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Usage and Perceptions of a Mobile Self-Management Application for People with Type 2 Diabetes: Qualitative Study of a Five-Month Trial

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Abstract

Despite a growing number of clinical-intervention studies of mobile applications for diabetes self-management, details of participants' engagement with the intervention tools and of usability and feasibility issues are seldom reported. The Few Touch application is a mobile-phone-based self-management system for people with Type 2 diabetes mellitus (T2DM) developed by involving patient-users in design processes from an early phase to a long-term trial. An improved version was tested in a five-month trial by 11 individuals either with T2DM or at high risk of T2DM. Results showed clearer correlations between usage and perceived usefulness among these individuals compared with those involved in the design process. However, feedback on usability issues was mostly consistent between the two trials. This study therefore confirmed: 1) the value of including patient-users not only in design-concept development but also in a long-term trial to identify as many factors critical to usability and usage as possible, and 2) the importance of reflecting their feedback in design iterations to minimize the number of critical factors.

Keywords:
Mobile health, Type 2 diabetes, Self-management.

Introduction

To prevent complications in patients with Type 2 diabetes mellitus (T2DM), proper self-management is essential [1,2]. Nevertheless, poor adherence to treatment regimens is commonly observed [3]. Technological evolution and pervasiveness of mobile phones have boosted research efforts to use mobile phones as a terminal of intervention for diabetes treatment to improve this situation [4–6]. However, due to considerable differences in study design and lack of reporting details on participants' engagement with the intervention tools, it is difficult to identify factors that may have positive effects [4,5,7]. Additionally, many studies fail to report details of usability issues and of user-centered design [7], which will be useful to understand motivational factors and barriers regarding use of the tool.

The Few Touch Application (FTA) is a mobile-phone-based application for self-management by patients with T2DM. It was designed by involving patients with T2DM, then tested on the same patients in a long-term trial ("Trial I") in which the FTA design was iteratively updated based on their feedback [8,9]. Our analyses of the results from the first year of Trial I clarified mechanisms of FTA usage and identified factors associated with usability and usage in a long-term perspective [10]. Following this study, we aimed to find out whether these findings were applicable to individuals with T2DM in general. Therefore, the FTA was subjected to a five-month trial ("Trial II"), in which we qualitatively researched how the FTA was used and perceived by individuals who had not been involved in the FTA design process. This paper presents findings from Trial II and compares them with the findings from the first year of Trial I.

Materials and Methods

Tested application: the Few Touch Application (FTA)

The FTA tested in Trial II consists of a software "Diabetes Diary" implemented on a mobile phone HTC Touch 2 with Windows Mobile 6.5 (HTC Corporation, Taiwan) and OneTouch Ultra 2 blood glucose (BG) meter (Lifescan Inc., Milpitas, CA) connected with a Polytel Bluetooth adapter (Polymap Wireless, LLC, Tucson, AZ). The start screen of the Diabetes Diary offers access to each function and to the mobile phone's home screen (Figure 1 (a)). The main components of the FTA are a BG sensor system with automatic wireless data transmission from the BG meter, a nutrition habit (NH) recording system, a physical activity (PA) recording system, goal-setting functions for physical activities and nutrition habits, and information including user instructions for the FTA, an encyclopedia with approximately 400 topics relevant to diabetes, and a tips bank containing 80 concise tips. Though some design updates were made after publishing previous work [8,9], some of which are presented in a previous publication [10], design details of most of the functions can be found in other previous publications [8,9].

The major difference between the FTA version used in Trial II and the version presented previously [8–10] is a function to record PA. Due to difficulties with production of the required number of our tailored step counters, we designed a manual PA recording system during Trial I. To comply with the "simple and as easy as possible" design principle for the FTA while following recommendations by the Norwegian Directorate of Health [11] and reflecting feedback on step counter use by the patients in Trial I [8–10], we employed two types of information to record: time and intensity of PA. The new PA recording system enables recording PA time like a stopwatch (Figure 1 (b), (c)). Time recording runs as a background process so that users can switch the phone to sleep mode or use other functions. While time is being recorded, the Activity icon ("Aktivitet" in Norwegian) on the start screen of the Diabetes Diary continues blinking as a reminder to the user. Pressing the Stop ("stopp" in Norwegian) button prompts the user to confirm and if necessary adjust the time and date (Figure 1 (d)), then to set the intensity level of the completed PA (Figure 1 (e)). Pressing the Save ("lagre" in Norwegian) button displays a feedback screen (Figure 1 (e)) with a bar chart of accumulated minutes of PA by intensity level for the last

Figure 1 – Screenshots of the main page of Diabetes Diary (a) and the physical activity recording system (b-f)

seven days, together with bars indicating progress toward set goals. When a goal is achieved, a yellow plain circle next to a progress bar turns to a smile emoticon. Two goals can be set for PA: daily and weekly accumulated time. Both are set based on one of the three intensity levels: high, moderate or low ("høy", "moderat" and "lav" in Norwegian). This design gives users some flexibility to set goals depending on their plan and capacity. As Figure 1 (b) and (c) show, users can view the feedback screen by pressing the Status button.

Trial II settings

Trial II was administered as part of the "Motivation with Mobile project" [12], which aimed to strengthen a "Motivation Group" course for patient-oriented learning arranged in the city of Harstad in northern Norway. The Motivation Group concept was initiated by the Norwegian Diabetes Association to offer opportunities to people with T2DM for helping each other to improve their lifestyle through regular meetings, typically held weekly [13]. A group activity is led by a representative patient with T2DM. It is locally organized by gathering people with T2DM or at high risk of T2DM. The 11 participants in the Motivation with Mobile project received information about Trial II, including the right to withdraw at any time without providing reasons and to choose whether to answer questionnaires; they agreed to participate in Trial II. The local regional ethical committee regarded Trial II as outside their scope of approval authority. The study protocol was therefore approved by the privacy officer at our local regional hospital.

To enable the participants to familiarize themselves with the phone, it was initially supplied without the Diabetes Diary. A week later, the Diabetes Diary was installed on the phone, a BG meter with a Bluetooth transmitter attached was provided, and the Diabetes Diary functions were explained to the participants. It was emphasized that the FTA could and should be used in a way that the participants considered useful and that usage was entirely voluntary.

Data collection

We used mixed methods, as we did for analysis of results from Trial I. As quantitative data, data recorded by the BG sensor system as well as the NH and PA recording systems were collected at the end of the study. To collect qualitative data, we distributed an original questionnaire consisting of 74 major questions at the end of Trial II. The questions and options for answers were designed based on the results of qualitative analysis of the results from the first year of Trial I. This method enabled us to analyze the results systematically and efficiently while gaining deep insight into the role that the FTA played in the participants' self-management activities. Due to limited time for answering the questionnaire at a meeting, most of the questions were in multiple-choice format with an option to add free-text comments. The original questionnaire covered the following themes:

1. Clinical characteristics
2. The BG sensor system
3. The PA recording system
4. The NH recording system,
5. The tips bank (excluding other parts of the information resource function)
6. The FTA as a whole application.

Major topics addressed under themes 2-6 were[1]:

1. Current level of self-management activity (a. frequency of BG measurements, b. frequency and length of PA, c. amount of fruit/vegetable/berry intake and frequency of meals with high/low carbohydrate content)
2. Degree of change in level of each self-activity described in Topic 1 compared with its level before using the FTA (2-4)
3. Reasons for change/no change in status of each self-management activity (2-4)
4. Level of satisfaction with the current status of each self-management activity (2-4), self-management of diabetes in total, and knowledge of their diabetes (6)
5. Agreement on motivational effect of a function (2-5)
6. Level of satisfaction with a function (2-5)
7. Perceived usefulness (5 and 6)
8. Features that they appreciate (2-5) and that they consider would increase motivation to use the FTA (6)

To supplement the answers to questions about FTA usability, a focus group session was held two months after the Trial II start.

The informed consent form for the Motivation with Mobile project included information that answering individual questions was voluntary.

Analysis of the data

To explore how the participants used the FTA over time, we focused on the number of days on which any data were recorded rather than the number of records or contents of records. We employed "usage rate," defined as the number of days per week [10] on which each function was used. A non-parametric test, the Mann-Kendall trend test [14], was applied on usage rates for weeks in which each function was available for seven days to examine usage trends over time. The test statistic tau is a measure of the monotonicity of the trend. Tau=1 means a monotonic increase; tau=0 indicates no trend either way; tau=-1 means a monotonic decrease. Degrees of usage of each function and usage of functions in combination were also measured as percentages of the duration in which the FTA was available for each participant.

[1] The numbers in parenthesis below correspond to themes described above

Answers from the questionnaires were collated to the results of analysis above to provide a better understanding of participants' experience of the FTA.

Results

Characteristics of the participants

Hereafter, we use the code "HPxx" to indicate a specific participant, where "xx" shows the participant's ID number in Trial II. The 11 participants (seven men and four women, age ranged from 40 to 73 with a mean age of 57.2 (Standard Deviation (SD): 8.6)) consisted of 10 patients with T2DM and one participant at high risk of T2DM (HP07). For the 10 participants with T2DM, disease duration ranged from two to 20 years (HP05 did not answer this question) with a mean duration of 10.3 (SD: 7.1). Regarding diabetes treatment, two (HP02 and HP09) used both insulin and oral medications, two (HP01 and HP11) did not use either insulin or oral medication, one (HP10) used only insulin, and the other five used only oral medications. Only HP05 had used PC-based software for diabetes self-management before participation in Trial II. None of the participants had previously used a mobile-phone-based self-management system.

Usage of the FTA and experiences

The FTA was available for 21 weeks for all the participants except HP07, who started participating in the Motivation with Mobile project six weeks later than the others and therefore used the FTA for 15 weeks. After analysis of the recorded data and questionnaire responses, we found that the participants could be roughly divided into three groups: frequent use with positive experience, moderate use with neutral experience, and little use with mixed experience. Key results of the analysis of recorded data are summarized in Table 1, Table 2, and Figure 2. Table 1 shows the mean and SD of degrees of usage among the participants in each group. Figure 2 shows degrees of usage of the FTA by each participant with color codes depending on the number of data types (BG values, NH, or PA) recorded on a day. Table 2 shows results from the Mann-Kendall trend test on usage rates over the trial duration for each function. Where no trend was observed (tau=0), *p*-values are shown as not applicable (N/A). A significantly ($p < .05$) increasing trend is indicated by an asterisk (*) while a significantly decreasing trend is indicated by a dagger (†). Key results that specifically characterize each group are described under the following sub-sections together with characteristics of usage.

Group A (HP02, HP04, HP09 and HP10): Frequent use with positive experience

Participants in Group A used the BG sensor system frequently throughout Trial II compared with the other participants (Table 1). HP02 and HP04 used the BG sensor system literally every day during the trial. Usage rates of the BG sensor system by HP09 and HP10 showed an increasing trend (Table 2). HP02 experienced minor problems with data transmission

Table 1 – Difference in degrees of usage, mean and SD (in parentheses) among the participants in each group

Group	BG sensor system	PA recording system	NH recording system
A	94% (8%)	46% (23%)	48% (31%)
B	47% (18%)	29% (13%)	41% (21%)
C	44% (28%)	6% (5%)	5% (3%)

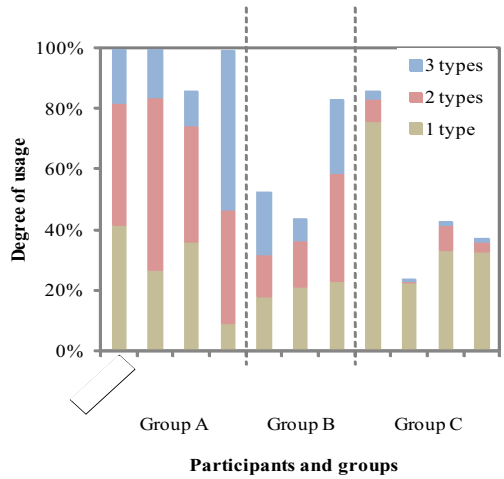

Figure 2 – Degree of FTA usage depending on the number of data types recorded

Table 2 – Results (tau-values) from Mann-Kendall trend test (the values in parentheses are p-values.)

Group / ID		BG sensor system	PA recording system	NH recording system
A	02	0.00 (N/A)	0.45 (.008) *	0.38 (.025) *
	04	0.00 (N/A)	-0.02 (.92)	-0.61 (<.001) †
	09	0.42 (.020) *	0.09 (.65)	0.61 (<.001) *
	10	0.42 (.020) *	0.50 (.002) *	0.31 (.10)
B	03	-0.01 (.98)	-0.07 (.69)	-0.13 (.46)
	07	0.12 (.60)	0.47 (.033) *	0.38 (.074)
	11	-0.61 (<.001) †	0.05 (.78)	-0.33 (.050)
C	01	0.01 (N/A)	-0.30 (.10)	-0.14 (0.44)
	05	0.38 (.031) *	-0.31 (.12)	-0.02 (.95)
	06	-0.28 (.10)	-0.42 (.017) †	-0.38 (.039) †
	08	-0.15 (.39)	-0.45 (.018) †	-0.15 (.45)

from the BG meter to Diabetes Diary, but the other three participants did not experience any problems with the BG sensor system. They often used both or either PA and/or NH recording systems on the days on which they used BG sensor system (Figure 2). H04 regarded choosing a category to record nutrition habit as difficult and gave score of two (indicating "dissatisfied") on the 5-point Likert scale for the question asking about satisfaction with the NH recording system. Except for this and a few other questions to which neutral answers were given, most of the answers were positive. All four participants increased the frequency of their BG measurements and PA, as well as the length of PA sessions, because they found each function motivating and/or each function made the participants more conscious about self-management activity. Usage rates of the PA and/or NH recording systems by HP02, HP09 and HP10 also showed an increasing trend, while usage rates for the NH recording system by HP04 showed a decreasing trend (Table 2). Regarding the FTA in total, all four participants gave the best score (seven on the 7-point Likert scale) to

perceived usefulness of the FTA for control over diabetes; they were all satisfied with both current self-management and knowledge about their diabetes, and the levels of satisfaction were higher than before they started using the FTA.

Group B (HP03, HP07 and HP11): Moderate use with relatively neutral experience

Participants in Group B used all three functions moderately (Table 2). Answers to the questionnaire showed different experiences between HP07 (the non-diagnosed tester) and the other two. HP07 gave positive answers regarding motivational effect and level of satisfaction with all the functions. HP07 did not change the amount of fruit/vegetable/berry intake, which had been 300-600 gram (2-4 portions) daily[2], because the NH recording system was not perceived as useful for HP07 to increase the amount. The other self-management activities were, however, improved because HP07 became more conscious and/or each function was motivating enough. In contrast, HP03 and HP11 answered that there was no change in self-management activities or level of satisfaction with their self-management and knowledge of their diabetes through using each function or the FTA as a whole. They gave a neutral answer (three on the 5-point Likert scale) to all the questions asking their opinion on the motivational effect of each function. They considered that they had been motivated enough or satisfied enough before starting to use the FTA, and on this basis they did not perceive the FTA as useful. In addition, HP11 experienced a problem with data transmission from the BG meter to Diabetes Diary since midway (late November 2010) in Trial II, which caused HP11 to discontinue using the BG sensor system (as shown in Table 2).

Group C (HP01, HP05, HP06 and HP08): Little use of the NH and PA recording systems with mixed experiences

Participants in Group C used the NH and PA recording systems very little (Table 1). Regarding the BG sensor system, only HP01 used it often (at a mean usage rate of 5.9 (SD:1.5)), while the other three used it very moderately (at mean usage rates of 1.6 (SD:2.4), 2.2 (SD:2.2) and 2.6 (1.7) for HP05, HP06 and HP08, respectively). While HP05 and HP08 did not change frequency of BG measurements, HP01 and HP06 increased it (less than doubled, scored four on the 5-point Likert scale). HP01, HP05 and HP06 agreed about the motivational effect of the BG system as well. However, HP01, HP05 and HP08 experienced problems with BG data transmission. HP05 clearly stated that s/he did not use the PA or NH recording system at all and that s/he continued using the same PC-based software for self-management that s/he had used before participating in Trial II rather than using the FTA. HP05 also showed a strong preference for having the Diabetes Diary on his/her own mobile phone, but not the provided phone. HP01, HP06 and HP08 were all "satisfied" (scored four on the 5-point Likert scale) with the PA recording system, but they did not change the PA frequency or length because they had been satisfied with their previous PA level. In contrast, the NH recording system was considered either neutral or negative regarding motivational effect and satisfaction with the function. These three participants did not change the amount of vegetable/fruit/berry intake, which was 0-300 gram (0-2 portions) daily, because the NH recording system was not considered useful enough for them to increase the amount.

Usability of the FTA

Answers to questions under Topic 8 themes 2-6, described in the previous section, and feedback we received in the focus group interview revealed FTA usability issues. Firstly, many usability problems with the mobile phone employed were reported regardless of the participants' age. One participant said that s/he was not using the provided phone as his/her personal mobile phone, but only as a terminal for the FTA. Regarding usability of the BG sensor system and the tips bank, most participants appreciated the features that the participants in Trial I had also liked. Suggestions for improvement were mostly about relatively minor issues, and were also generally in line with the feedback we obtained in Trial I. Most of the design features of the PA recording system were perceived positively in general (HP05 did not answer corresponding questions). Additional feedback on potential improvements included setting the time frame for the bar chart and the weekly goal to a calendar week rather than the last seven days; making it possible to edit saved records if they had been saved by mistake; displaying intensity levels more accurately on the feedback screen, to reflect a choice on screen (e) in Figure 1; and enabling more specific data recording including activity types. Concrete suggestions for improving the NH recording system were also consistent with the results from Trial I. However, the participants' level of satisfaction regarding how easy it was to record NH and to understand the feedback screens was lower than in Trial I, indicated by the greater number of participants who gave a negative score on the 5-point Likert scale for each issue (three participants for ease of recording and four participants for ease of understanding the feedback screens, out of eight who answered these questions) than a positive score (two and three participants, respectively). No participants gave a negative score to the same questions in Trial I. In the focus group session, we became aware that many participants had had problems in deciding on a category to record. They wished that user instructions had provided better information. Nine participants showed a preference for a possibility to record details of nutrition habits as well.

Discussion

This study aimed to research qualitatively how individuals in a broader population with T2DM or at high risk of T2DM had used and perceived a mobile self-management application, the FTA, which had been designed with intensive involvement of patient-users. User involvement in design processes has been deemed important to ensure that the resulting system adequately meets the needs of users [15]. Considering that the feedback on FTA usability issues in Trial I and Trial II was fairly consistent in both positive and negative aspects, this study primarily confirmed the value of including a long-term trial in a design process involving patient-users. This made it possible to identify factors associated with usability and usage in a long-term perspective. Conducting a long-term trial of a working prototype by recruiting new patients demands far greater resources than continuing involvement of the same patients in a trial. This study also confirmed the importance of performing enough design iterations to minimize the number of critical factors for usability and longitudinal usage. In fact, some of the critical opinions on design of the nutrition habits (NH) recording system were also given in Trial I. Even though many cycles of iteration on the design and functionalities were performed before Trial II, we were not able to address all usability problems. For the participants in Trial II, a clearer correlation was observed between perception of a function and usage of the function in both negative and positive ways, compared with results from Trial I. Decreasing trends in usage rates were observed among the participants in Group C who used each function very little; HP04 who was dissatisfied with the NH recording system due to difficulty in choosing appropriate category to register, and HP11 who had problems with

[2] Norwegian Diabetes Association recommends 750 gram (5 portions) daily

data transmission of the BG sensor system. In contrast to Trial I, we could not identify any cases in Trial II where a participant stopped using the FTA or a function of it because s/he had learned enough about his/her diabetes by using the FTA. On the contrary, an increasing trend in usage rates was observed among five participants. Three out of the five were in Group A. Increasing trends in usage rates were observed for two functions for each of the three participants. This phenomenon implies that perceived usefulness has a greater impact on the degree of usage for the individuals with T2DM or at high risk of T2DM in general than those who were involved in the design process. Because Trial II was shorter than Trial I, however, additional follow-up of the participants may be necessary to study how their usage changes over a longer duration.

Given the purpose and characteristics of the Motivation Group, the Trial II participants may have had even higher motivation than the Trial I participants. Although we did not measure their motivation level at the beginning of Trial II, possibly high level of their motivation may be considered as a limitation of this study. For technical feasibility piloting or design processes, however, settings like Motivation Group where regular meetings are held will be suitable. A new research question arises about the influence of such meetings on use of an intervention tool or design input, which needs to be investigated in future work.

Conclusion

One of the main findings from this study is that perceived usefulness implies a greater impact on the degree of usage for the individuals with T2DM or a high risk of T2DM in general than for those who were involved in the design process. However, many of our findings on factors associated with usability and usage for patient-users who had been involved in the design process were also applicable to the users who had not been involved in the design process.

The FTA is now the subject of an ongoing RCT [16] in which effects of using the FTA on diabetes management will be examined by measures of clinical outcomes and standardized questionnaires. We did not investigate how the regular meetings with learning opportunities in Trial II might have influenced FTA usage. Such meetings will not be included in the RCT [16], to exclude the effects that they might have on self-management activities and diabetes control. Though the participants in Trial I are no longer involved in design processes, the FTA is evolving through many research projects in which new functions are implemented and feedback for improvement is given [17]. Such series of studies will provide useful insights into factors associated with usage and usability of a mobile self-management system.

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