THE ROLE OF SELF-MONITORING IN THE MAINTENANCE OF WEIGHT LOSS SUCCESS

By

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To my mother, for inspiring me to pursue a graduate degree in a field I love, and to my father, for reminding me that some of the most important education occurs outside the classroom

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Self-monitoring has been shown to be a crucial part of initial weight loss success in behavioral interventions. However, less is known about the role of self-monitoring in the long run. Research suggests participants will gain back approximately one third or more of weight lost within the year following treatment. The current study examined the role of self-monitoring during an initial 6-month intervention phase (PH1) and a 12-month extended care phase (PH2) in a group of 167 obese older women (M±SD: BMI = 37.0±5.1 kg/m^2, age = 59.9±6.2 years). Cluster analysis identified three groups of participants with low, moderate, and high success rates for weight loss during PH1 and PH2. A one-way ANOVA revealed no significant differences in self-monitoring frequency between groups during PH1 (p = .645), but significant differences between all three groups during PH2 (p = .001). High success participants completed the most self-monitoring records, followed by the moderate group. The low success group completed the least number of records. Furthermore, self-monitoring during PH2 significantly mediated the relationship between follow-up session attendance and percent weight loss (95% CI [-.004, -.001], p < .001), and this mediational relationship remained significant when controlling for age, education, race, and ethnicity (95% CI [-.003, -

.001]). While previous research has shown the benefits of self-monitoring during behavioral interventions, these results highlight the importance of continuing self-monitoring after the initial phase of treatment.

CHAPTER 1
INTRODUCTION

Overview

Behavioral scientists continue to search for effective treatments for obesity, but it is clear that current treatments lack the results necessary in order to help the majority of individuals both lose clinically significant amounts of weight and maintain this weight loss long-term. Furthermore, research suggests that participants respond differently to even the most effective types of treatment. For the majority of overweight and obese individuals enrolled in behavioral treatment programs, however, we know that consistent self-monitoring of caloric intake and weight change has been shown to be a vital method in achieving initial weight loss. The effectiveness of self-monitoring has yet to be fully assessed as a long-term approach to weight management following a behavioral intervention. Therefore, the current study first sought to examine how participants could be categorized based on weight loss success during a behavioral intervention and a long-term extended care period, and then to identify the role of self-monitoring during both phases.

Prevalence and Health Risks

The most recent data from the National Health and Nutrition Examination Survey suggests that over a third of individuals aged 20 and above in the United States (34.9%) met criteria for obesity during the time period from 2011-2012, indicating that they have a Body Mass Index (BMI) greater than or equal to 30 kg/m^2 (Ogden, Carroll, Kit, & Flegal, 2013). Other recent estimates suggest that an additional third of the population is defined as overweight, with a BMI greater than or equal to 25 kg/m^2. These numbers indicate that a majority of the United Sates adult population falls outside of the normal

weight category (BMI = 18-25 kg/m^2; Flegal, Carroll, Kit, & Ogden, 2012). Adults who meet criteria for overweight and obesity are also at risk for various other chronic health conditions, including diabetes mellitus, cardiovascular disease and hypertension, gallbladder disease, arthritis, and some forms of cancer (Bray 2003). Generally, prevalence rates for obesity-related diseases increase as body weight increases, and this is especially true for both diabetes mellitus and hypertension (Must, Spadano, Coakley, Field, Colditz, & Dietz, 1999). Moreover, as compared to individuals in the normal weight category, those who meet criteria for overweight and obesity are at greater risk for premature death (Flegal, Garubard, Williamson, & Gail, 2005). This may be in part due to the association between obesity and high-risk diseases such as cardiovascular and kidney diseases, diabetes mellitus, and obesity-related cancers (Mokdad, Marks, Stroup, & Gerberding, 2004).

Lifestyle Interventions for Obesity

Research shows that overweight and obesity are risk factors for both morbidity and mortality, but it also demonstrates that treatment of obesity can significantly reduce risk factors associated with obesity-related diseases. The National Heart, Lung, and Blood Institute suggests that a 10% reduction in body weight can help individuals improve their health by reducing cholesterol levels, triglycerides, and blood glucose levels (1998). However, even smaller reductions in weight can have a beneficial impact on health. Although magnitude of weight loss is positively correlated with health improvements, modest losses of 5-10% have been shown to significantly improve risk factors for cardiovascular disease (Wang et al., 2011; Douketis & Sharma 2005). Even losses as small as 3-5% have been shown to decrease levels of low-density lipoprotein

cholesterol, total cholesterol, triglycerides, blood glucose, and insulin (Dattilo & Kris-Etherton, 1992; Flechtner-Mors, Ditschuneit, Johnson, Suchard, & Adler, 2000).

Due to the significant benefits of weight loss, public and behavioral health research has focused on developing effective lifestyle and behavioral treatments for obesity. Based on the potential health risks and cost impact of pharmacotherapy and weight loss surgery, this type of treatment may be the most effective way of achieving weight loss for the majority of obese individuals (McTigue et al., 2003). In terms of overall structure, a characteristic lifestyle intervention will involve weekly meetings with a group of 10-15 individuals, as group sessions have been shown to result in greater reductions in weight for all participants when compared to individual meetings with a trained interventionist (Renjilian, Perri, Nezu, McKelvey, Shermer, & Anton, 2001). Groups are led by professionals with training in nutrition, exercise, or psychology-related fields. Sessions take place for 60-90 minutes and involve a mix of health education, skills training, and the use of cognitive-behavioral strategies (Butryn, Webb, & Wadden, 2012). Initial treatment lasts four to six months, and more often, programs are offering maintenance sessions after the intervention that involve further group meetings on a biweekly or monthly basis.

Behavioral or lifestyle intervention programs have several distinctive features: a process-oriented approach designed to help individuals identify and adopt healthy behaviors; a focus on small, incremental steps toward weight loss; the use of goal-setting to help participants change eating and exercise behaviors; and training in problem-solving skills in order to help participants learn to overcome weight loss obstacles they may face outside of the group process (Foster, Makris, & Bailer, 2005).

In order to help participants make changes related to food intake and physical activity, treatment methods are based on the premise of shaping behaviors by setting small goals and reinforcing actions that move participants closer to the target behavior. The concept of shaping as applied to behavioral treatment was first proposed by students of B.F. Skinner and is based on the principles of operant conditioning, in which actions are either reinforced or punished to bring about eventual behavior change (Ferster, Nurenberger, & Levitt, 1962). Other cognitive-behavioral components incorporated in treatment include stimulus control, teaching individuals to control cues related to unhealthy eating behaviors; cognitive restructuring, helping participants to identify and reframe irrational or negative thoughts that may be undermining weight loss efforts; and self-monitoring, the process of maintaining daily records of food, physical activity, and weight change throughout the course of treatment (Wadden & Butryn, 2003). The use of these cognitive and behavioral strategies has been shown to be most effective when paired with development of a low-calorie eating plan (e.g., a diet of 1,200 to 1,800 kcal per day) and the addition of regular physical activity (e.g., moderate intensity physical activity for 150 minutes or more per week; Van Dorsten & Lindley, 2011).

Typical Response to Treatment

When analyzing the results of lifestyle interventions, the majority of studies present the mean response to treatment over time. The most typical response among participants is a loss of approximately 8-10% of weight over the course of a four to six month treatment period. This is similar to the amount that has been deemed clinically significant in helping participants attain the previously mentioned health benefits (Sarwer, von Sydow Green, Vetter, & Wadden, 2013). Several recent studies indicate that severely obese (BMI ≥ 40 kg/m^2) participants may demonstrate more noticeable

decreases in weight than overweight or obese individuals (Unick et al., 2011; Goodpaster et al., 2010), but the majority of studies continue to cite results that range from 5-10% weight lost (Yanovski & Yanovski, 2002).

Despite these stated initial losses, long-term weight reductions are often more difficult to maintain. Many studies confirm that participants gain back approximately one-third of lost weight within one year following intervention, with slightly slower rates of regain ensuing over the next three to five years (Anderson, Konz, Frederich, & Wood, 2001). Over half of participants will have returned to their starting weight by the five-year mark (Wadden, Butryn, & Byrne 2004). Therefore, an increased number of studies are focusing on ways to improve long-term weight maintenance. Current research highlights approaches such as increasing the intensity or extending the length of the preliminary intervention, improving long-term motivation for weight control, and using both the primary intervention and a long-term extended care period to teach maintenance-specific skills, above and beyond what is taught in a usual lifestyle program (Jeffrey et al., 2000). Such research represents an improvement upon earlier versions of treatment programs, as participants who are enrolled in extended care periods following treatment generally show improved weight maintenance (Perri et al., 2008; Svetkey et al., 2008). However, even these additions to behavioral treatment have yet to provide the definitive formula for maintained weight loss over a long period of time.

Mean weight loss and regain statistics demonstrate the pattern of weight change for a typical participant both during and after intervention. Standard outcome studies for behavioral weight loss trials report these statistics and their associated levels of significance, but showing only these responses to treatment can mask the results of

individuals who may be more or less successful than the mean. One of the few research studies that does present categorical responses to treatment suggests that of participants enrolled in “intense lifestyle modification interventions,” who attended an average of 37 hours of treatment sessions during a yearlong period, 28% lost 10% or more weight, 26% lost 5-9.9% of their initial weight, and 38% lost 0.1-4.9% of initial weight (Christian, Tsai, & Bessesen, 2010). Recent research has also seen a small trend toward examining the behaviors of those who are very successful at weight loss in order to discover patterns that may ultimately be most predictive of success. One study looked at participants enrolled in the National Weight Control Registry, who are required to have lost greater than or equal to 13.6 kg (30 lbs) and maintained this loss for over a year. Within the registry, researchers found a sample of 629 women and 155 men in the United States who had lost an average of 30 kg and maintained at least a 13.6 kg weight loss for five years (Klem, Wing, McGuire, Seagle, Hill, 1997). Some, but not all, individuals in the sample had participated in a structured behavioral treatment program. Other studies suggest that of those who do take part in lifestyle interventions, about 20% are able to maintain 5% or greater weight reductions after five years (Wing & Hill, 2001). Examining only the mean responses to behavioral interventions therefore may make it difficult to judge components of treatment that are associated with the greatest rates of success. Future research that focuses on categorical responses to intervention will help to elucidate these key factors and help researchers understand differing responses to treatment.

Self-Monitoring and the Model of Self-Regulation

Self-monitoring, or the recording of one’s activities or behaviors, is rooted in the theory of self-regulation. The process of self-monitoring was originally proposed as a

tool for change by behaviorists such as Kanfer and Karoly, who stated that individuals could use their ability for self-reflection to evaluate problematic health-related behaviors. They then are able to exercise control over their well-being by monitoring (and altering) these behaviors (Kanfer & Karoly, 1971). Scientists have linked this to the concept of weight reduction, as the process of losing weight is fundamentally an issue of consuming fewer calories than one is able to expend. Therefore, changing behaviors related to food consumption will help to alter this energy balance. Self-monitoring serves as a trigger for executing new eating or exercise behaviors or for preventing the continuation of related unhealthy behaviors (Kanfer, 1970). The act of monitoring is viewed as the first step in behavior change, by helping the individual to become aware of current actions and observing challenging patterns. The process allows individuals the opportunity to both establish goals for behavior change and track progress in achieving these goals (Febbraro & Clum, 1998).

Self-monitoring is seen as the initial step in the three part feedback loop proposed by Kanfer. It requires both the careful observation and recording of the target behaviors (e.g., eating). This process naturally leads the individual to the second step of self-evaluation, during which they compare the results of their monitoring to what behaviors or actions are necessary in order to reach the desired outcome. This allows a person to assess whether what they are currently doing is adequate for achievement of their goals. Finally, during the self-reinforcement stage, the individual is able to strengthen their current behavior, or alter behavior to more appropriately align with their goals based on the results of their evaluation (Mace & Kratochwill, 1985).

This model of self-regulation is seen as a central part of the goal-setting process used so frequently in behavioral weight loss theory. For participants, seeing what they have accomplished across a period of time is essential in providing them with the opportunity for reinforcement. Ultimately it is the measurement of the behavior via self-monitoring that initializes this feedback loop, making the process of self-monitoring fundamental for change. In the context of behavioral lifestyle interventions for obesity, self-monitoring can be done through the tracking of food and drink intake, physical activity, or weight change. It is typically seen as one of the foundations of behavioral treatment (Wadden, Crerand, & Brock, 2005). Furthermore, it has been shown to be correlated with long-term success in weight loss (Head & Brookhart, 1997; Wing, Jeffery, Hellerstedt, & Burton, 1996). Individuals who are more consistent in this behavior have been shown to have higher rates of weight loss, and even individuals who struggle to self-monitor consistently show greater rates of weight loss during periods of frequent monitoring when compared to periods of sporadic monitoring (Baker & Kirschenbaum, 1993). Boutelle and Kirschenbaum have suggested that self-monitoring for at least 75% of days may be the optimal amount for enhanced weight loss success (1998).

The Utilization of Self-Monitoring in Behavioral Weight Loss Treatment

The definitive goal of behavioral weight loss treatment is to reduce body weight by a clinically significant amount, in order to improve health and reduce the risk of chronic disease. In order to do this, most programs aim for a weight loss of 0.4 kg (0.5-1 lbs) per week for overweight or obese individuals, and slightly higher losses of 0.8 kg (1-2 lbs) per week for individuals with a BMI equal to or greater than 35 kg/m^2, in accordance with recommendations from the National Heart, Lung, and Blood Institute

(1998). To attain these rates of weight loss, participants must aim to burn more calories than they expend on a daily basis. This energy imbalance is achieved by reducing caloric intake by 300-500 kcal per day for overweight or obese individuals or by 500-1,000 kcal per day for those who are more severely obese. Generally, the reduction in caloric intake is done primarily through setting a calorie goal in combination with the additional of moderate physical activity.

In behavioral treatment programs, participants first complete a week of tracking food intake without altering their diet in any way, in order to obtain a general estimate of baseline caloric intake. Group leaders then use these baseline records to help participants set goals for reducing the number of calories consumed per day. Participants are asked not only to track the type and amount of food eaten, but the associated caloric content, as well as information regarding time and location of eating, and emotions accompanying the eating (Wadden & Foster, 2000). Many programs will also request that participants track exercise in order to make progress in increasing physical activity levels and calories burned. Finally, self-monitoring may also take the form of periodic self-weighing to help participants track weight over time. All three approaches have been shown to be associated with weight loss, although self-monitoring of caloric intake remains the most studied and perhaps most effective way of helping individuals to lose weight (Burke, Wang, & Sevick, 2011).

When individuals self-monitor on their own, without the help of a trained professional, the literature suggests that they tend to underestimate their caloric intake (Black & Cole, 2001). Most participants will have difficulties estimating both the amount of food eaten as well as caloric value of each food (Lansky & Brownell, 1982). This

tends to be especially true for those who are more obese (Lichtman et al., 1992), such that underreporting of caloric intake is positively correlated with the BMI of the individual who is recording (Braam, Ocké, Bueno-de-Mesquita, & Seidell, 1998; Johansson, Wikman, Ahrén, Hallmans, & Johansson, 2001). Suggested explanations for underreporting include social desirability (Hebert, Clemow, Pbert, Ockene, & Ockene, 1995; Scagliusi 2003), a reluctance to report foods seen as unhealthy (Cook, Pryer, & Shetty, 2000), dissatisfaction with body image (Novotny et al., 2003), and the inconvenience of detailed tracking (Macdiarmid & Blundell, 1998). However, despite the trend of underreporting, food records still serve as a method of helping participants monitor eating over the course of a day. They also provide group leaders with an estimate of participant progress and remain a crucial measurement of whether a participant is adhering to their recommended calorie goal. Therefore, even when participants do underreport, food records serve as a basis for the feedback loop that helps them to evaluate and adjust behavior throughout the intervention. Despite the limitations of self-monitoring, participants who record what they eat are more likely to see clinically significant reductions in weight and thus, it remains a foundational element of lifestyle intervention programs.

Specific Aims and Measures

Specific Aim 1

Characterize participants in a behavioral treatment program by their weight loss both during the intervention and the extended-care period. We hypothesized that participants would fall into clear groups based on their patterns of percent weight change over time, with some participants demonstrating results similar to the mean response (i.e., clinically significant weight loss followed by a regain during extended

care of one-third to one-half the amount initially lost), and other participants showing results that are noticeably different from what is typically reported.

Specific Aim 2

Determine if the aforementioned groups differ in self-monitoring frequency during both the intervention and follow-up periods. Based on the previously mentioned research that suggests self-monitoring is a key component of weight loss, we expected that participants in groups that demonstrated more significant success at weight loss would also have completed more records of food and drink intake during both phases of the study. For the purposes of this analysis, frequency of self-monitoring was defined as the number of food records returned by participants that were either partially or fully completed.

Specific Aim 3

Determine if self-monitoring frequency mediated the relationship between group attendance and weight change during both phases of the study. This was examined as a follow-up to the first two aims. If, during either phase, the groups of participants were found to differ in self-monitoring frequency, we believed that self-monitoring would partially explain the relationship between treatment attendance and weight change from 0-6 months (following the intervention) and 6-18 months (following the extended care phase). Treatment attendance during intervention was defined as participants who had arrived in person for the majority of the group session. For participants who were enrolled in the phone-based extended care condition, attendance was defined as completing a session check in on the phone with their group leader.

Exploratory Aim

Determine if any potential mediational relationships remained significant with the inclusion of covariates. Previous research has found mixed results describing the effect of age, educational level, and race/ethnicity of lifestyle intervention participants. Some research suggests that older adults are more successful than younger adults and that patterns of weight loss vary among individuals of different races or ethnicities (Kumanyika, Obarzanek, Stevens, Hebert, & Whelton, 1991; Wadden et al., 2012). Other studies have shown that minorities initially have less success during lifestyle interventions, but that these differences disappear in the long term (Stevens et al., 2001). Finally, some studies have shown that educational attainment is related major weight gain or loss later in life (Kahn & Williamson, 1990), and that higher levels of education are associated with greater reductions in BMI (Halkjær, Holst, & Sørensen, 2012). Therefore, we investigated the effect of controlling for these variables in any mediational relationships found to be significant in the previous aim. We hypothesized that the mediation would remain significant when age, education, and race/ethnicity variables were held constant.

CHAPTER 2
MATERIALS AND METHODS

Treatment of Obesity in Underserved Rural Settings (TOURS) Study

The TOURS study was a randomized controlled trial funded by the National Institutes of Health and conducted in six rural counties in northern Florida from 2003 through 2007 (Perri et al., 2008). The study investigated differing impacts of two types of extended care treatments that were designed to sustain weight loss following a behavioral intervention. The primary outcome was change in body weight during the extended care period, while secondary outcomes included changes in systolic and diastolic blood pressure, lipid profile, glycemic control, and physical fitness during the same time period.

The study was conducted in two phases. During the initial intervention phase, or Phase 1, participants attended 24 weekly meetings in groups of 10-14 women at local County Extension Offices. Group leaders were Family and Consumer Science (FCS) Agents, or trained leaders with bachelor's or master's degrees in relevant fields. The Phase 1 intervention program was based on the Diabetes Prevention Program (The Diabetes Prevention Program, 1999) but was modified slightly to address the special issues of women living in rural communities. Changes included education on ways to adapt Southern cooking recipes in order to reduce calories and grams of fat, as well as ways to exercise in rural areas where sidewalks or walking paths may not be available. Overall, the program focused on helping participants follow low-calorie eating plans of 1,200 kcal/day and increase physical activity at home to 30 minutes per day of moderate intensity walking in order to create a caloric deficit that would result in approximately .04 kg per week of weight loss. Participants also received training in

cognitive-behavioral strategies such as self-monitoring and goal setting to help support diet and physical activity goals. Participants were asked to self-monitor by recording food and drink intake on a daily basis using standardized forms designed to track eating (See Appendix). Participants also were provided with cooking demonstrations to increase knowledge of low-fat, low-calorie food preparation; stress management strategies; and techniques to help participants maintain a healthy diet when eating outside the home.

During the extended care phase, Phase 2, participants were randomly assigned to one of three conditions: an office-based maintenance program, a telephone-based maintenance program, or an educational control group. Prior to the start of this follow-up phase, every participant received written handouts on problem-solving strategies. They were also provided with a 12-month supply of eating and exercise logs in order to continue monitoring eating and activity levels. Participants were encouraged to continue to self-monitor three days per week, including at least one weekend day. After the start of the follow-up sessions, participants in every group received contact two times per month. The office-based condition continued to meet in their initial weight loss groups, whereas participants in the telephone-based condition received individual telephone sessions and participants in the educational control group received newsletters in the mail. In total, the extended care phase lasted for 12 months.

Participants

The current study included 167 women, aged 50-75, with a BMI ≥ 30 kg/m^2, yet weighing less than 159 kg (350 lbs) in order to allow weight measurement on a standard balance beam scale. All women were required to live in one of six rural counties in northern Florida. Exclusion criteria included underlying diseases likely to limit lifespan,

such as cancer requiring treatment within the last five years, serious infectious disease, or cardiovascular events occurring within the last six months; abnormal lab values, including a fasting blood glucose > 125 mg/dl and fasting serum triglycerides > 400 mg/dl or a resting blood pressure > 140/90 mmHG despite appropriate drug treatment; and the use of certain medications, including antipsychotic agents, monoamine oxidase inhibitors, systemic corticosteroids, antibiotics for HIV or TB, chemotherapeutic drugs, or prescription weight-loss drugs. In addition, individuals were excluded if they were unable or unwilling to provide informed consent, were unable to read English at a 5th grade level, were unwilling to accept random assignment, were unable to travel to an extension office for group meetings, or were currently participating in another randomized research project. Finally, individuals who reported a weight loss of greater than 10 pounds in the previous six months, excessive alcohol intake, or a diagnosis of a major psychiatric disorder were also excluded.

A total of 559 women responded to study recruitment announcements, and 261 of these women were excluded prior to the start of the study. Of the 261 women who were found ineligible for participation, 82 were excluded for elevated blood pressure, 76 had abnormal lab values, 26 had contraindications based on medical history, 27 had other abnormal screening visit results, 17 had a BMI out of the required range, and 30 declined to participate. A total of 234 women completed Phase 1 of the study; however, participants randomized to the educational control group displayed significantly different weight change patterns during the extended care phase. These participants were therefore removed from the current study and a total of 167 participants were included in the final analysis.

Procedures

Potential participants were contacted via methods of direct solicitation, including direct mailings and presentations at community events. Those who expressed interest in the program were encouraged to complete a brief telephone screening, and women who meet initial eligibility requirements were scheduled for an in-person screening appointment. At this appointment, the study was described in detail, informed consent was obtained, and demographic information, a comprehensive medical history, and a current medication inventory were collected. Participants who continued to meet study requirements were scheduled for a second appointment, which included: questionnaires assessing dietary intake, physical activity levels, health related quality of life, depressive symptoms and problem solving abilities; height, weight, and waist measurements; resting heart rate and blood pressure; a fasting blood draw; a six minute walk test; and an electrocardiogram. Participants who were judged as meeting eligibility criteria after the second screening visits were randomized to a study group and extended care condition.

Measures

Body weight

Body weight was measured at baseline, 6 months (following the initial intervention), and 18 months (following the extended care period). Participants were measured in light indoor clothing without shoes and with pockets emptied by a study nurse who was masked to the treatment condition of the participants. Measures were taken using a calibrated and certified balance beam scale and were measured to the nearest tenth of a kilogram. Percent change in weight over time was then calculated for all participants based on initial weight, 6 month weight, and 18 month weight.

Self-monitoring

Participants were given standardized food intake logs on which they were able to record all food and drink consumption on a daily basis. Records were used to measure total caloric intake, to help participants set calorie goals, and to evaluate their progress in meeting these goals. Each food record provided spaces for participants to log types of food eaten and the associated amount of food and calories consumed, as well as the time of day the eating occurred, activities completed while eating (e.g. driving, watching television), feelings while eating (e.g. tired, bored), and location where the eating occurred (e.g. kitchen, car). Participants also had an optional space to record grams of fat in each food consumed if they desired. For caloric and fat intake, participants had space to calculate subtotals for each meal (breakfast, lunch, dinner, planned snacks, and unplanned eating), as well as a grand total for the day. At the end of each week, participants were provided space to calculate an average caloric intake across the seven-day period.

During the intervention, participants were asked to self-monitor on a daily basis. The majority of participants were asked to set caloric goals of 1,200 kcal per day. Records were returned to group leaders and reviewed at weekly group meetings. At the beginning of the extended care phase, all participants were provided with a year's supply of food records. Participants were asked to monitor a minimum of two weekdays and one weekend day every week, although some chose to monitor more often. Caloric goals were adjusted for the extended care phase based on intervention weight change and long-term weight maintenance plans. Food records were collected in person by group leaders for those attending office-based follow up meetings. For those receiving

telephone-based contact, stamped and addressed envelopes were provided so food records could be returned to the group leaders as necessary.

Statistical Analysis

The statistical software package SPSS 21.0 for Windows (SPSS Inc., IL) was used to conduct the statistical analysis for this research study.

Specific Aim 1

A two-step cluster analysis was conducted in order to classify participants into separate groups based on weight change patterns across the course of the study. Cluster analysis is a statistical procedure which categorizes participants into groups while ensuring that within-cluster differences are minimized and between-cluster differences are maximized. It is a technique that has been advocated as particularly useful to health psychologists in order to identify groups of individuals who may be most in need of intervention, resources, or specific services (Clatworty, Buick, Hankins, Weinman, & Horne, 2005). A two-step cluster analysis was chosen as most relevant for this data, as it is an exploratory technique that does not require the number of clusters to be pre-determined; however, for the purposes of this study, the number of clusters was limited to three in order to ensure that clusters were of a meaningful size for further analyses. Clusters were analyzed based on individual participant weight change from baseline to 6 months and from 6 months to 18 months. The clustering solution was determined using log-likelihood estimation and the squared Euclidean distance method was used to assess similarity between clusters in order to take into account elevation of weight change scores (Blashfield, 1980). Stability of clusters was assessed by random division of the sample into two halves, followed by repeated cluster analysis and visual inspection of the data (Clatworty, Buick, Hankins, Weinman, & Horne, 2005).

Specific Aim 2

We examined the hypothesis that clusters would differ based on self-monitoring frequency across the intervention and extended care periods. Therefore, following the cluster analysis, the resulting groups were compared based on self-monitoring frequency (i.e., how many food records were completed) during Phase 1 and Phase 2 using a one-way independent Analysis of Variance (ANOVA). Normality was assessed using tests of skewness-kurtosis and visual inspection of Q-Q plots. Post-hoc tests were used to determine, when applicable, where specific differences between clusters could be found.

Specific Aim 3

As a preliminary analysis for the third aim, correlational tests were used in order to test for significant relationships between group attendance, self-monitoring frequency, and percent weight change. These correlational measures were completed separately for the variables from Phase 1 and Phase 2 of the study. Where significant correlations were found, the Preacher and Hayes model was used to determine if self-monitoring frequency mediated the relationship between treatment attendance and percent weight change. The number of treatment sessions attended was entered as the independent variable and percent weight change for the designated phase of the study was entered as the dependent variable. Number of self-monitoring records was entered as the potential mediating variable. The Preacher and Hayes model for mediation was chosen in order to reduce the possibility of Type I error and increase statistical power. Results were bootstrapped to 5,000 samples, as bootstrapping is an effective technique for smaller sample sizes and avoids making parametric assumptions about the distribution

of indirect effects. Effect size was measured using κ^2 to assess the ratio of analyzed indirect effect to maximum possible indirect effect.

Exploratory Aim

Based on the results of the previous aim, covariates were added to the Preacher and Hayes bootstrapped model in order to determine if any mediational relationships still held. The covariates included in the analysis included: age at baseline, highest level of education obtained, and race/ethnicity variables.

CHAPTER 3
RESULTS

Baseline Characteristics

The study sample used for all analyses consisted of 167 obese older women from rural counties in Northern Florida, with a mean age of 59.9 years and a mean BMI of 37.0 kg/m^2. Overall, the sample was predominantly White, non-Hispanic (77.2%), married (74.3%), with a trade, vocational, or associate's degree (44.9%). Participants were primarily employed, either full-time or part-time (47.3%). Further baseline characteristics of the sample are summarized in Table 3-1.

Specific Aim 1

The cluster analysis of participants' percent weight change during intervention and follow-up revealed three distinct groups of participants, based on their patterns of weight loss and potential regain over time. The largest cluster consisted of 82 participants, or 49.10% of the sample. These participants demonstrated a mean weight change of -11.09% during Phase 1, but regained +4.78% mean weight during Phase 2. This cluster demonstrated results most typical of behavioral weight loss treatment, and was labelled the Moderate Success group. The next largest cluster evidenced low rates of achievement, and was labelled the Low Success group. This cluster contained 50 participants, or 29.94% of the sample. These individuals showed a mean weight change of -2.58% during Phase 1, and a regain of +1.50% mean weight during Phase 2. Finally, the remaining women fell within a third cluster of 35 participants, or 20.96% of the sample, and were labelled the High Success group based a pattern of continued weight loss over time. These participants initially showed a mean weight change of -13.99% during Phase 1, and an additional -7.44% mean weight change during Phase 2. Results

are presented visually in Figure 3-1 and descriptive statistics for the three clusters are shown in table 3-2. Visual inspection of the scatter plots for repeated analyses using split-half data demonstrated stability of clusters.

Specific Aim 2

During Phase 1, the initial intervention, the three clusters of Low, Moderate, and High Success participants did not differ significantly in terms of number of food records completed, F (2, 164) = 1.93, p = .149. However, an ANOVA revealed significant differences between clusters for number of records completed during Phase 2, the extended care period, F (2, 164) = 22.91, p < .001. As Levene's test was significant for the Phase 2 data, Games-Howell post-hoc testing was used to correct for the potential differences of variance. The post-hoc analyses revealed significant differences between the Low and Moderate Success groups (p = .005), the Low and High Success groups (p < .001), and the Moderate and High Success groups (p < .001). The differences were such that, during Phase 2, the Moderate Success group completed a mean 52.43 additional records when compared to the Low Success group, and in turn, the High Success group completed a mean 91.59 more records when compared to the Moderate Success group during the year-long extended care phase. The High Success group also completed a mean of 143.93 additional records when compared to the Low Success group. Mean number of food records submitted by group and associated significant differences are presented in Table 3-3.

Specific Aim 3

The final aim of this study was to examine the relationship between Phase 2 treatment attendance, percent weight change, and number of self-monitoring records completed. Phase 2 self-monitoring frequency was seen as a potential mediator as it

correlated significantly with both Phase 2 attendance ($p < .001$) and Phase 2 percent weight change ($p = .03$). To estimate any direct and indirect effects of self-monitoring, a Preacher and Hayes simple mediational analysis was conducted and 5,000 bootstrapped estimations were used in order to create a confidence interval for the indirect effect (Preacher & Hayes, 2008). Results of the mediational analysis showed that the overall effect of treatment attendance on percent weight change (total effect = -.0002, $p < .001$) became non-significant when self-monitoring frequency was added to the model as a mediator (direct effect of self-monitoring = .0005, $p = .403$). The analysis also indicated that the indirect effect of self-monitoring during Phase 2 was significant, as the 95% confidence interval did not include zero (95% CI: -.0026, -.0008). Thus, the number of food records completed during Phase 2 fully mediated the relationship between session attendance and percent weight change. Participants who completed more records also showed greater weight loss than participants who completed fewer records during this time. The κ^2 value (ratio of established indirect effect to maximum possible indirect effect) was .20, which suggests a moderate effect size.

Exploratory Aim

As an additional exploratory analysis, the mediational macro was run again with the inclusion of age, education, and race/ethnicity as covariates. When these three variables were held constant, results remained similar. The total effect of group attendance on percent weight change (total effect = -.001, $p = .040$) again became non-significant with the inclusion of self-monitoring as a mediator (direct effect of self-monitoring = .0005, $p = .440$). The 95% confidence interval for the indirect effect also indicated mediation as the range still did not include zero (95% CI:-.0026, -.006). Therefore, results of the analysis suggest that self-monitoring during the follow-up

period of behavioral interventions plays an important role in weight maintenance or further weight loss and completely mediates the relationship between session attendance and weight change.

Table 3-1. Participant baseline characteristics

Characteristics	
Age in years, *M* (*SD*)	59.9 (6.2)
BMI in kg/m^2, *M* (*SD*)	37.0 (5.1)
Ethnicity, n (%)	
Hispanic/Latino	2 (1.2)
Other	165 (98.8)
Race, n (%)	
White	131 (78.4)
Black	34 (20.4)
American Indian or Pacific Islander	2 (1.2)
Highest Level of Education, n (%)	
Less than 12 years	62 (37.1)
Trade, vocational, or associate's degree	75 (44.9)
Bachelor's degree	18 (10.8)
Advanced degree	29 (16.0)
Marital Status, n (%)	
Never Married	1 (0.6)
Divorced or separated	23 (13.8)
Widowed	17 (10.2)
Presently Married	124 (74.3)
Living in marriage like relationship	2 (1.2)
Employment Category, n (%)	
Not working	13 (7.8)
Retired	42 (25.1)
Homemaker	8 (4.8)
Employed, full-time or part-time	79 (47.3)
Disabled	2 (1.2)
Other	3 (1.8)
More than one category	20 (12.0)
Total Annual Family Income, n (%)	
Less than $10,000	9 (5.4)
$10,000-19,000	32 (19.2)
$20,000-34,999	41 (24.6)
$35,000-49,999	34 (20.4)
$50,000-74,000	32 (19.2)
$75,000-99,999	4 (2.4)
$100,000-149,999	2 (1.2)
Don't know	2 (1.2)

Table 3-2. Cluster data

Participant Clusters	
"Low Success" Participants (n=50)	M±SD
Age in years	59.45 ± 6.54
Percent weight change, Phase 1	-2.58 ± 2.39
Percent weight change, Phase 2	1.50 ± 3.42
Percent weight change, Total	-1.07 ± 4.57
"Moderate Success" Participants (n = 82)	M±SD
Age in years	59.73 ± 6.12
Percent weight change, Phase 1	-11.09 ± 3.92
Percent weight change, Phase 2	4.78 ± 3.53
Percent weight change, Total	-6.31 ± 4.86
"High Success" Participants (n=35)	M±SD
Age in years	60.87 ± 6.03
Percent weight change, Phase 1	-13.99 ± 4.31
Percent weight change, Phase 2	-7.44 ± 3.90
Percent weight change, Total	-21.43 ± 5.19

Table 3-3. Number of completed food records submitted by clusters

Study Phase	
Phase 1	M±SD
"Low Success" Participants	117.4 ± 53.5
"Moderate Success" Participants	125.5 ± 46.7
"High Success" Participants	123.2 ± 45.6
Phase 2	M±SD
"Low Success" Participants	59.4 ± 84.8
"Moderate Success" Participants	111.8 ± 83.2 [a]
"High Success" Participants	203.3 ± 115.2[b]

[a] p = .005 versus the low group, [b] p < .001 versus the low and moderate groups

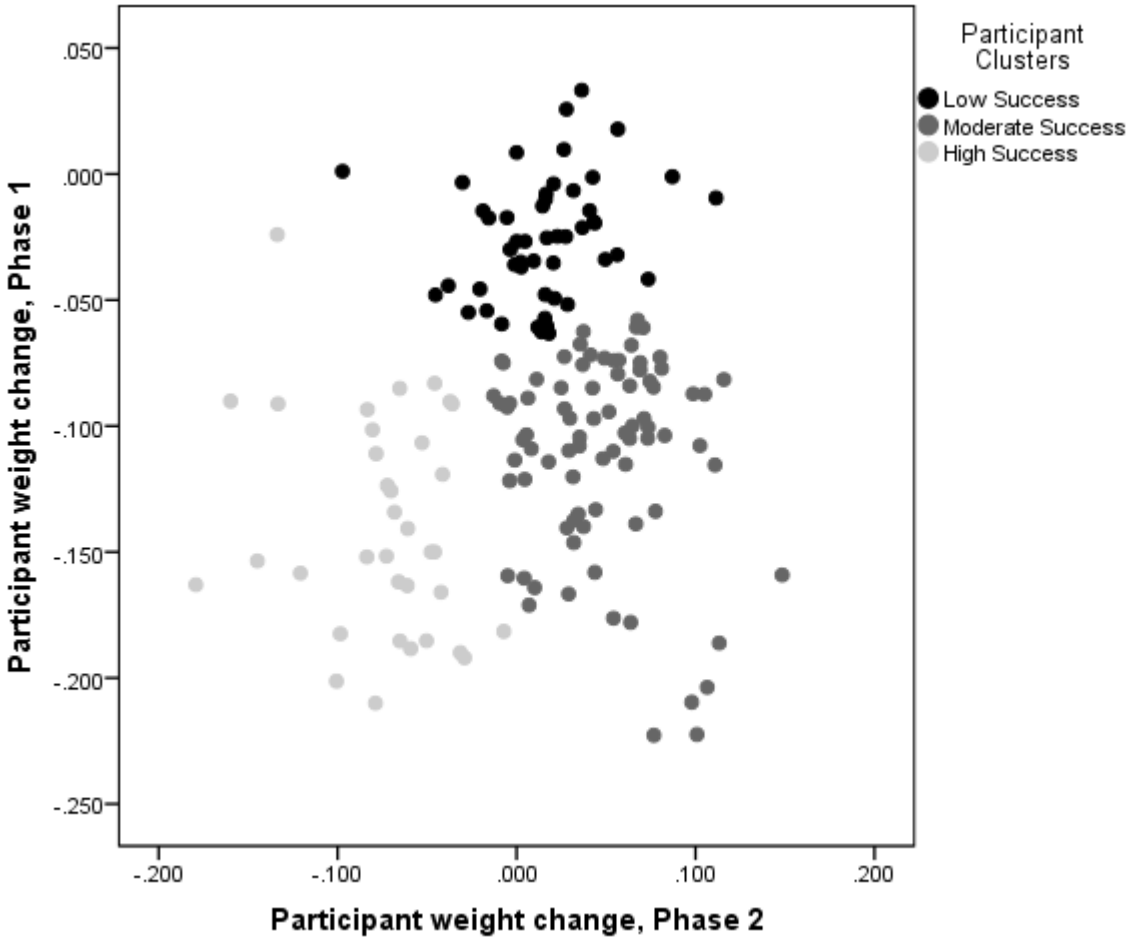

Figure 3-1. Results of cluster analysis by participant weight change

CHAPTER 4
DISCUSSION

The purpose of the current study was both to identify different groups of participants based on their patterns of weight loss and to assess for differences between groups in terms of frequency of self-monitoring. In addition, the mediational effect of self-monitoring on the relationship between behavioral weight loss program attendance and weight change was examined. The overall role of self-monitoring was explored both during an initial lifestyle intervention and a long-term extended-care phase that focused on weight maintenance strategies.

Results of statistical analyses demonstrated clear patterns of weight loss that differed among intervention participants, such that individuals fell into three separate groups based on rates of success throughout both phases of the study. The largest group, classified as the Moderate Success group and accounting for about half of all participants, demonstrated results most typical of the mean – an initial clinically significant loss of weight during the intervention, followed by a regain of almost half that weight during the year after intervention. Two smaller groups, however, demonstrated very different patterns. A Low Success group lost less than three percent weight initially, and regained almost all of weight lost during the extended care phase. The smallest group, labeled the High Success cluster, demonstrated results that may be closest to ideal for behavioral programs. These participants initially lost more than one-fifth of their body weight. They also continued to lose clinically significant amounts during the extended-care period, which is a substantial difference from results typically seen in lifestyle intervention programs.

When comparing these three groups based on self-monitoring frequency during intervention and follow up, none of the groups demonstrated significant differences regarding the number of food records completed during the initial intervention period. However, each group differed significantly from the other groups during the extended care phase. Results showed that the most successful participants completed the highest number of self-monitoring records, followed by the moderately successful participants (those demonstrating results closest to the mean). The group that showed the lowest rates of success also completed the smallest number of self-monitoring records. In further inspecting the role self-monitoring played during the extended care phase, the indirect effect of self-monitoring frequency on the relationship between group attendance and weight loss was examined. A significant direct effect between attendance and weight change was found during follow up. After running a mediational analysis, results showed that self-monitoring fully mediated the relationship between attendance and weight change. These results held constant with the inclusion of age, education, and race/ethnicity as covariates.

Generally, these results suggest that individuals can be characterized by patterns of weight loss and that approximately half of all participants in behavioral interventions do not follow the pattern of weight loss typically described in the literature. This study highlights an approach that researchers have not yet taken in observing response to treatment by categorizing weight loss participants using an empirically driven method, as opposed to only the use of descriptive statistics. The unique responses demonstrated by the three separate clusters indicates that there is room for future studies that more fully investigate the behaviors of those in the most and least

successful groups, in order to determine what components of treatment are most helpful in achieving weight loss. Perhaps by comparing behavioral patterns and program adherence between these groups, researchers will be able to find how best to encourage the low achievers. Furthermore, by establishing a recognized categorical response to behavioral treatments, stepped care interventions can be designed to target those who may be at risk for low rates of weight loss or eventual higher rates of weight regain. These types of treatment methods are designed so that minimally intrusive interventions are the first to be implemented. Participants who are unable to meet weight loss goals are then provided with more intensive interventions. This practice helps study staff preserve resources for those who may be in the most need while avoiding excessive treatment for those participants who may already be successful (Davis, 2000). Recent investigations on a stepped care approach suggest mixed results when compared to standard behavioral interventions, with some studies demonstrating equal amounts of weight loss and others demonstrating lesser rates of weight loss in the stepped care interventions. When stepped care methods are effective, they also have been shown to significantly reduce the costs associated with implementing lifestyle interventions (Carels et al., 2012; Jakicic et al., 2012).

Results indicate that during the intervention phase, self-monitoring may not be the only component of treatment that predicts success. During the initial program, none of the three groups differed significantly in self-monitoring frequency. Rather, all groups showed fairly high levels of self-monitoring during treatment despite their differing rates of weight loss, and only began to demonstrate significantly different rates of record keeping during extended care. These findings suggest that additional factors may be

contributing to the differing rates of success, such as comprehension of treatment materials, adherence to other aspects of treatment, or amount of support received from friends and family. Participants may also have varied physical responses to caloric deprivation due to underlying physiological mechanisms. Future research should focus on identifying limiting factors to weight loss early on during interventions in order address these issues in lower success participants. Depending on findings, it may be important to focus on increasing education or skills training for lower success participants, or screening participants for physiological traits that may thwart weight loss so that treatment can be altered appropriately. Alternatively, it will be important to identify characteristics of the most successful participants that can be emphasized as important to treatment to help improve the results of both the moderate and the low success participants.

Finally, results of this study suggest that self-monitoring remains important during extended care, and in fact fully explains the relationship between group attendance and weight loss. Thus, it seems crucial that participants be encouraged to continued tracking food and drink intake. Even minor amounts of weight loss have been shown to be beneficial to individuals, and therefore it is important to both prevent weight regain and retain any amount of weight lost, no matter how small. By identifying individual obstacles to weight loss early on, we can perhaps prevent participants from becoming discouraged and stopping the effective behavioral change methods they have learned during treatment in order to maintain their weight or even continue to lose small amounts over time.

It is important to address some of the limitations of the current study. Primarily, the current analyses are correlational in nature. Therefore, the differences in self-monitoring may be based on other aspects of treatment or individual differences that have yet to be explored. Additionally, it is essential to point out that, due to the nature of pen-and-paper record keeping, there is no way to determine intervals between eating and self-monitoring. Research indicates that shorter intervals between eating and recording are more predictive of ultimate weight loss (Burke, Sereika, Music, Warziski, Styn, & Stone, 2008). This falls in line with the concept of the feedback loop mentioned earlier. Participants who hastily fill out a week's worth of records before their weekly meeting, or even record a full day of eating before bed, are denied the opportunity for immediate self-evaluation that leads to the reinforcement or altering of observed behaviors. The effectiveness of self-monitoring lies in the opportunity it provides individuals to consistently remain an active participant in the feedback loop. Because paper records were utilized for the purposes of this study, it is impossible to determine if successful individuals were truly recording food and drink intake at the time of consumption. Finally, the participants in this study were all older women living in rural southern communities, and therefore, results cannot be generalized to a broader population without further research.

Given these limitations, it will be interesting to follow up on the results of the current study with the advent of new forms of self-monitoring that take advantage of easy-to-use electronic devices. With the popularity of computer and cell phone applications that allow the efficient tracking of food intake, self-monitoring may become more appealing to a larger range of people. Recent studies have focused on

computerized software and online applications to help participants self-monitor, and have shown encouraging results (Yon, Johnson, Harvey-Berino, Cold, & Howard, 2007; Glanz, Murphy, Moylan, Evensen, & Curb, 2006; Krukowski, Harvey-Berino, Bursac, Ashikaga, & West, 2013). New forms of technology are also being used to monitor other self-regulated behavior, including physical activity and step goals (Kirwan, Duncan, Vandelanotte, & Kerry, 2012) and the management of blood glucose in diabetics (Anoop, Hou, Golnik, Flaherty, & Vu, 2010). These types of software and mobile applications may make it easier for participants to self-monitor and for researchers to understand when and how frequently participants are tracking their eating. Furthermore, different forms of self-monitoring are being explored that may address both the problems of efficiency and the interval between the behavior and the recording. Daily self-weighing may be an effective way to help individuals track the results of eating and exercise behaviors on a regular basis in order to understand what behaviors lead to weight loss and weight gain, and thus reinforce or alter these behaviors in line with the theory of self-regulation. Studies on self-weighing have shown that more frequent weighing is associated with a lower BMI (Butryn, Phelan, Hill, & Wing, 2012), as well as increased weight loss or decreased weight regain (Linde, Jeffery, French, Pronk, & Boyle, 2005; Van Wormer et al., 2009). Focusing future research efforts on forms of self-monitoring that are more efficient or more accessible to participants may motivate participants to self-monitor more frequently, and can help to specifically address the problems of individuals who are discouraged from continued self-monitoring after the end of an intervention.

The results of the current study helped to determine differences between weight loss program participants in terms of patterns of weight loss and regain. The resulting clusters highlight the differences between the typical response to treatment shown by approximately half of participants, and patterns of little weight loss or exceptional weight loss found among smaller but still significant portions of the sample. Additional results helped to further define the role self-monitoring plays following the conclusion of initial behavioral treatment, and the importance of continuing to track behaviors to maintain or even lose additional weight. During an extended care phase, the amount of self-monitoring records completed helped to explain differences between participants evidencing low, moderate, and high rates of success. Moreover, it fully mediated the relationship between extended care treatment attendance and weight change after the end of the treatment program, even with the inclusion of age, education, and race/ethnicity as covariates. Overall, results both emphasize the need for expanding on the methods used to conceptualize patterns of weight loss among participants in lifestyle interventions, and also suggest that ongoing vigilance via self-monitoring is likely to help enhance long-term weight management.

APPENDIX
SELF-MONITORING RECORD

Keeping Track Log

Today's Date: _____

Time	Food Name	Amount	Activity	Feelings/ Place	Calories	Fat Grams
Breakfast						
Lunch				**Breakfast Total**		
Dinner				**Lunch Total:**		
Planned Snacks				**Dinner Total:**		
Unplanned Eating		**Planned Snack Total:**				
		Unplanned Eating Total:				
		Total meals and snack calories today:				

Did you meet your goals today?	**Yes/No**	**Planned Exercise Today**	
Stay within calorie goal.		**Type of Exercise**	**Time**
Meet step count goal.			
Follow my eating Plan: 3 meals & 1 snack			
Stay within fat gram goal?			
Total Steps Today:			

Notes

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BIOGRAPHICAL SKETCH

Melissa Laitner was born in Lincoln, Nebraska, but spent the majority of her childhood in Virginia. She graduated from West Potomac High School in 2007. Melissa went on to graduate from the University of South Carolina *summa cum laude* in 2011 with a B.A. in Experimental Psychology and a minor in Spanish. Following her graduation, Melissa came to the University of Florida to continue her education in the fields of clinical and health psychology and public health. Melissa received her M.S. from the University of Florida in 2014 and is currently pursuing her research interests in the areas of obesity and health disparities.