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Process and Outcome Evaluation of a Social-Networking Website for Health Promotion

Sarah Ormseth
Loma Linda University

LOMA LINDA UNIVERSITY
School of Science and Technology
in conjunction with the
Faculty of Graduate Studies

Process and Outcome Evaluation of a Social-Networking Website
for Health Promotion

by

Sarah R. Ormseth

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Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree Master of Arts.

____, Chairperson
Jason Owen, Associate Professor of Psychology

____
Adam Aréchiga, Assistant Professor of Psychology

____
Kendal Boyd, Associate Professor of Psychology

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ABSTRACT OF THE THESIS

Process and Outcome Evaluation of a Social-Networking Website for Health Promotion

by

Sarah R. Ormseth

Master of Arts, Graduate Program in Clinical Psychology
Loma Linda University, March 2011
Dr. Jason E. Owen, Chairperson

Overweight and obesity pose a significant threat to the health and wellbeing of college students. However, studies of interventions to improve the health behaviors of college students are few in number, largely atheoretical, and have limited potential for widespread dissemination. The goal of this study was to evaluate a pilot of an internet-based social-networking intervention to promote health behavior change. Specific aims were to assess the role of behavioral engagement as a mechanism of change over time, review qualitative feedback regarding participants' likes and dislikes of the website, and use social networking analysis (SNA) to analyze structural support and its effects on behavior change. The sample consisted of 39 students from the Loma Linda University School of Public Health. Participants each selected a specific health behavior goal that they wished to achieve in the 10-week period of the study and completed the web-based individual health behavior change project as part of the coursework. Results showed a significant improvement in participant health behavior across the course of the study period. Results also indicated that level of peer feedback and support received significantly moderated change in health behavior across time such that greater improvement in health behavior was observed in those who received a greater amount of peer feedback. Qualitative analysis revealed participants reported the features of peer

feedback, personal blog, and line graph of heath behavior change to be the most helpful. The most commonly reported frustrations were website technical difficulties, particularly at the start of the study. The SNA showed that indegree (number of ties received) and, to a lesser extent, outdegree (number of ties originated with another) predicted attainment of clinically significant change. Furthermore, examination of the structural network diagram revealed that more concentrated sets of reciprocal ties existed among participants who attained clinically significant change. Although further research is needed, these findings suggest that web-based social support interventions may be effective in promoting change in variety of health behaviors and that SNA is a useful technique for investigating the influence of aspects of structural support on health behavior change.

Conceptual Framework and Literature Review

Overweight and obesity have reached epidemic proportions in the United States, adversely affecting the health and well-being of over 150 million American adults (Weight-control Information Network [WIN], 2008). As compared to the general population, college students are at increased risk for weight gain and obesity (Bowman et al., 1999). Since health behaviors adopted in college are likely to persist into adulthood (Snow & Sparling, 2002), it is important that more research be conducted to determine how to better promote the health behaviors of college students. Research has provided support for the efficacy of a number of strategies for obesity prevention and reduction, including efforts to promote physical activity (Cholewa & Irwin, 2008; Leslie, Sparling, & Owen, 2001; Alcaraz, Calfas, Gehrman, Johnson, & Sallis, 1999) and healthier dietary choices among college students (Matvienko, Lewis, & Schafer 2001; Skinner, 1991). These studies are limited in a number of respects however, including a lack of consideration of the theoretical mechanisms associated with positive change as well as barriers that would hinder the widespread dissemination of existing interventions.

With increasing levels of access and advances in technologies that better enable objective evaluation of behavioral engagement, the internet has emerged as a promising channel of delivery that offers potential for wide-scale dissemination and direct measurement of behavioral mechanisms of change and health behavior outcomes. Furthermore, in view of evidence that peer-support and enhanced user interactivity promote greater program utilization and enhance positive outcomes (McKay, Glasgow, Feil, Boles, & Barrera, 2002; Schneider, Walter, & O'Donnell, 1990), the rise of web-based social-networking capabilities make the Internet increasingly attractive as a channel of delivery for health behavior interventions. However, existing research of web-based interventions has generally not fully utilized the aforementioned benefits and capabilities. Websites for interventions were largely designed with older technologies rather than incorporating recent advances in user interactivity and were limited in terms of the type and amount of website usage data collected. Therefore, research of technologically innovative interventions that assess more objective behavioral mechanisms of change and link these mechanisms to health behavior outcomes are imperative. Such research could provide a better understanding of not just what works and for whom but how and perhaps even why (Paul, 1967).

The primary goal of the present study is to evaluate a pilot of an internet-based social-networking intervention to promote participant behavior change and explore the mechanisms of action associated with this change. To provide a more detailed review of these issues, as well as to outline the conceptual framework for this thesis, the literature review is organized into the following topic areas: (a) obesity and health behaviors of college students, (b) theories of health behavior and mechanisms of change, (c) process evaluations in health behavior change research, (d) web-based health behavior change programs, and (e) aims and hypotheses.

Obesity and the Health Behaviors of College Students

The United States has experienced what is best described as a spread in obesity of epidemic proportions and this unfortunate trend is now global in its proportions (Centers for Disease Control and Prevention [CDC], 2006; U.S. Office of Disease Prevention and Health Promotion [USODPHP], 2005; World Health Organization [WHO], 2006). The rise in rates of overweight and obesity have significantly burdened the U.S. healthcare system, American employers, as well as the lives of individual Americans (Goetzel, Hawkins, Ozminkowski, & Wang, 2003; U.S. Department of Health and Human Services [USDHHS], 2007; WHO, 2006). Since 1980, rates of obesity in America have doubled in adults, and current estimates indicate that 33.8% of adults, or 72 million people, are obese and 34.2% of adults are overweight (USDHHS, 2007). In this same time period, the rate of obesity among American children has tripled with 16.9% of children now classified as obese and an additional 14.8% as overweight (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010).

Parallel to the rising rates of obesity are increasing medical costs, with obesity driving 27% of healthcare spending growth between 1987 and 2001 (Thorpe, Florence, Howard, & Joski, 2004). In 2008, obesity-related medical spending was estimated at $34 billion for Medicare, $28 billion for Medicaid, and $75 billion for private payers for a total approaching $150 billion (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Per capita healthcare costs for obese individuals were $1429 (42%) greater than costs for normal-weight individuals (Finkelstein et al., 2009). The economic repercussions of obesity are not limited to their impact on the direct costs of public and private payers; the problem also affects American employers' health care expenditures, particularly in terms of indirect expenses. Indirect costs attributable to obesity, such as absenteeism, worker's compensation, disability utilization, are estimated to exceed $65 billion in the United States (Trogdon, Finkelstein, Hylands, Dellea, & Kamal-Bahl, 2008). Although the public and private sector shoulder a significant burden of the financial repercussions of overweight and obesity, it is the overweight and obese Americans themselves who pay the most significant costs (USDHHS, 2007; WHO, 2003).

A number of genetic, environment, and social factors are posited to contribute to obesity among Americans. Research indicates that genetic factors affect risk for obesity. Evidence that obesity in a family member places an individual at increased risk for overweight and obesity provides support for the presence of a significant genetic underpinning (Lyon & Hirschhorn, 2005) and specific genes identified related to adiposity and energy regulation include PPARg2 (Pro12Ala), b-adrenoceptor 2 (Gln27Glu), and uncoupling proteins 1, 2 and 3 (Marti, Martinez-González, & Martinez, 2008). Lifestyle and environmental factors significantly associated with overweight and obesity include time spent in sedentary activities and less physical activity as well as increases in dining out frequency as well as greater access to larger portions of high-fat, high-calorie foods (WIN, 2008).

Because common lifestyle factors are often shared among family members it is difficult to differentiate the effects of nature versus nurture. Current evidence suggests that genetic background does not have primary aetiological role in obesity but instead interact with environmental factors such that the phenotypic response (e.g., weight gain) to environmental changes (i.e., overeating) is dependent upon genetic factors (Marti et al., 2008). Social factors have also been shown to negatively affect the health of Americans. Circumstances such as poverty and lower levels of education are linked to obesity (WIN, 2008). While this health crisis is national in its scope, the problem can be evaluated and better understood through examination of those in society most adversely impacted, including ethnic minorities, women, children, and young adults (e.g., college and university students).

Obesity among college students. The increased risk for overweight or obesity associated with the period of transition from adolescence to adulthood has contributed to obesity being a growing problem on university campuses (Nelson, Gortmaker, Subramanian, Cheung, & Wechsler, 2007). Students are at particular risk during the first semester of their freshman year when rate of weight gain (4.2 pounds in 12 weeks or 0.35 pounds per week) is significantly greater than the average of the general population (0.02 pounds per week; Levitsky, Halbmaier, & Mrdjenovic, 2004). As compared to five years earlier when the rates of overweight and obesity among college students was estimated at 20.5% and 8.5%, respectively (American College Health Association [ACHA], 2002), the results of a recent survey indicated that rate of overweight and obesity among college students to be 23% and 13.7%, respectively (ACHA, 2007). Furthermore, the rise in obesity rates among college students is greater than that observed among other populations (Bowman et al., 1999). For example, the rate of overweight and obesity among adolescents is estimated to be 18%, which represents just a two percent increase compared to five years earlier (16% overweight and obese in 2002; USDHHS, 2009a).

Health consequences of obesity. Obesity negatively impacts multiple aspects of wellbeing and has a number of adverse physical and psychosocial effects (CDC, 2009). Health organizations widely recognize the serious medical conditions associated with obesity, including: heart disease, high blood pressure, high cholesterol, adult onset diabetes, stroke, arthritis, sleep disturbances, certain types of cancer (CDC, 2008a; USODPHP, 2005; WHO, 2003). In addition to its serious physical consequences obesity also shown to deleteriously influence psychological wellbeing.

Evidence suggests that the emphasis on physical appearance in modern society and the value placed upon the thin ideal negatively affects the self-image and emotional well-being of individuals who are overweight. Some contend that the emotional effects of being overweight, particularly for women, may be one of the most painful effects of obesity (WIN, 2008). Aside from the physical and psychological consequences, the social consequences of obesity are also significant, and obese individuals are oftentimes stereotyped or discriminated against (WIN, 2008). These misperceptions often result in obese people facing discrimination or prejudice at school, work, and in social situations (Puhl & Brownell, 2001). Due to the lack of social acceptance of obesity, obese individuals potentially have to deal with depression, shame, or feelings of rejection (USDHHS, 2006). Due to increasing recognition of the health risks and potential physical, psychological, and social consequences, prevention strategies have been undertaken in an effort address the problem (USDHHS, 2009b).

Obesity reduction and prevention strategies. Obesity reduction and prevention have been identified as a national health priority. *Healthy People 2020,* a national health promotion and disease prevention agenda, outlined specific objectives related to increasing physical activity levels and reducing overweight and obesity among Americans (USDHHS, 2009b). Research has consistently shown engagement in physical activity as an effective improve health and reduce obesity (ACSM, 2007; CDC, 2008b) and is described as "one of the most important steps that Americans of all ages can take to improve their health" (USDHHS, 2008a, vi).

Benefits of physical activity. Numerous physical and mental benefits are linked to physical activity (CDC, 2008b; WHO, 2008). Physical health benefits include weight loss and reduced risk of heart disease, type 2 diabetes, and cancers. Several psychological benefits are also associated with engagement in physical activity including reduced stress, enhanced body image, improved mood, and reduced anxiety and depression (AHA, 2009; CDC, 2008b; WHO, 2008). Overall, few other lifestyle behaviors can have such a large positive impact on the health of a person (AHA, 2009).

Despite a general awareness of the benefits of exercise, an increasing number of adults and children are inactive and there has been little progress in terms of getting the public to move more in daily life (USDHHS, 2008b). It is estimated that 50% of Americans percent do not get adequate daily physical activity, and 25% of individuals engage in no physical leisure activity at all (CDC, 2008b). Research has shown a continual decline in physical activity with age, but most dramatic decline occurs in the transition from adolescence and young adulthood (Bray, 2007). Surveys show that while 64% of high school students participate in adequate amounts of physical activity (USDHHS, 2009a), this drops to 46% among college and university students (ACHA, 2008).

Physical activity among college students. Entering college or graduate school is recognized as a major life event for young adults and one that is accompanied by a number of changes. Many factors to contribute to the changes associated with this adjustment period, including a different place to live, a number of new stresses relating to money, academics, and social pressures, transitioning to adulthood, and enjoying all of the newfound freedom that accompanies such a transition (Fish & Nies, 1996; Lawrence & Schank, 1995; Pender, Walker, Sechrist, & Stromborg, 1988; Kantanis, 2000). Perhaps relating to this newfound freedom, research indicates that university students are at increased risk for years of life lost from preventable illnesses and injuries from a number of environmental and behavioral risk factors (Grace, 1997).

A specific identified behavioral risk factor is a decline in amount physical activity when a student begins college (Bray, 2007; Born & Bray, 2004; Douglas et al., 1997). Over half of college students do not meet the recommendations for physical activity (ACHA, 2008) and college students' physical activity levels are not any higher than those seen in the general adult population (Keating, Guan, Piñero, & Bridges, 2005). The decline in physical activity associated with entering college is observed to continue throughout the college years (Keating et al., 2005). These initial and continual declines are particularly concerning because students who are inactive in college and continue onto sedentary lifestyles are much more likely to gain weight after graduation than those who are active as students (Snow & Sparling, 2002).

Despite the significance of the problem and evidence that health behaviors adopted in college are likely to continue into adulthood, research on interventions to increase physical activity in college students is limited (Booth, McKenzie, Stone, & Welk, 1998; Keating et al., 2005). Furthermore, many of these studies are descriptive in nature and not grounded in a theoretical framework (Biddle & Nigg, 2000). It is recommended health behavior intervention studies be based in theory to better identify the variables through which interventions influence behavior change (Bauman, Sallis, Dzewaltowski, & Owen, 2002) and to inform development of intervention content (Conn, Rantz, Wipke-Tevis, & Maas, 2001). Given the importance of grounding health behavior interventions for college students in theory (Snow & Sparling, 2002), health behavior change theory and the framework that guided components of the present intervention will be reviewed.

Theory of Health Behavior Change

Given that determinants of health behavior are not limited to discrete domains, an important criterion in the selection of a theoretical framework to guide research is comprehensiveness. For example, determinants of physical activity have been shown to include demographic factors, psychological and cognitive factors, behavioral attributes and skills, social factors, environmental factors, and characteristics of the physical activity itself (Sallis & Owen, 1998). Because health behavior is not a static trait and is most accurately characterized as dynamic in nature, a theory selected to describe health behavior change should be process oriented. The theoretical framework should also have practical utility, including constructs that are amenable to change that can be targeted by health behavior change interventions.

Overview of Social Cognitive Theory. Social Cognitive Theory (SCT; Bandura, 1986) is comprehensive in its scope and addresses psychosocial influences of health behavior and methods to effect behavior change. It incorporates previously disparate behavioral, cognitive, and affective models for behavior change and provides a rich source of mediating variables, including self-regulation, social support, self-efficacy, and outcome expectancies (Baranowski, Perry, & Parcel, 2002). SCT offers a dynamic and multilevel view of human behavior in which behavior is described in terms of reciprocal determinism, defined as the interplay between personal, behavioral and environmental influences (Bandura, 1986). Furthermore, SCT is flexible and can be integrated with the theories of other disciplines which further enhances potential for comprehensive understanding (Baranowski et al., 2002). SCT has been used to explain behavior change in adults and children and has provided the foundation for numerous health behavior change interventions (Bandura, 2004; Contento et al., 1995).

The key SCT constructs as related to health behavior change can be considered in terms of the three domains of the foundational precept of reciprocal determinism of behavior, the person, and the environment (see below for a more detailed description). Evidence demonstrates an association between the aforementioned SCT constructs and health behavior change (Centola, 2010). The influence of SCT constructs and the determinants of change identified in applied health research will be examined in greater detail in later sections.

Behavior. The SCT construct in the domain of behavior, *behavioral capability,* refers to the knowledge and skills necessary for an individual to perform a behavior (Thompson, Baranowski, Cullen, & Baranowski, 2007). The concept of behavioral capability maintains that if a person is to perform a particular behavior, he or she must know what the behavior is (knowledge of the behavior) and how to perform it (skill). The concept of behavioral capability distinguishes between learning and performance because a task can be learned and not performed. Performance, however, presumes learning (Baranowski et al., 2002).

Person. For this study, the person domain of SCT will be defined in terms of the three well-recognized constructs of self-efficacy, self-regulation, and outcome expectations.

Self-efficacy. The central construct of self efficacy refers to the confidence one can perform a behavior and successfully overcome the problems likely to be encountered

(Thompson et al., 2007).   SCT identifies four major ways in which self-efficacy can be developed (Bandura, 1998). *Mastery experience* enables the person to succeed in attainable but increasingly challenging performances of desired behaviors. The experience of performance mastery is the strongest influence on self-efficacy belief. Mastery experience is "best accomplished through instruction, modeling, and planned actions with goals, corrective feedback and problem solving" (Bandura, 1986). *Social modeling* entails showing the person that others like themselves can do it. This should include detailed demonstrations of the small steps taken in the attainment of a complex objective. *Social persuasion* involves telling the person that he or she can do it. Strong encouragement can boost confidence enough to induce first efforts toward behavior change. *Improving physical and emotional states* necessitates that people are well-rested and relaxed before attempting a new behavior. This can include efforts to reduce stress and depression while building positive emotions.

Outcome expectations. Outcome expectations refer to "beliefs about the likelihood of various outcomes that might result from the behaviors that a person might choose to perform, and the perceived value of those outcomes" (McAlister, Perry, and Parcel, 2008). The basic idea is that people act to maximize benefits and minimize costs- is fundamental to both animal and human learning theory (McAlister et al., 2008). Self-evaluative outcome expectations are those related to how people will feel about themselves if they do or do not perform a certain behavior. According to SCT, expectations about self-evaluative outcomes can be more powerful than expectations about social and material outcomes for some individuals (McAlister et al., 2008). Social outcome expectations are defined as the expectations about how different people will evaluate our behavior and our willingness to be guided by their evaluations (social outcome expectations correspond to concept of social norms in the Theory of Planned Behavior, TPB or the Theory of Reasoned Action, TRA; McAlister et al., 2008). Physical outcome expectations refer to the pleasant or aversive experiences and physical sensations that accompany the behavior.

The SCT identifies four major ways in which outcome expectations are learned (Baranowski et al., 2002). *Previous experience* are expectations learned from previous experience in similar situations (performance attainment). *Vicarious experience* contribute to expectations learned from observing others in similar situations. *Social persuasion* shapes expectations through hearing about situations from other people. Through *physiological arousal* expectations are learned from emotional or physical responses to behavior.

Self-regulation. The construct of self-regulation refers to amount of control a person has over making a change (Edberg, 2007). Bandura (1997) identifies six strategies though which self-regulation is achieved. Note that these strategies are both similar to and overlapping with approaches to change behavior by increasing self-efficacy (McAlister et al., 2008). *Self-monitoring* refers to a person's systematic observation of his or her own behavior. *Goal-setting* involves the identification of incremental and long-term changes that can be obtained. *Feedback* entails receipt of information about the quality of the performance and how it might be improved. In *self-reward,* a person provides tangible or intangible rewards for himself or herself. *Self-instruction* occurs when people talk to themselves before and during the performance of a complex behavior. *Enlistment of social support* is achieved when a person finds people who encourage his or her efforts to exert self-control.

Environment. In SCT, environment refers to the objective factors that can affect behavior but that are physically external to a person (Baranowski et al., 2002). The significance of environmental determinants in SCT are their influence upon behavioral activation and development (Bandura, 1986). However, it is worth noting that this description is vastly oversimplified, in that environment (actual environment) and situation (perceived environment) are not differentiated and have been shown to be poorly correlated (Ball et al., 2008; Kirtland et al., 2003; Troped et al., 2001). The environmental domain includes the constructs of physical environment, observational learning, and social environment. Aspects of the physical environment that might influence behavior include the size of a room, the weather or climate, or access to fitness facilities (Baranowski et al., 2002). Of greatest relevance to the present study are the environmental constructs of observational learning and social support.

Observational learning. Bandura contends that learning is an information processing activity and that observational learning, through which a person learns by observing the behavior of others and the consequences of that behavior, is characteristic of most learning that occurs over the lifespan. Studies have shown that models are imitated most frequently when observers perceive the models as similar to themselves, making peer modeling a well-recognized method for influencing behavior (Schank, 1987 as cited in McAlister et al., 2008).

According to Bandura, four processes govern observational learning (McAlister et al., 2008). Note that attention and retention are essential for learning whereas production and motivation are necessary for performance. Access to family, peer, and media models determines what behaviors a person is able to observe, while the perceived functional value of the outcomes expected from the modeled behavior determines what they choose to attend to closely. *Attention* determines what is selectively observed in the profusion of modeling influences and what information is extracted from ongoing modeled events. A number of factors influence the exploration and construal of what is modeled. Some of these determinants concern the cognitive skills, preconceptions, and value preferences of the observers. Others are related to the salience, attractiveness, and functional value of the modeled activities themselves. Still other factors are the structural arrangements of human interactions and associational networks, which largely determine the types of models to which people have ready access (Bandura, 2001). Cognitive *retention* of an observed behavior depends on intellectual capacities such as reading ability. The *production*, or performance, of the modeled behavior depends on physical and communication skills and on self-efficacy for performing. The process of *motivation* is determined by outcome expectations about the costs and benefits of the observed behavior. In addition to the aforementioned processes, the Elaboration Likelihood Model (ELM) is particularly well suited to further explicate the process of learning and attention and will be discussed in greater detail in a later section.

Social environment. The social environment is defined in terms of the structural network of those with whom an individual associates, including family members, friends, and peers at work or in the classroom (Baranowski et al., 2002). The social environment is significant in SCT for a number of reasons. The social environment provides behavioral models to facilitate observational learning. Interactions with others in the social network shape the evaluative standards through which an individual judges his or her own behavior. Furthermore, because criteria for evaluation of performance are often socially bound, information from social comparison significantly shapes self-efficacy appraisals (Bandura, 1986). The aspect of the social environment upon which greatest research focus is placed in SCT is social support and most salient for purposes of this study is the structural model of social support.

Intersection of SCT with social-networking theory. The structural model of social support defines and operationalizes the morphologic characteristics of networks which are most important. Generally speaking, a network is a set of units (or actors) and the relationships (or ties) of specific types that occur among them (Scott, 2000; Wasserman & Faust, 1994). The concept of network emphasizes the fact that each individual has ties to other individuals, each of whom in turn is tied to a few, some or many others, and that a social structure can be expressed as patterns or regularities in relationships among those interacting units. Social Network Analysis (SNA) is the study of social relations among the set of actors, focusing on uncovering the patterns of interactions among individual units.

Network data are defined by individual social entities and the linkages among them. These individual entities are "discrete individual, corporate, or collective social units" (Wasserman & Faust, 1994, p. 17) which are called *actors*, and the linkage between them are called *ties*. Larger subsets with more actors and ties among them are called *subgroups*. *Ego-centric network* analysis views the network from the perspective of the network actor. *Whole network analysis* describes the ties among all actors within a population and enables network patterns to be identified, quantified and tracked.

According to this SNA, the structural morphology of the network as described by these parameters provides the optimal characterization of the social network. This approach focuses not on individual characteristics of network members but on the structural properties of an individual's personal network of ties.

The study of those structural properties yields valuable insights not available using traditional methods of studying individual actors as independent elements (Wellman, 1988). Social support is assumed to be among the many resources that flow among these relations. Empirical research on the properties of networks has provided evidence for the influence of structure on diffusion. For example, clustered-lattice network structures, in which redundant ties promote social reinforcement, have been shown useful in the diffusion of health behaviors (Centola, 2010).

The Elaboration Likelihood Model. To enable greater understanding of Bandura's processes of observational learning, the Social Cognitive Theoretical basis of this study will be supplemented with the Elaboration Likelihood Model. The Elaboration Likelihood Model (ELM) suggests persuasion occurs through two primary routes depending on the degree to which a person is likely to engage in "elaboration", or issue-relevant thinking (Petty, Barden, & Wheeler, 2002). This model suggests that the nature of the persuasion will vary according to the route of processing. The recipient of a message is considered to have high elaboration likelihood given a high ability to process a communication combined with a high motivation to do so (Petty et al., 2002). In view of such conditions a recipient could be expected to expend substantial mental effort to attend to the message and to consider the content of the message in terms of existing knowledge. Processing conditions comprised of adequate motivation and ability to think are characteristic of central route persuasion.

In contrast, in processing in which low elaboration likelihood exists, the recipient is unlikely to engage in critical thinking. In this case, persuasion is likely to occur via the peripheral route in which processes are mostly reliant upon simple cues and heuristic devices (Petty et al., 2002). The central route and the peripheral route differ not just in terms of characteristic processes but also the consequences for the changed attitude. Persuasion that occurs via central route processes tends to be enduring, resistant to change, and predictive of future behavior, while peripheral route persuasion is considered to be somewhat temporary, susceptible to change, and not predictive of future behavior (Petty et al., 2002). It is important to note that although the processes of the ELM have been discussed in terms of two seemingly dichotomous routes, that a central tenet of the ELM that persuasion occurs across an elaboration likelihood continuum in which central and peripheral processes exert simultaneous influence (Petty et al., 2002).

The ELM posits that several factors may enhance motivation for elaboration, including high perceived message relevance and high level of issue involvement of the recipient. Interactivity is also shown to enhance motivation for elaboration through facilitation of increased levels of cognitive engagement of the message recipient (Tremayne & Dunwoody, 2001). Beyond those that influence level of motivation, additional variables are hypothesized to affect the amount of thoughtful consideration. The nature of the medium or channel of message delivery is an example of a communication variable that is a significant determinant of likelihood of elaboration. For instance, it is plausible that web-based communication may facilitate central route persuasion to a greater extent than face-to-face communication in which verbal as well as non-verbal signals may detract from central route processes (Blasio & Milani, 2008).

Summary of mechanisms of health behavior change. Social Cognitive Theory offers a broad and comprehensive framework though which the determinants of health behavior may be adequately explored. Through its principal of reciprocal determinism, it characterizes behavior as a dynamic process in which the determinants exert reciprocal influence. Moreover, the SCT has practical utility since its primary constructs can be targeted for influence by behavior change interventions. The ability of the SCT to address the dynamics of individual behavior and offer direction in the design and implementation of interventions is what makes the theory so attractive for health educators and program developers (Baranowski et al., 2002). Because the SCT construct of social support fits well with Social Networking Theory, it is also allows for consideration of health behaviors in terms of structural properties and patterns of interactions that most contribute to diffusion of change. Moreover, the Elaboration Likelihood Model offers a comprehensive framework though which to understand the processes of observational learning within the SCT. To better assess the effectiveness of the SCT in explaining health behavior in the population of interest, a review of literature of SCT constructs as predictors of health behavior was performed.

Literature about health behavior change in college students. Though it is necessary to understand the process through which theoretical constructs influence behavior change in college students, descriptive literature about the predictors of health behavior as well as intervention research is limited in this population (Ebert, Kang, Ngamvitroj, Park, & Von Ah, 2003). Among studies assessing SCT determinants of health behavior in this population, key determinants identified include self regulation, social support, and self-efficacy. In college student populations self-regulation has been shown to be a significant predictor of physical activity (Rovniak, Anderson, Winett, & Stephens, 2002; Petosa, Suminski, & Hortz, 2003). Social support has also been found to predict physical activity engagement in college students, with family and friend support associated with higher levels of physical activity (Sylvia-Bobiak & Caldwell, 2006; Petosa et al., 2003; Rovniak et al., 2002; Leslie et al., 1999) and greater exercise readiness to change (Wallace, Buckworth, Kirby, & Sherman, 2000).

Similar to research in the general population, self-efficacy is largely shown as a significant predictor of change in college students. Research shows self-efficacy to positively influence exercise readiness to change (Wallace et al., 2000) and physical activity engagement (Taber, Meischke, & Maciejewski, 2010; Doerksen, Umstattd, & McAuley, 2009; Sylvia-Bobiak & Caldwell, 2006; Petosa et al., 2003; Rovniak et al., 2002; Coureya & McAuley, 1994), though some studies fail to report a significant association (Leslie et al., 1999). Among studies investigating the role of outcome expectations and expectancies in behavior change among college students, findings are mixed. Some research indicates outcome expectancy significantly impacts vigorous physical activity in college students (Petosa et al., 2003) while other findings did not show outcome expectations to exert a significant effect (Taber et al., 2010; Rovniak et al., 2002).

In sum, extant research indicates that self-regulation, social support, and self-efficacy positively influence physical activity in college students while the influence of outcome expectations and expectancies remain unclear. As previously mentioned though, research of correlates of health behavior change in college students is limited. Furthermore, among existing studies variations in construct operationalization and measurement make it difficult to consider this body of research as definitive; there is a need for research that can clearly delineate the correlates of behavior change in college students.

In contrast to research on physical activity programs in children and adolescents, studies of interventions to promote physical activity in college students are scant. Participation in physical education and health promotion courses during college have been shown to promote increased physical activity (Cholewa & Irwin, 2008; Leslie et al., 2001; Alcaraz et al., 1999) as well as greater exercise readiness to change (Buckworth, 2001). Similar improvement has been observed in research of structured extracurricular programs to promote physical activity (Wadsworth & Hallam, 2010; D'Alonzo, Stevenson, & Davis, 2004). Furthermore, some research indicates that participation in conceptually based physical education classes in college may contribute to sustained improvement over time (Brynteson & Adams, 1993; Slava, Laurie, & Corbin, 1984).

Research has also evaluated the effectiveness of college nutrition and weight management programs to help students achieve and maintain a healthy body weight. College-level nutrition science courses have been shown to promote weight loss (Matvienko et al., 2001) and decrease calorie and fat consumption among students (Skinner, 1991). Similarly, educational and behavioral seminars have been found to effectively promote maintenance of a healthy body weight (Hivert, Langlois, Berard, Cuerrier, & Carpentier, 2007; Sloan, Tobias, Stapell, Twiss Ho, & Beagle, 1976), and to effect weight maintenance long-term (Hudiburgh, 1984). Alternative approaches such as daily weighing combined with weekly feedback have also shown promise in helping to prevent weight gain in college students (Levitsky, Garay, Nausbaum, Neighbors, & DellaValle, 2006).

Studies demonstrate that physical activity as well as nutrition and dietary interventions can be effective in the college student population. Since physical activity and health behaviors adopted in college are likely to sustain throughout the lifespan (Snow & Sparling, 2002) it is necessary that research identify how to most effectively promote physical activity among college students. However, few studies used a process evaluation to evaluate whether the intervention was implemented as planned. Furthermore, among research in which positive effects were observed, investigators did not utilize process evaluation to identify the intervention components most associated with the outcome of interest. Given that process evaluation is an essential component of health behavior intervention research, the methodology and existing literature of the mechanisms of action associated with health behavior change interventions will be reviewed.

Process Evaluation

Process evaluation is an increasingly used methodology in health behavior research for the evaluation of interventions to assess factors that might have an effect on the implementation of a program (Bauman et al., 2002). Specifically, process evaluations are "a form of program monitoring designed to determine whether the program is delivered as intended to the target recipients" (Rossi et al., 2004, p. 64). This methodology helps to elucidate study findings, both significant and insignificant, and shed light upon the reasons behind the success or failure of a project (Stechler & Linnan, 2002). The information gained provides the rationale to expand and/or improve extant interventions, ultimately leading to improved public health.

The purpose of a process evaluation is to evaluate how and why an intervention works, including mechanisms of change or mediating processes (Baranowski & Stables, 2000; Sidani & Braden, 1998; Stechler & Linnan, 2002). Whereas quality assurance were once the primary focus of process evaluations, the functions of this methodology have expanded to include establishment of intervention reliability, program monitoring to enable correction of problems in real-time, and provision of data to assess the associations among the intervention, mechanisms of change, and program results (Stechler & Linnan, 2002; Baranowski & Stables, 2000; Sidani & Braden, 1998).

Literature about mechanisms of health behavior change. An integral part of the process evaluation, analysis of mechanisms of change attempts to identify the variables through which the intervention influenced behavior change (Bauman et al., 2002; Sidani & Braden, 1998). Identification of mechanisms of action associated with behavior change interventions is essential to improving intervention efficacy and effectiveness and to gain an understanding which participants are most likely to benefit from which types of intervention components and support. Researchers are increasingly being encouraged to examine theory-based mechanisms of change in the design, implementation, and evaluation of interventions of physical activity and dietary behaviors.

Physical activity. Studies of physical activity interventions that assess mechanisms of change generally do not provide evidence for a strong link between change in targeted constructs and improvement in levels of physical activity. An association between intervention constructs and physical activity has been observed in some studies, including improvement in self-regulation and increases physical activity (Wadsworth & Hallam, 2010; Madsen et al., 1993). More often however, in studies of children and adolescents, increases in physical activity level (McKenzie et al., 1996; Parcel et al., 1989) and exercise readiness to change (Neumark-Sztainer et al., 2003) are observed despite a lack of discernable improvement on most targeted intervention constructs.

Dietary behaviors. Interventions to increase healthy dietary behaviors generally show significant positive changes in targeted constructs. In studies of children and adolescents, improvements have been reported among some targeted constructs including diet behavior capabilities (Parcel et al., 1989), knowledge of health eating (Edmundson et al., 1996; Perry et al., 1987), dietary self-efficacy (Parcel et al., 1989), and behavioral expectations (Parcel et al., 1989). Findings of healthy behavioral change with regard to food consumption are less consistent. While significant increases in healthy food choice have been observed in some research (Edmundson et al., 1996), other studies have reported group-specific improvement (e.g., in girls only, Perry et al., 1987) or found no intervention effect on dietary behavior (Parcel et al., 1989).

Summary of literature of mechanisms of change. Across physical activity and dietary behavior interventions some SCT constructs were shown amenable to change. The reported association between construct change and actual heath behavior improvement however remains uncertain. There is little consistency however in the manner in which posited mechanisms of change are measured, making direct comparison of study outcomes difficult. Furthermore, research has relied primarily upon self-report instruments as measures of mechanisms of change that largely disallow direct evaluation of the dose-response relationship of mechanisms of change and health behavior outcomes.

In view of these challenges, appreciation for the internet as a channel of delivery for health behavior interventions is increasing as it enables more precise and objective measurement of behavioral mechanisms of change. This enhanced measurement potential, together with the seeming ubiquity of the internet and the degree to which it has become an integral part of everyday life, suggests that the web offers a promising channel of delivery of health behavior interventions, particularly to college students.

Internet-Based Health Behavior Change Programs

Efforts to transform efficacious interventions to effective health behavior changes programs have shown only limited success (Brownson et al., 2007) and a number of barriers have hindered potential for diffusion (Glasgow & Emmons, 2007). For example, though face-to-face group support programs have shown promise in research, the characteristics of such support (e.g., requiring participants to meet at specific time in a particular location) preclude participation of a number of participants, including individuals with busy schedules, patients with health limitations, and residents of geographically isolated areas. Furthermore, the widespread dissemination of programs dependent on the services of professionals is not feasible given the significant costs associated with reimbursement of the professional for his or her services (Kushner, 1995). These and other challenges have contributed to an increasing awareness of the need for further development of innovative channels to deliver efficacious health behavior programs to the larger population.

The Internet serves as a channel that enables wide-scale dissemination of health behavior programs. Increasing levels of Internet access have created new opportunities for improving diffusion of empirically-supported health behavior change interventions. Internet use among Americans is estimated at 79% among adults and 93% among adolescents (Pew Internet & American Life Project, 2010a). Use of the internet among college students is even greater and survey results indicate 99% of students report using the six or seven days a week for an average of two and one-half hours per day (Escoffery et al., 2005). The Internet is also already a source of health information for a majority of its users with 75% reporting having used the Internet to seek health information (Pew Internet & American Life Project, 2010b). Additionally, among college students, 27.5% of those surveyed expressed significant interest in participation of a web-based health behavior intervention (Escoffery et al., 2005). In view of its power as a channel to disseminate interventions to a large number of individuals, research in the area of web-based health behavior interventions is growing.

Outcomes of internet-based behavior change programs. Though results of internet-based programs to promote health behavior change are promising, the efficacy of interventions delivered via the web is still being established. A review of Internet-based physical activity interventions showed that over half of the controlled trials showed significant improvements in participant physical activity engagement (Vandelanotte, Spathonis, Eakin, & Owen, 2007). Among college students, web-based interventions have promoted increased engagement in physical activity and greater compliance with guidelines for fruit and vegetable consumption (Kypri & McAnally, 2004).

Use of a web-based intervention has been shown to promote increased physical activity among children (Palmer, Graham, & Elliott, 2005). Among adolescents, use of a web-based intervention has been shown to promote greater physical activity levels (Frenn et al., 2005; Winett et al., 1999), improved dietary behavior (Frenn et al., 2005; Winett et al., 1999) and reduce fat consumption (Long et al., 2006). Web-based interventions have also been shown to impact health behaviors in adults including increased walking (Napolitano et al., 2003; Hager, Hardy, Aldana, & George, 2002), decreased in average time spent sitting (Marshall et al., 2003), and improved dietary behavior (Block et al., 2005). In other research however no difference was shown between the activity levels of the web-based intervention participants and those in the control group (Carr et al., 2008).

There is increasing evidence for the benefit of use of personalized or tailored interventions in promoting health behavior though support for increased efficacy of a tailored approach is not universal. As compared to a standard intervention, use of tailored Internet-based intervention have been shown to be associated with improved dietary behavior (Oenama, Brug, Dijkstra, de Werrdt, & de Vries, 2008; Huang et al., 2006) and greater weight loss (Gold et al., 2007; Williamson et al., 2006). With regard to physical activity, use of a tailored web-based intervention has been found to yield greater effects than use of a non-tailored internet intervention (Hager et al., 2002). In contrast, other studies indicate that while improvements in physical activity have been observed with use of tailored web-based interventions, the changes were similar to those observed associated with standard web-based programs (Spittaels et al., 2007; Marcus et al., 2007; McKay, King, Eakin, Seeley, & Glasgow, 2001). Sometimes however, no discernable effect is associated with use of tailored web-based health behavior interventions

(Hageman, Walker, & Pullen, 2005; Palmer et al., 2005; Verheijden et al., 2004; Womble et al., 2004).

Summary of outcomes of web-based interventions. Although progress has been made, research on website-delivered health behavior change interventions is still at an early stage of development. A primary benefit of web-based interventions is the ability to monitor indicators of engagement such as time spent online or dose of intervention but this research has been limited by underutilization of technologies to gather objective data on behavioral interactions. A review of web-based physical activity interventions reported that only five of the 15 reviewed studies included objective data about website usage (Vandelanotte et al., 2007). These studies reported low levels of engagement (e.g., only 26% of participants logged-on more than once; Marshall et al., 2003) and a decline in usage over time (e.g., average weekly logon rate dropped from 1.35 per participant to 0.25 per participant; McKay et al., 2001). Among studies that failed to show improvements in participant health behavior, some researchers posit that low rates of use of web-based interventions may have contributed to the lack of a significant effect (e.g., Verheijden et al., 2004; Womble et al., 2004). Indeed, available evidence suggests that higher levels of engagement are associated with improved outcomes (e.g., improvements in physical activity level for participants with three or more logons per week; McKay et al., 2001).

The rich objective behavioral data of web-based interventions hold the potential for identifying key mechanisms of action necessary to increase intervention effect sizes. However, among the few studies that reported objective data, evaluation of the association between objective web usage data and health outcomes only a limited number of measures of behavioral engagement were considered (e.g., to evaluate the association between behavioral engagement and health outcomes only number of logons considered; McKay et al., 2001). Consideration of multiple measures of website usage is necessary to more accurately quantify intervention dose as well as know to which intervention elements to attribute positive outcomes (Bellg et al., 2004). In sum, although several studies show promising results, much remains to be learned about optimizing and enhancing web-based interventions to increase their efficacy (Vandelanotte et al., 2007). Since the publication of much of the aforementioned research, social-networking technologies have emerged and become widely adopted by web developers and users. Through eliciting increased participant exposure to program material, use of social-networking features has significant potential to further enhance the efficacy of health behavior interventions.

Social-networking websites and intervention dissemination. Because of technological advances on the internet, including the proliferation of social-networking webs sites, it is possible to couple web-based health behavior interventions with social-networking capabilities. The emergence of social-networking has significantly altered patterns of web use, and social-networking websites have emerged as the preferred destination for many Internet users (Grossman, 2006). Use of social networking sites has grown rapidly. As compared to five years ago when only five percent of adults in the United States reported using social networking sites, estimates place current social networking website use among adults at 41% (Pew Internet & American Life Project, 2010b). Among those who access the internet in the United States, social network use exceeds 57% and is estimated to approach 66% by 2014 (eMarketer, 2010). The unique characteristics of social-networking websites, including the capacity for personalized content and advanced features for establishing and maintaining contact with other members, have lead users to spend increasing amounts of time on accessing content on these sites (Gonzalez, 2007). A recent survey reported that, among social media users in the United States, the most frequent activities of respondents include reading blogs (96%), commenting to blogs (69%), writing blogs (68%), and reading message boards (68%; BlogHer, & iVillage, 2010). Despite its increasing popularity, use of social networking and online social support to promote health behavior change is limited as existing web-based programs use static information and computer-generated tailored messages (Vandelanotte et al., 2007).

Web-based social-support interventions. The benefits of social support interventions in promoting health behavioral change are well established (Davison, Pennebaker, & Dickerson, 2000). Social-networking has the potential to increase the effectiveness of existing, evidence-based interventions (Stevens et al., 2008) and inclusion of a peer-support component has been shown to promote higher levels of utilization (McKay et al., 2002; Schneider et al., 1990). Furthermore, several studies have shown that the Internet interventions can increase perceptions of support, including among individuals with diabetes, cancer, and HIV (Barrera et al., 2002, Gustafson Robinson, Ansley, Adler, & Brennan, 1999; Gustafson et al., 2001). Taken together, these studies indicate that individuals seek and exchange support over the Internet and perceive their Internet interactions as supportive. Given the extent to which individuals use the Internet for information and support, it appears that it may be possible to synthesize support through Internet exchanges and study the effects of different types of support on health outcomes. This would have obvious research advantages because it would allow for documentation of all exchanges of peer support.

Research Plan

The primary goal of the proposed project is to assess a pilot of an internet-based social-networking intervention to promote health behavior change. From there, the mechanisms of action associated with this change will be explored, particularly the role of behavioral engagement as a mediator of positive change over time. Furthermore, participant feedback will be evaluated to inform future improvements in intervention methodology and user experience. The use of SNA for analysis of aspects of structural support and the influence support on health behavior change will also be investigated. Findings from the proposed study will contribute to further development of technologically innovative health promotions interventions and provide a better understanding of mechanisms of change through linking objective behavioral data to health behavior outcomes. Findings will also enhance understanding of the dynamics of network structure and individual outcomes. To accomplish these goals, four specific aims and associated hypotheses are proposed.

Aims and Hypotheses

Aim 1. To evaluate the effects of a web-based social-networking intervention on health behaviors of participants.

Hypothesis 1. A positive change in participant health behavior will be observed across the four periods of observation of the intervention.

Aim 2. To identify the behavioral mechanisms through which the web-based social networking intervention positively affected health behavior change.

Hypothesis 2. Higher levels of behavioral engagement will be associated with positive change. Specifically, website process measures will show higher levels of participant engagement and interactivity to moderate change over time.

Aim 3. To evaluate participant feedback to identify strengths and weakness of the website to inform improvements in intervention methodology and user experience for future follow-up studies.

Hypothesis 3. Participants' evaluations of website features will be predominately positive. In particular, reports will show that interactive features that enabled social engagement (e.g., peer feedback and discussion board) and allowed users to track and monitor progress (e.g., personal blog and graph of health behavior change) will be described as helpful.

Aim 4. To validate the use SNA in this study and its usefulness as an empirical technique for investigating the influence of aspects of structural support on change. Because SNA is a novel approach to evaluating a social-networking website for health behavior change, this aim is largely exploratory and not associated with any directional hypotheses. Instead, two research questions are posed.

Research Question 4a. What ego-centric network dimensions, including the characteristics of degree centrality, closeness centrality, betweenness centrality, indegree, and outdegree, are associated with positive behavior change? (Please see next section for detailed definition of characteristics of ego-centric network data).

Research Question 4b. What structural patterns, including the properties of core/periphery, components, isolates, cliques/subgroups, and density will emerge in the network? (Please see next section for detailed definitions of whole network properties).

As previously mentioned, these questions are exploratory in nature given that SNA is an emerging methodology. However, SNA holds significant potential to elucidate the complex and dynamic interdependence of individual and structural characteristics and their association with behavioral outcomes.

> …to obtain a deeper understanding of social action and social structure, it is necessary to study the dynamics of individual outcomes and network structure, and how these mutually impinge upon one another. In methodological terms, this means that complete network structure as well as relevant actor attributes—indicators of performance and success, attitudes and cognitions, behavioral tendencies—must be studied as joint dependent variables in a longitudinal framework where the network structure and the individual attributes mutually influence one another. (Steglich, Snijders, & Pearson, 2010, p. 2).

Method

Participants

The sample consisted of 39 graduate students from the Loma Linda University School of Public Health, Department of Health Promotion and Education. Participants were enrolled in HPRO 509 class, Principles of Health Behavior. Forty-three students were originally enrolled but four withdrew prior to creating a profile webpage or posting any comments to the intervention website, leaving 39 participants with evaluable data. The course provided an introduction to key health behavior change theories and psychosocial determinants of health behaviors and consisted of a classroom lecture and participation in a web-based health behavior change project. Class sessions were held once a week over a 10-week period during two hour and fifty minute sections.

Intervention

Participants spent additional time outside of class to complete the web-based individual health behavior change project. Self-Directed Behavior Change (Watson & Tharp, 2002) was the required text and utilized for web-based assignments. All tasks related to the health behavior change project were submitted to the website setup by the course instructor. Although the purpose of the project was to promote positive health behavior change among participants, participant progress and end-of-quarter outcomes had no bearing on course grades.

The website. The intervention framework was built on a Linux server implementing Apache, Practical Extraction and Report Language (PERL), and mySQL. The program manages user security, survey administration, recruitment tracking, tailoring page content to individuals, and storage and retrieval of user-specific data and user interactions with the website. To best promote participant interaction and engagement with the content, Health-space.net featured “Web 2.0” technologies personal profile pages and a discussion board. Each participant created his or her own profile webpage that featured a personal avatar (a graphical representation of a user), a description of the participant’s health behavior goal, a graph of the participant’s progress towards his or her health behavior goal, a blog for the participant to post personal reflections and responses to web-based assignments, and a section featuring the feedback provided by other participants (see Figure 1). A page with links to personal pages of all other users (accessed through the “View Others’ Project” link) enabled participants to follow others’ progress and offer advice and encouragement one another (see Figure 2).

The website also featured a visually-oriented and full-featured discussion board (see Figure 3). Unlike blogs, the discussion board was communally created and allowed participants to post comments and engage in group wide discussion to promote a sense of community. Furthermore, the website incorporated a number of relevant theoretical constructs from SCT to facilitate positive health behavior change (e.g., behavioral capability, self-efficacy, outcome expectations, self-regulation, and social support) and ELM (e.g., personal relevance, cognitive engagement, and central-route processing; see Table 1). Participants provided a confidential username and password to the instructor during the first class session that they then used to log in to the website over the course of the intervention (see Figure 4).

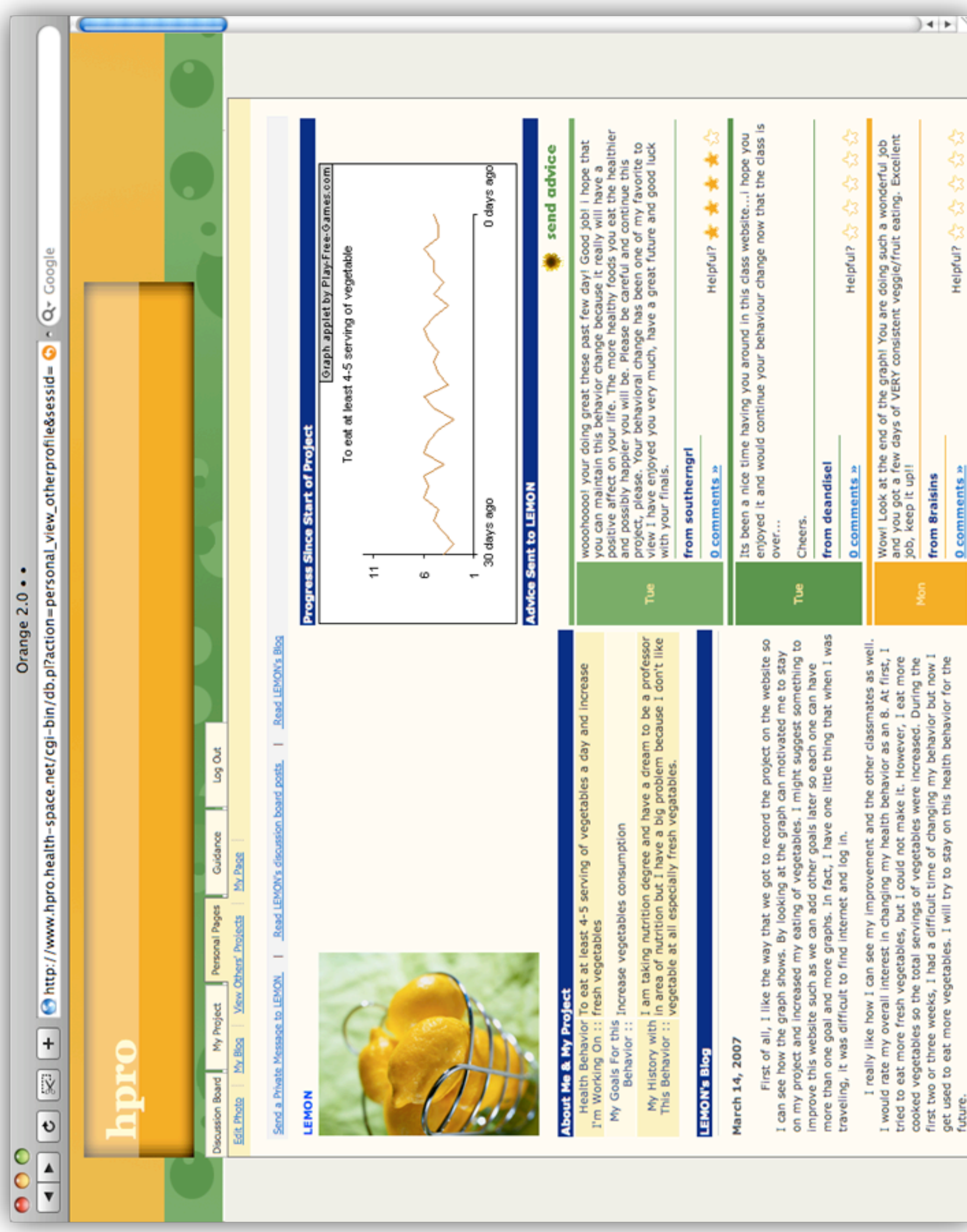

Figure 1. Personal Page for User "Lemon"

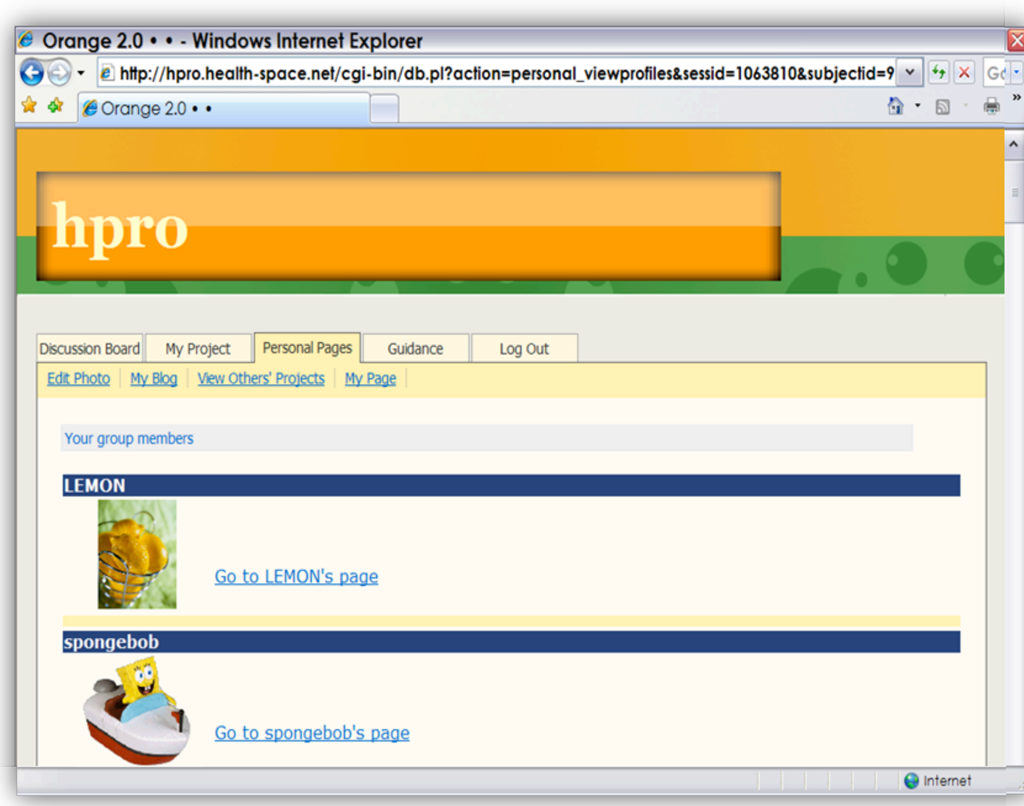

Figure 2. Links to Personal Pages

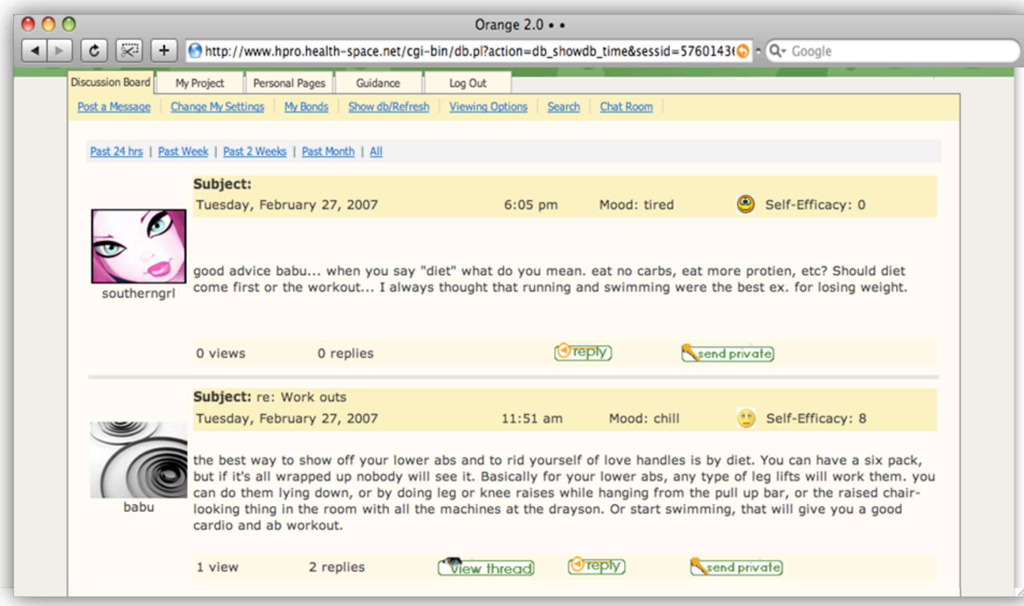

Figure 3. Discussion Board

Table 1

Theoretical Constructs and Corresponding HPRO Intervention Components

Construct	Definition	Intervention Component
Social Cognitive Theory		
Behavioral capability	Knowledge (what the behavior is) and skills (how to perform the it) are prerequisite to the performance of a behavior.	Educational components of class (i.e., lecture and textbook). Informational support via advice messages from peers.
Self-Efficacy	The confidence one can perform a behavior and overcome problems.	
Mastery experience	Enabling a person to succeed in attainable but increasingly challenging performance of the desired behavior.	Behavior-specific goal setting, including identification of subgoals. Feedback to inform participants of progress and whether goal revision may be necessary to better enable performance.
Vicarious experience (social modeling)	Showing the person that others like themselves can do it.	Observation of the successes of peers via information shown on the personal pages, etc.
Verbal persuasion (social persuasion)	Telling the person that he or she can do it.	Encouragement via emotional support via advice messages from peers.
Physiological and emotional states	People rely on information about physiological and emotional states as indicators of efficacy.	Discussion ofreinterpretation of physiological signs and states and to encourage stress relief related to behavior change via asynchronous communications.
Outcome Expectations		
Social outcome expectations	Anticipation of how others will evaluate one's behavior and one's willingness to be guided by others' evaluations.	Knowledge of peer appraisal of behavior change efforts, as depicted on graph, serves to enhance a sense of social accountability which may enhance motivation.
Self-evaluative outcome expectations	Anticipation of how a person will feel about him or herself if a behavior is or is not performed.	Interaction, via asynchronous communications, with peers on website provides exposure to norms by which an individual evaluates his or her own behavior. Specific SCT mechanisms include vicarious experience, verbal persuasion, and social comparison.
Self-Regulation	The self-regulation of behavior or how much control a person has over making a change.	
Self-monitoring	Person's systematic behavioral observations.	Participants asked to enter daily behavior updates on the website.

Goal-setting	The identification and incremental and long-term change that can be obtained.	Participants each selected a goal they wished to achieve and were required to operationally define the goal and the specific units through which the goal will be measured.
Feedback	Information about the quality of the performance and how it might be improved	Individual feedback both through graph (quality of performance) on personal page and advice messages received (quality of performance and suggestions for improvement).
Environment	Factors physically external to the person that provide opportunities and social support.	
Facilitation	Provision of new structures or resources that enable behaviors or make them easier to perform (provides empowerment).	The social environment of the website provides participants models for behavior in the form of their peers. The similarity of the participants (e.g., all university students with a similar focus of study) is especially important because models most imitated are those that an observer perceives as most similar to him or herself.
Reinforcement	Provision of rewards and punishments for desired or undesired behaviors	
Direct reinforcement	Operant conditioning.	Appraisal support via peer feedback messages to provide positive reinforcement?
Vicarious reinforcement	Observation of reinforcement of a social model.	Observation of the positive outcomes derived for peers resulting from change in health behavior via information shown on the personal pages, etc.
Self-reinforcement	Provision of self-initiated rewards and incentives.	The text promotes self-reinforcement in which performance of behavior is tied to self-reward.
Elaboration Likelihood Model		
Level of Motivation	Enhanced via increased personal relevance	Use of personal pages for each participant
	Enhanced via increased cognitive engagement	Interactivity
Level of Cognition	Enhanced via increase central-route processing	Web-based intervention allows for greater central route processing as compared with face-to-face channel of delivery.

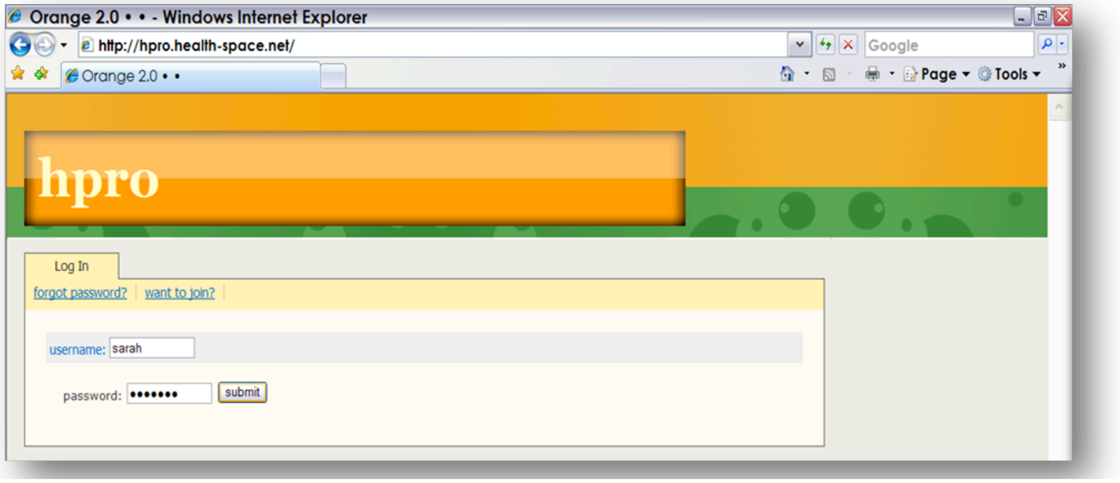

Figure 4. Website Log In Page

The health behavior change project. All participants developed and implemented an individual behavior change project. Tasks related to the behavior change project were submitted to a website setup by the instructor for this class. Tasks for the project included identifying and describing the health behavior targeted for change, tracking progress of behavior change, engaging in weekly assignments, and giving counsel, suggestions, and advice to other participants. First, participants each selected a personal health behavior goal that they wished to achieve by increasing or decreasing a specific behavior. For example, to achieve the goal "to increase vegetable consumption" a participant may work on the health behavior "to eat at least 4-5 servings of vegetables a day" (see Figure 5). Furthermore, participants were encouraged to submit daily or near-daily updates on their progress (see Figure 6).

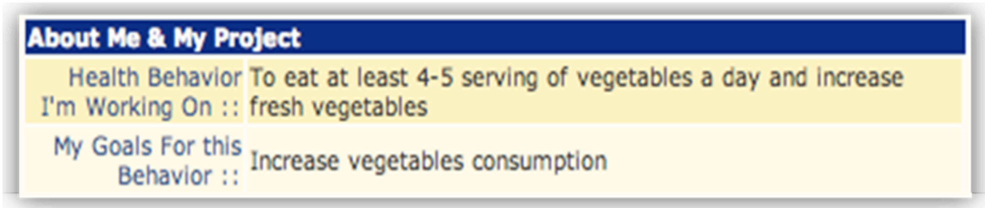

Figure 5. Personal Health Behavior Goal for User "Lemon"

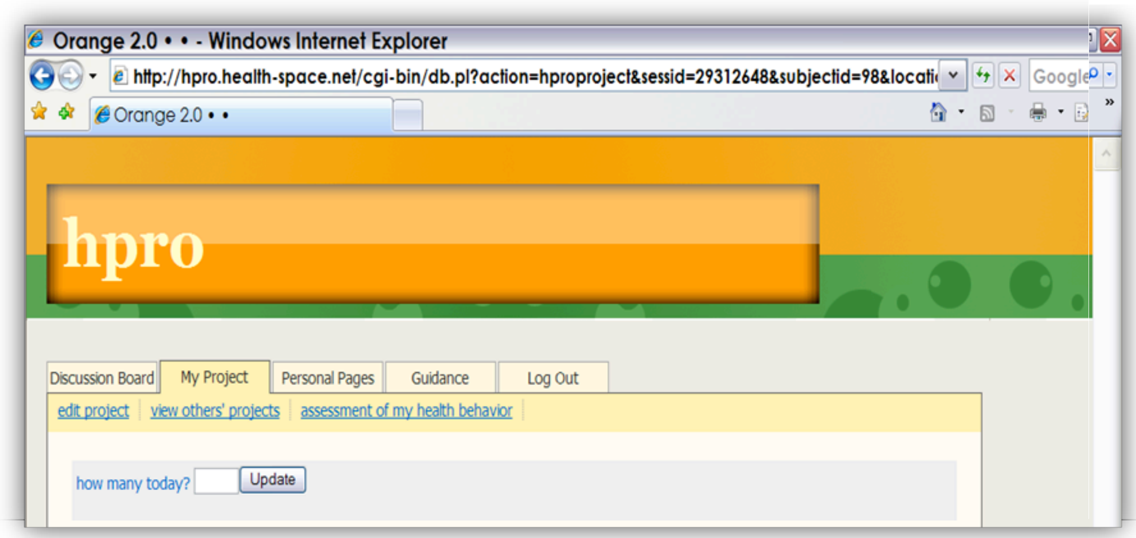

Figure 6. Daily or Near-Daily Update on Progress

Each time participants provided an update on level of engagement in their specific health behavior, their progress was tracked via a dynamically-generated graph to provide a visual representation of progress over time (see Figure 7). For example, participants were asked to identify an initial goal (e.g., "to increase vegetable consumption") and a unit for measuring daily progress on the goal (e.g., "number of servings of vegetables per day"). On the basis of this information the application "built" a dynamically-generated graph of progress and provided longitudinal information that enabled participants to evaluate if they were making expected progress.

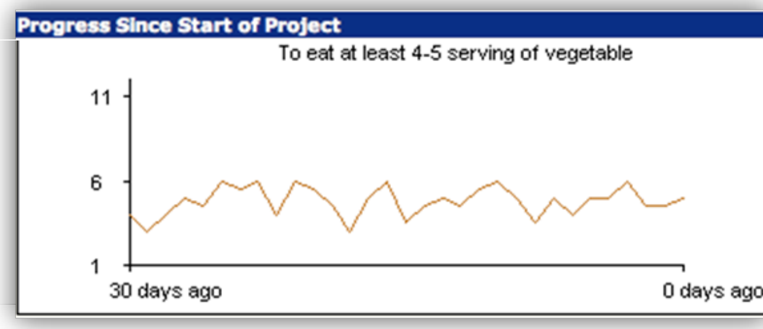

Figure 7. Graph of Progress Over Time for User "Lemon"

Participants also completed weekly assignments. Each week, assignments for the behavior project were made available in class or on the website. Each participant responded to topics on his or her personal page as a blog entry. Topics for the blog entries included pros and cons of behavior change, anticipated challenges, antecedents, behavior, and consequences of the desired behavior, and reflection on progress and barriers to change (see Table 2 for descriptions of all web assignments).

By posting responses to assigned topics in a blog, other participants were able to read and provide feedback to the entry. Additionally, in order to facilitate an understanding of how to effectively provide feedback about health behavior change, participants were asked to send "advice" to other participants at least once a week. A "send advice" button on each personal page allowed participants to send supportive messages to other participants and to provide encouragement specific to their health behavior change goals (see Figure 8).

Table 2

Topics for Web Assignments

1. Five situations that make improvement on project more difficult
2. Pros and cons of changing health behavior
3. Final health behavior goal and subgoals
4. Successes and failures
5. Structured diary
   - Record at least 5 diary entries
     - Include antecedent, behaviors, and consequences related to health behavior project.
6. Antecedents, behavior, and consequences
   - Antecedents
     - What stimuli seem to control the behavior? In what situations does the behavior occur?
     - Do you react to some cue with an unwanted emotion? What is the conditioned stimulus for it?
     - What are you saying to yourself before the behavior?
   - Behavior
     - Is it strong and frequent or weak and infrequent? What does this tell about what to do to change it?
     - Is any element of your problem due to something you are avoiding, perhaps unnecessarily?
     - Are you aware of models in your past whose behavior you may have copied?
     - Does any part of your goal involve changing behaviors that are resistant to extinction, either because they are intermittently reinforced or because they are avoidance behaviors?
   - Consequences
     - Are your desired behaviors positively reinforced?
     - What actions make the desired behavior difficult? Are they reinforced?
     - Is it possible that the desired behavior is being punished?
     - Is your own self- speech rewarding or punishing your behavior?
     - Are the consequences for behaviors difficult to identify because of intermittent reinforcement?
7. Summary of progress so far
   - Progress to date and barriers to change
8. Reinforcers of avoidance behavior and analysis of graph
9. Improvements to the website
10. What I liked best about the website

Figure 8. Advice Sent by Other Participants to User "Lemon"

Measures

The Perl-based program that drives the website was used to capture specific, individual-level behavioral data, including: time spent on each page of the website, number of discussion board posts, number of personal blog entries, number of peer feedback messages sent and received, strength of social bonds with peers, and number of health behavior updates. Qualitative information of users' self-reported likes and dislikes of the website was also collected. As previously discussed, participants each selected a health behavior goal that they wished to achieve in the 10-week period of the study and were asked to report daily updates about their health behavior. Health behavior data were standardized and split into four Quartiles across the 10-week observation period to account for differences in start times.

Outcome measures. For purposes of this study, outcomes were considered in terms of absolute change in health behavior activity as well as the clinical, as distinct from statistical, significance of the results.

Health behavior change. Self-report data were used as the measure of level or amount of health behavior activity. Participants were asked to report daily updates about their health behavior across the period of the intervention, yielding 69 possible occasions of measurement. Because each student was permitted to select the health behavior he or she most wished to change, health behavior data were standardized within participants to account for differences in units of measurement and number of updates provided. To accomplish this, the health behavior updates of the participants (updates per participant $M = 39.23$, $SD = 12.95$, range 14-64) were divided into Quartiles. Specifically, the health activity updates of each participant were grouped into four parts across the course of the intervention. A mean was computed for the behavioral data within each Quartile for each participant. To standardize the data, the overall mean (across all points of measurement) of a participant was subtracted from each of his or her four Quartile mean scores, and then divided by the overall standard deviation of his or her data. To ensure that higher scores indicated higher levels of positive health behavior, in cases where a decrease in score reflected positive health behavior change (e.g., number of pounds lost), the valance of the health behavior scores were reversed.

Clinically significant change. Consistent with the recommendations of widely-cited review articles, (Eysenbach, Powell, Englesakis, Rizo, & Stern, 2004; Nguyen, Carrieri-Kohlman, Rankin, Slaughter, & Stulbarg, 2004), the clinical significance of the results obtained was also considered. In order to determine the clinical significance of the treatment effects, an approach consistent with that proposed by Jacobson, Follette and Revenstorf (1984) and Jacobson and Truax (1991) was utilized. Because data from a normative sample are not available for calculating a cutoff point for clinically significant change, criterion "a" or "the two standard deviation solution" (Jacobson & Truax, 1991, p. 13) was used for purposes of this study:

$$a = \text{Pretreatment} + 2S_1$$

Pretreatment is the standardized health behavior score at baseline for a participant and S_1 is the standard deviation of baseline scores for all participants. When a participant's end-of-study score is more than two standard deviations higher than his or her pretreatment score, Jacobson and Traux (1991) consider the participant to have demonstrated clinically significant change. The cutoff score for this sample is as follows:

$$a = \text{Pretreatment} + 2*.51 = \text{Pretreatment} + 1.02$$

Process measures. A variety of behavioral engagement data were tracked to evaluate program implementation and to gain an understanding of how the intervention worked. Data tracked included general measures of website use and of participant engagement and interactivity. Qualitative data were also collected to evaluate participant satisfaction the website.

Website use statistics. Basic measures of intervention dose included time spent on each page of the website (total number of minutes participant was logged in on website) and total word count (total number of words typed by participant on website).

Participant engagement and interactivity. Engagement with the website was quantified in terms of number of social bonds (total number of different individuals with whom participant communicated/made contact), number of personal blog entries (total number of unique blog entries made by participant), number of discussion board posts (total number of unique discussion board posts made by participant), number of advice messages sent (total number of advice messages sent to other individuals by participant), and number of advice messages received (total number of advice received by participant from other individuals).

Qualitative user feedback. Two simple open-ended items ("What did you like best about this website?" and "What did you like least about this website?") were posed to elicit thoughtful feedback about users' likes and dislikes of the website.

Social support measures. The morphologic characteristics of the network were operationalized and analyzed in terms of ego-centric network data, including degree centrality, closeness centrality, betweenness centrality, indegree, and outdegree, and whole network properties such as core/periphery, components, isolates, cliques/subgroups, and density.

Ego network analysis. *Degree centrality* focuses on the direct links between group members and was measured by counting the number of relationships maintained by each actor in a network. In a graph, this can be achieved by counting the number of ties or lines into or out of a particular node. The actor with the most lines has the highest degree and therefore is most central. In a network not all ties are of equal value in that if a person has ties to others who have many ties that person is relatively central. However, if a person has ties to other who have very few ties, then the person is not very central.

The *geodesic* was used to quantify this notion of tie value and is the smallest number of paths connecting two persons. The largest value that the geodesic can take is the number of persons in the network less one. *Closeness centrality* was measured as the number of path lengths or steps required for one actor to reach all other actors in the network. It is the sum of the geodesics for each actor with every possible partner in which a higher value of closeness indicates lower centrality. Centrality was also measured in terms of *betweenness centrality*, which examines the extent to which a particular actor lies "between" the various other actors in the network through determination of number of geodesies within which an actor lies.

The aforementioned centrality indices are unidirectional and do not distinguish the direction of the flow of the interaction. Because analysis of directional relations may illuminate the roles of network actors, *indegree*, the number of ties received by an actor, and *outdegree*, the number of ties originated with another, was also be considered. In this study indegree represents the sum of all messages sent to an individual by other network members and outdegree the sum of all messages sent to the other participants. Various combinations of level of indegree compared to outdegree are associated with different roles identified throughout social network literature.

Whole network analysis. *Density* is a measure of the level of connectivity within the network and reflects the actual number of links as a proportion of total possible links. Network *core and periphery* structure was discerned using centrality indices to partition network actors into two sets: the core, whose members are densely tied to each other (higher centrality scores), and the periphery, whose members have more ties to core members than to each other (lower centrality scores). *Components and isolates* represent the extent to which the network actors are connected. A component exists when a set of actors in the network are connected within themselves but the set is disconnected from others in the network. An actor not connected to any other actor is considered an isolate. A *clique* is a subset of a network in which actors are tied more closely to each other than to other network members. For purposes of network analysis, a clique was defined in terms of a subset of at least three actors who have all possible ties present among themselves.

Data Analysis

Analyses were performed using SPSS 16.0 for Windows (SPSS Inc., 2007) and PSY: A Program for Contrast Analysis (Bird, Hadzi-Pavlovic, & Isaac, 2000). Additionally, UCINET (Borgatti, Everett, & Freeman, 1999) was used for social network analyses and the network was mapped and diagramed using Netdraw (Borgatti, 2002).

Power analyses were conducted with GPower 3 (Erdfelder, Faul, & Buchner, 1996), evaluating the *a priori* sample size required to detect a medium-sized effect (f = .25; Cohen, 1988) for the group x time interaction. Assuming two-tailed alpha = .05 and autocorrelations between repeated measures of r = .50, adequate power (.80) to detect a medium-sized group x time effect (f = .25) would be achieved with a total sample size of 30. Given the sample size of 39, observed power was more than adequate to detect a medium-sized effect (power = .92).

Prior to analysis, data were inspected with respect to the assumptions of the analyses. Normality was assessed through evaluation of descriptive statistics, histograms, and the Fisher skewness coefficient (skewness divided by standard error for skewness; Pett, 1997). The distribution of a variable was considered to be markedly skewed if its Fisher skewness coefficient fell outside ±2.58, indicating skew significant at $p < .01$. The assumption of homogeneity of variance was assessed using Levene's test for the univariate analyses. For repeated measures ANOVA the assumption of sphericity was evaluated using Mauchly's test; if the assumption of sphericity was shown to have been violated degrees of freedom were corrected using Huynh-Feldt estimate of sphericity.

To meet statistical assumptions of normal distribution, predictor variables with non-normal distributions (i.e., show excessive skewness or kurtosis) were trichotomized. The cutoffs used for creating the three subgroups for the trichotomized predictors approximately corresponded to the scores at the 33rd and 66th percentiles of the distribution. As opposed to dichotomization, trichotomization leads to a better estimator (Fedorov, Mannino & Zhang, 2009), does not severely obscure important complexities in the data (Altman, 2005), and does not necessarily lessen statistical power (Farrington & Loeber, 2000).

For social network analyses, relations between participants were manually recorded into a Microsoft Excel spreadsheet (see Figure 9) in which each table column and row represent a participant. The relations in the matrix are directional in that both the originators and recipients of communications are represented. Specifically, the numbers of messages sent are contained within rows while the columns indicate messages received. Furthermore, the relations indicate the strength of the tie and show the frequency of message exchanges between participants. This matrix was imported into UCINET for ego and whole network analyses. Netdraw, a graph drawing program that produces graphical network maps, was used to provide a visual representation of the structural network (see Figure 10).

	4	5	7	8	10	11	12	13	14	15	16	17	18	19	20	21	23	24	25
4	0	0	0	1	1	0	0	0	0	0	0	0	1	2	0	1	1	0	1
5	0	0	2	4	1	0	0	2	1	0	3	2	1	2	2	3	1	0	0
7	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0
8	0	1	0	0	0	0	0	0	1	0	0	0	1	0	3	0	0	0	1
10	1	0	0	1	0	1	1	0	4	0	0	2	2	0	1	3	0	2	1
11	1	0	1	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0
12	1	0	0	0	1	0	0	0	0	2	0	1	0	3	0	0	1	0	0
13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
14	0	0	1	0	0	1	0	1	0	0	0	1	0	0	1	1	0	2	1
15	0	0	0	0	0	0	2	0	0	0	0	0	2	0	1	0	0	0	0
16	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
18	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
19	1	2	0	1	1	0	0	0	0	0	0	1	2	0	1	0	0	0	1
20	0	3	0	3	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0
21	0	1	1	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	1
23	0	2	0	1	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0
24	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0
25	1	0	0	0	0	0	0	1	2	0	0	0	0	1	1	0	0	0	0

Figure 9. Portion of Directional Network Matrix for Message Exchange with Participant Number as Row and Column Labels
Note. Values above the diagonal represent messages sent and values below diagonal represent messages received.

For the first hypothesis, a one-way repeated measures ANOVA was employed to determine the effect of use of the social networking website on change in participant health behavior. Of primary interest in these analyses was the main effect of progression across Quartiles. A significant main effect was followed by custom non-orthogonal planned contrasts in which repeated comparisons were made between adjacent Quartiles (Quartile 1 versus Quartile 2, Quartile 2 versus Quartile 3, and Quartile 3 versus Quartile 4) and baseline to end of study (Quartile 1 versus Quartile 4). Because non-orthogonal comparisons produce test statistics and *p*-values that somewhat correlate, familywise error rate were controlled using the conservative Bonferroni correction (Field, 2005).

To verify that positive health behavior increased among participants who demonstrated clinically significant change, the effect of use of the social networking website on change in participant health behavior was assessed separately for participants who attained clinically significant change and those who did not using separate group one-way repeated measures ANOVAs. A significant main effect was followed by custom non-orthogonal planned contrasts between adjacent Quartiles.

To examine the second hypothesis, two-way mixed ANOVAs with one between-subjects factor (level of behavioral engagement) and one within-subjects factor (behavior change across Quartiles) were used to evaluate the interaction between participant engagement with the website and health behavior change over time. Behavioral engagement and the interaction of behavioral engagement and time (progression across quartiles) were the primary independent variables of interest. A significant main effect for behavioral engagement would indicate an overall difference across levels of behavioral engagement that is consistent across the four Quartiles. The interaction effect, if significant, would represent significant differences among levels of behavioral engagement in health behavior change across Quartiles. Significant a priori selected interaction effects were followed by custom non-orthogonal planned contrasts. Significant interaction effects were decomposed using simple effects post hoc analyses in which behavioral engagement was evaluated as a moderator of between-Quartile change in health behavior. Because SPSS is not amenable to non-standard contrast analyses within a mixed-model design, planned comparisons were performed using PSY: A

Program for Contrast Analysis. PSY is an easy to use program that allows for the control of family-wise error rates for custom planned contrast analysis. PSY can also supply standard or Bonferroni-adjusted critical values.

Behavioral engagement was also considered in terms of its association with clinically significant change in health behavior. Specifically, independent samples t-test and chi-square test were used to test whether there were significant differences between participants who demonstrated clinically significant change and those who did not show significant change.

For the third hypothesis, content analysis was performed on participants' free-text responses to the questions regarding their likes and dislikes of the website. Responses were reviewed by two advanced graduate students to identify themes and patterns and develop a coding system to best describe the data. Each response was subsequently read and coded independently by the two reviewers.

To explore the research questions corresponding to the fourth aim, UCINET was used to analyze the network matrix and calculate indices of centrality (i.e., indegree, outdegree, betweenness, and closeness), yielding a score for each actor on the ego-centric network dimensions of interest. Given that these data are at the respondent level and may be analyzed at the level of the individual participant, scores on these indices were imported from UCINET into SPSS. Two-way mixed ANOVAs with one between-subjects factor (network centrality score) and one within-subjects factor (behavior change across Quartiles) were used to explore the association between actor level network centrality and health behavior change over time. Significant a priori selected interaction effects were followed by custom non-orthogonal planned contrasts. To examine the association between network centrality and clinically significant health behavior change, the centrality scores of participants who demonstrated clinically significant and those who did not were compared using independent samples t-tests. UCINET was also be used to explore structural network properties including core/periphery, components, isolates, cliques/subgroups, and density. Additionally, the graphical network map from Netdraw was assessed to gain additional insight into structural network patterns.

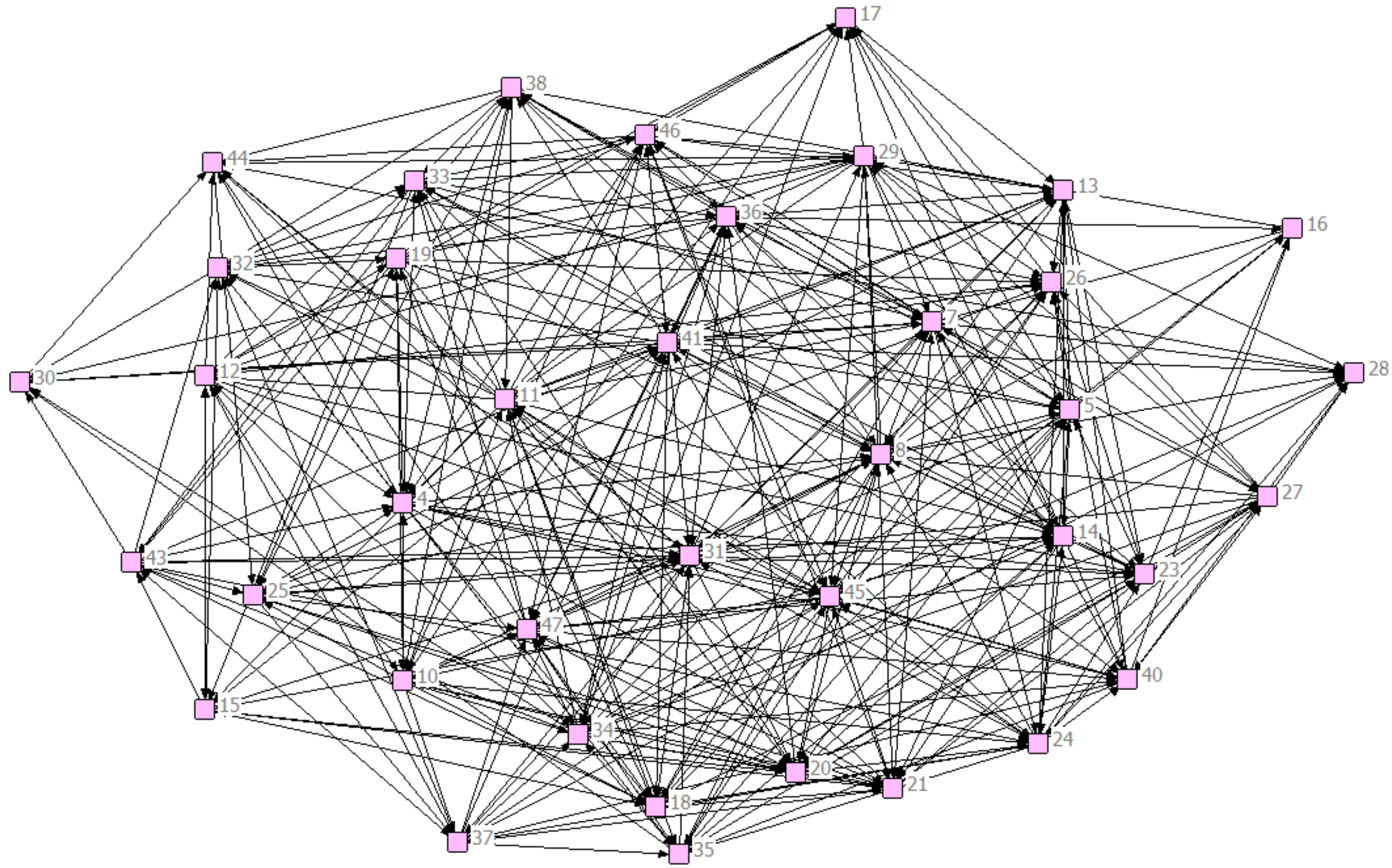

Figure 10. Social Network Diagram Where Nodes Represent Participants and Lines Represent Message Flow

Results

Preliminary Data Analysis

Prior to performing analyses data normality was assessed. Inspection of the histograms of the measures of behavioral engagement revealed that the distributions for the variables total number of minutes logged in, word count and number of discussion board posts were markedly positively skewed and this was confirmed via review of the Fisher skewness coefficients. The advice messages sent and advice messages received variables were also shown to be skewed (i.e., Fisher skewness coefficients exceeded 2.58, indicating positive skew significant at $p < .01$). To meet assumptions of normal distribution, the variables demonstrating significant positive skew (i.e., minutes logged on, word count, discussion board posts, advice messages sent, and advice messages received) were trichotomized with cutoffs corresponding to approximately the 33rd and 66th percentiles of each variables' distribution. Variables shown to have normal distributions (i.e., social bonds and personal blog entries) were treated as continuous. Descriptive statistics for each behavioral engagement variable are shown in Table 3.

Health Behavior Change Over Time

The mean number of health behavior updates submitted by participants was 39.23 (SD = 12.95). The primary health behavior of participants was physical activity (71.8%, n = 28 participants), followed by diet and nutrition (20.51%, n = 8) and other behaviors (i.e., adequate sleep each night and increase communication with loved ones; 7.69%, n = 3). A repeated measures ANOVA was conducted to determine if there was a significant effect of the web-based social-networking intervention on participant health behavior.

Table 3

Descriptive Statistics of Behavioral Engagement Variables

	Mean	*SD*	Median	Skewness[a]	Fisher Skewness Coefficient	Kurtosis[b]
Minutes logged in	914.15	662.15	758.48	2.18	**5.77**	5.24
Total word count	6810.67	3338.41	6270.00	2.04	**5.40**	5.50
Social bonds	21.67	3.71	21.00	0.62	1.64	-0.58
Personal blog entries	33.92	11.60	33.00	0.47	1.24	0.50
Discussion board posts	3.97	4.53	2.00	1.96	**3.74**	1.37
Advice messages sent	22.44	15.13	16.00	1.27	**3.36**	0.87
Advice messages received	16.00	6.27	14.00	0.99	**2.62**	0.82

Note. Boldface denotes significant skew for which variables were trichotomized.
[a]Standard error (*SE*) of skewness = .38. [b]Standard error (*SE*) of kurtosis = .74

Mauchly's test indicated that the assumption of sphericity had been violated, χ^2 (5) = 20.12, $p = .001$, so degrees of freedom were corrected using Huynh-Feldt estimate ($\varepsilon = .76$). As hypothesized, a significant increase in positive health behavior was observed across the four periods of observation of the intervention, $F(2.28, 86.61) = 11.20$, $p < .001$ (see Figure11). Planned contrasts were performed to examine differences between adjacent Quartiles and from Quartile 1 to Quartile 4. The Bonferroni procedure was used to guard against Type 1 error; therefore, the significance level for the planned comparisons was .013. Planned contrasts revealed a significant improvement in health behavior from Quartile 1 to Quartile 2, $F(1, 38) = 19.72$, $p < .001$ and from Quartile 1 to Quartile 4, $F(1, 38) = 19.39$, $p < .001$. Comparisons of other adjacent Quartiles failed to reach significance at the .013 level [Quartile 2 to Quartile 3, $F(1, 38) = 0.10$, $p = .753$; Quartile 3 to Quartile 4, $F(1, 38) = 4.63$, $p = .038$].

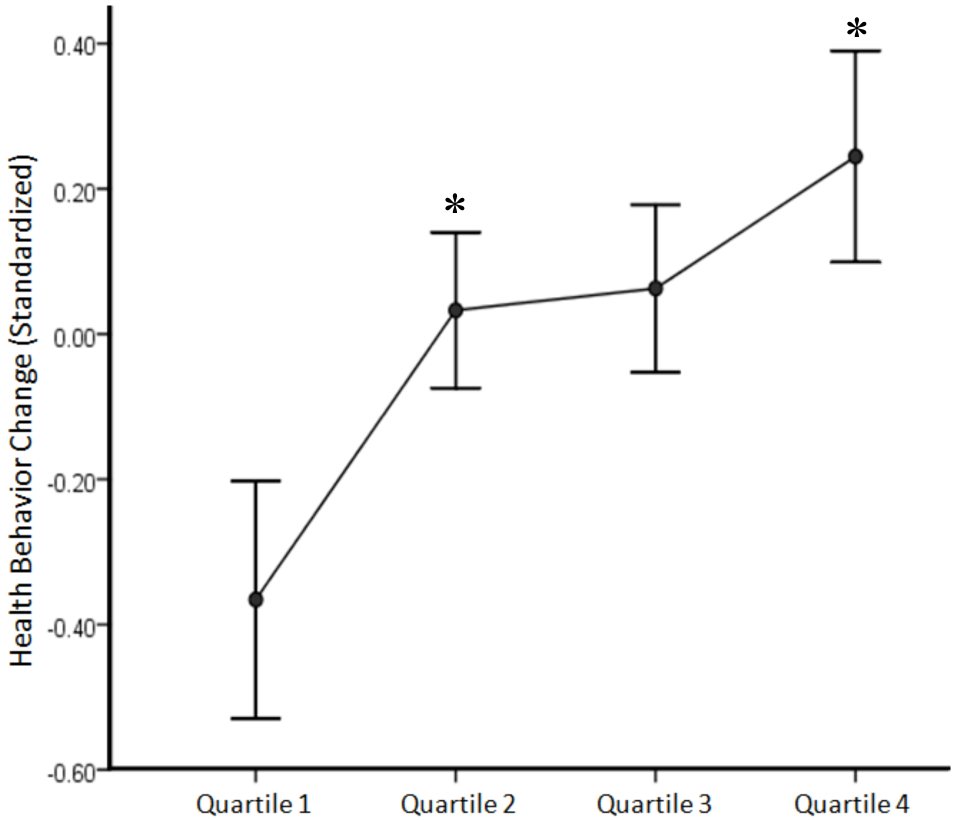

Figure 11. Means plot of standardized health behavior change across time.
Note. * Indicates significant increase in positive health behavior compared to Quartile 1.

The effect of the web-based social-networking intervention on health behavior was also compared between participants who attained clinically significant change and those who did not. Specifically, separate group repeated measures ANOVAs were conducted to verify that positive health behavior increased among participants who demonstrated clinically significant change but not for those who did not show clinically significant change. Mauchly's test was not significant for the analysis of participants who attained clinically significant change, $\chi^2(5) = 9.40$, $p = .096$, or for participants who did not, $\chi^2(5) = 0.83$, $p = .975$, so the assumption of sphericity was accepted. Repeated measures ANOVAs indicated a significant main effect of time on change in health behavior for participants who attained clinically significant change, $F(3, 30) = 56.83$, $p < .001$, but not for those who did not demonstrate significant change, $F(3, 81) = 1.66$, $p = .181$, (see Figure 12). For participants who attained clinically significant change, planned contrasts between adjacent Quartiles, using the Bonferroni procedure (significance level for the comparisons was .016), revealed a significant improvement in health behavior from Quartile 1 to Quartile 2, $F(1, 10) = 72.19$, $p < .001$, from Quartile 2 to Quartile 3, $F(1, 10) = 9.89$, $p = .010$, and from Quartile 3 to Quartile 4, $F(1, 10) = 11.55$, $p = .007$.

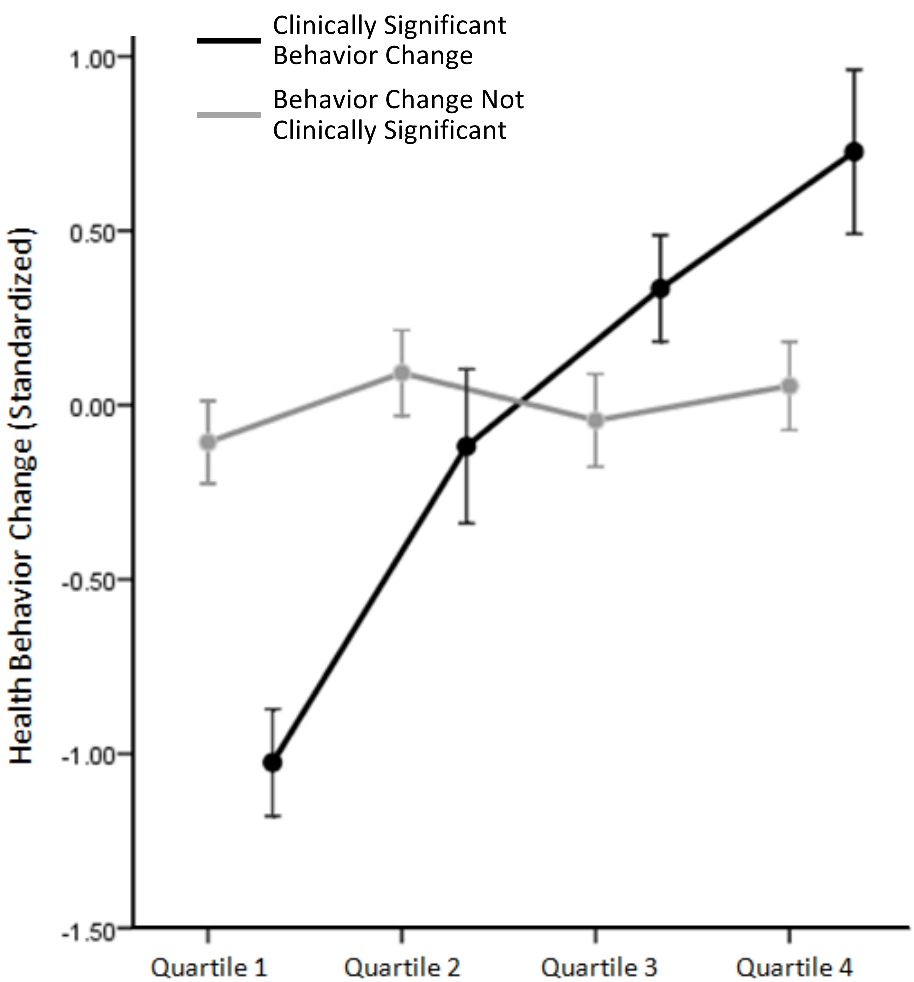

Figure 12. Means plot of standardized health behavior change across time based on achievement of clinically significant change

Association Between Behavioral Engagement and Positive Change

Two-way mixed ANOVAs with one between-subjects factor (level of behavioral engagement) and one within-subjects factor (behavior change across Quartiles) were performed to evaluate the association between measures of behavioral engagement and website and health behavior change over time (see Table 4). Mauchly's test indicated that the assumption of sphericity had been violated for the repeated measures ANOVAs for social bonds, $\chi^2(5) = 18.43$, $p = .002$, personal blog entries, $\chi^2(5) = 17.74$, $p = .003$, minutes logged on, $\chi^2(5) = 16.51$, $p = .006$, total word count, $\chi^2(5) = 22.01$, $p = .001$, discussion board posts, $\chi^2(5) = 19.69$, $p = .001$, advice messages sent, $\chi^2(5) = 18.89$, $p = .002$, and advice messages received, $\chi^2(5) = 13.46$, $p = .020$ so degrees of freedom were corrected using Huynh-Feldt estimate of sphericity.

Table 4

Repeated Measures Models to Compare Behavioral Engagement Across Quartiles

	df	Main Effect (Behavioral Engagement)		Interaction (Time x Behavioral Engagement)	
		F	*p*	*F*	*p*
Social bonds	2.39, 88.48	0.69	.411	2.76	.059
Personal blog entries	2.41, 89.29	0.23	.631	1.80	.163
Minutes logged in	5.02, 90.43	1.39	.262	1.31	.267
Total word count	4.63, 83.39	0.40	.674	0.93	.463
Discussion board posts	4.78, 85.97	1.45	.248	0.29	.914
Advice messages sent	4.83, 86.94	2.04	.145	1.27	.283
Advice messages received	5.29, 95.26	1.06	.356	3.65	.004

Hypothesis 2 was partially supported. No main effects were shown on any measure of behavioral engagement and behavioral engagement was not observed to moderate change across time in terms of number of social bonds, blogs posted, minutes logged in, total word count, discussion board posts, and advice messages sent. In contrast, the interaction effect between time and level of peer feedback was shown to be significant $F(5.29, 95.26) = 3.65$, p =.004, (see Figure 13).

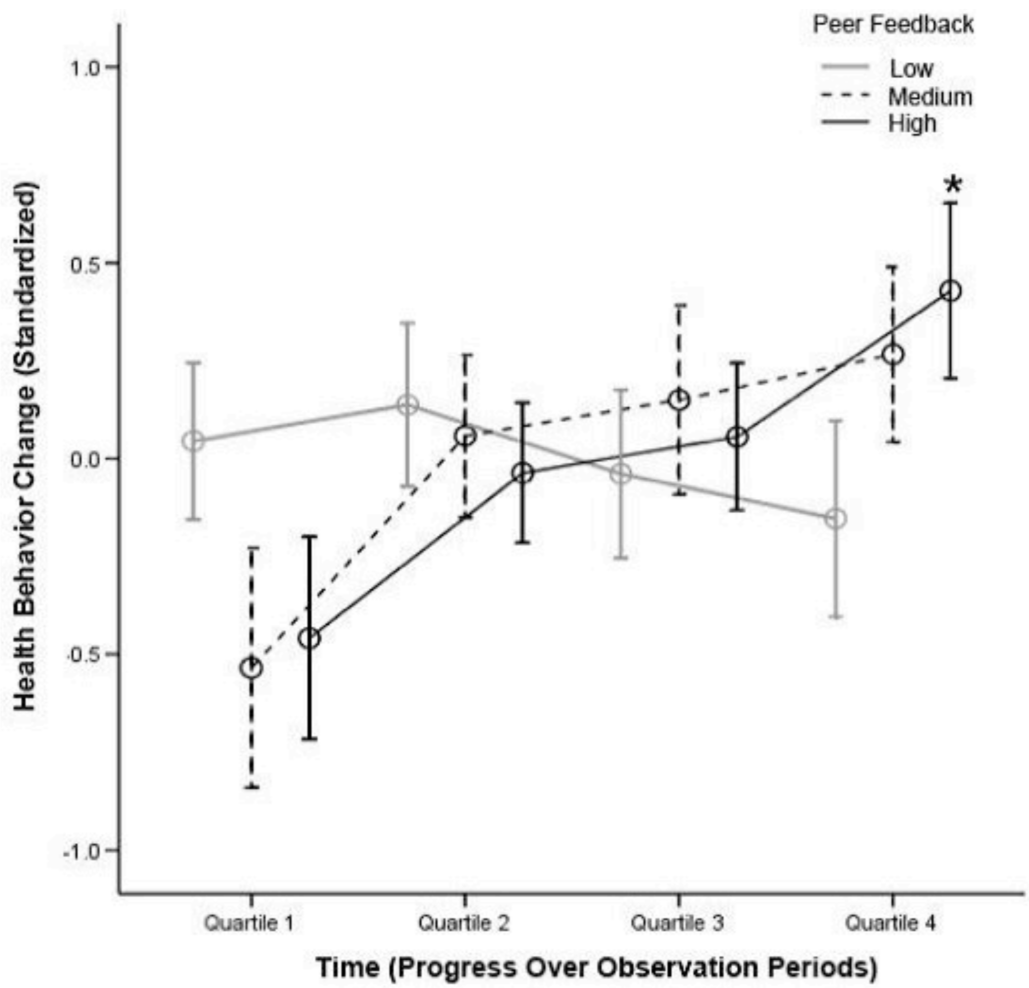

Figure 13. Means plot of change across time based on level of advice messages received

Planned contrasts revealed significant differences across levels of peer feedback in health behavior change between Quartile 1 (*M* = -0.37, *SD* = 0.51) and Quartile 4 (*M* = 0.24, *SD* = 0.45), $F(2, 36) = 6.67$, $p = .003$, and simple effects analyses demonstrated that, as compared to participants who received a low level of peer feedback, greater improvement in health behavior was observed in those who received a medium level of feedback, $F(1, 36) = 8.89$, $p < .05$, and those who received a high level of feedback, $F(1, 36) = 12.25$, $p < .05$, (see Table 5).

Table 5

Mean Health Behavior Scores Over Time as a Function of Level of Advice Received

Number of Advice Messages Received	Quartile 1		Quartile 2		Quartile 3		Quartile 4	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Fewer than 11messages[ab]	0.05	0.26	0.14	0.27	-0.04	0.28	-0.15	0.33
11-15 messages[a]	-0.53	0.48	0.06	0.33	0.15	0.38	0.27	0.35
16 or more messages[b]	-0.46	0.52	-0.04	0.36	0.06	0.38	0.43	0.45

Note. Shared superscripts indicate significant between-group differences in health behavior change between Quartile 1 and Quartile 4.

To further evaluate the association between health behavior change and website usage, participants who attained clinically significant change were compared to participants who did not across the measures of behavioral engagement (see Table 6). At study conclusion, 28.21% ($n = 11$) of the participants demonstrated clinically significant behavior change as determined by the approach suggested by Jacobson and Traux (1991). Participants who showed clinically significant change in health behavior interacted with more peers than those who did not achieve clinically significant change. Participants who achieved clinically significant change had a greater number of social bonds (*M* = 23.82, *SD* = 3.97) than those who did not (*M* = 20.82, *SD* = 3.30), *t*(37) = -2.41, *p* = .021.

Table 6

Behavioral Engagement Based on Clinically Significant Behavior Change

Variable	Clinically Significant Behavior Change (*n* = 11)	Behavior Change Not Clinically Significant (*n* = 28)		
	M (*SD*)	*M* (*SD*)	*t* (37)	*p*
Social bonds	23.82 (3.97)	20.82 (3.30)	-2.41	.021
Personal blog entries	14.82 (4.12)	11.68 (10.33)	-2.48	.018
	n (%)	*n* (%)	$\chi^2(2)$	*p*
Minutes logged in			1.46	.481
Fewer than 500	2 (18.18)	10 (35.71)		
500-899	4 (36.36)	10 (35.71)		
900 or more	5 (45.46)	8 (28.57)		
Total word count			0.10	.949
Fewer than 5500	3 (27.27)	9 (32.14)		
5500-6750	4 (36.36)	9 (32.14)		
6750 or more	4 (36.36)	10 (35.71)		
Discussion board posts			2.09	.352
None	3 (27.27)	8 (28.57)		
1-3	2 (18.18)	11 (39.29)		
4 or more	6 (54.55)	9 (32.14)		
Advice messages sent			0.71	.700
Fewer than 14	3 (27.27)	8 (28.57)		
14-20	3 (27.27)	11 (39.29)		
21 or more	5 (45.46)	9 (32.14)		
Advice messages received			7.08	.029
Fewer than 11	0 (0.00)	9 (32.14)		
11-15	4 (36.36)	8 (28.57)		
16 or more	7 (63.64)	11 (39.29)		

Additionally, participants who demonstrated clinically significant change received more advice than those who did not, $\chi^2(2) = 7.08$, $p = .029$: none received fewer than 11 messages, four (36.36%) received 11-15 messages and seven (63.64%) received 16 or more messages. In contrast, among participants who did not achieve clinically significant change, nine (32.14%) received fewer than 11 messages, eight (28.57%) received 11-15 messages, and 11 (39.14%) received 16 or more messages.

Clinically significant change in health behavior was also associated number of blog entries. Participants who a showed clinically significant change had a greater number of blog posts ($M = 14.82$, $SD = 4.12$) as compared to those who did not ($M = 11.68$, $SD = 3.33$), $t(37) = -2.48$, $p = .018$. Clinically significant health behavior change was not found to be associated with number of minutes logged in, total word count, number of discussion board posts, or number of advice messages sent to peers. Descriptive data for behavioral engagement based on clinically significant behavior change are summarized in Table 6.

Qualitative User Feedback

What participants liked most about the website. The graph was the most frequently cited positive website feature, with 28 participants (82.35%) describing this visual representation of behavior change to be helpful. Sixteen participants (47.06%) mentioned the blog feature (writing personal blog and reading the blogs of peers) as particularly useful. Fifteen participants (44.12%) made positive remarks about the advice feature. The ability to record progress via the daily or near daily updates feature was mentioned as useful by 13 participants (38.24%). Ten participants (29.41%) described exchanging messages with peers (general comments not limited to advice messages) as a positive feature. Table 7 summarizes the website features perceived most favorably.

Table 7

What Participants Liked Most About the Website

Theme	Examples	*N* (%)
Graphs	"The graph was…a nice way to effectively show quantifiable progress which…helped to positively reinforce my health behavior."	28 (82.35)
	"I…really liked the graph because it allowed me to immediately see and analyze my progress or lack thereof."	
Blogs	"To me this is like writing in my journal, but of course with the exception of 36 or so other folks seeing my log….it is fun because you can dialogue with your classmate about your health behavior..."	16 (47.06)
	"I…liked being able to see other people's projects and their blogs…to see that I was not the only one going through the same issue…"	
Advice	"…this project is very similar to the popular MYSPACE phenomenon….By allowing us to comment on each other's "wall", we are giving feedback that is helping us make our… changes."	15 (44.12)
	"After looking at my web page, I realized that there were quite a few people who gave me really helpful advice that I could definitely use or remember while continuing to change my behavior."	
Recording Progress	"Daily check-ins made me think about my progress…The website was easy to use and helped me think about my goals daily."	13 (38.24)
	"The best thing about the website is probably the feature where you could record your progress. This helped me prove to myself how much improvement I have gone through over time."	
Messages	"…students comments were very encouraging…"	10 (29.41)
	"I enjoyed exchanging notes with my fellow students who had the same problems as I did…"	
Discussion Board	"I love the discussion board ☺ It always managed to entertain me and to feel like I was part of a bigger thing."	5 (14.71)
	"I really did like the discussion board because I felt I could write about anything I wanted and communicate with the whole class. It also served as a means for us to discuss any questions…"	
Support	"I…really liked the support from others. I did not feel like I needed a specific type of support; just a "good job" was reinforcing enough."	5 (14.71)

What participants liked least about the website. Though fewer in number than the aforementioned positive remarks, participants also offered comments regarding areas in which website functionality and usability might be improved. The most frequently discussed area in need of improvement was general technical difficulties, with ten participants (29.41%) describing problems such as trouble accessing the website at intervention outset and inability to view the graph because this feature was dependent upon use of a third party plug-in (i.e., JAVA). Four participants (11.77%) mentioned that graph scaling and labeling could be improved so that the graph better represented their targeted health behavior and to make other participants' graphs easier to read.

Three participants (8.82%) reported frustration with the "View Other's Projects" page in that the sequence of the links to other participants' personal pages reshuffled each time the page was viewed. As a result of this reshuffling, participants described difficulty tracking which participants' pages they had viewed and those they had not yet visited. Difficulties encountered in customizing their avatar were mentioned by two participants (5.88%). Two participants expressed dislike of the anonymous nature of the website interactions and described that their experience would have been enhanced had they known the identity of the classmates with whom they interacted. Table 8 summarizes the features of the website perceived least favorably by participants.

Social Networking Analysis

Association between ego-centric properties and behavior change. Prior to analyses, ego-centric variables (i.e., centrality index scores) were assessed for normality. Inspection of the histograms did not indicate that distributions for the variables displayed marked skew. Fisher skewness coefficient and kurtosis values confirmed that the

Table 8

What Participants Liked Least About the Website

Theme	Examples	*N* (%)
Technical Difficulties	"Initially there was certainly some frustration due to problems with the operation of the website....this was corrected as we as a class collectively encountered these bugs. "The problem with JAVA dependence resulted in an inability to see certain graphical features, but this was not a fatal flaw."	10 (29.41)
Graph Scaling	A "…thing that could be improved is providing appropriate labels on the x and y axis on the graph and the on the title of the graph. For example, mine should have days/night on the x axis, number of hours slept on the y-axis…" "…because there were no units shown on the y-axis…it became very difficult to figure out the level of progress regarding everyone's health behavior…"	4 (11.77)
Reshuffling User List	"The thing that really annoys me is the fact that when I go to view other profiles, the sequence reshuffles and I so it's hard for me to remember or note who I haven't really seen yet or comment because they are always out of order every time I go back to view other profile."	3 (8.82)
Avatar Difficulties	"…I was never able to upload a picture although I tried maybe times throughout the quarter. It would work sometimes and towards the end would not work at all!"	2 (5.88)
Disliked Anonymity	"I would have liked to know who people were …support means more if it is personal…some classmates gave me wonderful support and I would have liked to thank them…"	2 (5.88)

variables (i.e., indegree, outdegree, betweenness, and closeness) showed normal distributions and therefore were treated as continuous in analyses. Descriptive statistics for each centrality variable are shown in Table 9. To determine the association between egocentric network data and health behavior change, two-way mixed ANOVAs with one between-subjects factor (network centrality) and one within-subjects factor (behavior change across Quartiles) were performed to evaluate the association between centrality index scores and health behavior change over time (see Table 10).

Table 9

Descriptive Statistics of Network Centrality Indices

Centrality Index	Mean	*SD*	Range	Skewness[a]	Fisher Skewness Coefficient	Kurtosis[b]	Network Centralization
Indegree	14.56	4.27	7.00-25.00	0.16	0.42	-0.25	5.64%
Outdegree	14.56	7.05	1.00-35.00	0.46	1.21	0.96	11.04%
Betweeness	1.51	0.77	0.15-3.41	0.51	1.34	-0.26	1.95%
Closeness	64.43	4.19	55.07-74.51	-0.06	0.16	0.08	20.97%

Note. [a]Standard error (*SE*) of skewness = .38. [b]Standard error (*SE*) of kurtosis = .74.

Table 10

Repeated Measures Models to Compare Network Centrality Across Quartiles

Centrality Index	*df*	Main Effect (Network Centrality)		Interaction (Time x Network Centrality)	
		F	*p*	*F*	*p*
Indegree	2.34, 86.47	0.23	.633	1.48	.232
Outdegree	2.32, 85.82	1.65	.207	1.62	.200
Betweeness	2.31, 85.28	0.03	.865	0.46	.664
Closeness	2.32, 85.66	0.15	.701	0.37	.546

Mauchly's test indicated that the assumption of sphericity had been violated for the repeated measures ANOVAs for indegree, $\chi^2(5) = 19.76$, $p = .001$, outdegree, $\chi^2(5) = 20.45$, $p = .001$, betweeness, $\chi^2(5) = 20.87$, $p = .001$, and closeness, $\chi^2(5) = 20.56$, $p = .001$ so degrees of freedom were corrected using Huynh-Feldt estimate of sphericity. As shown in Table 10, none of the main effects for the centrality indices or interaction effects between time and network centrality were found to be significant.

The association between egocentric network data and health behavior change was also considered in terms of participant attainment of clinically significant change (see Table 11). Clinically significant change in health behavior was associated with indegree. Participants who a showed clinically significant change had higher indegree scores (M = 17.18, SD = 4.02) as compared to those who did not (M = 13.54, SD = 4.05), $t(37) = -2.54$, $p = .016$. Furthermore, there was a trend for participants with clinically significant change to demonstrate higher outdegree scores (M = 17.64, SD = 7.33) as compared to those who did not (M = 13.36, SD = 6.82), $t(37) = -1.73$, $p = .092$. Clinically significant change was not found to be associated with betweenness or closeness centrality scores.

Table 11

Network Centrality by Clinically Significant Change

Variable	Clinically Significant Behavior Change (n = 11)	Behavior Change Not Clinically Significant (n = 28)		
	M (SD)	M (SD)	t (37)	p
InDegree	17.18 (4.02)	13.54 (4.05)	-2.54	.016
OutDegree	17.64 (7.33)	13.36 (6.82)	-1.73	.092
Betweeness	1.59 (0.64)	1.48 (0.83)	-0.42	.680
Closeness	65.03 (2.92)	64.20 (4.69)	-0.54	.592

Whole network analysis. The density value for the adjacency matrix for the network, representing the average number of messages exchanged between any two participants, was 0.28 (SD = 0.45). The density for the dichotomized matrix was 0.38, indicating that 38% of all possible ties among participants were realized. The standard deviation of the density value for the dichotomized matrix of 0.73 was close to twice as large as the mean, suggesting considerable variability between participants in terms of number of different peers with whom messages were exchanged. Network core/periphery structure indicates that core members held more centralized positions in the network (see Figure 14). Furthermore, members were connected overall; no isolates or components were shown.

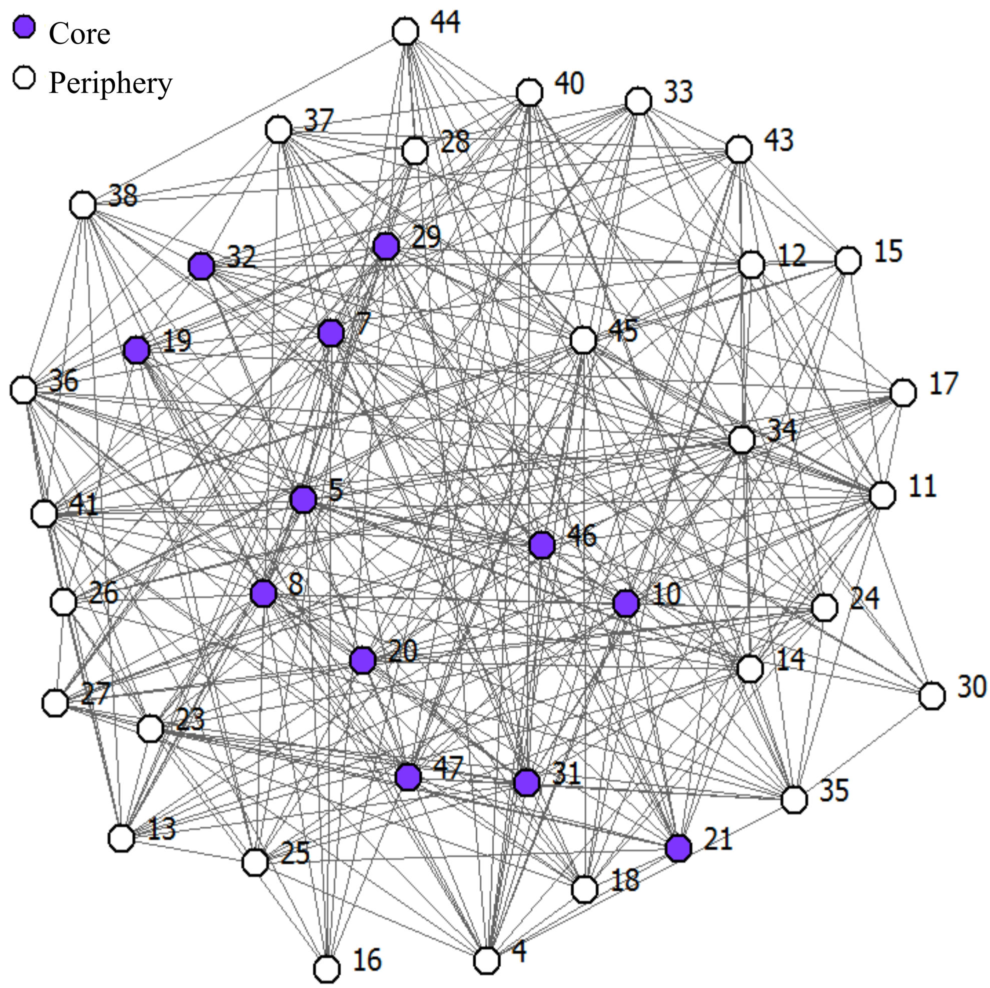

Figure 14. Diagram of Network Core/Periphery Structure

Clique analysis was performed to evaluate the presence of subgroups in the network. When defined in terms of a subgroup of at least three participants who have all possible ties present among themselves, 18 cliques of size three were identified (see Table 12 and Figure 15).

Table 12

Cliques of Size Three

Clique	Members		
1	**5**	**7**	**21**
2	**5**	**21**	**29**
3	**5**	**21**	46
4	**5**	8	20
5	**5**	19	**32**
6	**5**	**29**	**32**
7	4	19	25
8	4	19	**32**
9	4	25	38
10	14	24	43
11	24	**31**	43
12	28	**29**	**44**
13	28	40	45
14	**23**	**31**	36
15	**7**	**31**	36
16	**31**	36	46
17	34	40	45
18	8	20	47

Note. Boldface denotes clinically significant change.

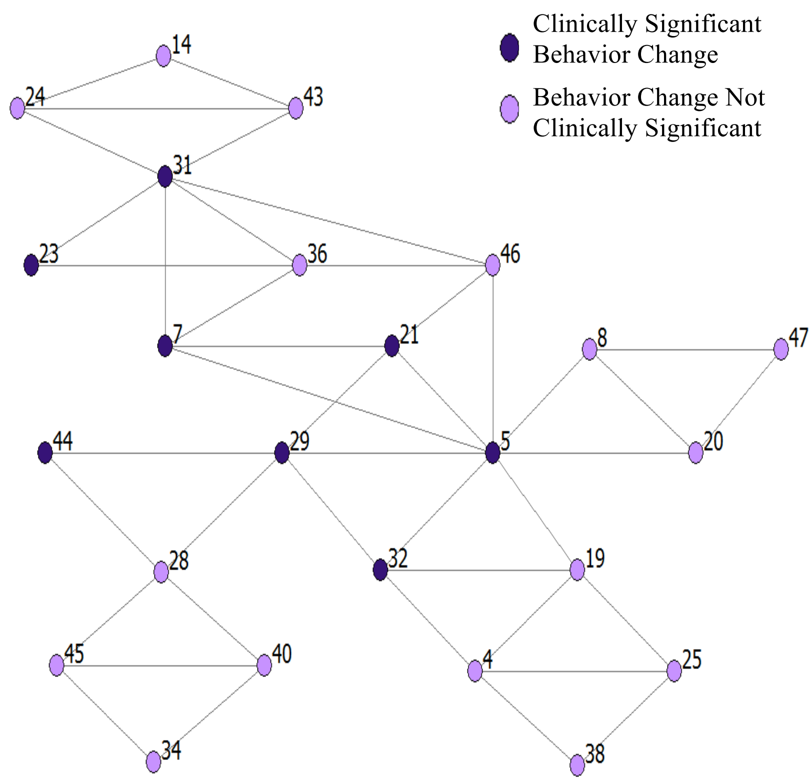

Figure 15. Diagram of Cliques Colored by Achievement of Clinically Significant Change

In terms of clique co-membership, of the 154 opportunities for shared membership between two cliques, 21 instances of co-membership of a single participant and 14 occasions of shared membership of two participants were identified. To assess clique composition and its association with health behavior change, membership patterns were considered in terms of clinically significant change in health behavior. As previously discussed, of the 39 participants, 11 (28.21%) demonstrated clinically significant health behavior change. Such change was more frequently observed among membership of the 18 identified cliques and of the 54 clique members, 22 (40.47%) were observed to have achieved clinically significant change, $\chi^2(1) = 9.05$, $p = .003$. Furthermore, an association between clique membership patterns and attainment of clinically significant change was observed with greater similarity in degree of health behavior change within than between cliques in the network, $\chi^2(17) = 2.95$, $p = .031$. In contrast, health behavior goal type (i.e., exercise, diet and other health behaviors) was not shown to be related to clique membership patterns, $\chi^2(34) = 2.88$, $p = .720$.

Structural network patterns were also assessed via diagrams generated using Netdraw. To create the visual representations of the network, iterative metric multidimensional scaling was used to position nodes in space such that between node distances meaningfully represents a relational construct (e.g., strength of tie). A diagram providing a visual representation of online network communication is shown in Figure 16. The network structure and shape indicate the network was well connected overall. Network connections were not dependent upon any single member, though some members appeared to have functioned as "hubs" (e.g., participants 8 and 45), helping to connect others in the network.

In general, and as might be expected, the larger sized (i.e., more central) nodes are positioned proximal to the network core while the smaller sized (i.e., less central) nodes tend to be situated closer to the periphery. For the association between network structure and degree of health behavior change, patterns are less easily observed. Node coloring does not appear to relate strongly to network centrality with regard to proximity to the core or node size. Node coloring (e.g., degree of health behavior change) seems better described in terms of a clustering pattern in which stronger ties (as indicated by closer proximity) are shown among participants who showed a greater degree of behavior change (darker node shading; e.g., participants 31, 10, 14, 35, and 25) as well as among those who demonstrated less change in health behaviors (lighter node shading; e.g., participants 7, 37, 38, 32, and 19).

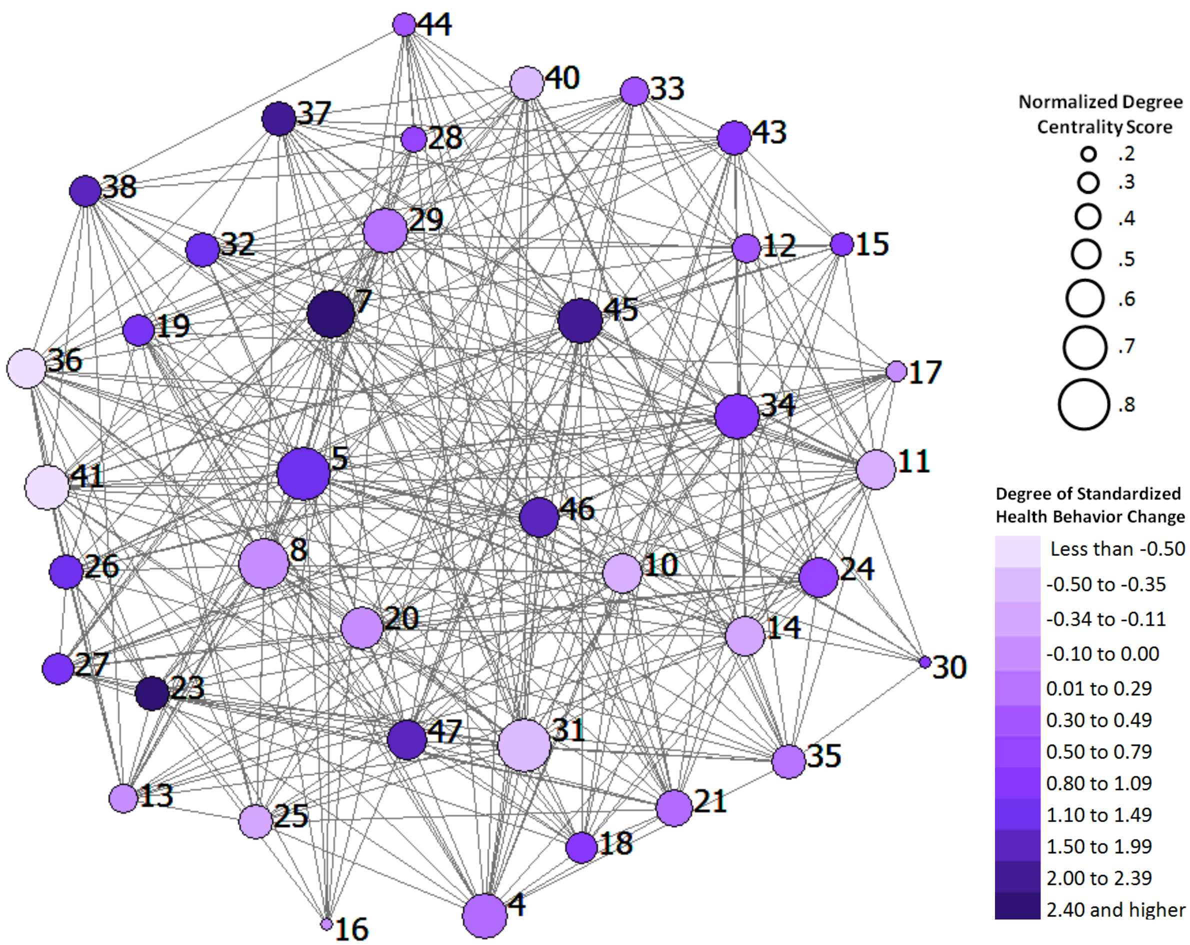

Figure 16. Diagram Where Node Size Represents Network Centrality and Node Shade Represents Degree of Participant Health Behavior Change

Another diagram providing a visual representation of online network communication is shown in Figure 17. Similar to the last figure, nodes have been sized to represent degree centrality. In this depiction, however, node color represents change in terms of achievement of clinically significant change. Furthermore, to enable consideration of the association between type of health behavior and network structure, node shapes have been altered to reflect behavior targeted for change by participants: physical activity (circle), diet/nutrition (diamond), and other health behaviors (square).

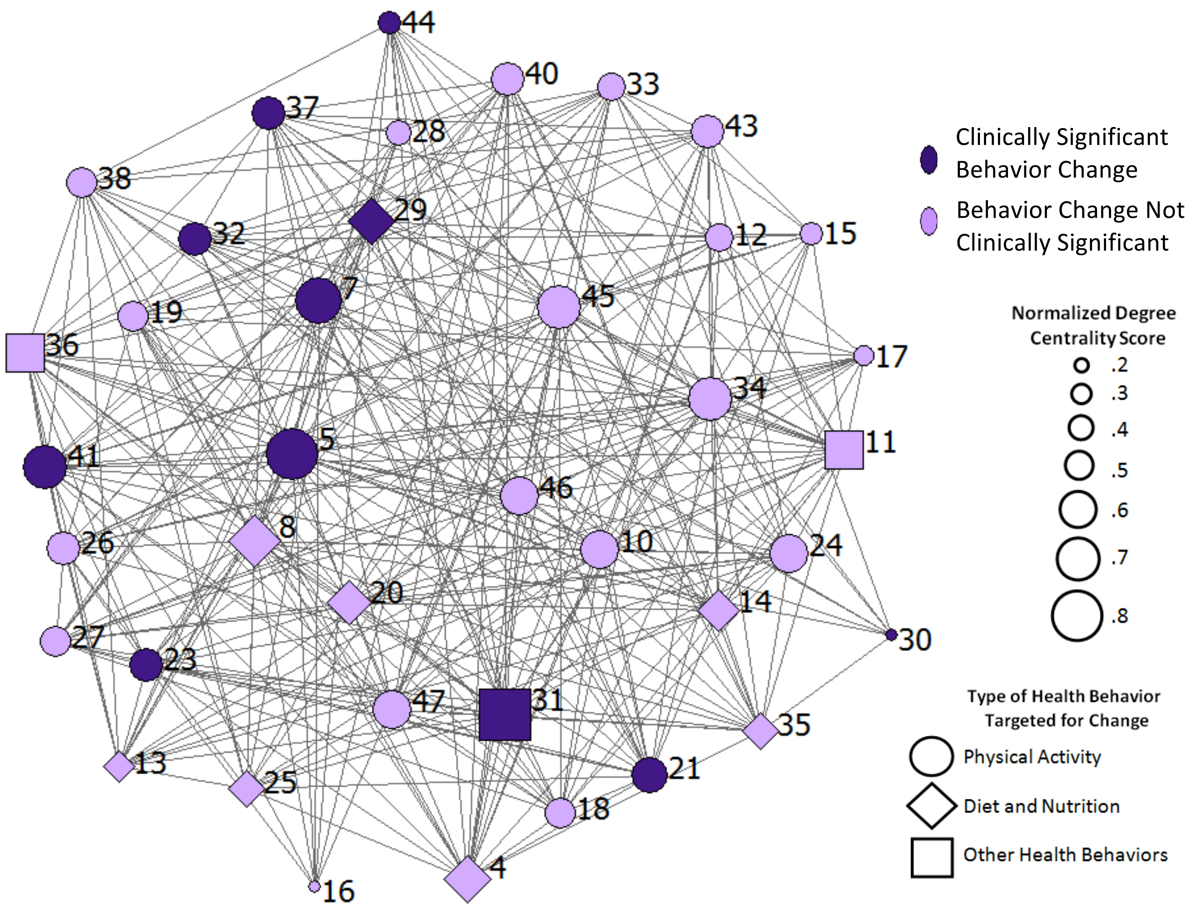

Figure 17. Diagram Where Node Size Represents Network Centrality, Node Color Represents Participant Achievement of Clinically Significant Change, and Node Shape Represents Type of Health Behavior Targeted for Change

Similar to the pattern observed in the previous diagram, the larger sized (e.g., more central) nodes appear to hold placements more proximal to the network core. In this diagram, while node color again seems unrelated to network centrality, participant health behavior change again seems better described in terms of a clustering pattern (e.g., participants 5, 7, 9, 32, and 37). Lastly, network structure appears unrelated to type of health behavior targeted for change as there is no discernable pattern in terms of the distribution of the three node shapes.

To better elucidate the association between network structure and participant health behavior change, network communication was also be considered in terms of reciprocal ties. In the previous two diagrams, ties represented communication that was reciprocal well as asymmetric (in which the relationship between nodes is unidirectional). A diagram providing a visual representation of online network communication focusing on reciprocal ties is shown in Figure 18. Node color represents participant achievement of clinically significant health behavior change and an alternative, circular configural pattern was selected for representation of network structure to provide added perspective on thssociation between tie strength and participant health behavior change. Similar to the other diagrams this visual representation depicts a generally well connected network. Participants 13, 16 and 30 emerge as isolates in this network of reciprocal ties, suggesting that all communications to and from these nodes were asymmetric in nature.

Clustering of nodes with respect to participant attainment of clinically significant change in health behavior is also present and in this diagram the pattern is apparent. Particularly striking is the group of nodes in the upper left portion of the diagram (participants 29, 21, 7, 5, 44, and 32) which represent the presence of a concentrated set of reciprocal ties among participants who all demonstrated clinically significant change in health behavior. The significance of this clustering is further enhanced by the relative absence of participants who achieved clinically significant change elsewhere in the network. Though the nature of the relationship remains unclear this diagram suggests the presence of an association between reciprocal network ties and participant health behavior change.

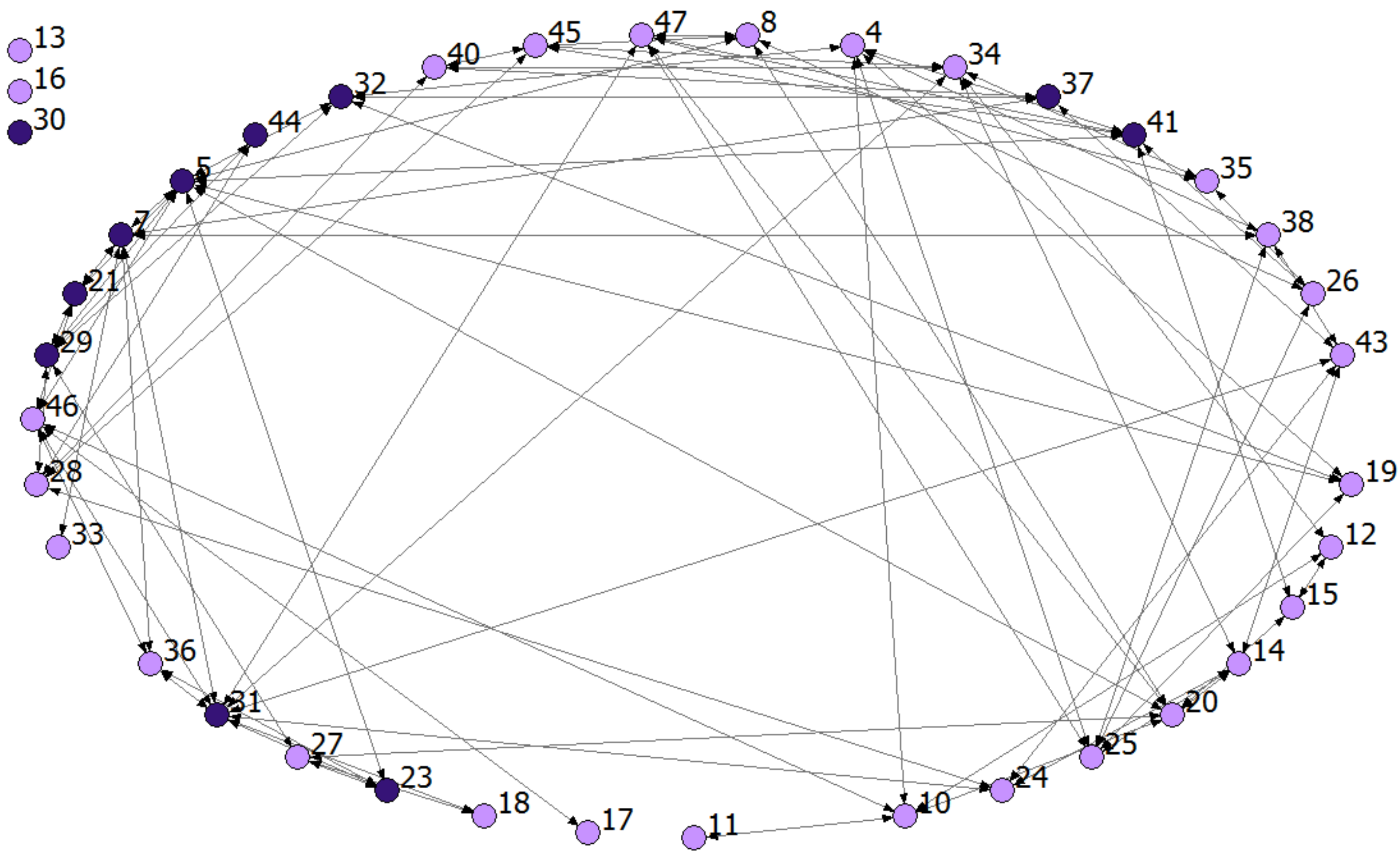

Figure 18. Diagram of Reciprocal Ties Where Node Color Represents Achievement of Clinically Significant Change

Discussion

Overweight and obesity is a growing problem among college and university students (Nelson et al., 2007). However, studies of interventions to improve the health behaviors of college students are limited in number (e.g., physical activity interventions, Booth et al., 1998; Keating et al., 2005), do not consider theoretical mechanisms linked to positive change (Biddle & Nigg, 2000) and fail to address barriers that hinder the widespread dissemination (Glasgow & Emmons, 2007). The internet holds potential for wide-scale dissemination and enables objective evaluation of behavioral engagement. The appeal of the internet as is further enhanced by the emergence of web-based social-networking given that peer-support has been associated with positive outcomes (McKay et al., 2002; Schneider et al., 1990). Extant web-based intervention research has not fully capitalized upon the aforementioned benefits and capabilities. The current study proposed to pilot an internet-based social-networking intervention for health behavior change, use objective web use data to evaluate the role of behavioral engagement as a mechanism of change over time, review qualitative feedback regarding participants' likes and dislikes of the website, and use of SNA to analyze structural support and its effects on health behavior change.

Findings of the Present Study

Health behavior change over time. Consistent with the first hypothesis, a significant increase in positive health behavior was observed across the four quartile periods of observation. Beyond providing additional support for the effectiveness of web-based health behavior interventions, this study is important because it is among the first to demonstrate the successful use of a novel web-based social networking intervention for health behavior change. Further, this intervention was piloted using a group of university students, a population about which health behavior change research is lacking (Ebert et al., 2003) and appears to be the first formal evaluation of an online social network designed to promote health behavior change in college and university students. Previous studies of interventions shown successful in improving health behaviors of college students utilize alternative strategies such as provision of personalized feedback (e.g., Kypri & McAnally, 2004). The results of the present study demonstrate the effective use of a non-tailored health behavior intervention among college students and provides further support to literature suggesting that tailored and non-tailored interventions are similarly effective (e.g., Spittaels et al., 2007; Marcus et al., 2007; McKay et al., 2001). In contrast to non-tailored interventions however, the greater cost and complexity of personalized, tailored interventions may limit their dissemination potential. Web-based social networking programs offer an effective, minimally intensive and easily disseminable alternative to traditional face-to-face and tailored approaches.

Although a positive outcome was observed in the present study, general literature about the efficacy of web-based health behavior interventions report mixed results and the primary source of difference between effective interventions and those that do not show significant results remains unclear (Vandelanotte et al., 2007). A better understanding of the mechanisms through which web-based interventions exert positive influence is needed (Marcus, Nigg, Riebe, & Forsyth, 2000), particularly identification of the most effective intervention elements. (Vandelanotte et al.). Among the web-based intervention studies of the association between objective web usage data and health outcomes, only a limited number of measures of website usage were discussed (e.g., McKay et al., 2001); consideration of a number of measures of website usage is recommended to best identify intervention elements associated with positive change (Bellg et al., 2004).

Association between behavioral engagement and positive change. In an attempt to better understand the key mechanisms of action underlying intervention effects, this study examined multiple measures of website use and engagement in relation to health behavior change. Health behavior change was found to be associated with some measures of behavioral engagement, lending partial support to the second hypothesis. Specifically, peer advice messages received was shown to significantly moderate change across time with greater improvements in health behavior observed among participants who received higher levels of advice messages. The importance of peer support in health behavior change was also evidenced by the significant association between clinically meaningful change and peer advice messages received as well as number of social bonds.

This finding is consistent with those of other web-based health behavior interventions that demonstrated the benefits of peer support in health behavior change. In general social support interventions have been shown to be effective in promoting health behavioral change (Davison et al., 2000). However, some research of non-web-based social support has indicated that larger social networks may contribute to negative outcomes (e.g., Deelstra et al., 2003; McIntosh, 1991). Web-based social networks however afford individuals greater control in selecting with whom and for how long they want to interact which may lessen the frequency and quantity of unhelpful or harmful social exchanges.

The findings of the present study support the inclusion of peer support capabilities to increase the effects of web-based health behavior change programs for college students. Bandura (1997) emphasized the importance of interactions with similar others in SCT to best facilitate observational learning and vicarious experience, indicating that the type of peer support offered in this intervention should be similarly effective in the promotion of health behavior in other groups. Research is needed to determine the efficacy of web-based social networking interventions in other populations and in the promotion of other health behaviors. Additionally, further research is needed to identify and design website functions and features that facilitate the expansion of the network of an individual and promote supportive reciprocal communication between network members.

Number of blog entries was also shown to be significantly associated with clinically meaningful change. Given that participants' blog entries primarily pertained to course assignments for the behavior change project, number of blog entries could be considered an indicator of intervention compliance. An association between higher levels of participant compliance and stronger intervention effects have been demonstrated in previous internet-delivered health behavior intervention studies (e.g., greater weight loss among participants who more consistently submitted food self-monitoring journals; Tate, Wing, & Winett, 2002). The general link between participant exposure to and engagement with intervention materials and positive outcomes has been recognized in the literature. A recent review of web-based physical activity interventions reported that while positive outcomes were demonstrated by 78% of studies with high levels of participant contact (i.e., more than five interactions), only 17% of the studies with low levels of participant contact (i.e., one to five interactions) showed positive results (Vandelanotte et al., 2007).

Low participant compliance and high rates of attrition have been identified as challenges for web-delivered health behavior interventions (Vandelanotte et al., 2007). In the present study however, no participants were lost to attrition and engagement with the website was high overall. The intervention website was designed to maximize participant engagement and incorporated a number of strategies shown effective in the literature such as inclusion of interactive features (Vandelanotte et al., 2007) and peer support capabilities (McKay et al., 2002). In view of the context of the intervention (i.e., a university class), the presence of a powerful incentive (i.e., course credit) may have impacted the levels of engagement and retention observed in the present study. In a study of a web-based body image intervention for college-aged women, high levels of compliance were attributed to using course credit as an incentive (Celio, Winzelberg, Dev, & Taylor, 2002). This suggests that the intervention piloted in the present study may be similarly effective if used with middle and high school students as part of a health or physical education course.

The findings of the presents study indicate that objective website use data are important indicators of program effectiveness. Consistent with expert recommendations (Vandelanotte et al., 2007), this study used captured data of participant website use to objectively quantify exposure to the intervention and levels of participant engagement. It is important to note however that because website usage data were aggregated into an overall mean score for each measure of behavioral engagement it was not possible to assess the potentially transactional relationship between engagement and behavior change or infer causation. For example, it is possible that individuals most motivated to improve their health behaviors were more diligent users of the website, resulting in an association between positive outcomes and higher levels of behavioral engagement.

It is also necessary to acknowledge though that measurers of behavioral engagement and health behavior change outcomes represent only two of a set of complementary indicators of broader program engagement. To best understand program engagement and ultimate intervention effectiveness it is necessary to consider other indicators of engagement such as participant comprehension of intervention material and measures of the theoretical constructs around which the intervention and its material were designed. With that said, given that capturing website use data is technically possible, it should be measured in future studies of web-based health behavior interventions.

Qualitative user feedback. Review of participant feedback about the website provided support for the third hypothesis: The features and usability of the website were generally described as positive and the interactive elements were most frequently reported as helpful. The majority of participants described the personalized progress graphs to be helpful. Peer support and the ability to exchange messages with others were also frequently reported as beneficial. These findings correspond to those of other reviews of the preferences of users of web-based health interventions in which the importance of website interactivity was emphasized. Among a series of focus groups of user preferences of web-based physical activity interventions, intervention elements reported to be helpful included a tool to track and monitor progress and access to communicate with supportive, like-minded others (Ferney & Marshall, 2006).

Though fewer in number than the positive comments, participants in the present study also offered some negative feedback. The lowest levels of user satisfaction related to minor website technical difficulties. Ease of use has been identified as a priority by users of web-based health interventions and it is recommended that websites undergo extensive usability testing prior to intervention commencement (Ferney & Marshall, 2006). Overall, participants in the present study expressed high levels of satisfaction with the website, suggesting that web-based social networking interventions are an acceptable mode of health behavior program delivery for university students. Further, through the use of two simple open ended questions about what participants liked most about the website and areas in need of improvement on the website, valuable and actionable feedback was elicited that can guide intervention website modifications to further enhance the experience of future participants.

Social networking analysis. The SNA measures examined in the present study provided useful information about participant interaction patterns. With regard to ego-centric network data, degree centrality indices were good estimators for the extent message exchange among network members. Higher indegree was shown to be associated with attainment of clinically significant change. In view of the significant relationship observed between peer advice messages received and health behavior change, this finding is not unexpected and confirms the similarity of the constructs. Furthermore, clique analysis was shown to be effective in identifying subgroups within the network. Additionally, the visualize representations of network structure created with

Netdraw demonstrated the utility of such diagrams in depicting network structure and the roles of network members. In the present study, the diagram of reciprocal network ties with nodes colored to represent clinically significant change was particularly illuminating as it depicted more concentrated sets of reciprocal ties among participants who attained clinically significant change and among those who did not. This observation is consistent with recent research indicating that clustered social networks best facilitate behavioral diffusion and that adoption of health behaviors increased through reinforcing ties inherent to clustered networks (Centola, 2010).

It is important to note that the emphasis of this study was on the examination of the provision of social support, particularly in terms of message exchanges between peers. The extent to which the advice messages were perceived by recipients as supportive in the manner intended was not considered. The mere existence of relationships does not mean they are supportive and to fully evaluate social support it is necessary to consider the nature, content, and quality of relationships. According to the Optimal Matching Theory (Cutrona & Russell, 1990), the effectiveness of any type of support depends on the extent to which it meets the demands of a stressor, and evidence increasingly suggests that the effectiveness of social support relates to the match between the functions provided by relationships and focal needs or concerns of an individual. In health behavior research, instrumental support and informational support have been linked to higher fruit and vegetable intake while emotional support has been found to predict physical activity among women but not men (Thrasher, Campbell, & Oates, 2004). Further research is needed to explore the differential influences of structural and functional aspects of support on health behavior change outcomes.

Furthermore, although SNA was shown to offer useful information about the social network, the cross-sectional nature of the social networking data did not allow for temporal analysis of the reciprocal interplay between evolving network structure and group- and individual-level health behavior change outcomes. Longitudinal or dynamic SNA is increasingly used in the social networking literature and represents a step forward in SNA research.

Limitations

Although the study intervention was shown effective and this process and outcome evaluation yielded a number of theoretical and practical implications, limitations to this study must be noted. The small sample size and lack of a control group limit conclusions about changes attributable to the web-based social support. Because the sample consisted of graduate students in the field of public heath, it is possible that these motivated and knowledgeable participants were not entirely representative of the general population of college and university students. The lack of information regarding individual-level characteristics of participants disallowed examination of for whom the interventions was most effective. Because engagement in the educational components of the course (i.e., lectures and readings) was not considered in the analyses, it cannot be known whether the positive change primarily derived from the web-based social support, the educational materials, or a combination of the two.

Another limitation in this study is that health behavior change data were based upon participant self report and may have been subject to several sources of error. Participants who purposefully or unintentionally misreported their health behavior change may have introduced bias. Further, the self-report format may have contributed to over report of positive, socially desirable outcomes. Use of objective measures of heath behavior may yield more data regarding the effectiveness of health behavior interventions among university students. A limitation of the data analysis strategy of the present study was use of repeated measures ANOVA to assess health behavior change over time. In order to make the data amenable to analysis in repeated measures ANOVA, daily update data were aggregated into four summary scores corresponding to the Quartiles of the intervention. Hierarchical linear modeling (HLM) enables the analysis of longitudinal data with varying numbers of occasions of measurement across participants. The level of precision afforded by HLM makes it possible to model transactional relationships such as that between social support and health behavior outcomes. Future studies of web-based social networking interventions would likely benefit from use of HLM for data analysis.

Implications

Although modest in scale, the present study extends the literature on web-based health behavior interventions and offers a number of implications. At a broad level, this study provides support for the effectiveness of internet interventions and demonstrates the importance of web-based social support in facilitating health behavior change Furthermore, some previous research has shown web-based heath interventions to be effective but the intervention mechanisms through which interventions exerted positive influence remained unclear. This study showed that positive health behavior change was related to higher levels of peer support (i.e., advice messages received and number of social bonds) as well as number of blog postings.

The present study also demonstrated the effectiveness of a low cost, minimally intensive support intervention. As such, this type of web-based support intervention may serve as an effective foundation in a stepped care approach for health behavior change. For clinical practice, this study provides a framework for and offers insight to individuals developing web-based social networking interventions for the promotion of physical activity, healthful diets and other health behaviors. The peer support provided through web-based social networks may complement and enhance the effects of interventions and support provided by healthcare professionals.

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