Designing mobile dietary management support technologies for people with diabetes

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Summary

We performed two cycles of laboratory-based usability testing of three food registration prototypes for people with diabetes. The design concepts were a commercial web application, various smartphones and a mobile phone photo blogging approach. Six adults with Type 1 diabetes and three adults with Type 2 diabetes participated in the usability tests. The results provided five distinct implications for devices for the future dietary management support of people with diabetes. Study participants valued many of the features offered by the three systems that were tested, although the usability tests also revealed several opportunities to enhance their design. Our findings suggest that further development is justified of mobile dietary and nutritional support for individuals living with diabetes. Applications that support healthy eating habits should be integrated with applications for managing blood glucose data and physical activity data, and potentially medication data as well.

Introduction

Information and communication technologies (ICTs) designed to capture and provide feedback on individuals' eating habits may enable people with diabetes to better manage their condition. Although relatively little is known about the effectiveness of these ICTs, recent studies[1–4] and commercial products[5–7] appear promising.

Researchers at the University of Washington (UW) and at the Norwegian Centre for Telemedicine (NST) have worked on ICTs for people with diabetes, including tools to enable self- management of dietary habits. The two research groups have taken different approaches. The UW group has focused primarily on developing tools for people with diabetes in collaboration with their physicians, nutritionists and other health-care providers, while the NST has developed ICTs designed for use in self-help contexts.

UW research programme

Over the past six years, a suite of web applications has been developed that enable people with diabetes to access their physician-generated medical records online, exchange information and communicate with their health-care providers over the Internet. The aim of the work is to enable people living with chronic illnesses to achieve better health through more effective self-management; this is supported by health-care professionals in between patients' face-to-face encounters with them. Based largely on participant feedback from clinical trials of these prototype systems[8–10] the most recent work has focused on design concepts to enable users to integrate these ICTs into their routine daily activities. Design concepts include mobile smartphones, blogging and text messaging.

NST research programme

A current focus of NST research is the development of diabetes self-help tools. To ensure a user-centred design approach, patients are involved in all phases of technology design and evaluation. Much of the research focuses on the design of personal applications run on programmable mobile phones.[11–13] Applications are being developed that will allow data to be uploaded wirelessly from blood glucose monitors, from sensors that measure physical activity and from user-generated records of routine eating habits.

Design concepts

The two groups have worked on three food registration design concepts.

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(1) *Smartphone*. The Few Touch smartphone prototype provides a browser-based application for individuals with diabetes. It operates on smartphone devices which have large, touch-sensitive screens (Figure 1). The prototype is designed for rapid entry of approximate records of eating habits. The user launches the application via the phone's web browser, which then displays six categories of food or meal types. Records of food consumption are created and recorded by touching the icon that best represents the food(s) consumed. Immediately following data entry the user is presented with a screen that shows their cumulative totals by category and their stated goals. The initial prototype development for the Few Touch smartphone application has been described elsewhere.[13]

(2) *Desktop PC*. The commercial web application Diabetes Partner (NuMedics, Inc., Tigard, Oregon, USA) is designed to capture and display data about users' dietary habits, use of insulin and other medications, and blood glucose levels. Blood glucose data are entered into the system directly from users' glucose meters. Insulin, medication and nutrition data are entered manually by users at the desktop (or laptop) via web forms (Figure 2). Time- and date-stamped records of food consumption can be created and recorded using two different approaches. Users can either create a brief record of estimated carbohydrates consumed via a standard web form, or create single food or composite meal records by using a search feature that returns a pick-list of food items with their nutritional content values. Individual food items with their accompanying nutritional values and portion sizes can then be selected from this list to create a single-item food consumption record, or to build a composite meal consisting of many food items. Once these single-item or composite meal records are created from the pick-list they can then be either deleted or recorded in the system by clicking a 'Submit Entry' button on the web form embedded in the application's 'Nutrition' web page.

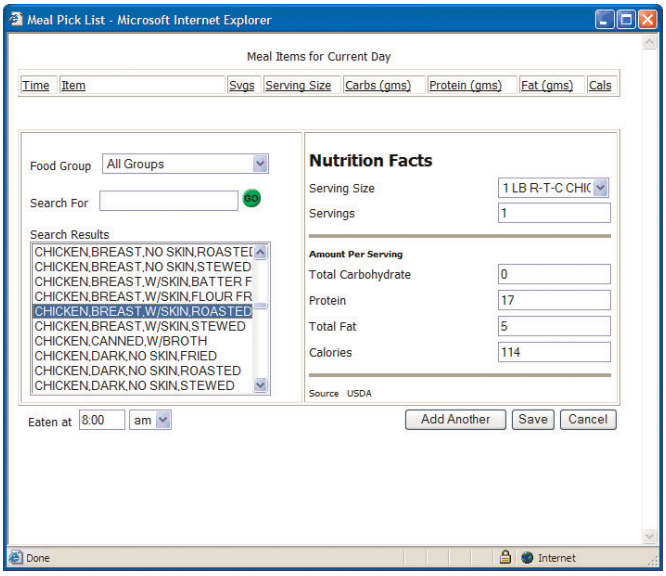

Figure 2 Desktop food pick-list (Diabetes Partner, NuMedics)

(3) *Smartphone picture-capture*. The Food Photo Moblog prototype represents an application that includes both smartphone and PC user interfaces. It is intended to be used by people with diabetes in collaboration with their nutritionist, physician or other health-care staff. The prototype relies on a mobile phone photo blogging or 'moblogging' approach to meal registration. The user creates records of food consumption by using the smartphone device to take a digital picture of the food(s) that will be consumed (Figure 3). The image can then be annotated with an estimate of carbohydrate content via free text entry, and the annotated picture posted to a web log or 'blog'. This photo blog can then be accessed via any

Figure 1 Smartphone touchscreen

Figure 3 Smartphone picture-capture

Internet-connected desktop or laptop PC by the user and by anyone to whom they grant access permissions. Health-care providers can then post written feedback in the blog on the accuracy and precision of the estimates included in photo annotations. The photo blog could also be integrated with a more comprehensive online shared medical record and personal health application.

Methods

We performed two cycles of laboratory-based usability testing, based on a modified think-aloud protocol.[14] Ethics approval was obtained from the appropriate committee. The first cycle elicited user feedback on the commercial web application, the usability of various smartphones and the Food Photo Moblog design concept. The second cycle also incorporated user testing of the Few Touch prototype and a functional prototype of the Food Photo Moblog system in addition to the commercial web application for PCs.

Each of the two cycles of testing comprised six test sessions. Each test session was conducted with a single participant. Participants included six people with Type 1 and three people with Type 2 diabetes, all aged 18–65 years. There were nine participants in all, three of whom participated in both testing cycles. Participants were recruited via paper flyers posted on bulletin boards. Tests were conducted at the University of Washington. Sessions averaged 90 min in length and were video-recorded. Participants were observed and interviewed while using the prototypes under simulated conditions to elicit their perceptions of the design strengths and weaknesses, ease of use, contexts of use and potential utility in supporting their diabetes management goals. Participants were also asked a series of predefined questions after completing each test case.

The first sessions explored the use of these tools in various contexts of diabetes management, including blood glucose monitoring, physical activity, messaging, nutrition and dietary habits. The second sessions focused exclusively on the use of these tools in nutrition management and dietary habit support. In addition to comparing and contrasting their preferences for various features, functions and overall design concepts associated with the three ICTs, participants were also prompted to comment on the use of these tools in both standalone self-help contexts and shared provider-supported contexts.

Two investigators analysed transcripts from the first sessions, and field notes and recordings from the second sessions to identify common themes. Thematic analysis focused on informing rapid prototyping via identification of implications for technology design and enhancement. An iterative approach was used in which one investigator developed an initial list of themes that were confirmed by the second investigator. Investigators re-read and discussed transcript excerpts and field notes and reviewed segments of audio recording files to clarify and resolve thematic discrepancies.

Results

Participants stated that, regardless of the specific design approach, the act of recording and reviewing records of their eating habits was inherently motivating, an important facet of diabetes management and a mechanism to 'keep yourself honest about what you eat' via self-monitoring of eating habits and behaviours. However, they also acknowledged that generating these records required work, and to achieve sustained use of these tools they should be designed so that each act of recording a meal is coupled with some form of reward at the time of data entry. Specifically, the tools should either teach the user something about the nutritional content of the foods while they are recording them (e.g. carbohydrate content) or provide realtime feedback about their progress towards their personal nutrition goals. The participants also clearly expressed that mobility was critical to the sustained use of any of these nutrition diary tools, and was a highly-desired feature in any of these systems – including the commercial web application for PCs. Participants also expressed their desires to self-configure and tailor these applications to meet their own needs and to support their own unique goals. They expressed varying opinions about the extent to which each application prototype would be useful in a self-care context versus a health-care provider (e.g. nutritionist) supported context, but all participants felt that at least one of these tools would be useful in each of these two contexts.

Participants felt that the mobile picture capture approach of the Food Photo Moblog prototype would not be practical for routine use. However, most participants commented that it could potentially be useful for occasional use to record meals or foods that were unfamiliar, assuming that the pictures would serve to facilitate discussion with their nutritionist. Nutritionist involvement was viewed as essential in using this system.

The food pick-list in the commercial web application for PCs was viewed as a useful and a potentially powerful tool in both self-care and provider-supported care. The most powerful feature of this approach was the automatic display of the foods' nutritional content at the time of data entry. However, participants commented on several usability problems that would reduce the likelihood that they would use it. Specifically, the food pick-list was too limited and should be expanded to include more items; re-ordered based on frequency of item selection; and allow for user entry of new food items. Also, the ability to edit meal and individual food item entries prior to submission should be made more flexible and robust, as should the functions for specifying portion and serving sizes. Finally, participants also

expressed the need to extend this system to a mobile (e.g. smartphone) device to enable routine use.

The smartphone touchscreen concept was generally well received. All participants commented on its ease of use and simplicity. Five of the six participants stated that they would be likely to use this tool routinely if given the ability to personalize the goals and recording categories.

Other desired enhancements included the ability to download the resulting data to a PC to enable more detailed analyses (including longitudinal analyses spanning more than one week); the ability to delete or edit entries after they were submitted (e.g. in the case of a touch screen error resulting in an unintended entry); and the addition of negative as well as positive reinforcement cues in the graphical user interface (e.g. 'frowney faces' as well as the 'smiley faces' as indicators of progress towards achieving goals). Participants commented that this would be a useful tool regardless of health-care provider involvement, although some commented on the extent to which provider involvement might enhance the usefulness of this approach. Participants also viewed the tool's realtime progress reporting as the incentive associated with individual food recording sessions, in contrast to the other two design approaches in which this reward took the form of learning about the nutritional content of the foods being recorded.

Discussion

The present study had certain limitations. Qualitative design research provides insights into design concepts, but is not intended to support formal hypothesis testing or generalizable claims of causality. Also, it is possible that self-selection bias in our sampling and recruitment strategy may have yielded participants with knowledge of nutritional facets of diabetes and perhaps higher expectations of the tested ICTs than other people with diabetes who might be less motivated or less engaged in managing their health. Although the Food Blog and Diabetes Partner web applications were designed to be used by patients in conjunction with providers, we did not directly address provider workflow.

Nonetheless, our findings suggest that further development is justified of mobile dietary and nutritional support for individuals living with diabetes. Applications that support healthy eating habits should be integrated with applications for managing blood glucose data and physical activity data, and potentially medication data as well. Future studies should address provider organizational structure and workflow to support these applications.

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