Fruit and vegetable intake and eating behaviors mediate the effect of a randomized text-message based weight loss program

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ABSTRACT

Introduction. We hypothesized that fruit/vegetable intake and eating behaviors mediate the relationship between experimental condition and weight loss in a randomized trial evaluating a text-message based weight loss program.

Methods. Overweight/obese individuals from San Diego, CA (N = 52 with complete data) were randomly assigned in 2007 into one of two groups for four months: 1) the intervention group that received 2–5 weight management text-messages p/day; 2) the usual-care comparison group. Three 24-hour recalls assessed fruit/vegetable intake change and the eating behavior inventory (EBI) measured change in eating behaviors. Regression path models tested intervention mediation.

Results. Direct effects of the intervention were found for change in body weight ($b = -3.84$, $R^2 = 0.074$), fruit/vegetable intake ($b = 2.00$, $R^2 = 0.083$), and EBI scores ($b = 7.15$, $R^2 = 0.229$) (ps < 0.05). The treatment group to weight change path was not statistically significant ($b = -0.673$, $R^2 = 0.208$) when fruit/vegetable intake change and EBI score change were specified as intervention mediators in the model. The total indirect effect was 3.17 lb indicating that the indirect paths explained 82.6% of the total effect on weight change.

Discussion. Fruit/vegetable intake and eating behaviors mediated the intervention's effect on weight change. The findings suggest that sending text-messages that promote healthy eating strategies resulted in moderate short-term weight loss.

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Introduction

In the U.S., 68% of adults age 20 and over are overweight or obese (Flegal et al., 2010) and by 2030, 50% are projected to be obese (Finkelstein et al., 2012). Obesity contributes to six of the ten leading causes of death in America, including heart disease, type 2 diabetes, certain cancers, and high blood pressure (Danaei et al., 2009). It is well known that for most people obesity is caused by a positive energy imbalance (NHLBI, 2007), which occurs primarily due to lack of physical activity and over consumption of an energy dense diet (Hill, 1998; Koplan, 1999). Fortunately, obesity is highly preventable and treatable with modifiable lifestyle changes (Curioni and Lourenço, 2005; Stiegler and Cunliffe, 2006). Research indicates that weight loss is best achieved through a combination of improved diet and physical activity behaviors (Knowler et al., 2002). Therefore, to reduce the burden of illness and disability caused by obesity, it is critical to design effective interventions that help individuals improve these behaviors.

One behavior that has been associated with an increase intervention-related weight loss success is the consumption of fruits and vegetables (Dolecek et al., 1997; Epstein et al., 2001; Weinsier et al., 2009). Because fruits and vegetables are high in water and fiber and low in energy density, consuming more of them can help increase satiety, reduce hunger, and decrease energy intake (Rolls et al., 2004). Another factor known to increase weight loss success is learning to manage other eating-related behaviors (e.g., healthy snacking, spacing of consumption, and self-monitoring of food intake) to reduce caloric intake. Frequent use of appropriate self-management strategies were related to weight loss when used in weight management interventions (BingBing and Dennis, 2000; Pellegrini et al., 2011; Unick et al., 2010). Increasing fruit and vegetable intake and healthy eating behaviors are important weight loss strategies, and therefore changes in these behaviors are potential mediators between an intervention program and weight loss outcomes.

Conducting a mediation analysis can provide information into the development of effective interventions for weight loss because mediators identify why and how interventions work. In its simplest form, mediation is when X (i.e., the independent variable) causes M (i.e., the mediator), which causes Y (i.e., the dependent variable) (MacKinnon et al., 2007). Statistical mediation occurs if, after adjusting for the influence of M on Y, the effect of X on Y is eliminated or diminished.

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Identifying mediators of the effect of an intervention program on weight loss informs theory and intervention design by providing evidence as to what mechanisms the intervention used to result in weight loss (Kraemer, 2002).

A promising new way to deliver information and reminders and communicate with obese individuals about weight loss strategies is through text-messaging (Haapala et al., 2009; Patrick et al., 2009). Text-messaging is an inexpensive, almost-instantaneous form of two-way communication that transmits brief written messages via a mobile phone and has many capabilities that can be harnessed for weight loss. For instance, depending on its function text messages can convey cues to action, prompts, goals, goal reminders, feedback and reinforcement; important constructs in several behavioral theories (Bandura, 1986; Patrick et al., 2005; Stokols, 1992). Unlike other modes of communication (e.g., brief advice, print material), text messaging is particularly unique in its ability to access individuals by mobile phone almost anywhere and anytime. If used properly, real-time access can be used to motivate individuals make healthful lifestyle decisions that are made continuously throughout the day, such as making healthful diet choices.

We are unaware of any research examining meditation in the context of a text-message based weight loss study. In this study, we used data from Patrick et al.'s (2009) Mobile Diet Intervention through Electronic Technology (mDIET) study to examine if fruit and vegetable intake and eating behaviors mediated the intervention effect on weight loss. mDIET was a randomized controlled trial of a text-message based weight loss intervention. We chose to test these two aspects of weight loss because they were the focus of the majority of the mDIET intervention content and were fairly uncorrelated variables ($r = .19$, $p = .178$). Fruit and vegetable intake served as a marker of diet quality, while eating behaviors served as an indicator of use of behavioral weight loss strategies. We hypothesized that fruit and vegetable intake and eating behaviors would mediate the relationship between treatment assignment (i.e., the intervention group vs. the comparison group) and weight loss explaining a significant amount of the effect of the intervention on participants' weight change.

Methods

Study design

Data for the current study were from Patrick et al.'s (2009) Mobile Diet Intervention through Electronic Technology (mDIET) study. This randomized controlled trial had two treatment groups: 1) the intervention group that received diet and physical activity weight related text-messages and 2) the usual-care comparison group that received print materials. Group assignment was by computer-generated simple randomization. Participants were recruited in 2007 and the intervention duration was four months. The Institutional Review Board at the University of California, San Diego, CA approved all study procedures, methods, and intervention strategies.

Inclusion criteria and participant recruitment

Sixty-five overweight and moderately obese men and women were recruited in 2007 from San Diego, CA via newspaper ads, flyers, and online announcements on Craigslist. Eligible individuals were 25 to 55 years old, overweight or obese (BMI ≥ 25.0–39.9), not taking medications known to cause weight gain, and owned a mobile phone capable of sending and receiving text-messages. Individuals were assigned to either the comparison or intervention group by computer-generated simple randomization. Study staff and participants were blinded to the treatment assignment until after completion of the baseline measurements.

Measures

Assessments were performed at baseline and four-months post baseline at the UCSD research offices by trained staff blinded to participant group assignment. The primary outcome was body weight (lb) measured using a calibrated digital (American Weights & Measures, Rancho Santa Fe, CA).

Fruit and vegetable intake was measured with three 24-hour recalls at each measurement wave. Trained data collectors conducted dietary recalls for two weekdays and one weekend day using the University of Minnesota Nutrition Data System for Research (NDS-R) software (Schakel et al., 1988). Participants were taught how to measure food portions with 3-dimensional food models. The first interview was conducted in person and the second and third by phone. Participants received two-dimensional food models to use for the second assessment. Servings of fruits and vegetables per 1000 kcals were calculated by averaging values from the two intake records. This is a commonly used method to adjust for energy intake (Anderson et al., 2007; Velentzis et al., 2011). Change in the intake of fruit and vegetable servings was one of the potential mediator variables in this analysis.

Eating behaviors associated with weight loss and weight management behaviors were measured using with the 26-item eating behavior inventory (EBI: Appendix A.) (O'Neil et al., 1979). Each behavior on the EBI is rated on a five-point scale (i.e., 1 = "Never or hardly ever" to 5 = "Always or almost always"). Summed scores can range from 26 to 130. Sample items include, "I refuse food offered to me by others" and "I decide ahead of time what I will eat for meals and snacks." The EBI has good test–retest reliability ($r = 0.74$) (O'Neil et al., 1979). This questionnaire has been used in over 20 weight loss intervention studies, which have shown the EBI as a valid tool for assessing weight management behaviors (O'Neil and Rieder, 2005). Change in EBI score (i.e., points) from baseline to four months was the second selected mediator variable in this analysis.

Intervention group

Each participant chose to receive two to five automatically scheduled, tailored, and sometimes interactive (i.e., asked for a specified response) text-messages a day on primarily diet and some physical activity weight management topics. Approximately 2/3 of the text messages related to diet, nutrition, food, or eating. Personal tailoring was accomplished by providing flexibility in the number and timing of receipt of messages each day. For example, users could choose different times during the day to receive a message—typically one in the morning and one in the evening, with one to three additional messages when the user thinks a reminder would be helpful. At the beginning of the intervention, participants also received a printed binder of materials organized by weekly weight management topics, each reinforced by several text-messages received that week. Monthly health counseling calls (5 to 15 min in duration) from a trained health coach provided encouragement and reinforcement of weight management topics.

The intervention was structured in weekly blocks based upon behavioral strategy topics known to positively influence weight management. The diet topics included: 1) goal setting (Knowler et al., 2002) and self-monitoring (Kruger et al., 2006; Wing and Hill, 2001); 2) understanding calories (Wardle et al., 2000); 3) volumetrics (i.e., consuming foods that are healthy and make one feel "full" such as fruits and vegetables) (Bell et al., 1998; Stubbs et al., 1998); 5) organization and meal planning (Kruger et al., 2006); 6) strategies for eating out (e.g., avoiding large portions and high energy dense foods (Guthrie et al., 2002; Duffey et al., 2007); and 7) strategies for creating healthy food environments (Hill, 1998; Stokols, 1992). Some example text-messages were: 1) Writing down what you ate and how you felt when you ate it will help you stay on track with your goals; 2) Organize your pantry so that healthier foods are facing forward and less healthier items are in the back and out of sight; 3) Find friends who share similar weight loss goals and support each other. It's fun to exchange healthy recipes too! Also included were picture messages, messages equivalent to text-messages in simplicity of content and message size that related to constructs such as serving size or tracking of personal weight status over time.

A database of over 3000 text and picture messages was developed. Approximately half of the messages were interactive (i.e., requested a reply) with the balance providing tips, suggestions, prompts, and reminders for improved behaviors. A total of 1500 rules programmed into the text-messaging system determined what message was sent based on the weekly behavioral strategy, the day of week, and time of day, as well as other parameters including self-reported responses from the baseline EBI assessment (O'Neil and Rieder, 2005; O'Neil et al., 1979). The EBI was used to identify diet behaviors that were unique to each participant that were also known to contribute to increased caloric intake. From the EBI data, target goals were created. These goals were presented to the user via text-message and goal reminders served as prompts for food selection and behavioral improvements.