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Review of Mobile Terminal-Based Tools for Diabetes Diet Management

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Abstract. Changing dietary habits is one of the most challenging tasks of diabetes self-management. Mobile terminals are increasingly used as platforms for tools to support diet management and health promotion. We present literature describing mobile terminal-based support tools for management of diabetes focused on diet. We also propose a summary of key success factors for designing such tools and discuss recommendations for future research.

Keywords. Diabetes, Nutrition, Diet, Self-help, Self-management, Mobile phone

1. Introduction

Medical recommendations in both Type 1 and Type 2 diabetes management involve nutrition, physical activity, and medications if necessary. Of these three elements, patients regard following nutrition recommendations as especially challenging, partly due to their lack of knowledge, understanding or skills concerning diet management.

Mobile terminals are considered to have high potential as a platform for supporting tools for people with diabetes, due to their portability and emerging technologies embedded [1]. For such tools to be useful for diet management, they should be designed so that users can easily and quickly find necessary information and eventually achieve healthy dietary habits [2].

In this paper, we present findings from reviewing academic literature that describes mobile-terminal-based tools supporting diet management in diabetes. The aim is to improve knowledge about how a tool for diabetes diet management should be designed to promote health.

2. Methods

PubMed, ACM digital library and IEEE Xplore were searched for relevant literature using the following combination of keywords: {(food OR nutrition OR diet) AND (cell phone OR mobile phone OR personal digital assistant (PDA) OR handheld)}. After removal of duplicates, only the papers including the keyword, 'Diabetes' were selected. The search was conducted in September 2010.

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Following exclusion criteria were applied: (i) papers not written in English; (ii) papers of which full text was not available; and (iii) review articles. Finally, the relevance of each publication was examined by reading the abstract and the whole text if needed. The following data were extracted from the final selected papers: study design, type of mobile terminal used, targeted population, main purpose of the tool used or developed, significant features of the tool regarding diet management, and the findings for each study.

3. Results

After removal of duplicates, 27 papers were found, of which five met the exclusion criteria. Based on the abstracts, 16 papers were selected as relevant to diet/nutrition. One of these focused on insulin therapy and another was found irrelevant to diabetes, leaving 14 papers for inclusion in this review.

3.1. Study Design, Terminal Type, and Target Population

Ten papers [3-12] describe design and development of management tools for people with diabetes. Of these, seven [3,5-10] describe results from evaluation of tools by potential users regarding usability, feasibility and general acceptance; two [11,12] report results from technical evaluation of tools; the last paper [4] describes the design and development of a tool from a technical perspective. Three of the papers [7,9,11] state that the design requirements were obtained by involving people with diabetes as potential users. Evaluations by potential users are conducted through field testing, namely evaluation by use of a tool in the users' real-life setting for a certain period [3,5,7-9], and through laboratory testing [6,10]. Clinical outcomes such as HbA1c were also examined in four studies [3,5,13,14]. In three studies described by the four other papers [13-16], the effectiveness, acceptance and feasibility of commercially available tools based on mobile terminals were investigated in the context of clinical intervention.

Six studies [3,6,7,9,11,12] involved mobile phones as the terminal; the others involved PDAs. Windows Mobile-based phones with a touch-sensitive screen were mostly used [6,7,9,11]. The commercially available applications were all PDA-based. The year of publication and of each study indicates a clear shift from PDAs to Smartphone-type mobile phones.

Six studies described in seven papers [7,8,10,13-16] target people with Type 2 diabetes, and two studies [3,11] target young people with Type 1 diabetes. The others do not specify the target population, but one study [9] limited participation to people aged over 18.

3.2. The Purpose of the Tool and Special Features

In six studies [3,4,7,10,11,13], a tool was used or developed for overall diabetes management with recording of blood glucose values, physical activities and other relevant data in addition to food intake. In the seven studies described in the eight other papers, a tool dedicated to dietary management was used or developed. Several tools are designed for use as a part of telemedicine intervention, where health care professionals support patients remotely by viewing and analyzing the stored data [3,6,10,11]. The tools described in four studies [4,5,13-16] give patients nutrition

information for a selected food item and/or results of automatic analysis of recorded foods in terms of nutrients and calorie intake; some provide feedback based on the patient's personal information, such as calorie balance or nutrition balance over meals [4,15,16]. One tool focuses on the glycaemic index (GI) of food items, showing a GI value with an indicator, low, medium or high, for assisting in food choices [14].

Recording of food or drink items uses various methods. The most common is to identify items from a database [4,5,8,10,13-16]. Not all the papers specify the number of items in the database, but one includes more than 4300 items [15,16] whereas another includes 423 items [8]. Portion size can be adjusted in some of these tools [8,10,15,16], and two tools present photographs of food or drink items that can be used as a reference [8,10]. Other methods of recording include free text input [11] and photographing using a camera on a mobile phone [6,12]. The tool described in paper [12] is designed to recognize a food item by semi-automatic analysis of the photo together with contextual information. Meal types, such as breakfast, lunch, or dinner, are also used as data for recording [4,8,10,14-16], and time for meal intake can also be recorded on two tools [8,11]. The tool used in two of the studies [6,7] has only six buttons for the user to select a meal, snack, or drink with high or low carbohydrate content, enabling simple and quick recording in only a few operations. After data entry, this tool shows cumulative totals of foods or drinks recorded by category together with feedback according to personal goals, and smileys when goals are achieved [7].

One study [9] involves tools designed and developed purely for educational purposes utilizing three types of games incorporating several education theories and customizable functions so that patients can play and learn about diet management.

3.3. Summary of Findings

In four of the studies [3,5,13,14] where clinical outcomes are evaluated, it is observed that HbA1c decreased among the participants in the intervention group who completed the study. However, in the study described in [5], decrease in HbA1c is only observed among the group of participants whose history of having diabetes is shorter than the other group. In the study described in [7], the participants improved their nutrition habits, especially intake of vegetables and fruits.

In most of the identified studies, the tools used are generally well accepted by participants in terms of ease of use [5,6,10,13-15], usefulness, problem-solving capabilities, learning and motivational effects in dietary management [5-7,9,13-15], and feasibility for patient interventions due to high accuracy and reliability of recorded data [8,15]. It is noteworthy that no drop-outs from the studies due to difficulties in using the tools are reported in the selected papers. However, in the studies described in [9,15], considerable time was devoted to instructions for use, and the 12 elderly participants without experience in using PDAs or with problems in motor skills remained in the study, but gave up on using the PDA [15]. In some studies, consequences such as drop-outs from the study, decrease in use, low use, or negative opinions of the tools were observed – partly due to burdensome or tiresome daily registration [7,13-15], apparent improvement in glycaemic control [13], or saturation of effects on diet management [7], or misunderstanding, underestimating importance of self-management or treatment regimens, or limited understanding [15].

Despite the generally positive opinions of the tools, some difficulties in behaviour change are reported in terms of nutrition habit [5] and adherence in self-monitoring of diet [16]. Sevick et al. found that adherence to diet self-monitoring is not associated

with sociodemographic characteristics, but rather with the level of adherence in the early phase of intervention [16].

Concerning tool features, customization or modification based on personal data or users' skills is considered important and beneficial [6,9,14]. Timely, automatic and personalized feedback should be incorporated in a motivating and easily interpretable manner [6,13-15]. A database showing nutrient and calorie content is considered powerful if it contains enough variety and numbers of food and drink items that are familiar to users [6,14]. Simple categorization for recording nutrition habits is well accepted and appreciated for routine use [6], but some participants consider such categorization too coarse [7]. Photographs of food and drink items are considered useful, especially if they include a scale or familiar cutlery as a reference of size, for adjusting portion sizes [10]. Photographing food and drink items for recording and later consultation is considered practical for occasional use, but not for routine use [6]. Educational games are considered most suited for the young population and for short-term use. Thus, the easiness and the ability to quickly launch and complete functions are important [9].

4. Discussion

The identified publications show that mobile terminal-based tools have been generally well accepted and shown to be effective for diet management or glycaemic control to a certain degree. For successful diet management, people with diabetes need a good understanding of their diet regimen. In order to make a diet management tool feasible and useful, it should enable recording of food intake in an easy, but accurate enough manner. It should also provide immediate analytical feedback based on personal data in an easily interpretable way, preferably with other data about and exercise so that patients can reflect on their total behaviour. The tool should also include educational materials, with a database of food and drink items familiar to patients. For accurate recording of food quantities, visual reference such as photographs taken using a familiar object to indicate size is considered useful.

From this review, key features to achieve both ease of use and accuracy in recording could not be clearly identified because of the mixed feedback from the participants, the time and effort required for user instructions, and the study designs, which do not compare the different tools in some of the studies. Food recognition by photographing may have a high impact when the technology enables reliable identification. Another challenge is how to design a tool that supports adherence in self-monitoring over a substantial period – long enough for achieving healthy effects. It might not be necessary for a tool to be used permanently, if use of the tool leads to better diet management, but often it needs to be used at least periodically for maintaining awareness of the importance of a healthy dietary regimen. As described in [6], simple and quick registration with immediate feedback would be suitable for routine use, but at the same time a tool should be designed so that it will not be tiresome or boring. Key features that encourage a wide variety of patients to be continuously engaged in using a tool should be investigated in future research, borrowing knowledge from the field of persuasive technology, human computer interaction, and psychology.

The market for advanced mobile phones, e.g. smartphones, is growing rapidly and a great number of mobile applications are available on the market today. Further

research is required to examine such applications to identify key features for design of effective and useful support tools for diet management for people with diabetes – and other disease cases that will benefit from diet management.

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