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Effectiveness of Theory-Based Intervention on Knowledge Level, Psychological Constructs, Metabolic Index and Physical Activity Status in Patients with Type 2 Diabetes: Application of the Health Action Process Approach (HAPA) Model

ABSTRACT

Objective: The aim of the study was to determine the effect of the educational intervention based on the health action process approach (HAPA) model on the level of knowledge, metabolic indicators, psychological constructs and physical activity status in type 2 diabetes (T2D) patients in 2022–2023.

Material and methods: The present study was a randomized controlled trial and 100 T2D patients were equally assigned to experimental and control groups using multi-stage random sampling. The educational program included six online sessions, targeted pamphlets, educational audio files and reminder messages. Data were collected before and 3 months after intervention with demographic items, awareness scale, constructs of HAPA model, IPAQ-s, HbA1c and fasting blood glucose (FBG). Data were entered to SPSS 25.0 and analyzed with chi-square, ANOVA and ANCOVA.

Results: After controlling the effect of the pre-test variable, the mean of the HAPA model constructs and mean of physical activity improved significantly in posttest. In addition, educational intervention explained 30.2%, 57.8%, 33.2%, 64.4%, 76.3%, 25.3%, 24.6%, 36.1% and 36.9% of the variance of health awareness, risk perception, outcome expectancy, action self-efficacy, maintenance self-efficacy, action plan, coping plan, behavioral intention and physical activity, respectively. In addition, the mean of FBG and HbA1c in the experimental group improved significantly after the intervention by controlling the pre-test effect ($p < 0.001$).

Conclusions: Providing theory-based educational interventions through the web and mobile can increasingly promote the effectiveness of cognitive behavioral interventions and facilitate the process of behavior change in T2D. (Clin Diabetol 2023; 12; 5: 290–300)

Keywords: diabetes, self-efficacy, mobile-based education, physical activity, HbA1c, risk perception

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Introduction

Behavior change in people with chronic diseases can prevent serious complications and reduce mortality [1]. Type 2 diabetes (T2D) patients can effectively prevent short-term and chronic complications of diabetes by following a low-calorie diet, regular and sufficient exercise, and following a medication regimen [2]. The key role of regular physical activity in the management of T2D, reducing chronic consequences and improving quality of life has been proven [3, 4]. Despite the vital role of physical activity in controlling the complications of T2D, estimates indicate that 37–60% of T2D patients do not exercise, and this low amount worsens with age [5].

Diabetes self-management education is a cost-effective strategy and leads to an increase in the level of knowledge and improvement of psychological and clinical outcomes [6, 7]. Moreover, in most secondary prevention programs such as cardiac rehabilitation (CR), patient education is considered a central component and structural quality indicator [8]. Education can have a positive effect on health awareness, silent beliefs, perceived risk and self-efficacy [9]. There is a significant relationship between the effectiveness of educational interventions and the logical application of behavior change models [10]. One of the widely used behavior change model for planning effective educational interventions is the Health Action Process Approach (HAPA) model [11]. Based on HAPA model, it can be assumed that performing a specific behavior by people requires passing through two motivational and voluntary stages. In the motivational phase, risk perception, outcome expectancy and action self-efficacy affect behavioral intention. Subsequently, people prepare themselves to adopt a certain behavior and make decisions related to it. After the formation of behavioral intention, people enter the volitional stage, which consists of the constructs of action and coping plan, and maintenance and recovery self-efficacy [12, 13]. The HAPA model has been used many times to describe variables affecting physical activity in different groups such as patients with diabetes [14–16].

In addition to the application of the appropriate model, one of the main challenges facing health education experts is the preparation of health education programs based on needs assessment and appropriate to patients' experiences and interests [17]. Indirect and virtual education is able to overcome the obstacles of face-to-face education, such as crowding of health care centers, different educational needs of patients, lack of diversity in educational programs, unfamiliarity with educational principles, lack of time, and insufficient response to the educational demands of patients along with irregular referrals [18, 19]. The findings of previous studies showed that mobile-based interventions can be used as a therapeutic strategy to optimize the management and treatment of diabetes [20].

Therefore, considering the increasing prevalence of T2D in Iran and its serious consequences, the importance of using behavior change models to design educational interventions, the efficiency of mobile based educational programs on improving clinical indicators and preventing disease complications, the present study was designed with the aim of determining the effect of the educational intervention based on the HAPA model on the level of knowledge, metabolic indicators, psychological constructs and physical activity status in T2D patients in 2022–2023.

Material and methods

Study design

The current study was a randomized controlled trial that was conducted from June 2022 to February 2023 in Qazvin city (trial registration code IRCT20210509051229N1). Using a pretest-posttest design, the effectiveness of theory-based educational intervention was evaluated regarding the level of knowledge, metabolic indicators, psychological constructs, and physical activity status in T2D patients.

Study population

All adults with type 2 diabetes covered by the comprehensive health care centers of Qazvin city participated in the present study as the target population. The sample size was calculated using G*Power software, confidence level 95%, test power 80% and impact factor 0.5. Finally, 50 T2D patients were selected to participate in each of the experimental and control groups.

The inclusion criteria were: 1) having type 2 diabetes with a definitive diagnosis of more than 6 months; 2) age 18 to 60 years and living in the Qazvin city; 3) registration of fasting blood glucose (FBG) more than 140 mg % during of two visits at least a month apart; 4) not suffering from diabetic foot ulcer (grade 2 and higher based on Wagner criteria and clinic expert confirmation); 5) an ability to communicate, read and write the Persian (Farsi) language; 6) having active medical records in health care centers; 7) being able to use a mobile phone equipped with What's App by the patient or close family members.

Family members participated in the research if they had the following characteristics: 1) living in the Qazvin city; 2) having enough time to help patients complete the questionnaire or participate in the online education process; 3) being a spouse, child, grandchild, sibling,

or friend, 4) the ability to use what's App, and 5) aged 18 years or older. All people who were suffering from chronic and severe complications caused by diabetes or suffered from severe physical and mental disorders that might affect the results of the study were excluded from participating in the study.

The exclusion criteria were: Returning incomplete questionnaires or refusing to complete them, non-participation in training sessions (less than 50% of sessions), unwillingness to perform blood glucose and HbA1c tests, suffering from uncontrolled underlying diseases such as high blood pressure despite taking medication (90/160 mmHg), and severe disability such as blindness, limb amputation, cardiovascular diseases and renal failure, using any type of psychoactive drugs.

In order to evaluate the effect of the intervention on the knowledge level, psychological constructs, metabolic index and physical activity status in patients with type 2 diabetes in Qazvin city, a single-blinded randomized controlled trial was designed and implemented.

Among the comprehensive health care centers of Qazvin city, in which diabetes education programs were not implemented, 5 centers were randomly selected. A list of all patients was prepared based on the inclusion criteria, and after obtaining their informed consent to participate in the trial, they were randomly assigned to control and experimental groups (ratio of 1:1). A matte envelope was prepared from a sequence of computer-generated random numbers to facilitate allocation. All participants signed a written consent form before starting the study and completing the questionnaires in the first phase. The research team provided full explanations about the objectives and steps of the research, as well as the random allocation of participants to control and experimental groups. A trained nurse was responsible for registering patients to participate in the trial. The diagram of allocation of patients to experimental and control groups is presented in Supplementary Table 1.

Data collection instruments

The data was collected using a set of questionnaires and in a self-report manner (face-to-face and online) as follows:

A) Demographic items that included age, gender, marital status, educational level, economic status, family history of diabetes, body mass index (BMI), and employment status.

B) Awareness scale, which consists of 12 questions, and the participants were asked to answer the questions using yes-no, true-false or multiple-choice answer options. The range of scores varied between 0 and 12, and higher scores indicated higher mean awareness and vice versa. The psychometric properties of the mentioned scale have been confirmed in previous studies [21, 22].

C) Fasting blood glucose (FBG) and glycated hemoglobin (HbA1c): These indicators were measured based on the guidelines for measuring FBG and HbA1c of the Iran Ministry of Health and 8-hours fasting [23].

D) HAPA constructs: a 35-item questionnaire taken from the study of Rouhani et al. (2018) was used to measure different HAPA model constructs [16], which includes subscales of risk perception (5 items), action self-efficacy (6 items), maintenance self-efficacy (4 items), outcome expectancy (5 items), action and coping planning (4 items each) and behavioral intention (3 items). Participants were asked to answer the questions of each subscale using a 5-point Likert scale. In order to confirm the psychometric characteristics of the mentioned subscales, a sample of 30 T2D patients — who were randomly selected from the main population and were excluded from the final study — were asked to complete the mentioned scales within two-week interval. The data included in the Supplementary Table 1 confirmed the validity and reliability of the HAPA related subscales.

E) International Physical Activity Questionnaire short (IPAQ-s): According to the IPAQ-s guideline, the total intensity of the physical activities performed by a person according to the energy consumed in the last 7 days is placed in one of three groups: light, medium and heavy. To calculate the total amount of physical activity per week, the amount of walking (metabolic rate × minutes × day) should be added to the amount of moderate and intense physical activity in the last week. The IPAQ-s has been used in many studies and its validity and reliability have been confirmed in Iranian studies [24]. The questionnaire was completed both online and in person by the T2D patients in approximately 35 to 40 minutes. The research team emphasized the importance of providing correct and accurate answers, the necessity of providing real answers and also completing all the items in the first phase of the trial and before completing the questionnaires. All participants answered the questions in two stages — before the theory based education and 3 months after the educational intervention.

Educational intervention program

Due to the conditions caused by the COVID-19 pandemic and to comply with health protocols, the educational program was designed using the capabilities of mobile phones and its applications. After forming virtual groups of 6–9 people on what's App, educational content based on the constructs of the

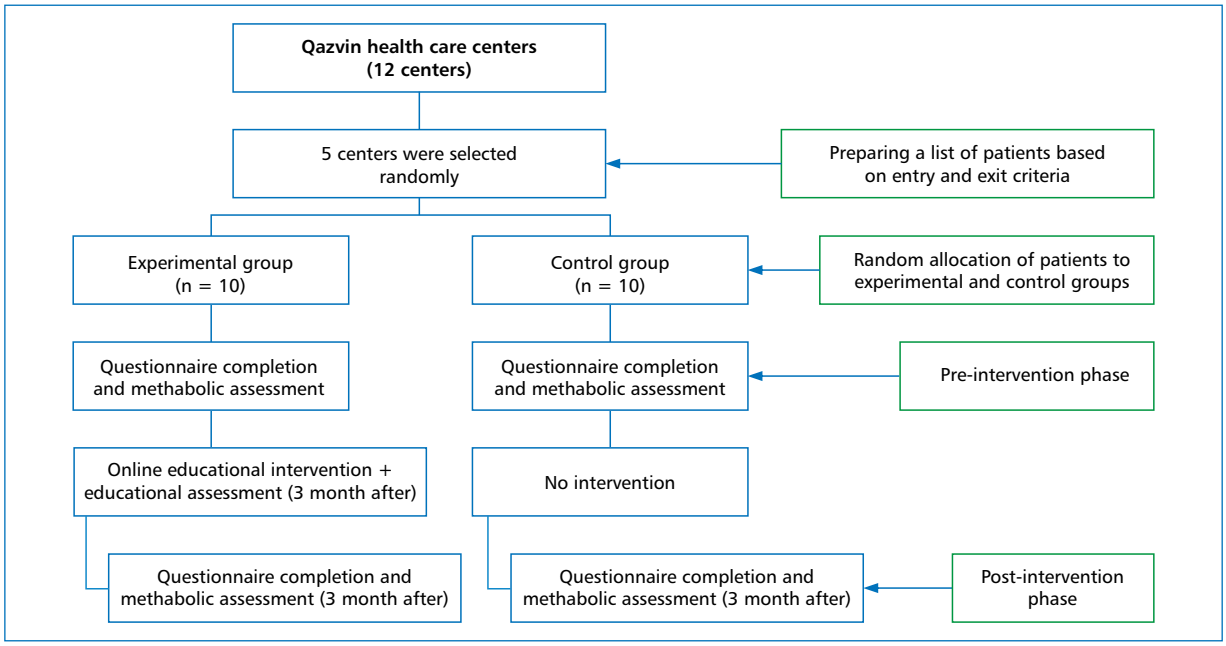

Figure 1. Consort Diagram of Study Process

HAPA model was presented in 6 online sessions for 6 weeks. The time (day and hour) of all the educational sessions was set with the coordination and opinion of the majority of the participants and was informed to all the T2D patients by phone call a week ago. In addition, two text messages (one day and one hour before the online educational session) were also sent to each patients to remind them of the time and purpose of the session. The duration of the training sessions — with the exception of the last session — was approximately 45 minutes, which sometimes lasted up to an hour due to the questions and answers at the end of the sessions. In each session, the educators presented a short speech of 10–15 minutes focusing on the general and specific goals. Then, the speaker presented main topics and then, the participants were asked to express their opinions about it. A summary of the educational content presented at the end of the training session and possible ambiguities were resolved using the question-answer method.

The content of each session was recorded and placed in the virtual group immediately after each session. A targeted training pamphlet along with an educational audio file was also considered for further training for each session. Five educational messages — which were summaries of the content presented in each session — were also presented to each participants in the interval between the sessions. The objectives of the sessions were as follows:

The first session: increasing knowledge (regarding diabetes risk factors, the causal relationship between diabetes and physical activity, the role of physical activity in regulating metabolism), *the second session*: the perceived risk and consequences expectancy (physical, psychological and social consequences of diabetes, positive consequences of adequate physical activity, reduction of negative emotions and replacement of positive thoughts and emotions). *The third and fourth sessions*: action and maintenance self-efficacy (identification of individual, environmental and motivational factors affecting the continuation of physical activity, expressing the successful experiences of patients, verbal encouragement from significant others, improving coping skills appropriate to an inactive lifestyle), *the fifth session*: action and coping plan (providing an action plan for physical activity for the elderly with diabetes and personalizing it, methods for assessing physical activity status, identifying barriers to regular physical activity and providing solutions. *Sixth session*: individual ten-minute face-to-face or online consultation (expressing problems, progress rate, providing feedback, strengthening individual motivations and providing environmental stimuli).

During the online training program, no specific training program was considered for the control group. Nevertheless, to comply with research ethics, an intensive training program including two online training sessions along with all training content was presented to the control group after the 3-month follow-up phase. The steps of conducting the study are shown in the consort Figure 1.

Table 1. Comparison of Demographic Characteristics between Patients Participating in the Experimental (n = 50) and Control (n = 50) Groups before the Educational Intervention

Variables	Groups	Control group frequency (%)	Experimental group frequency (%)	Significance level
Age [years]		55.7 (12.3)	54.6 (10.6)	0.335
BMI* [kg/m^2]		27.34 (3.46)	27.86 (3.78)	0.426
Disease duration		(6.85) 7.13	(7.00) 7.26	0.511
Gender	Male	14 (28.0)	17 (34.0)	0.644
	Female	36 (72.0)	33 (66.0)	
Economic status	Excellent	6 (12.0)	4 (8.0)	0.356
	Good	11 (22.0)	9 (18.0)	
	Medium	23 (46.0)	25 (50.0)	
	Week	10 (20.0)	12 (24.0)	
Marriage status	Married	47 (94.0)	46 (92.0)	0.822
	Single, divorced, others	3 (6.0)	4 (8.0)	
Job	Employed	13 (26.0)	15 (30.0)	0.650
	Housewife	31 (62.0)	30 (60.0)	
	Unemployed	6 (12.0)	5 (10.0)	
Educational level	Elementary and mid school	11 (22.0)	13 (26.0)	0.493
	High school and diploma	32 (64.0)	31 (62.0)	
	University	7 (14.0)	6 (12.0)	
Family history of T2D	Yes	28 (56.0)	26 (52.0)	0.818
	No	22 (44.0)	24 (48.0)	
Treatment type	Hypoglycemic drugs	24 (48.0)	26 (52.0)	0.577
	Insulin	14 (28.0)	11 (22.0)	
	Hypoglycemic drug + insulin	12 (24.0)	13 (26.0)	

BMI — body mass index; T2D — type 2 diabetes

Statistical analysis

The data were entered into SPSS 25.0 and the Kolmogorov Smirnov test was used to evaluate the normality of data distribution. Chi-square test, independent t-test, one-way ANOVA, and ANCOVA tests were used to compare the difference between the two groups and also the effect of the educational intervention on the psychological variables, FBG and physical activity by controlling the pre-test effect. The significance level was considered less than 0.05 in the current study.

Ethical considerations

All stages and processes of the research, from data collection to the implementation of interventions, have been approved by the Ethics Committee of Qazvin University of Medical Sciences (IR.QUMS.REC.1400.029). The study has been approved by TCTR Committee on 30 August 2022. The TCTR identification number is IRCT20210509051229N1. Voluntary participation in the research, anonymity of the questionnaires, confidentiality of all information and other rights of the participants were explained to them before the study.

Results

The mean age of the participants was 54.3 ± ± 10.33 years and 69% of the patients were women. Respectively, 93% and 28% of the T2D patients were married and employed, and 40% had a family history of diabetes. Comparison of demographic characteristics did not show significant difference between the two groups before the theory-based educational intervention. More information is shown in Table 1.

The findings related to the comparison of the mean of the HAPA model constructs in the pre-test stage and 3 months after the theory-based educational intervention in the experimental and control groups are shown in Table 2. The results indicate that there was no significant difference between the two groups before the theory-based educational intervention, but the results of the paired t-test showed a significant increase in the mean of the HAPA model constructs in the experimental group after the educational intervention ($p < 0.001$). In addition, the comparison of the physical activity status of T2D patients participating in the experimental and control groups before and after the theory based educational intervention is shown

Table 2. The Results of the Effect of the Educational Intervention on the Psychological Constructs of the HAPA Model and Physical Activity in the Experimental and Control Groups

Constructs	Group	Pre-education Mean ± SD	Post-intervention Mean ± SD	*P-value
Risk perception	Control	15.02 ± 4.2	15.78 ± 3.8	0.360
	Experimental	15.75 ± 5.4	21.27 ± 6.2	p < 0.001
	**P-value	0.352	p < 0.001	
Health awareness	Control	5.88 ± 2.3	6.15 ± 2.9	0.284
	Experimental	6.13 ± 3.0	10.24 ± 3.5	p < 0.001
	**P-value	0.198	p < 0.001	
Outcome expectancy	Control	13.2 ± 3.4	13.67 ± 4.1	0.614
	Experimental	13.5 ±4.2	17.12 ± 4.6	p < 0.001
	**P-value	0.452	p < 0.001	
Action self-efficacy	Control	15.65 ± 4.4	15.67 ± 3.3	0.433
	Experimental	15.15 ± 4.2	20.32 ± 5.3	p < 0.001
	**P-value	0.329	p < 0.001	
Maintenance self-efficacy	Control	10.32 ± 3.2	11.37 ± 3.5	0.277
	Experimental	10.84 ± 3.8	15.95 ± 4.1	p < 0.001
	**P-value	0.219	p < 0.001	
Action plan	Control	12.25 ± 3.2	12.52 ± 3.4	0.215
	Experimental	13.12 ± 3.2	16.74 ± 3.3	p < 0.001
	**P-value	0.853	p < 0.001	
Coping plan	Control	10.29 ± 3.9	10.62 4.2	0.635
	Experimental	11.14 ± 4.1	16.57 ± 5.0	p < 0.001
	**P-value	0.337	p < 0.001	
Behavioral intention	Control	9.36 ± 3.2	9.12 ± 3.5	0.435
	Experimental	9.75 ± 3.8	13.10 ± 4.6	p < 0.001
	**P-value	0.510	p < 0.001	
Physical activity	Control	34.4 ± 26.3	36.2 ± 37.3	0.176
	Experimental	33.8 ± 27.1	52.6 ± 38.5	p < 0.001
	**P-value	0.520	p < 0.001	

*P-value between control and experimental group; ** P-value pre-post intervention;
SD — standard deviation

in Table 2. Although there was no significant difference between the two groups before the educational intervention, the results of the paired t-test showed a significant increase in the mean of physical activity after the theory-based educational intervention in the experimental group ($p < 0.001$).

The results of the analysis of covariance regarding the effect of the educational intervention based on the HAPA constructs by controlling the effect of the pre-test are showed in Table 3. The findings have shown that by controlling the effect of the pre-test variable, the mean of the HAPA constructs and mean score of physical activity improved significantly after the theory-based educational intervention. In addition, based on the Eta coefficient, it can be concluded that the educational intervention explained 30.2%, 57.8%, 33.2%, 64.4%, 76.3%, 25.3%, 24.6%, 36.1% and 36.9% of the variance of health awareness, risk perception, outcome expectancy, action self-efficacy, maintenance self-efficacy, action plan, coping plan, behavioral intention and physical activity, respectively.

Table 4 shows the results related to the comparison of FBG and HbA1c in experimental and control group patients before and after theory-based educational intervention. The results showed that there was no significant difference between the two groups in terms of the mentioned metabolic indicators before the educational intervention; however, the results of the paired t-test showed a significant decrease in mean of FBG and HbA1c after the theory-based educational intervention in the experimental group ($p < 0.001$).

Table 3. The Results of the Analysis of Covariance Regarding the HAPA Constructs in the Post-Test Phrase

Constructs	Sources	Type III sum of squares	df	Mean square	F	Sig	Partial eta squared
Health awareness	pre	427.378	1	427.378	42.978	p < 0.001	0.259
	group	529.195	1	529.195	53.217	p < 0.001	0.302
Risk perception	pre	3789.392	1	3789.392	636.848	p < 0.001	0.838
	group	1001.022	1	1001.022	168.233	p < 0.001	0.578
Outcome expectancy	pre	2146.929	1	2146.929	486.627	p < 0.001	0.796
	group	270.586	1	270.586	61.332	p < 0.001	0.332
Action self-efficacy	pre	1782.043	1	1782.043	328.824	p < 0.001	0.728
	group	1207.897	1	1207.897	222.882	p < 0.001	0.644
Maintenance self-efficacy	pre	574.524	1	574.524	206.867	p < 0.001	0.627
	group	1099.557	1	1099.557	395.915	p < 0.001	0.763
Action plan	pre	434.781	1	434.781	63.711	p < 0.001	0.348
	group	273.210	1	273.210	40.035	p < 0.001	0.253
Coping plan	pre	489.200	1	489.200	67.343	p < 0.001	0.335
	group	286.615	1	286.615	41.622	p < 0.001	0.246
Behavioral intention	pre	320.512	1	320.512	122.518	p < 0.001	0.499
	group	181.494	1	181.494	69.377	p < 0.001	0.361
Physical activity	pre	1455.602	1	1455.602	73.851	p < 0.001	0.372
	group	1438.548	1	1438.548	71.010	p < 0.001	0.369

Df — degrees of freedom; sig — significance

Table 4. Results of the Effect of Mobile-based Educational Intervention on FBG and HbA1c in the Experimental and Control Groups

Variables	Group	Baseline Mean ± SD	Post-intervention Mean ± SD	P-value*
FBG	Control	157.8 ± 55.46	150.7 ± 50.45	0.119
	Experimental	161.3 ± 59.82	118.1 ± 23.45	p < 0.011
	**P-value	0.275	p < 0.001	
HbA1c	Control	7.46 ± 1.85	7.53 ± 1.94	0.277
	Experimental	7.23 ± 1. 74	6.20 ± 1.12	p < 0.001
	**P-value	0.303	p < 0.011	

*P-value: between control and experimental group; ** P-value: pre-post intervention; FBG — fasting blood glucose; HbA1c — glycated hemoglobin; SD — standard deviation

Discussion

The current study was conducted with the aim of investigating the effectiveness of the theory-based educational intervention regarding using the HAPA model constructs on the health knowledge, metabolic indicators, and physical activity status in T2D patients. The results of the study showed the positive effect of theory-based educational intervention on psychological constructs such as risk perception, outcome expectation, self-efficacy, action and coping planning, knowledge level, metabolic indicators and physical activity level in T2D patients.

Most of behavior change models emphasize on increasing the amount of knowledge, improving awareness, access to information and proper risk perception. In fact, raising knowledge level is the first steps in changing behavior process. In the present study, the level of knowledge of T2D patients in the experimental group improved significantly after the theory-based educational intervention, which was in line with the findings of previous studies [25–27]. It seems that providing simple and understandable information related to the mechanism and cause-and--effect relationships between regular physical activity and the consequences of T2D along with the repetition of educational SMS has led to an increase in the awareness of patients.

In line with previous researches, the results of the present study showed the improvement of FBG and HbA1c levels in the experimental group after the theory-based educational intervention [25–28]. Abaza and Marschollek (2012) emphasized that SMS based education to promote self-management caused a 1% decrease in HbA1c in middle and low-income patients [27]. Chen (2019) also emphasized that the use of a mobile app led to the improvement of self-care behaviors and a reduction in the severity of diabetes in the elderly [29]. The study of the effect of mobile-delivered diabetes prevention program on long-term weight loss and blood glucose levels by Toro-Ramos et al. (2020) showed a 0.28 percent reduction in blood glucose in patients with pre-diabetes [30]. These results confirm that providing a theory-based educational program using mobile phone capabilities can have positive effects on patients' HbA1c control. The main goal of treating patients with diabetes is to achieve optimal control (HbA1c less than 7%), which is related to the reduction of morbidity and mortality. In addition, blood glucose control has a significant relationship with better quality of life, and poor blood glucose control in T2D patients is considered a form of stress that has an adverse effect on the quality of life of these patients. In addition, considering that a 1% increase in this variable causes a 12% increase in coronary artery diseases, therefore, the reduction of this index should be considered by all health care personnel in various counseling programs and cognitive behavioral interventions. Clinical indicators such as HbA1c and FBG have a significant relationship with LDL, HDL, BMI and the amount of physical activity, and adding a regular physical activity program and weight loss program can significantly increase the effectiveness of interventions.

The significant improvement of the mean of outcome expectancy in the T2D patients is another important finding of the current study, which was consistent with the results of previous studies [22, 29, 31]. The results of Aliabad et al. (2014) research with the aim of evaluating the effect of the intervention based on the HAPA model and family support in maintaining physical activity capacity in coronary heart patients after discharge showed an improvement in the mean of outcome expectancy and other HAPA related constructs [22]. Outcome expectancy — which is also called behavioral beliefs, decisional balance and perceived barriers/ /benefits in some studies — is considered as a person's perception that is the result of a specific behavior and emphasizes the possibility of performing a behavior based on its various consequences Positive consequences (such as improving physical and mental health) and negative consequences (such as the possibility of injury and being time-consuming). Moreover, the predictive feature of physical activity by the outcome expectancy has been emphasized in the meta-analysis of Bohlen et al. (2022) [32]. The emphasis of cognitive behavioral interventions should be on the importance of assessing the benefits and barriers of physical activity in the T2D patients and clarifying the social, physical and mental consequences and providing frequent and diverse emotional feedback through mobile phones can be effective in strengthening behavioral intention and adjusting physical activity.

Another finding of the current research was a significant improvement in the mean score of the social support in the T2D patients, which was consistent with the findings of Liang et al. (2022), and Baillot et al. (2022) [33, 34]. Social support can directly and indirectly strengthen behavior. Direct social support is related to doing physical activity together or performing household tasks such as caring for family members to create opportunities for the individual to be physical active. Indirect support is defined as activities such as encouraging a family members or friends to start an exercise program. Social support has a positive and constructive effect on encouraging people to participate in the changing behavior and improving lifestyle by strengthening self-efficacy [35]. Providing the opportunity to exchange opinions, participation of family members along with their encouragement through the formation of virtual friendly groups in What's App should be considered as a part of the educational program aimed at preventing and controlling the complications of T2D.

In accordance with the findings of previous researches, the results of the present study also showed a significant increase in the mean of the action and maintenance self-efficacy constructs in the T2D patients after participating in the mobile-based educational program based on the HAPA model [36–38]. People who have strong beliefs about their abilities show more effort and persistence in doing tasks than people who doubt their abilities, and as a result, their performance in doing tasks is better. Human success requires commitment, cooperation and perseverance, which are achieved through self-efficacy [38]. Educational interventions should strengthen self-efficacy by using strategies such as verbal persuasion, self--encouragement, modeling, and using informational feedback. Therefore, health education experts should consider the identification of barriers, facilitators and factors affecting self-efficacy as an important step in increasing the probability of success in achieving predetermined educational goals when designing cognitive behavioral interventions.

Another important result of the current study was the significant improvement of the mean of the action and coping planning in the T2D patients after participating in the mobile-based educational program regarding the HAPA model, which were consistent with the findings of Okati Aliabad et al. (2022), Labudek et al. (2022), and Schroé et al. (2022) [22, 39, 40]. Planning is a prospective self-regulatory strategy that connects individual responses and anticipated situational guiding factors. When interventions are designed, health education experts can reduce the intention-behavior gap by improving self-regulation skills and encourage clients to think about the conditions affecting physical activity. Action planning acts as a reminder to perform a behavior, and even when self-regulation skills and memory capacity are low, planning can play a constructive role in forming healthy behavioral habits [41]. Goal setting, complete description of behavioral goals, describing the steps or processes necessary to achieve the goals, determining the necessary resources, determining the criteria for measuring progress, various solutions to deal with obstacles are part of the strategies used in online training were aimed at strengthening "action and coping planning" to improve physical activity in the T2D patients.

Finally, the results of the present study emphasized the improvement of the physical activity status in the T2D patients participating in a theory-based online educational intervention, which was in line with the results of previous studies [33, 36, 37]. A systematic review of 52 studies focusing on web-based behavior change interventions by Lin et al. (2022) indicated that providing strategies such as self-monitoring of behavior, problem solving, while significantly increasing the mean of the HAPA model constructs and Self-regulation, led to an improvement in the level of physical activity in patients with chronic diseases [36]. Electronic self-care education and telephone follow-up have been introduced as one of the standard programs for continuous and regular patient's education. Moreover, one of the common instructions to promote a healthy lifestyle is continuous access to up-to-date educational resources, which should be focused on general knowledge of diabetes, self-control of blood glucose, and self-care education [17, 30]. T2D patients can get essential health information without leaving home, save time and money, and communicate effectively with health experts [42]. In addition, inadequate education, irregular follow-ups and age restrictions in the T2D patients are considered effective factors in promoting lifestyle and self-care behaviors, which can be resolved through web-based or mobile-phone based cognitive-behavioral interventions. Considering the importance and acceptability of social networks in strengthening social mobilizations and transferring information, the increasing capabilities of mobile phone applications and sending large volumes of educational text, photos, audios and videos, it is recommended to use this communication channel to increase access to educational resources and facilitate the process of behavior change.

Conclusions

The findings of the study showed that mobile-based educational intervention using HAPA model framework could improve the knowledge level, psychological constructs, Hb1Ac, FBG and the physical activity status in T2D patients. Therefore, considering the importance and acceptability of social networks it is recommended to use the capacities of mobile phones and its applications such as what's App in the design, implementation and evaluation of theory-based educational interventions.

Strengths and limitations

The strengths of the current study included the design of the educational program based on the HAPA model, mobile-based education, and the randomization of the participants. Nevertheless, the present study also contains limitations, which include: A) the follow-up was done only 3 months after the intervention. Therefore, regular follow-ups at intervals of 6 months and 1 year after the theory-based intervention will make it possible to evaluate the stability of the effect of the educational intervention. B) Only patients from Qazvin city participated in the present study, which prevents the generalization of the results to the T2D patient's society. Therefore, random selection of T2D patients from rural health centers or other cities will increase the generalizability of the results. C) The results of the educational intervention based on the HAPA model were compared with the control group (lack of training). Therefore, future studies can consider more groups in the trial design to compare different behavior change models or various intervention methods.

Article information

Supplementary materials

The Supplementary materials for this article can be found at https://journals.viamedica.pl/clinical_diabetology/article/view/96203#supplementaryFiles

Data availability statement

Upon request, the authors can offer onsite access to external researchers to the data analyzed at Qazvin University of Medical Sciences, Isfahan, Iran.

Ethics statement

The ethics committee of Qazvin University of Medical Sciences approved the present study (IR.QUMS.REC.1400.029). In addition, all participants were aware of the voluntary participation in the research and signed the voluntary participation form. All questionnaires were anonymous and were assured that the information included in the questionnaires would remain confidential.

Authors' contributions

All authors contributed to this work and commented on the manuscript at all stages, and the last version was approved for publication.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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