# PmEB: A Mobile Phone Application for Monitoring Caloric Balance

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## Abstract
In this paper, we present PmEB, an application for mobile phones that allows users to monitor their caloric balance as a part of weight management. PmEB allows users to track their caloric balance by recording food intake and physical activity on their mobile phones. Daily reminder messages are sent via SMS messages to encourage compliance. Collected data is sent automatically every 24 hours to a central server where it can be analyzed in detail. PmEB was designed as a tool for both users to self-monitor and manage their food consumption and physical activity and primary health care providers to study behavioral patterns in overweight patients. Formative evaluation with seven health-intervention experts and a week-long user study with six clinically overweight, non-expert participants have shown PmEB to have promising potential for improving self-efficacy in dietary and exercise behavior.

## Keywords
Health, obesity, weight management, user-centered design, ubiquitous computing, behavior intervention.

## ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces; J.3. Life and Medical Sciences.

## Introduction
During the past 20 years, obesity among both adults and young people has reached epidemic proportions in

the United States. The latest data from the National Center for Health Statistics show that 30 percent of U.S. adults 20 years of age and older—over 60 million people—are obese, and 65 percent are considered overweight. Among children and teens aged 6–19 years, 16 percent—over 9 million young people—are considered overweight. Although many factors play into obesity, some of which are beyond one's control (e.g. genetic and metabolic influences), the main cause is attributed to poor eating and exercise habits [2].

Modifying one's eating and exercise habits is not an easy task, and even if one succeeds, long-term maintenance can be difficult [7]. To address this problem, behavior modification approaches have been developed for lifestyle intervention and studies have shown that they are more effective than conventional health education and appraisal [4]. Self-monitoring of food intake and physical activity is an integral part of these approaches, being described as the cornerstone of behavioral treatment in weight loss management [9]. By heightening self-awareness, self-monitoring has been shown to have a consistent relationship with success in losing weight [8].Current techniques to self-monitoring, however, are less than ideal.

Current techniques for self-monitoring typically require either carrying around a diary to record food intake and exercise throughout the day or completing retrospective reports at the end of the day. Both techniques have been shown to be problematic. The burden of carrying around diaries results in low long-term user compliance [1], and retrospective reports have been shown to be unreliable due to possible recall bias [5].

A compelling approach to self-monitoring that can potentially eliminate these issues is to leverage mobile phones as a tool for recording data. The always-carried and always-on nature of phones means that the ability to record data is consistently available throughout the daily life of the user without the need for additional equipment. In addition, mobile phone technology allows for new methods for improving data reliability, such as the ability to record *when* the entries were made.

Yet, the feasibility of cell-phone monitoring is unclear. The limited input capabilities of mobile phones combined with the tendency to use cell phones while committed to other tasks suggests a simplistic user interface. Sessions must be relatively brief, so as not to disrupt participants, which can result in low compliance. Can cell-phone monitoring of diet and physical activity improve user compliance over conventional paper-based techniques? Are the phone's capabilities in data entry and viewing adequate?

To explore these questions, we designed and developed PACE-mEB (Patient-Centered Assessment & Counseling for Exercise & Nutrition - Mobile Energy Balance, or PmEB), an application for mobile phones that allows users to monitor their caloric balance as a part of weight management. We evaluated our initial prototype with seven health-intervention experts, mostly comprised of researchers in the PACE group at UCSD. We then redesigned PmEB based on their constructive suggestions and evaluation results. Finally, we conducted a user study with six clinically overweight participants that included a week-long deployment. All but one participant said they found the application to be generally useful in helping to change their eating and exercise habits.


**figure 2 –** Screenshots of the first prototype. (a) is the main application menu. (b) is the current caloric balance page. (c) is the meal selection page. Note that the bottom portion is cut off to make space.

## Related Work

Among the number of studies involving mobile applications used in clinical trials for behavior modification in various health contexts, two stand out as most relevant. In [3], Collins et. al. report on the benefits of cell-phone monitoring as substantiated by a comparative study with paper-and-pencil monitoring. In [6], Intille et. al. report on a prototype of a PDA application that aims to encourage better dietary decision making through just-in-time motivation at the point of food purchase.

## Usage Scenario

The design of the PmEB system was motivated by two main usage scenarios. First, we wanted users to be able to effortlessly enter and view calorie intake and expenditure data on their mobile phones throughout their daily lives. Second, we wanted to allow for health counselors and primary health care providers to remotely monitor the progress of patients using PmEB through a web-based interface.

## Description of Prototype

The PmEB system consists of a client application running on the user's mobile phone and a server application running on a web application server (See Figure 1). We built the client application using Java 2 Mobile Edition (J2ME) and the server application using Tomcat. The J2ME client application can in theory run on any mobile phone that is J2ME compliant. However, we only tested it on the Nokia 6620 and the Motorola V300, which were the only phones we had available for our study. A web-based setup page is used to create a user account in the PACE system.

The client application is the primary way the user interacts with the PmEB system. The server application has three primary functions: to send reminder messages to the clients to update caloric information, to store the food and activity database, and to keep a record of the users' daily calorie data. This delocalized approach to saving data on a separate location allows for more reliable data storage (due to the risk of the cell phone errors) and more sophisticated methods for displaying and analyzing of data than the phone can support. Currently, a web-based interface for analyzing the data on the PACE server doesn't exist, and we therefore leave it out as future work.

Our database is comprised of calorie amounts for 751 foods and calorie expenditure estimates for 37 physical activities, with variation for different intensity levels. Information in the database is sent and stored on the cell phone client during the application setup.

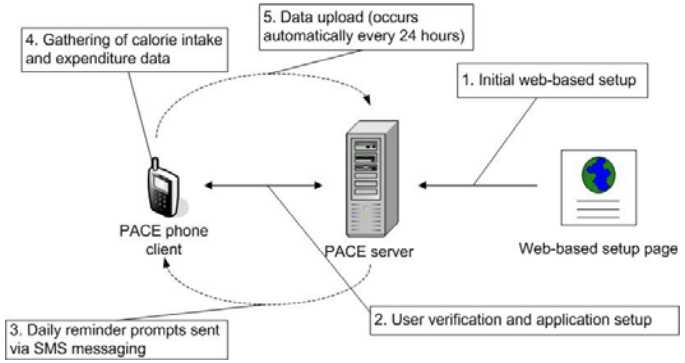
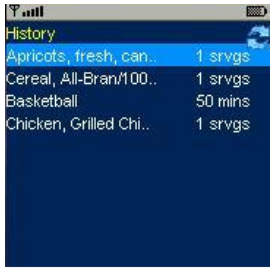



**figure 1 –** Overview of PmEB system

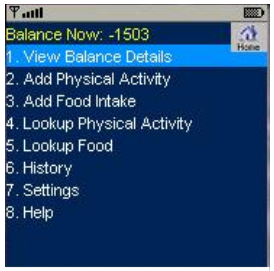
*Client Application Design*

The first prototype of PmEB phone client supports the ability to view current caloric balance, enter calorie intake and expenditure, lookup food and activity


(a)




(b)




(c)

**figure 3 –** Screenshots of the second prototype. (a) is the new caloric balance page. (b) is the history page. (c) is the new main menu page.

information and set the times of daily reminder prompts (Figure 2a). Current caloric balance is given as a sum of calorie counts for diet, activity and Resting Metabolic Rate (RMR) (Figure 2b). Lists of food items are categorized by six meal types to facilitate navigation—breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack (Figure 2c). Calorie consumption is tracked by these meal types to help in identifying behavioral patterns. To add food intake, users must first select the meal type and then select a food from the associated food list. These meal "cheat sheets" are specified by the user during the web-based setup process. To add a food not in the cheat sheet, users can either search for the food or select the food item from a comprehensive list of foods by selecting the "more foods" option. Entering in a physical activity is designed as a similar process, with physical activities separated by locations (e.g. Home, Gym, Work). An option to manually enter a calorie intake and expenditure amount is available in case the food or activity is not in our database. Users may also enter a step count and have it be converted to a calorie amount (for use with pedometers). All entries are logged with a timestamp.

## Evaluation

To inform the design evolution of our prototype, we conducted an in-lab, formative evaluation of PmEB with seven experts of health intervention, mostly comprised of researchers in the UCSD PACE group.

### Method

We conducted task-driven interviews one participant at a time. Each participant was asked to perform ten primary functions of PmEB as we timed how long they took to complete them. We encouraged our participants to think aloud through the process. As they performed each task, we noted user interface issues that caused confusion, frustration or otherwise made it difficult to perform the task quickly and with ease.

After completing all seven individual interviews, we held a discussion session with four of the participants. During this session, participants critiqued the application and its functionality, discussed user interface issues they thought needed work, and brainstormed alternative designs.

### Results from Evaluation Study

Our participants generally liked our application and thought it was easy to use. However, three major user interface issues stood out as needing improvement. First, we noticed that the current caloric balance page sometimes caused confusion and took quite a cognitive effort to interpret. Our goal was for it to be quick, intuitive, and easy. Second, our participants suggested allowing users to view a history of past entries, with an option to modify and/or delete them. Our application at the time had no support for doing this. Third, some of our participants easily got lost on what page they were on, asking questions like "am I in the main menu now?"

We resolved these issues by 1. creating an intuitive, graphical display of the current caloric balance, 2. adding a history page to record previous entries that were made, and 3. adding unique icons for each major pages to allow users to quickly identify where they were in the application (See Figure 3).

## User Study

After completing the changes discussed above, we

conducted an exploratory week-long user study with six participants who are clinically overweight.

### Participants

Participants were recruited by word-of-mouth and emails through friends and family. The six chosen participants consisted of working professionals and a retiree, ages 32-78, three male and three female. All were regular cell-phone users. Their body-mass index varied between 28 to 34, which is in the clinically overweight and obese range. Three participants were on a diet plan at the time, and employed other forms of self-monitoring including memory, writing in a calendar and filling out daily forms.

### Method

The study was conducted in three steps: a pre-study interview, a week-long deployment, and a post-study interview. The pre-study interview began with a questionnaire regarding demographic information, mobile phone usage habits, and current weight-control methods employed by the participant, if any. We set up the application to incorporate the users' weight, frequent foods, and activity locations and then provided each participant with a Nokia 6600 and a pedometer to use during the study. We provided a general walk-through of the application and also provided them with a 13-page manual detailing use of the application. We asked the participants to incorporate the application into their daily lives and routines, using the application to record calorie information whenever appropriate.

The study concluded with each participant returning their Nokia 6600 and a 45 minute post-study interview that included a questionnaire regarding their experiences and a discussion of their responses.

## Key Findings

Our results were analyzed based on three key assessments: 1) user compliance, 2) usability and user satisfaction, and 3) users' reports on the impact on their dietary and activity habits.

### User Compliance

Four of the six participants used the application daily throughout the full week. One participant stopped using it after the first day upon becoming frustrated with the user interface. It should be noted, however, that this participant was 78 years old. Another participant stopped using it 3 days after being frustrated with a bug in the application. The average number of times per day that each participant interacted with the application ranged from 2 to 4.

### Usability and User Satisfaction

We received generally positive responses regarding the usability of our application. Five participants thought that the application behaved as expected and provided them with functions they expected. However, they also reported being frustrated with the application at least one point during their trial periods. Based on discussions with the participants, we attribute this to the lack of a comprehensive food database. All of our participants reported that at least one food item they had eaten weren't in the database. When this happened, they had to resort to "guestimating" the amount of calories and entering it in manually.

Nevertheless, four participants thought the application was enjoyable, intuitive, and easy to use and navigate. Five participants said that they would recommend the application to their family and friends. When asked whether they would purchase the application for a

monthly fee, five answered yes for a fee ranging from $15 to $20.

### Impact on Users' Dietary and Activity Habits

All but one participant said the application generally helped to change their nutrition and physical activity habits. All but one also said the application motivated them to balance their calories. Two remarked that an especially motivating factor was the fact that the data was being sent to a remote server, where health counselors or even family and friends could monitor their progress. One participant commented:

> *You cheat yourself all the time, but when you feel that someone is watching you, you become more motivated* [to comply honestly].

Another participant commented that the reminder messages helped him plan, and that motivated him to eat and exercise better. Three also commented that the application encouraged them to read the nutrition labels, raising awareness of their calorie intake.

## Conclusion and Future Work

PmEB addresses the challenge of improving user compliance, data reliability, and self-efficacy of self-monitoring of calorie intake and expenditures. Preliminary results have shown that PmEB has promising potential for facilitating weight loss and management. Future work includes expanding the food database and developing a web-based interface to allow users to view and analyze data on the server. Following this, we will conduct a month-long feasibility study with 30 participants—20 participants using PmEB and 10 participants using paper-and-pencil monitoring. Primary measures of feasibility will be user compliance and user satisfaction. Secondary measures will be impact on self-efficacy, physical activity, diet, and BMI.

## Acknowledgements

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