Chapter 69

A Review of Web-Based Dietary Interventions From the HF/E Perspective

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ABSTRACT

Web-based dietary interventions have been widely used to change people's dietary behaviors and improve their health. Copious features and technologies have been developed and used: from a simple HTML page to interactive online games. Due to the variety of these features, a practitioner who plans to create or improve an intervention website may wonder which features should be used to maximize the impacts of a web-based intervention. Unfortunately, in spite of extensive literature review, we failed to find straightforward guidelines for practitioners. Thus, the aim of this study is to collect preliminary information to eventually create practical guidelines. We selected 47 papers regarding web-based dietary interventions and reviewed the papers to identify what kinds of technologies have been used and how these have impacted on measured outcomes. Through this review, we identified several interesting patterns, and their implications were discussed.

Keywords: Web-based dietary intervention, review, human-computer interaction

INTRODUCTION

Web-based interventions have been widely adopted by patients and family members to educate and manage their nutrition intakes (ChanLin, Huang, and K. C. Chan 2002). Many studies have been conducted to investigate the effectiveness of different approaches in web-based intervention, and several review studies (e.g., Lustria et al., 2009) summarized the outcomes of these studies. These studies generally proved the positive effects of web-based dietary interventions.

More specifically, the review studies generally emphasize the importance of the three general features, such as tailoring, monitoring, and social support. Rimer and Kreuter (2006) highlighted the importance of tailored information to individual users in health interventions. Self-monitoring to allow users to voluntarily assess the progress of their dietary interventions was also found effective on behavioral changes (Siu et al., 2007; Kubiak et al., 2006). The social support was realized in many ways such as motivational interviews and counseling, which led to improve self-efficacy (Thijs, 2007).

Though these review studies identified important general features (tailoring, monitoring, and social support), those guidelines may not be sufficiently detailed for practitioners who create or improve a web-based dietary intervention. For example, "provide more social support" could be helpful advice, but what kinds of detailed feature should be added to "provide more social support?" When one finds out that an online discussion board and an online chatting service with experts are potential social-support features, which one is more effective? Unfortunately, we could not answer these practical questions even after extensive literature review of existing review studies. Many of these review studies conducted from the perspective of healthcare (Rimer and Kreuter 2006; Thijs 2007), so the detailed descriptions that may be necessary for practitioners were not discussed.

Thus, the main goal of this study is to identify detailed features used in web-based dietary interventions and their effectiveness. The findings from this study will be a stepping-stone toward practical design guidelines for successful web-based dietary interventions.

METHODS

We conducted an extensive search for academic studies on web-based dietary intervention published in peer-reviewed journals, both in the healthcare and human-computer interaction (HCI) domains, from 2001 through 2009. The search was conducted in the following electronic journal archives: Medline, Science Direct, and Springer for the healthcare studies, and IEEE Xplore and ACM Digital Library for the HCI studies. Search keywords used in the selection process were every possible combination of terms from each block: (Block1: "Internet", "web", "online"), (Block2: "dietary", "nutrition"), and (Block3: "intervention" and "system").

Explicit inclusion and exclusion criteria were applied to the selection process.

First, titles of the papers were reviewed to judge their general eligibility for the review. Included studies involved dietary interventions for dietary changes or weight loss. We excluded review papers and studies irrelevant to healthcare interventions in this step. Second, we judged the foci of study interventions in the abstract. Studies including non-dietary interventions (e.g., physical exercise) were excluded. Third, we interpreted "web-based" broadly, so we also included other information technologies using the Internet, such as mobile technologies (Tanguay, 2007). Last, we iteratively evaluated once-selected papers whether or not to keep in the final list based on details of technical components described in the paper or website. We included studies that utilized simple techniques used in web-based health intervention systems only if the features were described in sufficient details. Eventually, total 47 papers[1] were chosen for the review.

After selection, two reviewers codified the 47 studies separately on several aspects, such as study characteristics, detailed features, and outcomes of studies. In addition, the purposes of interventions, theories used, demographic information of research participants, and periods of evaluation study were also codified. Then, the two reviewers combined the two separately codified data. When conflicts between the two codified data occurred, the two reviewers made an agreement on a single code based on evidence found in the corresponding papers.

RESULTS

GENERAL CHARACTERISTICS

Each paper was unique, but there were some general trends. User's diet control was the most popular theme (25 papers) among 47 papers, and we also found weight loss (6 papers) and nutrition education (6 papers) as other popular themes. The other papers (10 papers) dealt with other topics, such as the effectiveness of nutrition labels. Popular theories used in selected papers were the social cognitive theory (5 papers), transtheoretical model (TTM) (3 papers), and planned behavior (3 papers), but most of the papers (36 papers) did not specify any theories. Target population varied among studies. Studies were targeted to the general population (20 papers), senior adults (4 papers), children (6 papers), obese adults (6 papers), and patients (2 papers), and the other studies did not clearly specify target users (9 papers). The mean age of the participants in studies ranged from 13 years old (Williamson et al. 2006) to 63 years old (Verheijden et al. 2004). Six studies out of 47 studies dealt with only female participants. The durations of evaluation studies vary, but most of them were less than or equal to 6 months (33 papers). Relatively small number of

[1] Due to the space limitation, the 47 papers are listed in the following webpage: https://engineering.purdue.edu/HIVELab/wiki/pmwiki.php/Main/FoodForTheHeartFullReferencesForAHFE2010

evaluation studies took more than 6 months (6 papers). Among 47 papers we reviewed, 20 papers were from healthcare, and 18 from HCI.

In order to measure the effectiveness of web-based interventions, multiple measures were used, which can be categorized into five different phases: intervention usages, knowledge level, psychological influences, dietary behavior, and health status. Intervention usages usually shed a light on usability of web-based intervention, and they are often measured by usefulness and ease of use. The change of the knowledge level is measured by a set of multiple-choice questions regarding specific healthcare facts (Silk et al 2008). The gained knowledge may cause psychological influence, so the intention to change behaviors or self-efficacy was measured to understand this psychological aspect. The actual behaviors changes were measured by nutrition intakes or reported food-eating habits (using food frequency questionnaire (FFQ), eating disorder inventory, or binge eating behavior). Health statuses, which could be ultimate measures of dietary interventions, were measured by weight, body mass index (BMI), high-density lipoprotein cholesterol (HDL), and triglyceride. It should be noted that one study often used a combination of these measures. Among total 47 studies, 34 studies tested the effects of dietary interventions using measures that belong to more than one category.

DETAILED FEATURES

Table 1. Summary of features used in web dietary intervention and corresponding outcomes.

Features	E/T[1]	K[2]	BI[3]	BC[4]	HI[5]
Self-monitoring with graphs	10/20	+2/2	+4[q]/4	+5/5	(-2 +6)/8
Online discussion board	11/17	+1/1	+5/5	+7/7	(-1 +6)/7
Self-goal-setting	10/12	+1/1	+4/4	+8/8	+6/6
Newsletter	9/10	+1/1	+2/2	+7/7	(-2 +2)/4
Personal feedback from experts	7/10	+1/1	+3/3	+4/4	(-1 +3)/4
Link to resources	6/9	+2/2	+4[q]/4	+4/4	+2/2
Offline class / module	6/8	+2/2	+3[q]/3	+2/2	+2/2
Calculator	5/7	0/0	+1/1	+1/1	(-1 +3)/4
Chatting rooms with experts	4/7	0/0	+4/4	+3/3	+3/3
Online quiz	4/6	+2/2	+2/2	+4/4	+2/2
Offline brochure and handbook	4/4	+1/1	+2[q]/2	+3/3	+3/3
Audio and video documentary	2/4	+2/2	0/0	+2/2	0/0
Offline assignment	2/3	+1/1	0/0	+1/1	+1/1
Video game	1/2	+1/1	+1[q]/1	0/0	0/0
Self-monitoring using a mobile device	1/1	0/0	0/0	+1[q]/1	0/0

[1] E/T: This column shows the total number of evaluation studies and the total number of studies that include the feature. For example, "10/20 for self-monitoring using a graphic report" means that 20 studies include the feature, but 10 out of 20 studies actually include evaluation studies.

[2-5]K: Change of knowledge level, BI: Change of behavior intention, BC: Change of behavior, and HI: Change of health status; The cell represent the number of negative and positive outcomes over the total number of evaluation studies. For example, "(-2 +6)/8" means that there were total 8 evaluation studies tested a feature, 2 studies reported negative outcomes and 6 studies reported positive outcomes.

[q] One of the studies used qualitative method to measure the outcomes.

As shown in Table 1, multiple features have been used in web-based intervention.

Some of features could be included in the three general features (tailoring, monitoring, and social support). Newsletters sent to a group of participants (10 papers) and individual feedbacks with well-matched advices and tips (10 papers) are examples of tailored information. Online discussion boards (17 papers) are examples of social supports. Self-goal-setting (12 papers) and self-reports or food diary and progress reports with graphs to assess the health status along with feedback (20 studies) would be examples of monitoring. However, there are many techniques are out of these three categories. General information with offline classes or module (8 papers), guidelines through brochure or handbooks (4 papers), and links to other sources for diet-related and health-related information (9 papers) were reported in the papers we reviewed, but they are more like untailored information. Sometimes, one feature could be related with multiple general categories. For example, a chatting service with experts could provide both tailored information and social support.

Some features are more frequently used in the reviewed studies, but some are not. Self-monitoring (e.g., food diary and track current calorie), personalized messages including advices, tips, goal-setting, using graphs for monitoring progress, and online discussion boards are often used in our studies. In contrast, sensors, providing a food planner, and generating ideal characters were tried recently, but there have not been tested by multiple studies. Few studies tested the effects of using those brand-new technologies.

Dietary interventions produced either positive or negative effects on dietary or health changes. Table 1 shows the numbers of positive or negative results in four outcome variables (i.e., knowledge, behavior intention, behavior, and health status). In most cases, we did not find negative outcomes on change of knowledge level, behavior intention, and behavior. Only negative outcomes were noticed in health status. The only feature that reported only positive outcomes on health status is self-goal setting (six positive outcomes out of six evaluation studies) after having more than four evaluation studies.

Technologies for interactivity with users, quiz and assignments always showed the positive influences on knowledge gain and behavior changes in six studies. However, calculators were found effective in health changes in three studies, but one study resulted in negative result. As technologies for visuals, graphics in reports and images were found effective in dietary changes in six studies out of eight, but the rest reported negative effects on health improvement. However, multimedia components such as video and audio were not tested on health improvement. Sensors were not tested in any study.

COMBINATIONS OF FEATURES

Single feature in the web-based dietary intervention did not guarantee dietary changes. Many of our interventions incorporate with more than one feature. In a study of Brown et al. (2004), behavior and health status were changed positively with their dietary intervention, which incorporated documentary style audio and video, personalized feedback, self-quizzes, self-monitoring, goal-setting, weekly

reading and writing assignments, and participation in the Internet discussion group.

Some features were identified together in a study producing positive effects in dietary and health changes. Self goal-setting and self-monitoring were used together in nine studies. Among the nine studies, five studies utilized graphical reports for the two functional features. Three out of the five studies targeted to overweight adults resulted in positive effects.

Online technologies and offline technologies were used together. Online discussion board and classes were found in five studies to deliver information. Self-monitoring and handbooks, and quiz and graphical reports were pairs frequently appeared together in three studies resulting in all positive results. Expert meeting and graphical reports existed in three studies with two positive results on behavior and health changes.

These combinations of features are summarized in Table 2.

Table 2. Summary of results of features combinations used in web dietary intervention

Features	E/T[1]	K[2]	BI[3]	BC[4]	HI[5]
Online discussion boards + Self-monitoring with graphs	4/6	0/0	+2/2	+1/1	(-1 +3)/4
Personal Feedback from experts + Online discussion boards	3/6	+1/1	+1/1	+1/1	(-1 +1)/2
Self-monitoring with graphs + Self-goal-setting	4/5	0/0	+2/2	+2/2	+4/4
Online discussion boards + Offline class / module	4/5	+1/1	+1/1	+2/2	+2/2
Personalized feedback (newsletter) + Self-monitoring with graphs	4/5	+1/1	0/0	+2/2	(-2 +1)/3
Offline brochure and handbook + Self-goal-setting	4/4	+1/1	+2[q]/2	+3/3	+3/3
Personal Feedback from experts + Self-goal-setting	4/4	+1/1	+2/2	+3/3	+2/2
Personal Feedback from experts + Self-monitoring with graphs	4/4	0/0	+2/2	+1/1	(-1 +3)/4
Personalized feedback (newsletter) + Calculator	3/4	0/0	0/0	+1/1	(-1 +1)/2
Offline class / module + Self-goal-setting	3/4	+1/1	0/0	+2/2	+1/1
Self-monitoring with graphs + Online quiz	3/3	+1/1	+2/2	+3/3	+2/2
Self-monitoring with graphs + Chatting rooms with Experts	2/3	0/0	+2/2	+1/1	+2/2

[1] E/T: This column shows the total number of evaluation studies and the total number of studies that include the feature. For example, "10/20 for self-monitoring using a graphic report" means that 20 studies include the feature, but 10 out of 20 studies actually include evaluation studies.

[2-5]K: Change of knowledge level, BI: Change of behavior intention, BC: Change of behavior, and HI: Change of health status; The cell represent the number of negative and positive outcomes over the total number of evaluation studies. For example, "(-2 +6)/8" means that there were total 8 evaluation studies tested a feature, 2 studies reported negative outcomes and 6 studies reported positive outcomes.

[q] One of the studies used qualitative method to measure the outcomes.

Different features were used depending on who is the target population. Interventions for children resulted in positive health status, adopted mentor support or mandatory assignments (Tate, Jackvony, and Wing 2006; Bruning Brown, Winzel-

berg, Abascal, and C. B. Taylor 2004). Dietary interventions for overweight adults utilized self goal-setting and self-monitoring with graphical reports (Svetkey et al. 2008). Personal feedbacks, online discussions, and calculators of calorie were used in the successful systems for obese users. For the old, tailored personal feedback including advices on recommended alternative meals was one of the commonly used components in web-based dietary interventions (ChanLin, Huang, and K. C. Chan 2002; Oenema, Tan, and Brug 2005). Dietary interventions for patients with certain diseases provided nutrition guidelines suggested by governments without many technological components such as interactivity, multimedia or reinforcement (Verheijden et al. 2004; Probst, Faraji, Batterham, Steel, and Tapsell 2008). Dietary interventions for normal adults utilized various features such as information (Papadaki and Scott 2008; Park et al. 2008), multimedia (Park et al. 2008; Silk et al. 2007), online discussion (G. Block et al. 2004; Carpenter, Finley, and Barlow 2004; Mamykina et al. 2008), but no dominant technologies used were found in the successful dietary interventions for the normal adults.

DISCUSSION AND CONCLUSIONS

As a preliminary review of existing literature regarding web-based dietary interventions, it was difficult to provide any definitive guidelines. However, we identified some interesting patterns. First, a few intervention feature were more commonly used in successful dietary interventions, such as personal feedback via email, a discussion board, and self goal-setting and self-monitoring using graphical reports. A practitioner might consider these features for his or her own web-based intervention technologies since there is evidence showing that these features led to successful intervention outcomes. Second, most of the successful web-based interventions used multiple features, not a single feature. This allude that web-based dietary interventions were multifaceted activities, and target users should be reached through multiple channels. Third, some of new features have been developed in the domain of HCI, such as interactive quizzes, multimedia, games, cell phones, and sensors. Though their effectiveness has not been fully tested, these new media and technologies could generate interesting innovation in the future. Fourth, different target populations appeared to be better served by different combinations of features. Thus, a practitioner should pay attention on whom the target user group is, and make a conscious decision in selecting technological components according to the target users.

However, this paper also has several limitations. First, we intentionally excluded studies having physical exercise components in order to focus on dietary changes and subsequent healthcare outcomes. However, we later found that this exclusion criterion might bias the review results because exercise is often essential component to improve health outcomes. Second, the discrepancy between two different domains, healthcare and HCI, impedes more in-depth analysis of different features and their outcomes. As shown in the Result section, healthcare studies tend to focus on rigorous evaluation, but their descriptions for used features are not detailed enough. In contrast, HCI studies tend to focus on developing innovative intervention tech-

nologies and describe them in details, but their evaluation tends to be not rigorous and detailed enough. The discrepancy should be resolved through collaborative effort between healthcare and HCI professionals in the future.

In future work, more comprehensive set of literature will be incorporated for our review in order to reveal trustworthy relationships between health outcomes and features in web-based dietary intervention systems. Meanwhile, this preliminary review of features can be utilized to improve and create web-based dietary interventions.

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