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Smart Phones are Useful for Food Intake and Physical Activity Surveys

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Abstract— Current self-report methods of recording food intake and Physical Activity (PA) are cumbersome and inaccurate. Food and activity surveys implemented on a smart phone will allow for immediate entry, data transfer to a researcher, and feedback to the user. Ten subjects followed a script, representative of one day, to enter food intake and PA on a smart phone. In the follow-up report, all subjects were interested in using the tested program to compare food intake with PA to predict weight gain and loss.

I. INTRODUCTION

THE prevalence of obesity is increasing in many countries due to inappropriate diet and decreased Physical Activity (PA) [1, 2]. An amazing 66% of American adults and 16% of children are either overweight or obese (BMI >25) [2]. Obesity is known to be a cause or risk for multiple forms of morbidity and mortality, with about 112,000 excess deaths per year in the U.S. population relative to healthy weight individuals [3]. Conditions already linked to overweight include type II diabetes, cardiovascular disease (such as heart attack, stroke, and congestive heart failure), some forms of cancer, arthritis, sleep apnea and digestive diseases [2, 4]. A recent study estimated annual U.S. health expenditures due to overweight and obesity to be as much as $92.6 billion in 2002 [5].

Patients seeking to lose weight and study subjects are often asked to complete diaries of food consumption and PA at the end of a day or week (recall record). Recall methods often produce inaccurate reports. Entries on food intake are hoarded or filled in just before infrequent appointments [6, 7]. Paper-based diaries are clumsy to carry and attract unwanted attention from peers. Electronic diaries are more inconspicuous, can apply time stamps to entries, and can prompt the user if data is incomplete. Electronic diaries with a remote data connection also allow for immediate feedback, reminders, and progress tracking for the subject. However, it is important that the user interface for electronic diaries is comfortable enough to encourage use several times a day for many months. Patients and investigators are poorly served if the system is not accessible to users independent of age, technical background, and health status [7].

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This paper describes tests of the usability of an electronic diary in the form of a smart phone to monitor food intake and PA in college students. This population was chosen because the period of "emerging adulthood" is characterized by declining levels of PA and increased consumption of unhealthy foods. While our goal was to produce a tool for researchers to use to examine food intake and physical activity in a wide range of populations, college students provided a convenience sample that is at risk for establishing habits leading to excess weight gain but who are also relatively familiar with smart phones.

II. METHODS

Subjects were college students recruited through emails and flyers posted around the University of Minnesota campus. The Social and Behavioral Sciences committee of the University of Minnesota Research Subjects' Protection Program approved the study protocol and consent forms. Subjects were compensated $20 for travel to the study.

A sample survey on diet and PA was written for a Motorola Q9h smart phone running Windows Mobile 6.1 using a Service Oriented Architecture approach (SOA). Web services have become widely accepted and allow for data collection to be separated from data analysis and provide a way for multiple participants to interact with the system [8].

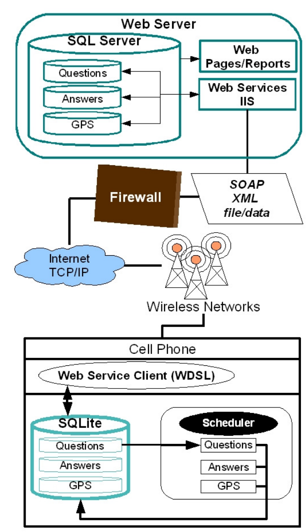

Fig 1. Data transport between smart phone and web server

The survey was written in C# with the Windows Mobile Version 6.1 SDK and .Net Compact Framework 3.5 edition. The data were stored in a local SQLite database with a timestamp. The survey responses were written to an XML file, and concurrent GPS data were written to a comma-delimited text file. At a convenient time, the files are pulled from SQLite and passed to a web service hosted remotely (Fig. 1). The remote web server was configured in Microsoft IIS to run web services written in C#. SQL Server 2005 was used to parse the uploaded file and store GPS and survey data.

The test was configured with surveys to simulate recording a full day of meals (breakfast, snacks, lunch, dinner) and three sessions of PA. To avoid influence of recall/decision delay, the participants were asked to follow a specific script and complete all records on the phone. Only a few entries were requested for each study to finish the test within approximately 1 h.

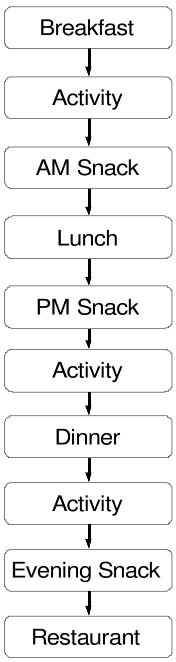

Fig 2. Survey order, in the script, subjects were asked to follow. The script also prompted answers for each survey.

The script prompted the order of surveys and provided the answers to the questions. The researchers gave the subject little information on how to use the program but were available for questions if needed. Video of the subject's hands and the phone (avoiding face and clothes) were captured for later analysis. The flow of surveys, from the script, is summarized in Fig. 2. *Restaurant* was presented last because we hypothesized that this survey would be the most difficult for users to complete.

Questions within each survey were presented in five different layouts (Fig. 3). In the choice tree with highlight (3.a), the user used the arrows on the phone to scroll through the list. The selected option was highlighted and then could be expanded to further refine choices. For the check boxes (b), a check appeared in the box next to the choice when selected. The text box (c) allowed the user to use the keypad on the phone to type desired letters. For the scroll bar (d), the user used the arrows on the phone to reach the desired number. To enter time (e), the user could employ arrows to scroll through the numbers or enter the time on the key pad. To move forward, to the next question the user selected a 'Next' softkey at the bottom of the screen.

As the user moved through the script, time stamps were recorded each time a new screen was presented. These stamps measured how long the user took to complete each part of the survey. If the user asked a question, the question and the location in the survey were recorded.

The script instructed users to record the same responses for the first and second activity surveys. Additionally, the script prompted the same number of foods to be chosen for the breakfast and lunch surveys. The answers to who, where, and recent activity in the breakfast and lunch surveys were also the same. These similarities in the surveys allowed us to compare the time it took to complete each question and determine if the subject became more familiar with the program and smart phone (learning effect).

After study subjects completed the script they were asked to answer questions in a follow-up report and discuss their opinions on the program with the researchers. Researchers asked the subjects about their preference in screen layout (check boxes, highlight, text boxes) and comfort with GPS tracking. Finally, the subjects were asked to discuss their opinions on ease of use of the program, visual appeal, and suggestions for changing or improving the usability of the program.

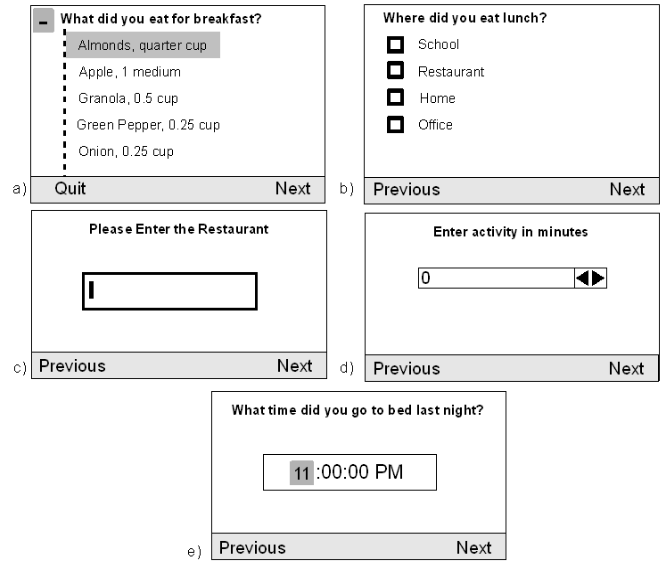

Fig 3. Information entry screen elements, a) choice tree with highlight, b) check Boxes, c) text box, d) scroll bar, e) time.

Questions in follow-up report:

1. On a scale of 1 to 10, with 1 being extremely difficult and 10 being extremely easy, how would you rate how easy it was to use this program?
2. The smart phone you are using has a GPS location system, meaning it can track the location of the phone. Would you be uncomfortable if such a phone was used to track your movements for a week?
3. Would you be comfortable allowing the phone to record you movements if only you and a single researcher would know who you are?
4. If you were given a phone and this program to use for one week, how sure are you that you would be able to keep up with reporting all of your food and physical activities?
5. Would you like to lose or gain weight?
6. Would using the smart phone to record the foods you eat help you control how much you eat?
7. Would recording more about your eating environments (where you were and who you were with) help you control how much you eat?
8. Would you consider using tools like those you just tested on a mobile phone to record your activity along with suggestions or a plan to be more active?
9. Would you be interested in having your smart phone's GPS record your movement and activity?
10. Would you be interested in this program if your physical activity information could be compared with

what you eat to help you predict if your will gain or lose weight?

11. Do you think this type of software on a smart phone is a good approach?

III. RESULTS

All tests were conducted at the Division of Epidemiology and Community Health at the University of Minnesota, Twin Cities. Ten subjects (5 female) between 18 and 35 y.o. (median 19 y.o.) were enrolled and completed the procedure. Subjects owned a cell phone for an average of 4.4 y. On average, subjects estimated that they used their cell phone to call and send text messages 65 min a day. Subjects considered themselves as white (n=8), Asian American (n=1), and Native Hawaiian or other Pacific Islander (n=1)

On average, it took 14.6 ± 20.7 s to complete each survey, or 8.1 ± 5.8 s per survey weighted by the number of questions in each. By type of survey element the respective average weighted times to complete check boxes, numeric scroll, highlight tree, time box and text boxes were 6.0 ± 1.4, 13.8 ± 2.6, 9.1 ± 4.2, 9.0 ± 2.6 and 23.6 ± 10.6 s.

In the follow-up questions, four subjects rated ease of use as 7 and six at 8 on a scale of 1 being extremely difficult and 10 being extremely easy. From discussions with the subjects and examining the questions subjects asked during the test, the restaurant survey seemed the least intuitive. Five subjects asked at least one question during this survey. Entering food options into text boxes in the restaurant survey (2 inputs) took the longest time (average 69 s) compared to the dinner survey which averaged 52 s with 10 inputs. Nine of the ten subjects said they preferred checkboxes to the highlight trees or the text boxes.

Five subjects took less time (4.5 s) to complete the first PA survey than the second PA (Table I). The first survey (breakfast) and the fourth survey (lunch) were compared because each had the same number of required responses (Table II). Subjects completed the lunch survey in significantly less time (p=0.008) than the breakfast.

Table I.
Difference in times required to complete the 1st and 2nd activity surveys

Subject	Time (s)
1	0
2	-8
3	-7
5	-7
6	-12
7	-7
8	2
10	3
Average	-4.5 ± 4.9

When asked if they would be willing to use such a phone application for one week, 5 subjects were somewhat sure and 3 were very sure that they would be able to keep up with reporting all food and PA. Of the ten subjects, seven said they would rather carry the mobile phone for a week, instead of a paper diary, to report food intake and PA. The three other subjects said the phone would be more convenient to carry, but thought writing food intake and PA would be faster than entering it into the phone. Seven subjects felt that this type of software on a mobile phone is a very good idea, 3 felt it was a somewhat good idea. One subject who had participated previously in a study that collected food intake noted that it was difficult to remember to bring the recording packet to restaurants and uncomfortable to fill out when with other people. She felt a smart phone would be less conspicuous.

Table II.
Differences in times to complete the Breakfast (1st Survey) and Lunch (4th Survey)

Subject	1	2	3	4	5	6	7	8	9	10
Food	-20	-24	-14	-30	-34	2	-43	-32	-40	-25
Where	-2	-2	-4	-1	0	0	-3	-3	-1	-4
Who	0	-2	3	-1	-2	0	0	0	2	-8
Activity	-2	0	-2	-5	1	1	-2	-17	2	3

Nine subjects agreed that using a smart phone to record foods they ate would help control how much food they consumed. Seven subjects said they would be interested in a device similar to the one tested here to record activity and provide suggestions to be more physically active. All 10 subjects (4 very, 6 somewhat) were interested in using the tested program if it could be used to compare food intake with PA to predict weight gain and loss.

All ten subjects said they would be comfortable with the GPS on the phone keeping track of their movements as long as they were informed about it. Some suggested adding a predictive text option and having some kind of confirmation that the data was received by the researcher.

IV. DISCUSSION

Most efforts to control weight have been unsuccessful, despite increasing awareness and individual efforts to lose weight. In a four month study that compared a group receiving Short Message Service (SMS) messages multiple times daily with a group that received printed material once a month, Patrick, *et al*, found that the SMS group had a higher average weight loss than the print material group [4].

Gaertner, *et al*, found that chronic pain patients preferred electronic diet and activity entry to paper forms by 20 to 4. Patients liked the alarm reminder and thought the electronic diary was easy to handle [9].

Shapiro, *et al*, examined self monitoring of PA and diet in children and their parents through SMS messages and paper diaries [10]. Of the participants using SMS messages, 43% completed self monitoring on required days, whereas only 19% of those using papers diaries did. The study was completed by 72% and 39% of participants in the SMS and paper diary groups, respectively. The authors suggested that investigators use more modern means of communication.

Savini, *et al.*, examined the use of cell phones paired with measuring devices to automatically collect physiological parameters. Physiological data collected with a medical device were sent to the phone through wireless or Bluetooth or entered manually by the patient. Once on the cell phone, the SOA protocol is followed to send the data to the server, then to the doctor, hospital, or database [8]. Our intent is for the smart phones to provide a system for measuring food intake and PA where all information is concentrated to a single device. This will reduce the burden on the subject and make it easier for the subject to carry the system at all times.

Limitations of previous studies include having to attach electronic devices to a computer or return them to the researcher for the recorded data to be transferred and having to preset reminders. The tested survey and smart phone provide a system that incorporates SMS, reminders and feedback to the subject. It allows data to be sent to the researcher automatically from any location for review in close to real time.

The researcher can use an internet website to create or edit questions and answer options on any section in the survey, allowing for personalized surveys for each subject. In addition to time and date data, the phone records GPS information which can be transferred to the researcher to learn about the subject's environment for behavioral context. There will also be reports provided to the user, which could include estimated caloric intake, types of food consumed, and suggestions for amount and types of PA. This study demonstrated the ease of use of a smart phone to record food intake and PA. Study participants felt the phone could be carried for at least a week to record data and were interested in using the phone to predict weight gain or loss. It was also clear that screen layout and information entry elements must be configured carefully and tested to ensure that users are not confused by or spend too much time on portions of a survey.

All of the participants owned a cell phone and used it daily for calling or text. Future research should include participants who are unfamiliar with cell phones; younger children or older adults. Other trials need to explore how large data sources, such as meshed food databases, can be presented on a smart phone while retaining the convenience of a personal electronic device. Finally, tests need to be done to demonstrate repeatability and to validate the smart phone system.

V. Conclusions

Tests of food and PA surveys on a smart phone were readily accepted by a group of young adults in the US. This tool should be suitable for timely data entry during long-term studies and weight management interventions. Survey configurations should be tested thoroughly to ensure that no steps are unnecessarily burdensome. Once complete, the smart phones and web services will provide a dynamic system, to study food intake and PA, allowing researchers to alter questions and responses specific to each subject.

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