The impact of electronic education on metabolic control indicators in patients with diabetes who need insulin: a randomised clinical control trial

Marzieh Moattari, Maryam Hashemi and Mohammad H Dabbaghmanesh

Aims and objectives. To determine the impact of electronic education on metabolic control indicators in patients with diabetes who were insulin dependent.

Background. Education can play an important role in controlling diabetes. Electronic (web-based, telehealth) education may be an efficient way to improve the patients’ ability to control this disease.

Design. Randomised clinical control study.

Methods. The participants in this clinical study were 48 insulin-dependent patients referred to diabetes centres in Shiraz, Iran. Serum concentrations of haemoglobin A\textsubscript{1C}, fasting blood sugar, triglycerides and high-density and low-density lipoprotein cholesterol were measured. Then the participants were divided randomly into control and experimental groups (n = 24). Participants in the experimental group received a specially designed electronic education programme for twelve weeks. The main components of the programme were a consultation service, quick answers to patients’ questions, contact with the healthcare team and educational materials. At the end of the intervention period, all serum values were measured again in both groups. The data were compared using SPSS v13.5 software.

Results. Serum concentrations of haemoglobin A\textsubscript{1C} (p < 0.001) and low-density lipoprotein cholesterol (p < 0.002) were significantly lower in the intervention group.

Conclusion. The electronic education programme was useful in lowering two metabolic indicators of diabetes.

Relevance to clinical practice. Electronic education can be associated with increased health and patient satisfaction, and can eliminate the need to train personnel.

Key words: diabetes mellitus; metabolic control, electronic education, haemoglobin A\textsubscript{1C}

Accepted for publication: 26 February 2012

Introduction

Diabetes is a chronic disease which needs long-term nursing and medical interventions. Patients also need to take an active part in their own management and treatment, and change their lifestyles to keep their metabolic status at a normal level (Lee \textit{et al.} 2007). One of the revolutions in education is electronic learning. This method has unique features which users like, and has made it possible to learn anywhere. It facilitates individual as well as group learning, and makes it possible to adapt the material according to the users’ needs. In the last 10 years, the Internet has become a
Music therapy

The impact of electronic education on metabolic control

rich source of healthcare information about health services, public and private education, counselling and health care (Cutilli 2006). The development of Internet sites that teach users about diabetes has removed the limitations of many diabetes education programmes and behavioural self-management interventions in terms of expense, time and availability. This in turn has made these programmes available to people who are unwilling or unable to take part in face-to-face or group education. In addition, the Internet can be used as an efficient system to receive information about the patients’ condition, collect data and provide suitable feedback and self-management counselling. This study was designed to find out the possible effects of an electronic education intervention on improving fasting blood sugar (FBS), haemoglobin A1C (HbA1C), triglyceride (TG) and cholesterol levels in patients with diabetes who need insulin.

Background/Literature

Many clinical studies suggest that keeping blood sugar at a suitable level can prevent the progression of side effects in patients with type 1 or type 2 diabetes. The American Diabetes Association recommends that all patients with diabetes try to keep their blood glucose at a normal level (Kim & Jeong 2007). Normal blood sugar levels for diabetes patients are shown in Table 1. Diabetes education has been shown to play a significant role in the control of this disease and in promoting quality of life (Thakurdesai et al. 2004). However, a clear challenge is ensuring adequate access to education for all patients. One study found that more than two-thirds of the patients did not receive information about their illness while they were in their doctor’s office, and many people did not receive information about their medications (Oermann 2003). Meanwhile, diabetes education has become more complicated as treatment modalities such as transplantation have improved and new techniques for medication administration have appeared. As a result, there is currently a need for systems to provide medical advice and recommendations in a timely manner and to effect behavioural changes in patients so they will keep their blood sugar at a normal level (Starren et al. 2002).

Table 1 International Diabetes Federation (IDF) recommendations on target blood glucose level ranges

<table>
<thead>
<tr>
<th>Target levels by type</th>
<th>Before meals (preprandial)</th>
<th>Two hours after (postprandial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-diabetic</td>
<td>4.0–5.9 mmol/l (72–106 mg/dl)</td>
<td>&lt; 7.8 mmol/l (140-4 mg/dl)</td>
</tr>
<tr>
<td>Type 2 diabetes</td>
<td>4.0–7.0 mmol/l (72–126 mg/dl)</td>
<td>&lt; 8.5 mmol/l (153 mg/dl)</td>
</tr>
<tr>
<td>Type 1 diabetes</td>
<td>4.0–7.0 mmol/l (72–126 mg/dl)</td>
<td>&lt; 9.0 mmol/l (162 mg/dl)</td>
</tr>
<tr>
<td>Children w/diabetes</td>
<td>4.0–8.0 mmol/l (72–144 mg/dl)</td>
<td>&lt; 10 mmol/l (180 mg/dl)</td>
</tr>
</tbody>
</table>


Considering that health service providers lack the time to train patients, one solution is for patients to use the Internet to complete their education (Oermann 2003). Many Internet sites have been designed to help patients find health information about and support for their chronic diseases (Lehmann & Deutsch 1995). Recently, the impact of computer- and Internet-based education on improving HbA1C level was reported (Kim & Jeong 2007). Haemoglobin A1C (glycosylated haemoglobin) reflects the blood sugar level during the 100–120 days before the test, and is the most important indicator to assess the long-term control of diabetes.

Methods

The participants in this randomised clinical trial study were 52 patients with diabetes who were on insulin and were being followed at the Nader Kasemi and Moshir Fatemi Diabetes Centers in Shiraz, Iran (affiliated with Shiraz University of Medical Sciences). The sample size was calculated as 24 participants in each group for an $\alpha$-value of 5% and a $\beta$-value of 80% (Kim 2007). Accordingly, from a total of 147 patients, those who satisfied the inclusion criteria and who were interested in this study were randomly (based on their file number (odds and even) assigned to either experimental or control group. Odd and even numbers were determined by throwing a coin (Fig. 1).

All participants in this study had Internet access in their homes. The basic inclusion criteria were having diabetes and needing insulin. Additional criteria were the ability of patients or one of their family members to monitor blood glucose with a glucometer and to inject insulin, the ability to use a website and input data on a website and having a cell phone. Exclusion criteria were chronic disease or renal failure (creatinine > 1.5 mg/dl), use of an insulin pump, and pregnancy in women. Patients in the experimental group were invited to take part in the intervention programme, whereas the control group received the usual educational advice provided in the research centre. This group was provided the opportunity to access the website after post-test data collection for ethical consideration. Patients who did not enter the necessary data on the sites or who stopped participating at
any time for any reason were not included in the data analysis.

**Electronic education intervention**

The intervention programme was based on electronic education, so the educational site on the Internet was designed to train patients with diabetes (http://www.diabetes-edu.sums.ac.ir; in Persian). The site covers educational subjects and contains frequently asked questions, educational films, galleries, chat rooms, a question-and-answer section, useful links and patients’ personal files. Access to the latter is password-controlled. The educational subjects were chosen based on well-known textbooks and the patient education site hosted by the American Diabetes Association. Considering patients’ need, a panel of experts selected the material appropriate for the patients under four main categories, including type of diabetes, diabetes and diet, prevention of diabetes complications and general topic (Table 2).

Before the intervention was begun, patients or a member of their family, depending on the researcher’s judgement (based on patient desire, willingness of family member and his/her free time), was taught about access to the site, working with the website and how to enter the data into the daily information record forms. This training lasted for about one to three hours. Patients who did not have access to Internet were provided with free Internet access to facilitate their connection to website.

Each patient had a personal file on the site. By entering their user name and password, they could access their file anytime to complete the daily information forms. These forms collected information about their self-monitored blood glucose level, the kind and dose of insulin they used for diabetes control and the amount and kind of their daily food intake. All participants were given enough stick glucometers for two daily measurements throughout the study period. The patients’ files, which were accessible to patients and healthcare providers involved in the study, included demographic information such as name and surname, educational level, profession, family illness history, email address, the results of primary tests, height, weight, body mass index (BMI) and blood pressure.

The website had a question-and-answer section where a physician, nurse and nutritionist provided information as appropriate. Communication with healthcare professionals via the website was non-synchronous, and further communication between the patients and the physician, nurse and nutritionist took place offline. Answers were sent to the patients within 24 hours.

Patients who needed a more immediate response could also ask questions via voice phone or SMS. They could also connect with each other 24 hours a day in the chat room or via an email list hosted on the website. If patients failed to enter their data during seven consecutive days, an email or SMS reminder was sent to them.

Only the patient and the healthcare team (the physician, nurse and nutritionist) had access to the patient’s file. The healthcare team studied personal files at the end of each week and sent their recommendations via email. Examples of the feedback and advice they sent are as follows: ‘Breakfast is an important meal which should include at least three food groups. So banana-flavored milk doesn’t mean breakfast.’ ‘Please pay attention to the amount of your food in each meal every day. Although you weren’t careful with your diet this week, an appropriate diet is an important factor to control blood sugar.’

**Data collection**

Baseline data were recorded before the intervention began. Venous blood samples were drawn to measure HbA1C, FBS, TG, total cholesterol (CHOL), high-density (HDL) and low-density lipoprotein (LDL) cholesterol. The concentration of HbA1C was measured with a high-performance liquid chromatography technique using variant 2 (Bio-Rad, Hercules, CA, USA), and FBS, TG, CHOL, LDL and HDL were measured by the glucose oxidase method using a Hitachi 717 analyser (Roche Co., Tokyo, Japan). Lab technician responsible for all measurements was blind to the group allocation of patients.

The intervention continued for twelve weeks, and at the end of this time, FBS, HbA1C, TG, CHOL, LDL and HDL

---

**Table 2 Outlines of educational materials provided on the website**

<table>
<thead>
<tr>
<th>Type of diabetes</th>
<th>All about type 1 diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating and diabetes</td>
<td>All about type 2 diabetes</td>
</tr>
<tr>
<td></td>
<td>What can I eat</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate counting</td>
</tr>
<tr>
<td></td>
<td>Glycaemic index and diabetes</td>
</tr>
<tr>
<td></td>
<td>Eating out when you have diabetes</td>
</tr>
<tr>
<td>Prevent diabetes</td>
<td>Take care of your eyes</td>
</tr>
<tr>
<td>complications</td>
<td>Take care of your heart</td>
</tr>
<tr>
<td></td>
<td>Take care of your skin and your feet</td>
</tr>
<tr>
<td></td>
<td>Take care of your nerves</td>
</tr>
<tr>
<td></td>
<td>Take care of your teeth</td>
</tr>
<tr>
<td></td>
<td>Take care of your kidney</td>
</tr>
<tr>
<td>General topic</td>
<td>Diabetes and depression</td>
</tr>
<tr>
<td></td>
<td>Diabetes and physical activity</td>
</tr>
<tr>
<td></td>
<td>Laboratory tests</td>
</tr>
<tr>
<td></td>
<td>Glucose monitoring</td>
</tr>
<tr>
<td></td>
<td>Insulin injection</td>
</tr>
</tbody>
</table>
were measured in both groups. The results were compared with Student’s t-tests for independent and paired samples with SPSS software version 13.5 (SPSS Inc., Chicago, IL, USA).

Results

Of the 52 patients initially enrolled, two patients from the experimental group were excluded because they did not enter information on the website for more than four weeks. Although these two patients were assessed in the post-test for ethical consideration, their test results were not used in data analysis. Also, two patients were excluded from the control group as a result of unwillingness to complete the study (attrition rate: 7/7). Therefore, the data analysis was performed on 48 patients. Slightly more than half of the participants were women (57%). The age range of the patients was 18–39 years, and mean age was 23.35 years. Almost all participants (97%) had type 1 diabetes. The results for different metabolic control indicators are shown in Table 3. In the experimental group, mean average HbA1C decreased significantly from 9.10% at the beginning of the intervention to 7.07% after twelve weeks (p < 0.001). Mean LDL decreased significantly from 180.70 mg/dl at the beginning of the intervention to 169.83 mg/dl after twelve weeks (p < 0.04). Mean HDL increased significantly from 40 mg/dl at the beginning of the intervention to 45.58 mg/dl after twelve weeks (p < 0.029). In the control group, HDL increased significantly, but there were no significant changes in the other variables. According to t-tests for independent samples, the mean changes in indicators differed significantly between groups for HbA1C and LDL.

Table 3 Metabolic control indicators in the intervention and control groups before and three months after the electronic education

<table>
<thead>
<tr>
<th>Metabolic indicators</th>
<th>Groups</th>
<th>Mean ± SD</th>
<th>Pre to postintervention changes</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental group</td>
<td>Control group</td>
<td></td>
<td>Experimental group</td>
</tr>
<tr>
<td></td>
<td>n = 24</td>
<td>n = 24</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>HbA1C (%)</td>
<td>9.10 ± 1.29</td>
<td>7.07 ± 1.19</td>
<td>9.42 ± 1.78</td>
<td>8.82 ± 1.31</td>
</tr>
<tr>
<td>p &lt; 0.001</td>
<td>180.70 ± 111.98</td>
<td>169.83 ± 102.73</td>
<td>173.91 ± 76.27</td>
<td>175.58 ± 96.50</td>
</tr>
<tr>
<td>Fasting blood sugar (mg/dl)</td>
<td>p = 0.654</td>
<td>164.04 ± 23.16</td>
<td>159.83 ± 32.65</td>
<td>159.04 ± 32.75</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>p = 0.380</td>
<td>155.04 ± 176.65</td>
<td>109.79 ± 58.69</td>
<td>163.79 ± 122.59</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>p = 0.243</td>
<td>45.58 ± 12.03</td>
<td>39.16 ± 9.11</td>
<td>42.04 ± 9.03</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dl)</td>
<td>p &lt; 0.029</td>
<td>103.04 ± 25.07</td>
<td>94.83 ± 21.81</td>
<td>94.75 ± 22.20</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dl)</td>
<td>p &lt; 0.04</td>
<td>103.04 ± 25.07</td>
<td>94.83 ± 21.81</td>
<td>94.75 ± 22.20</td>
</tr>
</tbody>
</table>

HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Discussion

We found that HbA1C, the most important long-term indicator for diabetes, differed significantly between our two groups at the end of the intervention period. This finding suggests that the electronic education programme we tested was effective in improving metabolic control in our patients with diabetes. Our programme provided a simple communication and consultation system for patients, straightforward contact with their healthcare team and easy access to educational material. Izquierdo et al. (2003) reported similar results. Their educational website together with consultation contributed to a significant decrease in mean HbA1C from 8.6 ± 1.8–7.8 ± 1.8.

Kim and Jeong (2007) tested the effect of short cell phone messages from a nurse on blood sugar levels in patients with diabetes. After a three-month intervention, HbA1C in the experimental group decreased by 1.15 units, and after six months, it decreased by 1.05 units; however, this decrease was not significant compared to that in the control group. In this study, the difference in mean HbA1C between the experimental and control groups was significant (p < 0.001). In the study by Kim and Jeong, a trained nurse was solely...
responsible for delivering advice to patients via cell phone, whereas members of the control group had access on request (during regular follow-up visits) to advice from their regular physician, a nurse or a dietician. In contrast, the healthcare team involved in our programme included a physician, a nurse and a nutritionist, all of whom were available to the patients to answer questions and provide feedback.

Another study by Cho et al. (2006) investigated the long-term effects of an Internet-based glucose monitoring system on HbA1C and blood sugar levels in type 2 diabetic patients. They confirmed the long-term effectiveness of the intervention on HbA1C of these patients. On the contrary, in this study, we did not measure the long-term effects of our web-based intervention. Therefore, further studies are recommended to find out the long-term effects of such interventions in different contexts. However, our study provides the evidence for the ability of electronic education to decrease HbA1C in three months. The reason for the prompt success of this intervention may be related in part to the fact that it provided consultation to patients, quick answers to their questions, easy contact with the health-care team, easy access to educational materials, free glucose monitoring strip and (when needed) free access to the Internet.

McMahon et al. (2005) investigated the effect of web management on diabetes and blood pressure control in the patients who had weak control of their diabetes. They studied 104 diabetic patients whose HbA1C was 9% or more. All participants took diabetes training classes and were then randomly divided into two 52-member groups to receive conventional (control) or Internet-based care (experimental group). The experimental group received a notebook and tools to monitor their blood sugar and blood pressure. Members of the health team responded to questions via the website during on-hours. At the end of the intervention, the decrease in HbA1C was significant in both groups ($p < 0.001$); however, the decrease was larger in the experimental group (1.6%) than in the control group (1.2%). Changes in FBS have also been used to evaluate the effectiveness of electronic education. In our experimental group, FBS after the intervention was significantly different from the baseline value, and the postintervention difference between the experimental and control groups was not significant. One of the possible reasons for the lack of effect on this metabolic indicator is that FBS is affected by recent illness and hyperglycaemia after meals and at night (Fauci et al. 2008). Also, our observations showed that some

---

**CONSORT 2010 flow diagram for the study**

**Enrollment**

Assessed for eligibility (n = 147)

Excluded (n = 95)
  - Not meeting inclusion criteria (n = 83)
  - Declined to participate (n = 12)

Randomised (n = 52)

Allocated to intervention (n = 26)
  - Received allocated intervention (n = 26)

Allocated to traditional intervention (n = 26)
  - Received allocated intervention (n = 26)

Follow-Up

Lost to follow-up (did not enter the required data on the web for more than 4 weeks) (n = 2)

Analysis

Analysed (n = 24)
  - Excluded from analysis (did not complete the intervention but they were assessed for ethical consideration) (n = 2)

Analysed (n = 24)

---

**Figure 1** CONSORT 2010 flow diagram for the study.
Considering the effect of cholesterol on the risk of heart disease, long-term programmes to decrease cholesterol are more suitable for the long-term monitoring of metabolic status in patients with diabetes. In this study, two-hour blood sugar was not measured, and the effect of electronic education on two-hour blood sugar in patients with diabetes should be investigated in future research. As postprandial hyperglycaemia is a risk factor for microvascular and macrovascular complications (Fauci et al. 2008), it is necessary to follow this indicator in patients with high blood sugar.

In a study of the impact of web-based nurse’s education on glycosylated haemoglobin in patients with type 2 diabetes, FBS decreased to 13.4 units, although this change was not statistically significant (Kim 2007). A study of the effect of self-management on predisposing and metabolic control indicators found a significant decrease in FBS in the intervention group ($p < 0.001$) (Ghobadi 2008). This study used individual, face-to-face education; therefore, perhaps this type of training intervention is more effective in enabling patients to control this metabolic indicator.

In our intervention group, LDL was lower than that in the control group at the end of the study period. The increase in HDL was significant in both groups, and the difference between groups in terms of the extent of this change was not significant. Based on the guidelines of the American Diabetes Association and American Heart association, the order of priority for hyperlipidaemia treatment is to (1) decrease LDL, (2) increase HDL, and (3) decrease TG. The primary treatment for all dyslipidaemias is dietary change and improved lifestyle (quitting smoking, controlling blood pressure, losing weight and more exercise). However, it should be kept in mind that feedback about dietary changes has only a small effect on metabolic indicators, accounting for less than 10% of the decrease in LDL. Better control of blood sugar decreased TG levels and had a smaller positive effect on increasing HDL (Fauci et al. 2008). The study by McMahon and colleagues failed to find significant changes in LDL in either group. In contrast, HDL increased significantly ($p < 0.05$) in the intervention group, and TG decreased significantly ($p < 0.01$). In their study, both groups participated in diabetes education classes before the intervention, and members of the experimental group received materials that included netbooks, digital blood pressure monitors and glucometers. Their intervention lasted for 12 months (McMahon et al. 2005), whereas our intervention period lasted three months, and our patients received only Internet cards and glucometer sticks.

Considering the effect of cholesterol on the risk of heart disease, long-term programmes to decrease cholesterol are advisable. Our results suggest that using Internet education can be a valuable aid to control and manage diabetes.

A point which needs to be considered is that our patients were given individual classes to learn how to work with the Internet and website environment, and were then given free material and facilities such as blood glucose strips and free Internet access. In addition, laboratory testing was free for our participants. This raises the question of whether patients will use electronic education without prior training or free facilities. Answers to this question will require studies of the efficacy of electronic education with and without these types of additional support. As a result of the above-mentioned support, we did not have considerable attrition rate among participants. However, further studies are suggested to generalise the finding to a variety of diabetes patients such as those who have poor control over their illnesses. Furthermore, this study involved a relatively young group of patients. The intervention may not have been applicable to older people and, therefore, may only benefit a subset of those with diabetes.

Conclusions

The results of this study suggest that electronic education in patients with diabetes who need insulin can lead to decreases in HbA1C and LDL. Considering the result, progressive use of electronic education and counselling is recommended. Regarding potential benefits of electronic education and counselling (such as the ease of asking questions confidentially, savings in terms of time and costs and overcoming limitations in time and space), further research aimed at designing suitable websites for patients with different diseases are recommended.

Acknowledgements

The authors thank the vice-chancellery of Shiraz University of Medical Sciences, Shiraz, Iran, for the financial support. We acknowledge the sincere contribution of Dr Gholamreza Rajaei-Fard in statistical analysis and contribution of Miss Parvin Beigi in the development of educational material. Also, we thank K. Shashok (AuthorAID in the Eastern Mediterranean) for improving the English of the manuscript. This manuscript is the thesis of the second author (4748).

Contributions

Study design: MM, MH, MHD; data collection and analysis: MM, MH and manuscript preparation: MM, MH.
References


The Journal of Clinical Nursing (JCN) is an international, peer reviewed journal that aims to promote a high standard of clinically related scholarship which supports the practice and discipline of nursing.

For further information and full author guidelines, please visit JCN on the Wiley Online Library website: http://wileyonlinelibrary.com/journal/jocn

Reasons to submit your paper to JCN:

High-impact forum: one of the world’s most cited nursing journals, with an impact factor of 1.118 – ranked 30/95 (Nursing (Social Science)) and 34/97 Nursing (Science) in the 2011 Journal Citation Reports® (Thomson Reuters, 2011)

One of the most read nursing journals in the world: over 1.9 million full text accesses in 2011 and accessible in over 8000 libraries worldwide (including over 3500 in developing countries with free or low cost access).

Early View: fully citable online publication ahead of inclusion in an issue.

Fast and easy online submission: online submission at http://mc.manuscriptcentral.com/jcnur.

Positive publishing experience: rapid double-blind peer review with constructive feedback.

Online Open: the option to make your article freely and openly accessible to non-subscribers upon publication in Wiley Online Library, as well as the option to deposit the article in your preferred archive.