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Effectiveness of structured distance education on metabolic control, self-care, and health literacy in newly diagnosed type 2 diabetes: A randomized controlled trial☆

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ABSTRACT

Aim: This study aimed to evaluate the effectiveness of a structured distance education program on metabolic control, self-care activities, and health literacy in patients with newly diagnosed type 2 diabetes mellitus.
Methods: A randomized controlled trial design with block randomization (1:1 allocation) was conducted at a university hospital's endocrine outpatient clinic. A total of 100 patients newly diagnosed with type 2 diabetes were randomly assigned to either an intervention group (n = 50), receiving structured weekly distance education via Zoom sessions (each 40 min) for four weeks, or a control group (n = 50) receiving routine outpatient care. Data were collected using metabolic control parameters (BMI, fasting blood sugar, HbA1c), Diabetes Self-Care Activities Questionnaire, and Health Literacy Scale at baseline and after three months.
Results: Significant improvements were observed in metabolic control parameters, self-care activities, and health literacy in the intervention group compared to the control group ($p < 0.01$). Positive correlations were identified between health literacy and diabetes self-care behaviors post-intervention.
Conclusion: Structured distance education significantly enhances metabolic control, self-care, and health literacy in newly diagnosed T2DM patients. The study highlights the importance and practicality of integrating telehealth technologies into routine diabetes management and patient education, offering effective strategies to overcome barriers inherent in traditional educational methods.

1. Introduction

Diabetes mellitus, particularly type 2 diabetes mellitus (T2DM), is an increasingly prevalent chronic condition characterized by impaired insulin sensitivity or insulin resistance [1]. Diabetes, which accounts for 11.5 % of global health expenditure,[1] should be carefully managed in the follow-up and treatment processes with the cooperation of healthcare professionals and patients. Managing T2DM effectively is crucial for preventing complications, improving quality of life, and reducing healthcare expenditures globally [2]. Diabetes self-care education is widely acknowledged as an essential strategy for managing the condition and enhancing patient outcomes; however, numerous barriers persist in delivering traditional face-to-face educational interventions [3].

It has been emphasized that the concept of health literacy is important in the development of self-care behaviors in patients with T2DM. It has been reported that patients with T2DM who have inadequate or low health literacy use emergency units more and have a higher risk of hospital readmission, developing diabetes-related complications, increased carbohydrate consumption compared to other food types, and developing severe hypoglycemia [4,5]. Forghani et al. found that there was a significant relationship between health literacy and HbA1c, self-care behaviors, foot care, drug use, and diet compliance [6]. It is necessary to provide continuous and regular education for patients with T2DM to achieve all these. However, it has been reported that health professionals can evaluate and promote diabetes self-management only a few times a year due to the inadequate number of health professionals and the limited number of medical appointments. Distance education

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has been reported as one of the influential methods to promote self-empowerment, better control the disease, and prevent diabetes-related complications in patients with T2DM [7]. In a study conducted with patients with T2DM, it was reported that participants used their mobile phones for an average of 4.5 h a day and that mobile phones could be used effectively for educating patients with T2DM [8,9]. The results of recent studies have shown that technological tools, such as the internet, computers, and mobile phones and technologies that allow distance monitoring and follow-up of patients at any time, can be used effectively in education, care, and treatment of patients with T2DM [10,11]. In studies in which educational messages are sent to patients' mobile phones, positive results have been reported in various areas, such as the follow-up and management of patients with T2DM, optimal glycemic control, cognitive-social patient adjustment, and improvement in metabolic control parameters [12,13]. For this reason, it is thought that distance education can be used to increase the education of individuals.

It is stated that continuous contact with nurses can be achieved and that nurses can undertake educational and organizational roles in this area, owing to the use of mobile phones. At the same time, it has been reported that individuals can live autonomously at home and long-term hospitalizations can be minimized [3]. Despite these advantages, the existing literature highlights several barriers limiting the widespread implementation of telehealth interventions. Technological access disparities, varying levels of digital literacy, patient engagement challenges, and questions regarding the sustainability of interventions are frequently identified concerns. These barriers underscore a critical gap in literature: the need for robust, accessible, and engaging distance education methods tailored specifically for individuals with newly diagnosed T2DM. It is estimated that patients with newly diagnosed T2DM may need more education about diabetes, which is a chronic disease that requires life changes. Therefore, this study was conducted to determine the effect of distance education provided to patients with newly diagnosed type 2 diabetes on their metabolic control, self-care, and health literacy. The specific hypotheses of the study are as follows:

1. The metabolic control parameters (BMI, fasting blood glucose, HbA1c) of patients with newly diagnosed T2DM who receive distance education will improve significantly compared to the control group.
2. The self-care activity levels of patients with newly diagnosed T2DM who receive distance education will increase significantly compared to the control group.
3. The health literacy levels of patients with newly diagnosed T2DM who receive distance education will show significant improvement compared to the control group.

2. Methods

2.1. Study design

This study was conducted using a parallel-group randomized controlled trial (RCT) design to rigorously assess the impact of distance education on metabolic control, self-care, and health literacy among patients with newly diagnosed type 2 diabetes mellitus (T2DM). A randomized controlled trial design was used in the study and it was reported using the Consolidated Standard of Reporting Trials-CONSORT 2010-guidelines (Supplementary 1) [14]. Randomization was performed using a computerized randomization software (https://www.randomizer.org/) employing block randomization with a 1:1 allocation ratio to ensure balanced group assignment. The use of RCT design and block randomization was selected to reduce potential selection bias and confounding factors, thus enhancing the validity of the study outcomes.

2.2. Sampling method and recruitment

Participants were recruited from the endocrine outpatient clinic of a university hospital between June 2022 and March 2023. The sampling method utilized was convenience sampling from patients who met the following inclusion criteria: newly diagnosed T2DM, aged between 18–65 years, ability to use a smartphone, receiving oral antidiabetic and/or insulin therapy, without hearing or speech impediments, without psychiatric disorders, and who consented to participate. Individuals unable to read or write or with significant visual or auditory impairments were excluded from the study. Eligible participants were informed about the study's aims and procedures by a diabetes education nurse who was not involved in the intervention.

The sample size was calculated using G*Power 3.1.9.2 software. The primary outcome was defined as the change in HbA1c between the intervention and control groups. Based on previous studies in newly diagnosed patients with type 2 diabetes, a mean difference of 0.8 % in HbA1c with a standard deviation of 1.2 was assumed [21,22]. With a two-tailed alpha of 0.05 and a power of 0.80, the minimum required sample size was calculated as 45 participants per group. To account for a possible 10 % attrition rate, the final sample size was set at 50 participants per group.

The final sample comprised 100 patients who were randomly assigned to either the intervention group (n = 50) or the control group (n = 50). The assignment of patients was performed according to the randomization list by an independent diabetes education nurse not involved in the delivery of the intervention. Allocation concealment was maintained, and the researcher administering the intervention accessed the randomization data only after the pretest. Blinding of participants and educators was not feasible due to the nature of the intervention; however, outcome assessment and data analysis were performed by blinded assessors to reduce bias.

2.3. Data collection and follow-up procedures

Baseline data collection involved completing a Personal Information Form, the Diabetes Self-Care Activities Questionnaire, and the Health Literacy Scale. Metabolic control parameters—Body Mass Index (BMI), Fasting Blood Sugar (FBS), and Hemoglobin A1c (HbA1c)—were measured initially and at a 3-month follow-up using standardized procedures and instruments. Follow-up data collection replicated baseline measures to ensure consistency [2,4,5,17–20].

2.4. Preparation of distance education program

The preparation phase (Phase 1) involved the development of educational content based on national and international diabetes management guidelines [1,15,16]. Expert feedback was obtained from a multidisciplinary panel of 10 specialists (endocrine physicians, nursing faculty, and diabetes education nurses) who reviewed the content for accuracy, relevance, and comprehensiveness. Subsequently, pilot patient feedback was gathered from 10 newly diagnosed patients to evaluate content comprehensibility, engagement, and practical usability. The early involvement of patients was essential to refine the educational materials, ensuring maximum patient engagement and adherence to the program. Patients with diabetes who were included in the first phase of the study were excluded from the second phase. All structured distance education sessions delivered via Zoom in the intervention phase were conducted by the researchers, who are experienced in diabetes education and patient counseling.

2.5. Routine care

As part of the routine diabetes education given at the hospital, all newly diagnosed patients with T2DM were given information on diabetes management, including self-care management, lifestyle changes,

and drug compliance. Based on the appointment system, 30-minute education sessions were planned once in three months for each person. Education was given by diabetes education nurses in endocrine outpatient clinics by using face-to-face presentations and brochures. Physical examination and laboratory tests were performed by national guidelines in each outpatient control of the patient. Education, follow-up frequency, and prescription update were planned according to the participants' needs.

2.6. Intervention

All patients with newly diagnosed T2DM who met the sampling criteria were given information about the study, and pretests were applied. A WhatsApp group was created to inform about the education schedule to the patients with T2DM in the intervention group. The first meeting was completed by informing participants that they could send questions through the WhatsApp group at any time. Patients' measurements were taken by the diabetes education nurse with a scale and height meter in the outpatient clinic. Routine test results (HbA1c, fasting blood glucose) were obtained from the hospital information system using the diabetes education nurse. Following the first meeting, the intervention consisted of four weekly educational sessions, each lasting approximately 40 min, conducted via the Zoom platform. Educational content covered critical diabetes management topics: disease knowledge, nutritional therapy, exercise, insulin use, blood glucose monitoring, diabetes complications, foot care, and lifestyle adjustments. Sessions included interactive presentations delivered by a diabetes education nurse, providing ample opportunity for participant interaction, discussion, and question-answer periods. Content development involved collaboration among healthcare professionals specialized in diabetes management and patient education. During the training, the participants were given the opportunity to ask the trainer any questions they wanted. Patients' questions were answered. The registrations were sent via whatsapp to the people who could not attend the training by registering during the training. After the data collection process was completed, the recordings made via Zoom were sent to the individuals in the control group, allowing them to benefit from the same training content. The flow chart of the study is given in Fig. 1. A total of 100 patients with newly diagnosed type 2 diabetes were randomized (50 intervention, 50 control). During follow-up, 3 participants in the intervention group and 2 participants in the control group did not complete the post-test assessments. However, all randomized participants were included in the final analyses using an intention-to-treat (ITT) approach, with missing values imputed by carrying forward baseline measurements (last observation carried forward).

2.7. Outcome measures and study instruments

Descriptive and disease-related characteristics of patients with newly diagnosed T2DM were collected using a personal information form. The primary outcome of the study was glycemic control, assessed using glycated hemoglobin (HbA1c). Blood samples were obtained after an overnight fast, and HbA1c levels were measured in the hospital's central biochemistry laboratory using the high-performance liquid chromatography (HPLC) method, which is considered the reference standard. Additional metabolic parameters included fasting blood sugar (FBS) and body mass index (BMI), measured using routine clinical protocols.

Secondary outcomes included self-care activities and health literacy. Self-care activities were assessed using the Diabetes Self-Care Activities Questionnaire, which evaluates dietary habits, physical activity, medication adherence, glucose monitoring, and foot care behaviors. Health literacy was measured using the Health Literacy Scale, which assesses individuals' ability to access, understand, and apply health information. Both instruments are validated and widely used in diabetes research.

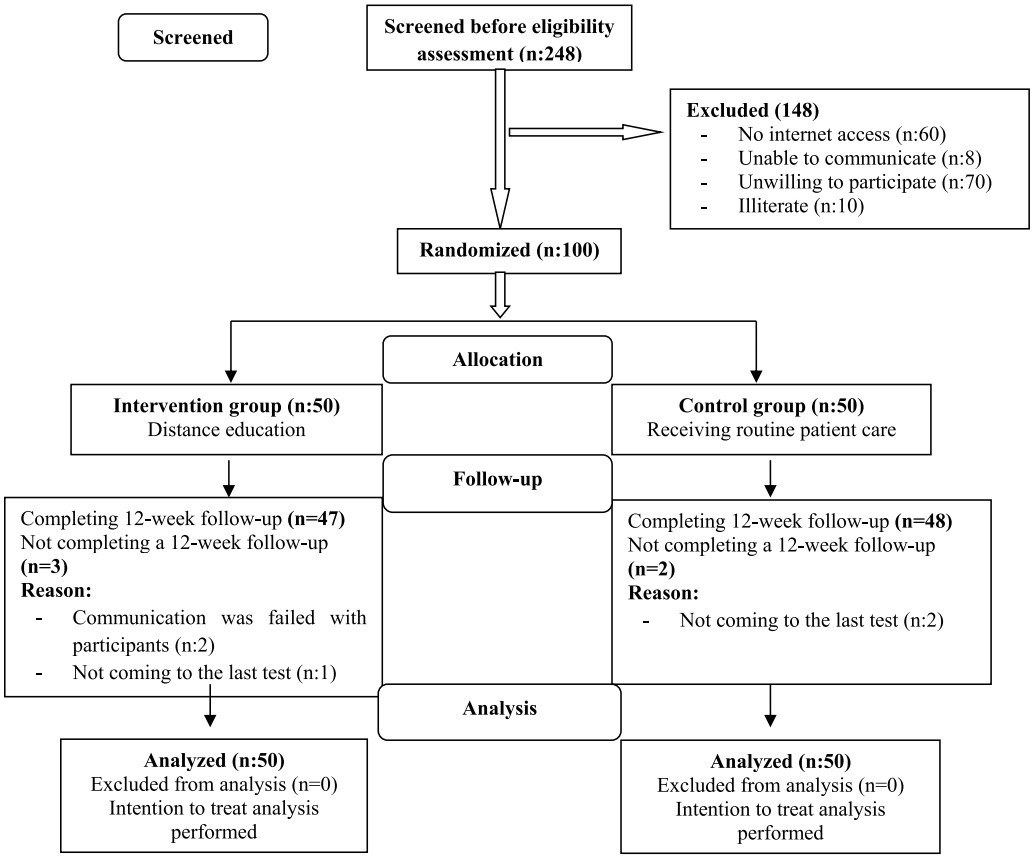


Fig. 1. Flow diagram of the randomized controlled study (CONSORT 2010).

Personal Information Form was created by the researchers following a review of the literature [2,4,5]. The form has 13 questions, including 5 about socio-demographic characteristics of patients with newly diagnosed T2DM, such as age, gender, marital status, educational status, and occupation, 3 about the presence of another disease, exercise status, and status of previous distance education, and 5 about metabolic control parameters, such as Fasting Blood Sugar (FBS), HbA1c, height, weight, and body mass index (BMI).

The Diabetes Self-Care Activities Questionnaire created by Toobert and Glasgow to assess the self-care activities of people with diabetes, and its scope was later expanded. The questionnaire consists of 11 items. These are diet (first 4 items, 4 items are reverse scored), exercise (5 and 6 items), blood sugar test (7th and 8th items), foot care (9th and 10th items) and cigarettes (11th item) [17]. Kav et al. conducted a Turkish validity and reliability study of the scale, and the total scale's Cronbach's alpha value was found to be 0.72 [18]. The internal consistency coefficient was found to be 0.89 in our study.

The Health Literacy Scale is a 4-point Likert-type measure with 14 items and three parts developed by Ishikawa et al. The scale was created to assess individuals with chronic diseases' functional, interactive, and critical health literacy [19]. Agrali and Akyar conducted the scale's Turkish validity and reliability study, and Cronbach's alpha for the total scale was found to be 0.96 [20]. In our study, Cronbach's alpha value was 0.87.

2.8. Data analysis

Data analyses were performed using SPSS 21 software. Normality was tested with Kolmogorov-Smirnov and Shapiro-Wilk tests. Continuous variables between groups were compared using Student's *t*-test or Mann-Whitney *U* test, and categorical variables with Pearson Chi-Square or Fisher's Exact test. Repeated measures comparisons within groups utilized paired T-tests or Wilcoxon signed-rank tests depending on data distribution. An intention-to-treat (ITT) analysis was conducted to handle missing data and minimize bias, thus preserving randomization integrity and study power. For participants with missing follow-up values ($n = 3$ in the intervention group and $n = 2$ in the control group), baseline values were carried forward (last observation carried forward method), ensuring that all randomized patients were included in the final analyses. The primary outcome measure was defined as the between-group differences at follow-up (intervention vs control). Within-group comparisons over time (pre- vs post-intervention) were performed as supportive analyses, but they were not considered the primary focus of the trial. A correlation analysis was also performed to examine relationships between health literacy and self-care scores. Statistical significance was set at $p < 0.05$.

2.9. Ethics of the study

This study was carried out by the Helsinki Declaration's principles. This was approved by XXX University's Ethics Committee (20.08.2020/GO 2020/189). The study's purpose was explained to the participants. They were assured that they could refuse to participate or withdraw from the study at any time without repercussions. Validity and reliability studies were conducted on all scales used in the study, and permission from the authors who created the scales used in the study was obtained via e-mail.

3. Results

The mean age of the participants in the intervention group that received distance education was 50.8 ± 10.49 years, and it was 51.8 ± 10.02 years in the control group. Of the participants in the intervention group, 57.4 % were male, and 87.2 % were married. In the control group, 60.4 % of the participants were male and 89.6 % were married. At baseline, demographic and disease-related characteristics of the participants showed no statistically significant differences between the intervention and control groups, indicating that both groups were homogenous and comparable (Table 1). Specifically, age, gender, marital status, educational level, occupational status, presence of other chronic diseases, exercise status, and previous distance learning experience were evenly distributed across both groups ($p > 0.05$).

The main analyses compared the outcomes between intervention and control groups at the 3-month follow-up (primary outcome). Additionally, within-group changes from baseline to follow-up were examined as secondary findings. Following the intervention, significant improvements were observed within and between groups regarding metabolic control parameters, specifically BMI, Fasting Blood Sugar (FBS), and HbA1c levels (Table 2). In the intervention group, BMI decreased significantly from baseline to follow-up ($p < 0.01$), with a greater reduction compared to the control group ($p < 0.01$). Similarly, FBS and HbA1c levels showed significant reductions from pretest to posttest in both groups, but the improvements were notably greater in the intervention group ($p < 0.01$ for both parameters).

The Diabetes Self-Care Activities scores significantly improved from baseline to follow-up in both groups; however, the intervention group exhibited a significantly greater improvement compared to the control group ($p < 0.01$; Table 2). Health Literacy Similarly, significant improvements were observed in Health Literacy Scale scores from baseline to follow-up assessments within both groups. Nonetheless, the intervention group demonstrated a statistically significantly greater increase in health literacy compared to the control group ($p < 0.01$; Table 2).

Multivariate analyses adjusting for age, sex, education level, and baseline values confirmed the robustness of the findings. The intervention group showed significantly greater improvements in HbA1c, fasting blood sugar, BMI, self-care, and health literacy compared to the control group (Table 3). These adjusted results were consistent with the bivariate analyses.

The scores of the participants the study obtained after distance

Table 1
Descriptive and disease characteristics of the patients in the intervention and control groups included in the study (pretest).

		Groups		*p*
		Intervention (n = 50)	Control (n = 50)	
Age	*Mean±SD*	50.8 ± 10.38	51.8 ± 10.02	[a]***0.649***
	Median (Min-Max)	52 (20-65)	50 (23-65)	
Gender	**Female**	21 (42)	20 (40)	[c]***0.769***
	Male	29 (58)	30 (60)	
Marital status	**Married**	43 (86)	42 (84)	[b]***0.759***
	Single	7 (14)	8 (16)	
Education level	**Primary school**	19 (38)	26 (52)	[b]***0.551***
	High school	21 (42)	17 (34)	
	Undergraduates and above	9 (18)	7 (14)	
Occupational status	**Housewife**	10 (20)	13 (26)	[b]***0.801***
	Public servant	6 (12)	5 (10)	
	Self-employed	13 (26)	14 (28)	
	Retired	21 (42)	18 (36)	
Presence of another disease	**Yes**	34 (72.0)	28 (56)	[c]***0.241***
	No	16 (38.0)	22 (44)	
Status of exercising	**Yes**	18 (36)	19 (38)	[c]***0.936***
	No	32 (64)	31 (62)	
Previous distance learning status	**Yes**	0	1 (2)	[c]***0.505***
	No	50 (100)	49 (98)	

SD: Standart Deviation
[a] Student-t Test
[b] Fisher Exact Test
[c] Pearson Chi-Square Test

Table 2
Compensating for the difference between the mean of Metabolic Control Parameters, Self-Care Activities, and Health Literacy Scale scores.

		Group		p
		Intervention (n = 50) Mean±SD	Control (n = 50) Mean±SD	
Body Mass Index				
Pretest		30.72 ± 6.35	30.08 ± 5.98	[e]***0.699***
Posttest		30.25 ± 6.03	29.99 ± 5.85	[a]***0.950***
	p	[w]***0.000*****	[w]***0.001*****	
Time x Group		0.47 ± 0.58	0.09 ± 0.30	[a]***0.000*****
Fasting Blood Sugar				
Pretest		136.06 ± 44.40	152.27 ± 48.95	[e]***0.095****
Posttest		114.00 ± 19.58	143.10 ± 47.03	[ea]***0.000*****
	p	[w]***0.001*****	[w]***0.001*****	
Time x Group		22.06 ± 40.60	9.16 ± 22.24	[e]***0.047***
HbA1c				
Pretest		7.38 ± 1.73	7.97 ± 1.91	[e]***0.081***
Posttest		6.46 ± 0.53	7.52 ± 1.58	[a]***0.000*****
	p	[b]***0.000*****	[b]***0.002*****	
Time x Group		0.92 ± 1.54	0.49 ± 0.62	[a]***0.003****
Diabetes Self-Care Activities Scale				
Pretest		3.89 ± 1.15	3.74 ± 1.24	[e]***0.545***
Posttest		4.41 ± 0.76	3.87 ± 1.12	[a]***0.007*****
	p	[w]***0.000*****	[w]***0.000*****	
Time x Group		1.52 ± 0.39	0.13 ± 0.12	[a]***0.000***
Health Literacy Scale				
Pretest		2.47 ± 0.40	2.39 ± 0.44	[a]***0.303***
Posttest		2.66 ± 0.33	2.43 ± 0.39	[a]***0.001*****
	p	[w]***0.000*****	[w]***0.016*****	
Time x Group		-0.19 ± 0.27	0.37 ± 0.11	[a]***0.012*****

[a] Mann Whitney-U Test
[e] Student-t Test
[w] Wilcoxon Test
** p < 0.01 SD: Standart Deviation

Table 3
Multivariate analysis of intervention effects on outcomes at 3 months (adjusted for age, sex, education, and baseline values).

Outcome (3-month follow-up)	β (Intervention vs Control)	95 % CI	p-value	Adjusted for
HbA1c (%)	-0.82	-1.20 to -0.45	<0.001	Age, sex, baseline HbA1c
Fasting Blood Sugar (mg/dl)	-17.5	-24.8 to -10.2	<0.001	Age, sex, baseline FBS
BMI (kg/m²)	-0.85	-1.30 to -0.40	0.002	Age, sex, baseline BMI
Self-care score	+5.4	+3.1 to +7.7	<0.001	Age, sex, education, baseline score
Health literacy score	+3.9	+1.8 to +6.0	<0.001	Age, sex, education, baseline score

education on the total and sub-dimensions of the Diabetes Self-Care Activities Scale and the total and sub-dimensions of the Health Literacy Scale showed a statistically significant correlation ($p < 0.05$). There was no significant relationship between the blood glucose measurement sub-dimension of the Diabetes Self-Care Activities Scale and the Functional sub-dimension of the Health Literacy Scale ($p > 0.05$) (Table 4). Tables presenting detailed statistical data clearly highlight significant differences and facilitate direct comparisons of outcomes between the groups, providing robust evidence supporting the effectiveness of the distance education intervention.

Table 4
The relationship between the Self-Care Activities Scale and the Health Literacy Scale after distance education.

Self-Care Activities Scale		Health Literacy Scale			
		Functional	Communicative	Critical	Total
Diet	*r*	-0.364	0.459	0.418	0.383
	p	***0.000****	***0.000****	***0.000****	***0.000****
Exercise	*r*	-0.442	0.453	0.425	0.336
	p	***0.000****	***0.000****	***0.000****	***0.001****
Blood Sugar	*r*	-0.121	0.286	0.240	0.324
	p	0.242	***0.005****	***0.019****	***0.001****
Foot Care	*r*	-0.412	0.503	0.411	0.386
	p	***0.000****	***0.000****	***0.000****	***0.000****
Total	*r*	-0.470	0.571	0.526	0.481
	p	***0.000****	***0.000****	***0.000****	***0.000****

r‡: Spearman Correlation Coefficient
* p < 0.05
** p < 0.01

4. Discussion

The findings from this study highlight significant improvements in metabolic control parameters, self-care activities, and health literacy among patients with newly diagnosed T2DM who participated in a structured distance education intervention. These results are consistent with previous literature emphasizing the positive impacts of telehealth and distance education interventions on chronic disease management, particularly diabetes. Therefore, it has been emphasized that education and follow-up of patients should be more intensive during the initial years after diagnosis [15]. Consequently, the demand for innovative health technologies to support diabetes education and self-management is growing rapidly. In this study, we tested the hypothesis that distance education given to patients with newly diagnosed T2DM was effective on their metabolic control, self-care, and health literacy. Our findings revealed no statistically significant difference in socio-demographic and diabetes-related characteristics before distance education between the intervention and control groups ($p > 0.05$). This revealed that the study group was homogeneous. This is important in terms of demonstrating that the results can be generalized independently of these characteristics.

Our study findings indicated that the difference between the mean BMI, FBS, and HbA1c of the intervention and control groups was not significant in the pre-education period, while the improvement in metabolic control parameters in the intervention group was significantly higher than those of the control group in the post-education period. In addition, the difference between the mean BMI, FBS, and HbA1c values of the intervention and control groups according to the pretest and posttest measurements was found to be statistically significant. When the results of the difference analysis of the means of metabolic control parameters between the groups were examined, it was found that the mean BMI, FBS, and HbA1c scores of the participants in the intervention group were significantly better than those of the control group. This result shows us that the group provided with distance education and counseling achieved a more meaningful improvement. Even after

adjusting for potential confounders, the intervention remained significantly associated with improvements in glycemic control, self-care, and health literacy, supporting the validity of the conclusions. In a study on the effect of video education given via mobile phones, it was reported that the participants in the intervention group had a significant improvement in HbA1c (mean -1.04), fasting blood sugar (-20.33 mg/dl), and BMI changes [12]. Similar findings were reported by Gerber et al. (2023) and, et al. (2021), who found significant improvements in glycemic control following telehealth-supported interventions [21,22]. Similar to our study, many studies in the literature have shown that the education given to individuals on type 2 diabetes self-management through communication technologies and mobile health applications affects individuals' health outcomes positively [11,23,24]. The greater improvements observed in the intervention group underscore the potential of structured, interactive distance education to enhance patient engagement and adherence to therapeutic regimens, emphasizing the importance of incorporating such educational strategies into standard diabetes care.

In our study, while the difference between the self-care levels of the intervention and control groups was not significant in the pre-education period, it was observed that the improvement in the self-care levels of the participants in the intervention group was significantly higher than that of the control group in the post-education period. In addition, the time-dependent variance between the self-care levels of both groups seems significant. In the evaluation of the time-dependent variance between self-care scores performed to determine the effectiveness of the education, it was seen that the improvement in the intervention group was significantly higher. This result showed that there was an increase in the self-care levels of the group that received distance education and counseling. In their study on the effect of distance video education given via mobile phones, Bayraktar et al. reported that self-efficacy levels improved over time [12]. Similar to our study, many studies in the literature have shown that distance education with internet technologies has a positive effect on self-care levels [11,24]. The use of the distance education method seems appropriate and contributes to the continuous and regular education of patients with T2DM.

The examination of the health literacy levels of the participants indicated a significant difference between the groups and in both groups after education according to time. In addition, when the difference analyses of the groups before and after the education were compared, the difference between the total mean scores for self-care and health literacy was found to be statistically significant. It was seen that the improvement in the health literacy levels of the participants in the intervention group was significantly higher. In a literature review, it was reported that counseling for glycemic control and prevention of complications had a significant effect on health literacy, self-care, and glycemic control [25]. Similar to our study, it has been observed that there are many studies in the literature showing the positive effects of education and counseling on health literacy [11,26]. Knowing that individuals' high level of diabetes health literacy is an important factor in achieving glycemic control [27] reveals the importance of these findings for our patients and the necessity of increasing nursing interventions in this regard.

According to the correlation analysis between self-care and health literacy levels in this study, it was seen that as the health literacy levels of the participants increased, their self-care levels increased, as well. Similar to our study, Nese et al. found that there was a positive and powerful relationship between health literacy and diabetes self-care levels [28]. In a similar studies conducted in Iran, a significant correlation was found between mean health literacy and self-care behavior scores, and it was shown that high health literacy could increase self-care behavior in patients with diabetes [29]. Similar to our study, many studies have shown that there is a positive relationship between health literacy and self-care [3,6,30]. In a randomized controlled trial conducted by Kim et al. on Korean Americans with type 2 diabetes, it was determined that health literacy indirectly affected glucose control and quality of life positively by improving self-care skills [31]. Contrary to the studies in the literature supporting our study findings, Kim stated that while there was no direct relationship between health literacy and self-care activities, their indirect effect that improving diabetes knowledge was important [32]. It is thought that the differences in these findings may be due to the difference in sample groups and the differences in the methods used. It is seen that nursing interventions to improve the level of health literacy in patients with T2DM can strengthen their self-care agency and, indirectly, diabetes management. The significant correlations identified between various dimensions of health literacy and self-care activities suggest that enhancing patient knowledge and empowerment through targeted education is pivotal for optimal diabetes management. These findings have substantial implications for healthcare providers, indicating the necessity to tailor educational interventions to effectively address health literacy barriers and reinforce self-management behaviors in chronic disease populations.

4.1. Strengths and limitations

Despite these promising results, several limitations should be acknowledged. Firstly, the study's single-center design may limit generalizability to broader populations. Secondly, the reliance on self-reported questionnaires for self-care and health literacy may introduce recall or reporting bias, although validated scales with established reliability were used. Thirdly, the relatively short follow-up period of three months may not fully capture the long-term sustainability of the observed benefits. In addition, the intervention group received more frequent and longer educational contact compared to routine care, which may have contributed to the observed improvements beyond the delivery mode itself. Finally, it is possible that part of the intervention's success reflected the novelty of the approach or the increased attention given to participants rather than the educational content alone. Nevertheless, this study also has important strengths, including its randomized controlled design, the use of validated outcome measures, and the focus on newly diagnosed patients, which together enhance the robustness and clinical relevance of the findings.

5. Conclusion

This study demonstrated that structured distance education significantly improves metabolic control, self-care activities, and health literacy among patients with newly diagnosed type 2 diabetes mellitus. Given these findings, it is highly recommended that healthcare providers integrate telehealth technologies, such as interactive online platforms, into routine diabetes education and management practices. Incorporating such technological tools not only enhances patient outcomes but also effectively addresses barriers associated with traditional diabetes education methods. Future practice should prioritize the sustained implementation of telehealth interventions to facilitate continuous patient engagement, improve diabetes management, and optimize long-term healthcare outcomes.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pcd.2025.09.002.

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