key components of diabetes management [7]. Adherence to medication and regular monitoring and treatment are also important in managing diabetes and preventing complications [8].

Poor control of diabetes can have negative consequences, including a lower quality of life for patients, increased healthcare costs, and a burden on individuals, communities, and the healthcare system.

1.3. Diabetes Self-Management Education

The long-term prognosis of diabetes mellitus is highly dependent on the self-care behavior of the affected people; research has proven that educational interventions influence knowledge, physical activity, food intake, self-efficacy, and health literacy [9]. Diabetes self-management education (DSME) is the process of facilitating the knowledge, attitudes, and abilities necessary for self-management. It helps patients with diabetes engage in and maintain lifestyle modifications that have been proven to enhance health outcomes [10].

The effectiveness of diabetes self-management programs in developing countries has shown promising results, as explored in numerous studies [9]-[17].

The aim of this study was to assess the effect of the diabetic self-management education intervention on medication adherence and diabetes control before and 3 months after the intervention.

2. Materials and Methods

2.1. Research Design

Quasi-experimental research with a single-group, pretest-posttest design. The primary outcomes expected were changes in HbA1c values, fasting blood glucose, and body mass index resulting from the educational intervention.

2.2. Population and Sampling

The study population comprised all T2DM patients attending six primary health care centers in six different cities in Sudan (*i.e.*, Khartoum, Portsudan, Kassala, Kusti, El Obied, and Elfashir) between September 2022 and March 2023.

The sample size was 244, and it was determined using the Yamane sample size equation [18]. We selected the sampling randomly in our research and aimed to reach all patients diagnosed with type 2 diabetes over the age of 18 who were receiving pharmacological treatment (for sample size calculation, refer to Appen-

dix A.).

2.3. Data Collection

2.3.1. Protocol for DSME

The methods and materials for the study were based on previous studies [19] [20], the DSME program was tailored to be appropriate both socio-demographically and culturally. In our study, the DSME program-implementing doctors underwent training sessions online for 2 weeks to ensure they delivered the same quality of education to all patients in different cities.

The patients in the study participated in a DSME program, which involved attending a two-hour lesson biweekly for eight weeks and adhering to the self-management guidelines within the study period. The program focused on imparting skills and knowledge related to healthy eating, physical activity, monitoring, medication management, problem-solving, risk reduction, and healthy coping.

The education included both visual and written materials related to the education, and the patients were provided with the education together with the education materials (a full-color book containing explanatory materials about diabetes and treatment goals appropriate to the education levels of the patients).

Additionally, blood tests (fasting blood sugar and HbA1c), as well as examinations of height, and weight, were conducted before the start of the DSME program as the baseline, and again three months after its completion (for DSME content, refer to Appendix C).

2.3.2. Purpose of the Education

Individuals with type 2 diabetes are responsible for making many decisions like diet selection, physical activity, taking medication, monitoring glucose, counting carbohydrates, and adjusting insulin doses. There are seven fundamental components that diabetes educators must discuss self-care behaviors, healthy eating, physical activity, monitoring blood glucose levels, using medication, reducing risks, solving problems, and healthy coping behaviors [21].

2.3.3. Data Collection Procedure

The data was collected using an interview carried out by the researcher in the local language (Arabic). All pretest data for the study was collected before the DSME program, and posttest data was collected 3 months after the intervention.

Contact information was obtained from each participant for the purpose of communication throughout the study to ensure attendance at educational sessions and to check whether or not the participant was following instruction.

2.4. Data Collection Instruments

Questionnaire. The questionnaire included questions regarding personal information, medication adherence, diabetes control, and BMI (for the questionnaire, refer to Appendix B).

Medication Adherence. Adherence to a medication regime was assessed for

the purposes of this study using the Arabic version of the General Medication Adherence Scale (GMAS) questionnaire, which has been previously validated and tested in a Sudanese population [19]. The GMAS is an 11-item self-reporting adherence measure. Each item has four outcomes and is given an adherence score. The highest possible total score is 33. The sum of all items yields a final score that is interpreted at various levels of adherence: high (30 - 33), good (27 - 29), partial (17 - 26), low (11 - 16), and poor (≤ 10).

Body Mass Index (BMI). For BMI calculation, the height and weight were recorded using a tape and a digital weight scale. The BMI was calculated using SPSS, and the unit of measurement was kg/m^2 .

Diabetes Control. Blood levels of glycosylated hemoglobin (A1C) and fasting blood sugar (FBS) were used as metrics for diabetes control. The unit of measurement for A1C level was percentage, while for FBS it was mg/dl .

2.5. Data Analysis

The data entry and statistical analysis were conducted using the Statistical Package for Social Sciences (SPSS) version 27.0, developed by SPSS Inc. in Chicago, IL. Continuous data, such as BMI, FBS, and HbA1c, were expressed as mean \pm standard deviation (SD).

The paired t-test was used for analysis. A p-value ≥ 0.05 was considered statistically significant, with a 95% level of confidence.

2.6. Ethical Considerations

The human material or human data in this study were conducted in compliance with the principles outlined in the Declaration of Helsinki. This includes obtaining informed consent from all participants, ensuring their rights, privacy, and well-being were safeguarded throughout the research process, and obtaining ethical approval from the Khartoum State Ministry of Health's Research Ethics Committee. The study adhered to ethical guidelines to protect the participants' rights and ensure the integrity of the research.

Attending the educational lectures directly benefited all the participants by increasing their skills and knowledge in various areas.

3. Results

The study on diabetes self-management education (DSME) in Sudanese adults with type 2 diabetes was conducted in primary health care centers in six cities in Sudan. It included 244 participants, 67% being males and with a mean age of 48.6 years, all of whom attended all the interventional sessions and stated that they followed the given instructions and information provided to them in the lectures. The study aimed to assess the impact of DSME on medication adherence and diabetes control.

The results showed that after the intervention, there was a decrease in poor, low, and partial adherence to medication and an increase in good and high ad-

herence. Additionally, there were statistically significant reductions in BMI, FBS, and HbA1c. These findings highlight the importance of patient education in improving glycemic control and enhancing self-management behaviors.

Table 1 shows the demographic characteristics of participants and information related to diabetes mellitus, including age at onset, duration of disease, and positive family history for diabetes mellitus ($N = 244$).

A paired t test was used to assess the change in adherence level pre- and post-intervention ($N = 221$) ($P = 0.048^*$). The result is shown in **Figure 1**.

A paired t test was used to assess changes in BMI, FBS, and HbA1c pre- and post-intervention ($N = 221$). The results are shown in **Table 2**.

4. Discussion

Recent studies have found the prevalence of DM in Sudan ranges from 18.7% to 20.8% [22] [23]. The best approach to long-term management of such a prevalent chronic disease, especially in low-resource settings like Sudan, is to educate

Table 1. Distribution of participants' demographic characteristics.

Variable	<i>n</i>	%
Sex		
Female	80	33
Male	164	67
Age		
	48.64 ± 9.33	
Marital status		
Single	34	13.8
Married	208	85.3
Widowed	2	0.9
Level of education		
Primary school	87	35.7
Secondary school	73	29.9
University	84	34.4
Age at onset of DM		
	40.60 ± 7.81	
Duration of DM		
5 years or less	109	44.6
6 to 10 years	81	33.2
11 or more years	54	22.2
Family history of DM		
Yes	205	84.1
No	39	15.9
TOTAL	244	100

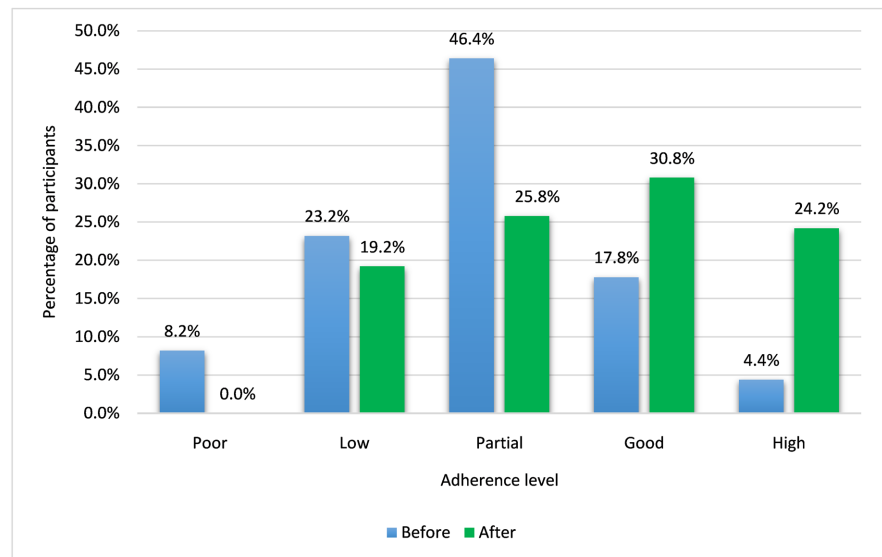


Figure 1. Adherence level to pharmacological treatment.

Table 2. Frequency distribution of health assessments.

Variable	Groups		p-Value
	Pre-education	Post education	
BMI (kg/m ²)	25.12 ± 3.71	24.02 ± 2.98	0.005*
FBS (mg/dl)	216.8 ± 86.6	147.8 ± 53.7	0.049*
HBA1C (%)	8.95 ± 1.69	7.74 ± 1.41	0.001*

*Statistically significant correlation.

patients to ensure they adhere to their medication regimen and properly understand DM. This will aid in a longer delay of DM onset and better management of the complications.

With this goal in mind, in our current study, we explored the effect of DSME on glycemic control and adherence to treatment in patients with type 2 diabetes.

It is evident from the existing literature that DSME interventions have been consistently associated with positive outcomes related to glycemic control and BMI [24] [25]. This is further supported by previous research, which also found statistically significant decreases in BMI following DSME interventions. Building on these findings, it is important to continue exploring and evaluating the effectiveness of DSME in improving various health outcomes for individuals with diabetes. DSME interventions have a significant impact on improving clinical outcomes and quality of life for individuals with diabetes.

Regarding adherence to both pharmacological and non-pharmacological treatment, we used the GMAS scale to see whether the educational intervention made a difference and whether the positive influence of diabetes self-management lectures could be observed.

The intervention demonstrated a significant effect on glycemic control, which was assessed by the changes in BMI, FBS, and HBA1c ($p \leq 0.05$).

In the current study, the decrease in BMI yielded a statistically significant result ($p = 0.005$). This finding corroborates with a prior study conducted in Sudan by Mahmoud *et al.*, where they also identified a statistically significant decline in mean BMI three months after implementing a similar intervention ($p = 0.001$) [20]. It is well-established that maintaining a normal BMI plays an important role in controlling diabetes, and even slight weight loss can lead to considerable reductions in HbA1c levels. The findings of this study indicate that the observed decrease in BMI may have indeed contributed to the reduction in HbA1c levels.

Regarding FBS levels, there was a decrease ($p = 0.049$). Similarly, a previous study by Mahmoud *et al.*, reported a significant decrease in FBS levels 3 months after the intervention ($p = 0.002$) [19]. These findings emphasize the potential of DSME in effectively managing FBS levels in individuals with diabetes. Expanding the scope of research in this area can yield valuable insights into the broader impact of DSME on various health outcomes for individuals with diabetes.

Furthermore, in the current study, HbA1c levels decreased ($p = 0.001$). This finding confirms a previous study by Bekele *et al.*, which also reported a significant reduction in HbA1c levels due to self-management education intervention as well [10].

Overall, our study suggests that the DSME intervention resulted in improvements in BMI, FBS, and HbA1c levels, indicating positive effects on diabetes management. These findings support the importance of self-management education in achieving better glycemic control and overall diabetes management.

However, our findings were unlike those a 6-month randomized controlled trial conducted in Kenya by Gathu *et al.* [26], in which DSME did not significantly improve the glycemic and metabolic control of suboptimally controlled type 2 diabetes patients. Although individualized diabetes education has been shown to improve outcomes in some studies, variability in duration and frequency of the intervention, content, and method of delivery are important determinants of the effectiveness of a program [26]. In comparison, according to a systematic review by Chryala *et al.* [27], interventions based on combination DSME (group, individual, and remote modes) achieved significant improvements in A1C, which were higher than single-mode DSME delivery.

The results of this study may have significant relevance for patient care and diabetes treatment. The study illustrated the significance of patient education in boosting self-management behaviors and increasing glycemic control by showing how a DSME intervention improved participant medication adherence and diabetes control. Our results highlight the need for a patient-centered approach by healthcare professionals, taking into account the patient's attitudes, beliefs, and level of knowledge regarding their condition and course of treatment. According to the study, DSME programs can successfully enhance the results of diabetes treatment, including medication adherence, FBS, BMI, and HbA1c levels. Healthcare practitioners may empower patients to better manage their diabetes and lower their risk of complications by arming them with the knowledge

and skills they need.

In line with the findings of a previous study by Amer *et al.*, [28] which also observed that self-efficacy was significantly associated with adherence to self-care activities, this suggests that educating patients with type 2 DM about proper medication usage and self-care activities can greatly improve their adherence to treatment and ultimately lead to better glycemic control.

Modifications based on patients' barriers and cultural considerations can significantly affect patient satisfaction and self-efficacy in DSME. For example, including family members in sessions can address the importance of family support and strengthen the patient's social network, leading to better engagement and outcomes [29]. Sociocultural factors, such as low literacy rates and transportation costs, can also influence program adherence and engagement. It is essential for healthcare interventions to consider these factors and develop strategies to overcome barriers. This may involve providing educational materials in accessible formats, offering transportation support, or utilizing community health workers who are familiar with the cultural context and can bridge communication gaps.

There are several challenges in implementing self-management programs for diabetes. One challenge is the lack of education and training among healthcare professionals. Many doctors and nurses lack sufficient knowledge or understanding of diabetes management, which can hinder their ability to effectively educate and communicate with patients about their condition. This can lead to inadequate support and guidance for patients in self-management. In our study, the doctor implementing the DSME program underwent online training sessions for 2 weeks to ensure they delivered the same quality of education to all patients in different cities.

Effective communication between healthcare providers and patients is also a challenge. Some healthcare professionals may feel uncomfortable discussing diabetes management with their patients, which can hinder effective education and support. Additionally, language barriers or cultural differences can further complicate communication and understanding [30].

4.1. Limitations

The relatively short study period and limited number of educational lecture sessions were the biggest limitations of our study; despite this, the results have answered all the research questions and opened a gate for future research.

4.2. Strengths

The strength of this study is that it covers different cities in Sudan, ranging from rural to semi-urban and urban cities, with different availability of drugs and health access. We can confidently generalize our findings to a national level.

5. Recommendations

It is crucial to strengthen the healthcare system in Sudan to provide accessible

and affordable healthcare services for DM patients. This includes increasing the number of healthcare professionals, particularly specialists in diabetes care, as well as improving the availability and affordability of medications and diagnostic tools.

It is recommended in future research, to extend the study period and increase the number of educational sessions to further assess the impact of diabetes self-management education on adherence and patient outcomes.

Additionally, future research should explore the role of social support and cultural factors in influencing adherence to self-care behaviors could provide valuable insights.

6. Conclusion

Addressing these challenges requires a comprehensive approach that includes improving healthcare professionals' knowledge through training, providing accessible and culturally sensitive diabetes education programs for patients, and addressing barriers to resources and support for self-management.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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