Design, Development, and Formative Evaluation of a Smartphone Application for Recording and Monitoring Physical Activity Levels: The 10,000 Steps "iStepLog"

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Abstract

Objectives. Limited research exists addressing the development of health-related smartphone apps, a new and potentially effective health promotion delivery strategy. This article describes the development and formative evaluation of a smartphone app associated with a physical activity promotion website. *Methods.* A combination of qualitative and quantitative techniques (performance measures, direct observation, and subjective participant preferences) were implemented during two usability testing sessions (pre- and postmodification) while participants were completing tasks using the app. *Results.* Design improvements to the app resulted in a reduction in the problems experienced and a decrease in the time taken to complete tasks. Four usability themes emerged from the data: design, feedback, navigation, and terminology. *Conclusion.* This study demonstrates the relevance of usability testing to the design and modification of a smartphone app related to a health promotion website. This study resulted in an app with much higher usability, which might increase usage and maintenance of health behavior change in the long term. *Practical implications.* This study demonstrates the need for formative evaluation in health-related smartphone apps. Attention should be given to basic design principles as well as feedback, navigation, and terminology in order to ensure utility and ease of use of future smartphone app designs.

Keywords

communication technology, formative evaluation, health promotion, physical activity/exercise, qualitative methods, web-based health education

Physical inactivity is the fourth leading risk factor for global mortality (World Health Organization, 2010a). Regardless of the widespread understanding of the benefits of a physically active lifestyle, rates of inactivity remain high (World Health Organization, 2010b). More than 60% of the world's population is insufficiently active to gain health benefits (World Health Organization, 2008). Researchers have attempted to better understand what factors lead to physical activity behavior, by attempting to identify its correlates. Self-regulatory behaviors, in particular the self-monitoring of physical activity levels, have been found to be an important contributor to maintaining an active lifestyle (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). Self-monitoring one's behavior as proposed in self-regulation theory (Bandura, 1991) is important, as it permits individuals to be aware of their current behaviors and to track their performance in comparison to specific goals (Wing & Phelan, 2005) or physical activity guidelines (Department of Health and Ageing, 1999). Various studies have shown that self-monitoring of health behaviors is correlated with improved health outcomes, increasing

physical activity levels (Conroy et al., 2010), and weight loss (Neve, Morgan, & Collins, 2011; Wing & Phelan, 2005). In an attempt to reduce current rates of inactivity, many behavioral modification programs using the Internet as a delivery mechanism have been developed (Feil, Glasgow, Boles, & McKay, 2000; Glasgow, Boles, McKay, Feil, & Barrera, 2003; Hageman, Walker, & Pullen, 2005; Kosma, Cardinal, & McCubbin, 2005). As the Internet can be accessed anywhere at any time, by ever-growing proportions of the population (Smith, 2010a), and has an extensive range of capabilities, such as providing

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efficient, interactive, and tailored content to the user (Ritterband, Thorndike, Cox, Kovatchev, & Gonder-Frederick, 2009), it is a popular platform to engage participants in the self-monitoring of physical activity levels, with the intention to improve an individual's health (Anderson-Bill, Winett, Wojcik, & Williams, 2011; Conroy et al., 2010; Harvey-Berino, Pintauro, Buzzell, & Gold, 2004; Harvey-Berino, Pintauro, & Gold, 2002). One such program is the 10,000 Steps project (www.10000steps.org.au).

The 10,000 Steps project is an online physical activity health promotion program that encourages the use of step-counting pedometers to monitor daily physical activity levels (Brown, Eakin, Mummery, & Trost, 2003; Brown, Mummery, Eakin, & Schofield, 2006). The 10,000 Steps website applies interactive features that encourage participants to be active. One of the most prominent features is the "Step Log," where participants can record and monitor their daily physical activity levels (Joyner & Mummery, 2006). The popularity of the program with the general public is shown through the increased number of members: In June 2006, Mummery, Schofield, Hinchliffe, Joyner, and Brown (2006) reported that the website had 18,000 registered members; as of November 2011, membership has grown to more than 178,600 (Hall, Corry, Hooker, Connolly, & Duncan, 2011). A study examining the usability and usefulness of the 10,000 Steps website, observed that 97% of current step log users reported that the daily steps entry functionality was useful or very useful (Joyner & Mummery, 2006).

There is substantial evidence that the more frequently individuals engage with an online health intervention, the more likely they are to improve or maintain health-related behaviors (McKay, King, Eakin, Seeley, & Glasgow, 2001; Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). However, reviews point out that engagement with website-delivered physical activity interventions is low and that to be more effective in terms of long-term behavior change and maintenance, efforts need to be undertaken to increase engagement (Vandelanotte, Spathonis, Eakin, & Owen, 2007). One possible way to increase participant engagement is through focusing on increasing self-regulation by using innovative devices that allow quick and easy self-monitoring, such as smartphones.

The world is in the midst of a wireless communication revolution. Mobile phones are now more prevalent than computers or Internet access across the globe (Donner, 2008; Kolko, Rose, & Johnson, 2007). Simple mobile phones (call-and-text devices) have evolved into smartphones: sophisticated mini personal computers integrated with e-mail, Internet, and specialized applications. Smartphone sales have surpassed those of personal computers (International Data Corp, 2011), and with half of U.S. adult mobile phone owners now having applications on their phones (Purcell, 2011), the potential of these specialized applications to offer a new delivery mode for health behavior change interventions provides a relevant area for researchers to investigate. Using a smartphone application (or "app") rather than a desktop computer to self-monitor may increase an individual's level of self-monitoring, as a mobile phone is convenient and may be taken most places by the owner (Verkasalo, 2010). More frequently, self-monitoring is considered as engaging with the intervention at a higher level and may see greater improvements in health outcomes (Conroy et al., 2010; Neve et al., 2011).

Having apps on your smartphone and using apps are not synonymous. Of the 50% of adult mobile phone owners who have apps on their phone, it has been reported that only about two thirds (68%) are actually using them (Purcell, 2011). A study by Park and Chen (2007), which was based on the technology acceptance model (Davis, 1989), has shown that a high level of perceived usefulness and ease of use of a smartphone device significantly influences the attitude of a user and the likelihood of him or her adopting the technology. The technology acceptance model has been applied broadly, and the findings that perceived usefulness and ease of use influence the adoption and acceptance of a technology is not limited to smartphones and has been observed for a number of different technologies: e-mail, voice mail, word processing applications (Adams, Nelson, & Todd, 1992), e-commerce (Hernández-García, Iglesias-Pradas, Chaparro-Peláez, & Pascual-Miguel, 2011), and e-learning systems (Šumak, Heričko, & Pušnik, 2011). Thus, conducting usability testing on a newly developed health-related smartphone app is an important first step to understanding the role the app may have in affecting the health behaviors of individuals who adopt the technology. For smartphone apps to facilitate health behavior change, the strategic conceptualization, design, development, and formative evaluation of such apps in both laboratory and real-world settings is required, even before efficacy is evaluated. Formative evaluation in health promotion programs is well established as a fundamental method for obtaining user feedback in the early stages of designing and developing intervention tools (Nutbeam & Bauman, 2006).

The Step Log function on the 10,000 Steps website (http://www.10000steps.org.au) is the catalyst for members to record and monitor their physical activity levels. Considering the popularity of smartphones and their potential to deliver health care interventions, a specialized app (iStepLog) was developed to mimic the current online step recording functionality of the 10,000 Steps website. Evaluating the usability of this app is imperative to ensure that usability issues are identified and user experiences are positive. Therefore, the aim of this study was to evaluate the design and usability of a physical activity self-monitoring smartphone app, using both quantitative and qualitative measures.

Method

Participant testing occurred in two phases. Premodification testing was conducted to identify usability issues with the

initial app by asking participants to complete a series of predefined basic operation tasks. The app was then modified based on recommended changes identified from the first phase of testing. A separate sample of participants completed the same series of tasks during the postmodification testing to examine the effectiveness of the modifications.

Participants

Participants were recruited via an e-mail sent to 10,000 Steps members living in Rockhampton, Australia (*n* = 1050) and Rockhampton-based staff from CQUniversity (*n* = 260). Twenty people (8 female) responded to the e-mail, of which 12 met the inclusion criteria of being an adult (≥18 years) having used an iPhone or iPod Touch for more than a month and being available to attend the lab-based usability-testing sessions. The 10,000 Steps program is aimed at adults, and the study required participants to have a smartphone compatible with the app we developed to limit the influence of user inexperience. It has been reported that conducting usability testing with just 5 participants will reveal 85% of usability problems (Nielsen, 1993; Nielsen & Landauer, 2000); thus, having 6 participants for both the pre- and postmodification usability sessions was sufficient for our purposes. When investigating the usability of an early prototype, such as the iStepLog app, a representative sample is not needed to produce valid and usable outcomes (Nielsen, 1993; Nielsen & Landauer, 2000). No incentives were offered to participants to join in this research.

Procedures and Measures

Three usability evaluation methods were used to collect both qualitative and quantitative data during both testing sessions (Hallahan, 2001; Hughes, 1999; Osterbauer, Kohle, Grechenig, & Tscheligi, 2000). First, participants were asked to perform a series of identified tasks using a fully developed version of the iStepLog app on an iPhone 3G. These tasks included the following:

1. Login to the iStepLog app using your own details, that is, e-mail address and password.
2. Enter a specified number of steps and physical activity on specified dates.
3. Edit and update information on one of the previously entered dates.
4. Synchronize the app with the website.
5. Edit information on previously entered dates and synchronize the app with the website to update information.

Participants were videotaped while conducting the tasks, and using this recording the time to complete each task was measured (in seconds). Second, while completing the tasks, participants were required to "think aloud." This method

requires participants to verbalize their actions, thoughts, and perceptions of the use of the app. This method allows the participants to effectively comment on how they are interacting with the app, what they are attempting to do, how they feel, and when they encounter problems. This method is also beneficial as it occurs simultaneously while the participant interacts with the app and does not rely on self-report measures, which can lead to incorrect or incomplete accounts of participants' actions (Nielsen, 1993).

Third, immediately following the completion of the tasks the participants were asked to complete a four-item usability questionnaire, using a 5-point Likert-type scale (1 = *strongly disagree*, 5 = *strongly agree*). The questions were used to assess subjective usability and were based on similar questions from a study evaluating the usability of the 10,000 Steps website (Hinchliffe & Mummery, 2008):

1. I think the iStepLog application is user-friendly.
2. I like the overall presentation of the iStepLog application.
3. I like the overall layout of the iStepLog application.
4. I was able to easily find my way around the iStepLog to complete the tasks.

Following the completion of the questionnaire, a semistructured interview was conducted (Table 1). During the interview, the participants were asked to provide additional feedback on their experience with the app (design, navigation, likes/dislikes), to elaborate on any problems, and to provide any suggestions or recommendations for improvement. Only one participant at a time was tested, and the tests were conducted by the primary investigator at the Institute for Health and Social Science Research's Population Research Laboratory, CQUniversity. Ethical approval was gained from CQUniversity Human Research Ethics Committee prior to commencement.

Analysis

Data analysis involved using a triangulation approach (Rice & Ezzy, 1999) to couple the data from the three usability evaluation methods, as this provides a comprehensive picture of the end users' responses to the app's usability (Jansky & Huang, 2009). For both the first usability-testing session (premodification) and second usability-testing session (postmodification), the audios from the video recording for each participant's tasks and semistructured interview were transcribed verbatim. The transcripts were then systematically scanned for critical episodes identifying any positive comments, recommendations, as well as problems, confusion, misunderstandings, or difficulties the participant may have experienced while using the app. In accordance with methods described by Patton (2002), transcripts and notes taken from the semistructured interviews were collated and a coding scheme

Table 1. Semistructured Interview Guide

Question	Prompt
1. What did you like about using the app?	What in particular did you like about that …?
	Can you tell me more about … Why do you think that is?
2. What did you not like about the app?	What in particular didn't you like about that …?
	Can you tell me more about it? Why do you think that is? How did it make you feel?
3. Are there any parts of the app which you found confusing or difficult to use / understand?	What in particular was confusing about that …?
	Can you tell me more about …? Why do you think that is? How could it be improved?
Here ask further questions related to particular instances where you observed the user to have hesitated or struggled to complete a task or showed confusion or uncertainty. Ask the user to expand on what was happening in that moment and how the design may be improved to prevent that happening in the future. For example, "I noticed on the login screen you were unsure of what the 'New User' icon did. . . . what did you think the 'New User' icon would do if you tapped it?"	
4. Now that you have used the app what changes would you suggest to improve it?	Why do you think that would improve it?
	Prompt interviewee in terms of screen design, colors, fonts, imagery, placement of elements on screen, gestures used, content, menu design, ease of use, consistent look/feel, learnability
5. Are there any parts of the app that should stay the same?	Can you tell me more about it? Why do you think that?
6. What apps do you use frequently?	Is there anything about those apps that you think we could adopt to improve ours?

was developed by the primary investigator in consultation with the other research team members. Outcomes were also discussed and interpreted with the software developer for the iStepLog app, which lead to the development and extraction of distinctive usability themes. The themes identified in the premodification testing phase were used as a guide to improve the design and functionality of the app. A comparison was made between each testing phase in terms of the number of problems encountered, time taken to complete tasks, and survey data to indicate change in usability. Descriptive statistics were used to analyze problem counts and time taken. Independent t tests and Mann–Whitney U tests (to examine differences in the applications usability pre- and postmodification) were conducted on the total time taken to complete all tasks and the mean usability score of the four questionnaire items. As there were no differences between both tests, only the t-test outcomes were reported. Statistical analysis was undertaken using SPSS, Version 18.0, with the significance level being set at α = .05.

Results

Participants

Twelve participants were recruited, and they covered a diverse age range (25-71 years) and included six females (age 33.0 ± 5.1 years) and six males (age 37.2 ± 17.2). Ninety percent of participants were Caucasian, with the remainder being Asian, and all had higher education

qualifications. Each participant had used an iPhone or iPod Touch for more than a month (M = 8.9 ± 3.6 months).

Identification of Problems

The five tasks completed by the premodification group revealed a total of 19 problems. These problems could be categorized under four themes: design, feedback, navigation, and terminology. These four themes are presented in detail in Table 2 with a description and example quotes from participants. The premodification group experienced four design, five feedback, four navigation, and five terminology problems. The postmodification group experienced one design and one navigation problem.

Informing the App Modifications

A combination of individual problems and emergent themes highlighted the areas of the app in which participants experienced difficulty. It was identified that logging into the app was the most problematic function, with poor design and misleading terminology on the login screen accounting for one third of all problems experienced. Positive comments recorded during testing were also used to ensure that the recommendations for the modifications did not eliminate the features and functionality that the participants positively commented on during the premodification phase. Figures 1 through 3 provide examples of the design of the app pre- and postmodifications.

Table 2. Codes and the Corresponding Usability Themes, Including a Definition and Example Quotes

Codes: Term or Phrase	Themes	Definitions	Examples From the Premodification Group
Visual element Placement Menu Color Aesthetics Size of element Buttons Screen design Font Layout	Interface design	This theme refers to the design and layout, including consistency, location of icons, and functions on each screen. Includes content, font, color, density, placement, images	"Previous month link is not large enough; finger keeps slipping onto the sync tab." "The font of the dates could be bigger so my finger doesn't slip." "I would prefer a table view rather than tab bars."
Learnability Sync status Color after sync Response time Gestures	Feedback	The application provides feedback to assist users in recovering from errors or guide them in completion of tasks	"Colour was a good indication of sync status, though the screen being gray afterwards confused me."
Link Navigate Scrolling Screen composition Knowing where I am Predictable	Navigation	Navigation refers to the way a user navigates throughout the application to complete tasks. Includes clear icons, tab views, and buttons and recognition of these so the users know where they are within the application at all times and how to get back to where they came from	"My first inclination is to go to bottom right-hand corner to 'save' rather than top left." "Possible calendar layout could be good alternative to scrolling to find a date." "Scrolling down so far is annoying."
Meaning of button Language Errors	Terminology	Terminology reflects the user's ability to identify with and understand the language used within the application. The language used should be consistent with native iPhone applications and the 10,000 Steps website terminology	"The 'New Member' button was misleading— am I new because I am using the app for the first time?" "Had trouble understanding the 'done' button, would prefer it to be 'save' or 'enter.'"

Redesign

In the redesign of the iStepLog app, the changes adopted were limited not just to the design of the interface, structure, or functionality but also to the responsiveness of the app to gestures from participants. Many of the design changes were identified from the video recording, most noticeably when participants would pause with their finger hovering above an icon, unsure of their next move or why the app had not responded. The think-aloud method was valuable for identifying confusion with the login screen terminology and the menu structure. Logging into the app was by far the most difficult task for users in the premodification group to complete. This was because four of the six participants in the premodification group showed confusion when trying to enter their e-mail address and password into the login screen; instead they clicked on the "New Member" button (Figure 1A). The common explanation was that this was their first time logging in using the iStepLog, so they considered themselves to be "New"; whereas in reality the "New Member" button related to people who had never used the

10,000 Steps program before, including the website version of the program, which was not the case for the participants in this study. All of these users corrected their error but noted that the "New Member" button was confusing. When a user had successfully entered his or her details and clicked "Go" on the keyboard, the app paused for approximately 3.5 seconds while processing this information. This pause also caused confusion to many users who thought they had done something incorrectly, and so they attempted to tap the screen to rectify the issue. To address these design concerns, the login screen was reconfigured so that when a user first opened the app, the cursor was flashing in the e-mail text icon (Figure 1B), prompting the user to enter his or her e-mail address. Additionally the "New Member" button was reworded to "Not a 10,000 Steps member? Join for FREE." This change to the terminology saw a significant improvement in users' understanding of how to login. Furthermore, a "Logging In" processing icon (Figure 1C) was added to reassure users their details were being processed. Similarly, a progress bar was added to the design of syncing steps screen, confirming to the user that pressing the "sync" icon

Figure 1. Login screen changes: (A) premodification screen; (B) postmodification screen—positioning of elements has changed, keyboard automatically appears, and cursor flashes to prompt user; (C) postmodification screen—a "logging in" icon communicates that the user's request is being processed

synchronized their steps with their online profile on the 10,000 Steps website (Figure 2). The logging steps screen was redesigned with a flashing cursor and keyboard automatically appearing, prompting the user to enter his or her steps (Figure 3). This redesign not only helped users know what to do but also reduced the number of gestures needed to enter and edit step entries, increasing the efficiency of this task.

Comparing the Pre- and Postmodification Results

The mean time taken to complete the five tasks in the premodification group (403.9 ± 159.6 seconds) was significantly greater, $t(10) = 2.655$, $p = .042$, compared with postmodification (182.1 ± 44.5 seconds). This translates to a 55% decrease in time to complete tasks. This significant improvement in the time taken to complete tasks is explained by the premodification group experiencing a total of 19 problems and the postmodification group experiencing a group total of 2. Table 3 provides a breakdown of the time

taken by each group to complete the assigned tasks and the corresponding number of problems experienced. Analysis of the usability questionnaire items did not show a significant improvement in the overall usability score, $t(10) = -1.451$, $p = .181$, between the premodification group ($M = 4.58$, $SD ± 0.47$) and postmodification group ($M = 4.25$, $SD ± 0.32$), although the scores were high for both groups indicating a high level of usability.

Discussion

The purpose of this study was to formally evaluate the usability of a prototype of the 10,000 Steps iStepLog smartphone app with the intent of improving the app. A number of usability evaluation methods were used to gather data before and after design changes. Pre- and postmodification comparisons highlighted the improvements made to the app, including a large decline number of problems and increased performance. Had a triangulation approach not been taken, some of these problems and subsequent improvements to the

Figure 2. Sync to web screen changes: (A) premodification; (B) postmodification—addition of a progress bar to demonstrate to users that their request is being processed

app may have been overlooked. Results from this study showed that the design changes significantly reduced the time taken for participants to complete the assigned tasks for which the app was designed. This is in line with a usability study conducted previously on the 10,000 Steps website that improved task efficiency by approximately 52% (Hinchliffe & Mummery, 2008). Interestingly, there was no improvement in participants' perceptions of usability with the app; however both the pre- and postmodification groups reported high levels of usability indicating a potential ceiling effect. Despite the premodification group experiencing a higher number of problems in completing the allocated tasks, both groups still considered the iStepLog app to have a usable design, agreeing that the overall presentation and layout was user-friendly. Perhaps this is because participants in either group were able to complete all the tasks successfully no

matter how many errors they made: Participants were always able to correct their errors and carry on.

As physical inactivity is a global public health problem (World Health Organization, 2008), new avenues to engage the populous in physical activity interventions are needed. There is substantial evidence that online physical activity promotion programs are successful in producing short-term behavior change (McKay et al., 2001; Napolitano et al., 2003; Spittaels, De Bourdeaudhuij, & Vandelanotte, 2007). However, high attrition rates in these programs is a significant problem (Leslie, Marshall, Owen, & Bauman, 2005; McKay et al., 2001; van den Berg et al., 2007), and it has been demonstrated that less exposure to the intervention results in a lower overall effectiveness of the program (Draper, Jennings, Barón, Erdur, & Shankar, 2000). Hence, there is consensus that more research is needed to examine
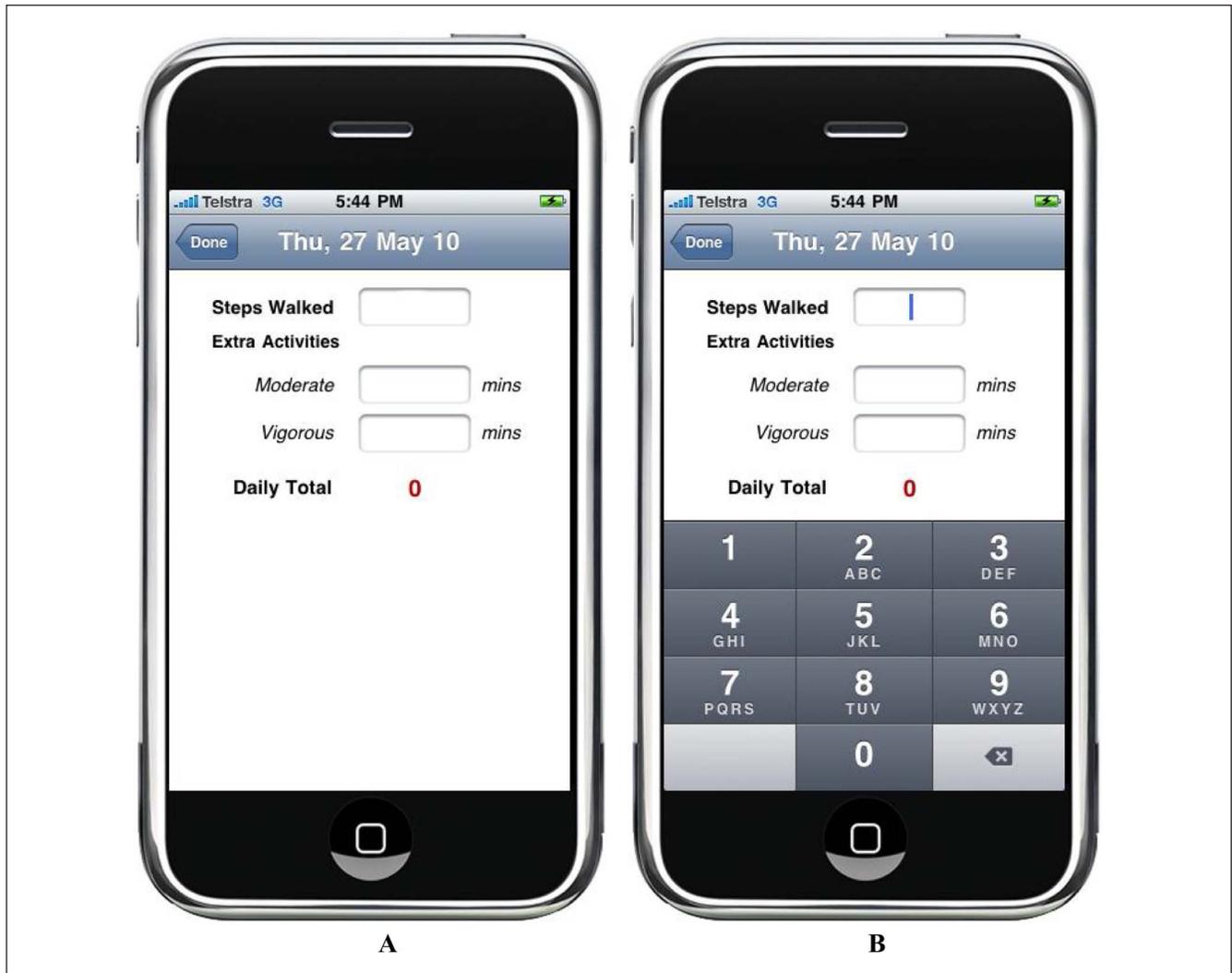
Figure 3. Logging steps screen changes: (A) premodification; (B) postmodification—cursor and keyboard automatically appear to prompt user for entry

avenues that may enhance program engagement (Leslie et al., 2005; Steele, Mummery, & Dwyer, 2007; Verheijden, Jans, Hildebrandt, & Hopman-Rock, 2007). As such, the development of innovative handheld technology has been highlighted as a potential tool for individuals to use in order to further engage in an intervention (Conroy et al., 2010; Krebs, Prochaska, & Rossi, 2010), concomitantly supporting the self-monitoring of physical activity levels, which is known to be a moderator of behavior change (Anderson, Wojcik, Winett, & Williams, 2006; Bandura, 1997, 2004; Gleeson-Kreig, 2006). In the case of the 10,000 Steps program, the iStepLog app may prove to be an effective avenue to further engage participants in self-regulation, thus assisting them in improving and maintaining their physical activity levels over a longer period of time. However, further effectiveness testing is required, but it is important to

acknowledge that for this approach to be effective, it is essential that the app has a high level of usability to facilitate the adoption and usage of the technology (Verkasalo, 2010).

When testing the iStepLog app, four usability themes emerged and were used to categorize the identified problems. These themes—interface design, feedback, navigation, and terminology—correlate closely to principles outlined in Apple's® (2008) "iPhone Human Interface Guidelines." Apple in 2008 distributed a formal guide to all app developers, outlining not only the minimum requirements for distribution in iTunes but also "optimal" principles to follow when designing the app to ensure it is user-friendly: a trademark of all Apple products. In congruence with the themes established in this research, Apple (2008) recommends that the interface design be easy for users to input their choices,

Table 3. Time Taken in Seconds to Complete Tasks and Problem Counts

Tasks	Premodification Group (*n* = 6)		Postmodification Group (*n* = 6)	
	Time Taken (*M* ± *SD*)	Problem Counts	Time Taken (*M* ± *SD*)	Problem Counts
Task 1: Logging in	57.6 ± 14.0	7	27.9 ± 16.1	1
Task 2: Logging steps	141.2 ± 69.5	4	75.1 ± 11.2	0
Task 3: Syncing steps	22.8 ± 6.7	3	12.7 ± 7.8	0
Task 4: Editing steps	47.3 ± 65.3	1	14.6 ± 11.5	1
Task 5: Editing and syncing steps	134.7 ± 82.2	4	51.6 ± 11.7	0
Total (seconds)	403.9 ± 159.6	19	182.1 ± 44.5	2

with a focus on minimizing the effort required for input and giving tappable elements on the app sufficient spacing. In terms of feedback Apple emphasizes the subtle use of animation to communicate and support gestures made by users. Apple also recommends offering users a logical path to follow in terms of navigation and the avoidance of technical terminology. It is recommended that organizations developing or maintaining a health-related smartphone app should consider the four themes identified in this study to guide, but not limit, their testing.

All too often individual adoption and usage of interactive health technologies are hampered by their poor design, which ensures that they are difficult to learn and complicated to use (Jaspers, 2009). Both quantitative and qualitative studies have highlighted examples whereby a lack of usability testing has lead to problems within health care systems, for example, errors concerning the ordering of laboratory tests (Peute & Jaspers, 2007), the entering and retrieving of patient information (Ash, Berg, & Coiera, 2004; Campbell, Guappone, Sittig, Dykstra, & Ash, 2009; Campbell, Sittig, Ash, Guappone, & Dykstra, 2006), the ordering of medications (Koppel et al., 2005), and the writing of prescriptions (Kushniruk, Triola, Borycki, Stein, & Kannry, 2005). Such medical errors have been correlated with higher levels of patient mortality (Han et al., 2005). Consequently, usability assessment is now widely recognized as critical to the success and uptake of handheld health related systems (Jaspers, 2009). Conducting usability testing on new health technologies is necessary and can provide great improvements in intervention quality with little effort. Hence, it is important that the outcomes of usability studies, such as the one presented here, are published in order to help others in developing effective tools to improve health. A new era of research is currently breaking ground, which includes the systematic examination of smartphone apps and their effectiveness in improving health behaviors (Abroms, Padmanabhan, Thaweethai, & Phillips, 2011). Despite the plethora of health-related smartphone apps currently available (Smith, 2010b), little research concerning the usability and perceived ease of use of these apps has been published (Koskinen & Salminen, 2007; Mattila, 2010).

App Design Recommendations

In conjunction with guidelines provided by Apple (2008) and by Google (2012), there are a number of recommendations for designing and developing health-related apps that can be made following from this study specifically. First, future designers should not underestimate the importance of on building on learned behaviors. It is helpful to understand the design patterns of the most popular health-related apps, as smartphone users are accustomed to the appearance and behavior of their favorite apps and tend to expect similar experiences in the new apps they download. Second, new apps must be tested "in-house" before conducting structured usability testing. The iStepLog app underwent numerous phases/prototypes prior to any end user usability testing being conducted. These phases were, in chronological order, the development of paper-based pictorial design/layout sketches, discussions with colleagues to walk through the app features and navigation, development of an electronic clickable PDF document to highlight navigation and gain feedback from colleagues, and finally the distribution of a prototype on the platform for preliminary identification of issues and "bugs." This process was particularly useful when using individuals with experience in the use of smartphones. Third, field testing is an important next step to take after the lab-based testing is completed, in order to ensure that users have a positive experience with app in the real world and that any bugs that were not revealed in the lab are ironed out.

Limitations

A usability study that examines a variety of issues, such as interface design, user-perceived ease of use and usefulness, and application performance–related measures, should ideally be conducted in both a laboratory and field setting (Zhang & Adipat, 2005). However, because of limited time and resources, the current research only investigated usability in a laboratory setting, limiting the ability to generalize the findings.

It should also be mentioned that although smartphone use is on the rise (Smith, 2011), certain population segments

do not own smartphones and will be not be reached through interventions that use these devices. However, it should also be noted that smartphone ownership is growing in minority groups and that many non-White, low-income, and less educated smartphone users use their device as their primary means of accessing the Internet (Smith, 2011), and as such, smartphones might actually be instrumental in bridging the digital divide.

Conclusion

The outcomes of this research highlight the importance of design for smartphone apps integrated in health promotion projects. The results of this study informed the redesign of the app and thus provided essential information for software engineers to develop a fully functioning version of the app. The provision of a well-functioning and usable app may increase participant use, which may lead to greater or more sustained behavior change; however such real-world efficacy testing remains to be conducted.

Practical Implications

Smartphones and their related apps represent an innovative alternative or additional medium for the delivery of health care intervention programs. Therefore, it is imperative that the aspects of design, development, and usability evaluation outcomes be shared. Conducting systematic usability testing on emerging health-related smartphone apps allows researchers to better understand the factors that may hinder or drive the usage of these apps. These factors will give investigators a better grounding of how to use this popular technology to better engage populations in adopting and maintaining health behaviors.

Declaration of Conflicting Interests

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References

Abroms, L. C., Padmanabhan, N., Thaweethai, L., & Phillips, T. (2011). iPhone apps for smoking cessation: A content analysis. *American Journal of Preventive Medicine, 40*, 279-285.

Adams, D. A., Nelson, R. R., & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly: Management Information Systems, 16*, 227-247.

Anderson-Bill, E. S., Winett, R. A., Wojcik, J. R., & Williams, D. M. (2011). Aging and the social cognitive determinants of physical activity behavior and behavior change: Evidence from the Guide to Health Trial. *Journal of Aging Research*. Advance online publication. doi:10.4061/2011/505928

Anderson, E. S., Wojcik, J. R., Winett, R. A., & Williams, D. M. (2006). Social-cognitive determinants of physical activity: The influence of social support, self-efficacy, outcome expectations, and self-regulation among participants in a church-based health promotion study. *Health Psychology, 25*, 510-520.

Apple, Inc. (2008). *iPhone human interface guidelines*. Retrieved from http://developer.apple.com

Ash, J. S., Berg, M., & Coiera, E. (2004). Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *Journal of the American Medical Informatics Association, 11*, 104-112.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*, 248-287.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior, 31*, 143-164.

Brown, W., Eakin, E., Mummery, W. K., & Trost, S. (2003). 10,000 steps Rockhampton: Establishing a multi-strategy physical activity promotion in a community. *Health Promotion Journal, Australia, 14*, 95-100.

Brown, W., Mummery, W. K., Eakin, E., & Schofield, G. (2006). 10,000 steps Rockhampton: Evaluation of a whole community approach to improving population levels of physical activity. *Journal of Physical Activity & Health, 3*, 1-14.

Campbell, E. M., Guappone, K. P., Sittig, D. F., Dykstra, R. H., & Ash, J. S. (2009). Computerized provider order entry adoption: Implications for clinical workflow. *Journal of General Internal Medicine, 24*, 21-26.

Campbell, E. M., Sittig, D. F., Ash, J. S., Guappone, K. P., & Dykstra, R. H. (2006). Types of unintended consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association, 13*, 547-556.

Conroy, M. B., Yang, K., Elci, O. U., Gabriel, K. P., Styn, M. A., Wang, J., . . . Burke, L. E. (2010). Physical activity self-monitoring and weight loss: 6-month results of the SMART trial. *Medicine & Science in Sports & Exercise, 43*, 1568-1574.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems, 13*, 319-339.

Department of Health and Ageing. (1999). *National physical activity guidelines for Australians*. Canberra, ACT, Australia: Author.

Donner, J. (2008). Research approaches to mobile use in the developing world: A review of the literature. *Information Society, 24*, 140-159.

Draper, M., Jennings, J., Barón, A., Erdur, O., & Shankar, L. (2000). *Dose–effect relationships in brief therapy based on a nationwide college counseling center sample* (Research Report No. 1). Austin: The University of Texas at Austin.

Feil, E. G., Glasgow, R. E., Boles, S., & McKay, H. G. (2000). Who participates in Internet-based self-management programs? A study among novice computer users in a primary care setting. *The Diabetes Educator, 26*, 806-811.

Glasgow, R. E., Boles, S. M., McKay, H. G., Feil, E. G., & Barrera, M., Jr. (2003). The D-Net diabetes self-management program: Long-term implementation, outcomes, and generalization results. *Preventive Medicine, 36*, 410-419.

Gleeson-Kreig, J. M. (2006). Self-monitoring of physical activity. *The Diabetes Educator, 32*, 69-77.

Google. (2012). *Android developers user interface guidelines*. Retrieved from http://developer.android.com/guide/developing/index.html

Hageman, P. A., Walker, S. N., & Pullen, C. H. (2005). Tailored versus standard Internet-delivered interventions to promote physical activity in older women. *Journal of Geriatric Physical Therapy, 28*, 28-33.

Hall, S., Corry, K., Hooker, C., Connolly, K., & Duncan, M. (2011). *Awareness of the 10,000 Steps Program across Queensland, 2011* (10,000 Steps Working Paper Series, Paper No. 14). Rockhampton, Queensland, Australia: Institute for Health and Social Science Research, CQUniversity.

Hallahan, K. (2001). Improving public relations web sites through usability research. *Public Relations Review, 27*, 223-239.

Han, Y. Y., Carcillo, J. A., Venkataraman, S. T., Clark, R. S. B., Watson, R. S., Nguyen, T. C., . . . Orr, R. A. (2005). Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. *Pediatrics, 116*, 1506-1512.

Harvey-Berino, J., Pintauro, S., Buzzell, P., & Gold, E. C. (2004). Effect of Internet support on the long-term maintenance of weight loss. *Obesity Research, 12*, 320-329.

Harvey-Berino, J., Pintauro, S. J., & Gold, E. C. (2002). The feasibility of using Internet support for the maintenance of weight loss. *Behavior Modification, 26*, 103-116.

Hernández-García, A., Iglesias-Pradas, S., Chaparro-Peláez, J., & Pascual-Miguel, F. (2011). Exploring the attitudes and intentions of non-shoppers in the acceptance of e-commerce. *Journal of Universal Computer Science, 17*, 1314-1328.

Hinchliffe, A., & Mummery, W. K. (2008). Applying usability testing techniques to improve a health promotion website. *Health Promotion Journal of Australia, 19*, 29-35.

Hughes, M. (1999). Rigor in usability testing. *Technical Communication, 46*, 488-494.

International Data Corp. (2011). *Worldwide quarterly mobile phone tracker*. Retrieved from http://www.idc.com/tracker/showproductinfo.jsp?prod_id=37

Jansky, L. J., & Huang, J. C. (2009). A multi-method approach to assess usability and acceptability: A case study of the patient-reported outcomes measurement system (PROMIS) workshop. *Social Science Computer Review, 27*, 262-270.

Jaspers, M. W. M. (2009). A comparison of usability methods for testing interactive health technologies: Methodological aspects and empirical evidence. *International Journal of Medical Informatics, 78*, 340-353.

Joyner, K., & Mummery, W. K. (2006). *Survey of current 10,000 Steps Step log users* (10,000 Steps Working Paper Series, Paper No. 3). Retrieved from http://www.10000steps.org.au/library/working-papers/

Kolko, B. E., Rose, E. J., & Johnson, E. J. (2007, May). *Communication as information-seeking: The case for mobile social software for developing regions*. Paper presented at the 16th International Conference on World Wide Web, Banff, Alberta, Canada.

Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. E., & Strom, B. L. (2005). Role of computerized physician order entry systems in facilitating medication errors. *Journal of the American Medical Association, 293*, 1197-1203.

Koskinen, E., & Salminen, J. (2007). A customizable mobile tool for supporting health behavior interventions. In *Conference Proceedings of the International Conference of IEEE Engineering in Medicine and Biology Society* (pp. 5908-5911). New York, NY: IEEE.

Kosma, M., Cardinal, B. J., & McCubbin, J. (2005). A pilot study of a web-based physical activity motivational program for adults with physical disabilities. *Disability and Rehabilitation, 27*, 1435-1442.

Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). A meta-analysis of computer-tailored interventions for health behavior change. *Preventive Medicine, 51*, 214-221.

Kushniruk, A. W., Triola, M. M., Borycki, E. M., Stein, B., & Kannry, J. L. (2005). Technology induced error and usability: The relationship between usability problems and prescription errors when using a handheld application. *International Journal of Medical Informatics, 74*, 519-526.

Leslie, E., Marshall, A. L., Owen, N., & Bauman, A. (2005). Engagement and retention of participants in a physical activity website. *Preventive Medicine, 40*, 54-59.

Mattila, E. (2010). *Design and evaluation of a mobile phone diary for personal health management* (VTT Publications 742). VTT Technical Research Centre of Finland. Retrieved from http://www.vtt.fi/inf/pdf/publications/2010/P742.pdf

McKay, H. G., King, D., Eakin, E. G., Seeley, J. R., & Glasgow, R. E. (2001). The diabetes network Internet-based physical activity intervention: A randomized pilot study. *Diabetes Care, 24*, 1328-1334.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*, 690-701.

Mummery, W. K., Schofield, G., Hinchliffe, A., Joyner, K., & Brown, W. (2006). Dissemination of a community-based physical activity project: The case of 10,000 steps. *Journal of Science and Medicine in Sport, 9*, 424-430.

Napolitano, M. A., Fotheringham, M., Tate, D., Sciamanna, C., Leslie, E., Owen, N., . . . Marcus, B. (2003). Evaluation of an

Internet-based physical activity intervention: A preliminary investigation. *Annals of Behavioral Medicine, 25*, 92-99.

Neve, M., Morgan, J. P., & Collins, E. C. (2011). Weight change in a commercial web-based weight loss program and its association with website use: Cohort study. *Journal of Medical Internet Research, 13*(4), e83.

Nielsen, J. (1993). *Usability engineering*. San Diego, CA: Academic Press.

Nielsen, J., & Landauer, T. (2000). *Why you only need to test with 5 users*. Retrieved from http://www.useit.com/alertbox/20000319.html

Nutbeam, D., & Bauman, A. (2006). *Evaluation in a nutshell: A practical guide to the evaluation of health promotion programs*. Sydney, New South Wales, Australia: McGraw-Hill.

Osterbauer, C., Kohle, M., Grechenig, T., & Tscheligi, M. (2000, June). *Web usability testing: A case study of usability testing of chosen sites*. Paper presented at the 6th Australian World Wide Web Conference, Cairns, Queensland, Australia.

Park, Y., & Chen, J. V. (2007). Acceptance and adoption of the innovative use of smartphone. *Industrial Management & Data Systems, 107*, 1349-1365.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3 ed.). London, UK: Sage.

Peute, L. W. P., & Jaspers, M. W. M. (2007). The significance of a usability evaluation of an emerging laboratory order entry system. *International Journal of Medical Informatics, 76*, 157-168.

Purcell, K. (2011). *Half of adult cell phone owners have apps on their phones*. Washington, DC: Pew Internet & American Life Project.

Rice, P., & Ezzy, D. (1999). *Qualitative research methods: A health focus*. Melbourne, Victoria, Australia: Oxford University Press.

Ritterband, L. M., Thorndike, F. P., Cox, D. J., Kovatchev, B. P., & Gonder-Frederick, L. A. (2009). A behavior change model for Internet interventions. *Annals of Behavioral Medicine, 38*, 18-27.

Smith, A. (2010a). *Home broadband 2010*. Washington, DC: Pew Internet & American Life Project.

Smith, A. (2010b). *Mobile access*. Retrieved from pewinternet.org/Reports/2010/Mobile-Access-2010/Summary-of-Findings.aspx

Smith, A. (2011). *Smartphone adoption and usage*. Washington, DC: Pew Internet & American Life Project.

Spittaels, H., De Bourdeaudhuij, I., & Vandelanotte, C. (2007). Evaluation of a website-delivered computer-tailored intervention for increasing physical activity in the general population. *Preventive Medicine, 44*, 209-217.

Steele, R., Mummery, K. W., & Dwyer, T. (2007). Development and process evaluation of an Internet-based physical activity behaviour change program. *Patient Education and Counseling, 67*, 127-136.

Šumak, B., Heričko, M., & Pušnik, M. (2011). A meta-analysis of e-learning technology acceptance: The role of user types and e-learning technology types. *Computers in Human Behavior, 27*, 2067-2077.

Vandelanotte, C., Spathonis, K. M., Eakin, E. G., & Owen, N. (2007). Website-delivered physical activity interventions: A review of the literature. *American Journal of Preventive Medicine, 33*, 54-64.

van den Berg, M. H., Ronday, H. K., Peeters, A. J., Voogt-van der Harst, E. M., Munneke, M., Breedveld, F. C., & Vliet Vlieland, T. P. (2007). Engagement and satisfaction with an Internet-based physical activity intervention in patients with rheumatoid arthritis. *Rheumatology, 46*, 545-552.

Verheijden, M. W., Jans, M. P., Hildebrandt, V. H., & Hopman-Rock, M. (2007). Rates and determinants of repeated participation in a web-based behavior change program for healthy body weight and healthy lifestyle. *Journal of Medical Internet Research, 9*(1), e1.

Verkasalo, H. (2010, June). *Analysis of smartphone user behavior*. Paper presented at the 9th International Conference on Mobile Business, Athens, Greece.

Wantland, D. J., Portillo, C. J., Holzemer, W. L., Slaughter, R., & McGhee, E. M. (2004). The effectiveness of web-based vs. non-web-based interventions: A meta-analysis of behavioral change outcomes. *Journal of Medical Internet Research, 6*(4), e40.

Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *American Journal of Clinical Nutrition, 82*(1), 222S-225S.

World Health Organization. (2008). *Physical inactivity: A global public health problem*. Retrieved from http://www.who.int/dietphysicalactivity/factsheet_inactivity/en/

World Health Organization. (2010a). *10 Facts on physical activity*. Retrieved from http://www.who.int/features/factfiles/physical_activity/en/

World Health Organization. (2010b). *Global strategy on diet and physical activity*. Retrieved from http://www.who.int/dietphysicalactivity/en/

Zhang, D., & Adipat, B. (2005). Challenges, methodologies, and issues in the usability testing of mobile applications. *International Journal of Human-Computer Interaction, 18*, 293-308.