SOCIAL PROBLEM SOLVING AND ADHERENCE TO SELF-MONITORING IN ASSOCIATION WITH CHANGES IN WEIGHT AND CARDIOMETABOLIC RISK FACTORS IN A BEHAVIORAL WEIGHT LOSS TRIAL

by

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Obesity prevalence remains high for U.S. adults. Standardized behavioral treatment (SBT) has been demonstrated to be efficacious in achieving weight loss. Yet, an evaluation of the effectiveness of each behavioral strategy used in SBT is needed to optimize SBT and achieve improved long-term outcomes.

This secondary analysis used baseline and 12-month data from a randomized clinical trial testing the effect of three different self-monitoring approaches (paper record [PR], personal digital assistant [PDA], and PDA with daily tailored feedback messages [PDA+FB]) on weight loss. Observed variable path analysis was used to examine the mediation effects of social problem solving and adherence to self-monitoring of diet and exercise in this trial. The group effect was evaluated considering two comparisons: 1) PDAs vs. PR, and 2) daily tailored feedback (DTF) vs. none. Self-monitoring adherence was measured by the proportion of weeks that participants adhered to dietary/exercise self-monitoring. Social problem solving was measured by the Social Problem Solving Inventory-Revised (SPSI-R). Cardiometabolic risk factors considered were waist circumference, systolic blood pressure [SBP], diastolic blood pressure [DBP], high-density lipoprotein [HDL], low-density lipoprotein [LDL], total cholesterol, triglycerides, and fasting glucose.

The sample was predominantly white (78%) and female (85%). Adherence to self-monitoring of diet and exercise partially mediated the group effect (PDAs vs. PR) on weight loss. Self-monitoring adherence also fully mediated the group effect (DTF vs. none) on changes in weight, waist circumference, SBP, DBP, total cholesterol, HDL, LDL, and triglycerides. Social problem solving did not mediate any group effect. Weight loss mediated the effect of social problem solving and self-monitoring adherence on changes in cardiometabolic risk factors. In addition, psychometric analysis revealed that the SPSI-R had high internal consistency reliability and convergent and concurrent validity in our sample. Age, income, education, mental health, perceived stress, and barriers to healthy eating were associated with social problem solving.

Future research examining the mechanism of social problem solving, adherence to self-monitoring of diet and exercise, and other behavioral factors used in SBT for obesity with longer follow-up in a larger sample is warranted to provide scientific evidence for optimizing SBT for the long-term.

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PREFACE

I would like to take this opportunity to thank all of the individuals who have helped me in accomplishing my PhD journey and starting my dream career as an academic nurse researcher. There are so many individuals that I would like to acknowledge here, but I may not be able to name everyone with this limited space….

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1.0 PROPOSAL

1.1 SPECIFIC AIMS

With two out of three adults in the United States being overweight (body mass index or BMI 25-30kg/m^2) or obese (BMI $\geq$ 30kg/m^2), the obesity epidemic is a cause for serious public health concern (Flegal, Carroll, Ogden, & Curtin, 2010). There are significant health as well as economic consequences associated with obesity (Mokdad, et al., 2001; Wolf & Colditz, 1998). An extensive body of evidence supports the efficacy of intensive lifestyle interventions focused on modifying one's diet and physical activity habits to achieve weight loss. However, it is a challenge to identify strategies to help individuals maintain weight loss and reduce their risks of developing cardiovascular disease and diabetes (Ratner, et al., 2005; Wadden, Butryn, & Byrne, 2004).

There is ample evidence that self-monitoring of eating and exercise behaviors, a central component of behavioral treatment, is related to successfully changing these behaviors that can result in weight loss (Baker & Kirschenbaum, 1993; Boutelle & Kirschenbaum, 1998; Carels, Darby, Rydin, et al., 2005). However, self-monitoring is often viewed as tedious and time-consuming. Technological advances could address these issues. Only one study has been reported comparing the use of a personal digital assistant (PDA) in one group to traditional paper diaries for self-monitoring in another group and they did not find differences in weight loss

between the two groups (Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007). Since concurrent comparison groups were not used in this study, it is difficult to generalize these findings. Therefore, a randomized clinical trial comparing the paper diary to the PDA was undertaken by Burke et al., (2009). This trial, which focused on different methods of self-monitoring and their effect on adherence to self-monitoring and its role in cardiovascular risk reduction, served as the parent study for this dissertation and will be described in more detail later.

In addition to self-monitoring, standard behavioral weight loss programs typically include social problem solving as an important strategy to facilitate behavioral change (D'Zurilla & Nezu, 1998; Perri, et al., 2001). However, few studies have measured problem solving; thus, there are few data to evaluate the role of problem solving in achieving weight loss success. Further, it is unclear how individuals' problem-solving skills impact weight loss and risk reduction related to development of type 2 diabetes and cardiovascular diseases.

We conducted a secondary data analysis to examine the role of social problem solving and adherence to self-monitoring of diet and exercise on weight loss and cardiometabolic risk factors using the baseline and 12 month data of a 24-month randomized clinical trial. The parent study examined the effect of using different self-monitoring approaches on weight loss among overweight and obese adults. The primary aims of this secondary data analysis study were to:

1. Examine the impact of the self-monitoring approach (paper record [PR] vs. PDA vs. PDA with feedback [PDA+FB]) on adherence to self-monitoring of diet and exercise and changes from baseline to 12 months in social problem solving, weight, and cardiometabolic risk factors (systolic blood pressure [SBP], diastolic blood pressure

[DBP], waist circumference, high-density lipoprotein [HDL], low-density lipoprotein [LDL], total cholesterol, triglycerides, and fasting glucose);

2. Examine the bivariate associations among adherence to self-monitoring of diet and exercise, changes in individuals' social problem solving skills, weight, and cardiometabolic risk factors from baseline to 12 months;

3. Explore the extent to which:

    a. change in individuals' social problem solving from baseline to 12 months mediated the relationship between the self-monitoring approaches and change in weight and cardiometabolic risk factors from baseline to 12 months;

    b. individuals' adherence to self-monitoring of diet and exercise during the 12-month intervention mediated the relationship between the self-monitoring approaches and changes in weight and cardiometabolic risk factors from baseline to 12 months;

    c. weight loss at 12 months mediated the relationship between change in individuals' social problem solving from baseline to 12 months and change in cardiometabolic risk factors from baseline to 12 months;

    d. weight loss at 12 months mediated the relationship between adherence to self-monitoring of diet and exercise during the 12-month intervention and change in cardiometabolic risk factors from baseline to 12 months;

4. Explore the relationship between social problem solving and adherence to self-monitoring of diet and exercise in their role of predicting change in weight and

cardiometabolic risk factors from baseline to 12 months across the three treatment groups.

Secondary aims were to:

1. Evaluate selected psychometric properties (internal consistency, construct validity, convergent validity with barriers to healthy eating, cholesterol-lowering self-efficacy, and binge eating, as well as concurrent validity with stress, psychological well being, diet and exercise behaviors at baseline and 12 months) of the Social Problem-Solving Inventory-Revised (SPSI-R);

2. Explore potential predictors (age, gender, ethnicity, education, marital status, employment status, income, history of psychiatric disorders, mental health quality of life, sleep duration, history of weight cycling, perceived stress, eating habits, barriers to healthy eating, cholesterol-lowering self-efficacy) of social problem solving at baseline.

1.2 BACKGROUND AND SIGNIFICANCE

1.2.1 Obesity

Two out of every three adults in the U.S. are overweight or obese (Flegal, et al., 2010). The high prevalence of obesity has resulted in a significant health and economic burden on the U.S. health care system. Obesity is associated with coronary heart disease, hypertension and type 2 diabetes (Mokdad, et al., 2001). It is estimated that obesity and its related diseases cost $75 billion in

2003 U.S. dollars (Finkelstein, Fiebelkorn, & Wang, 2004; Wolf & Colditz, 1998); together with hypertension and dyslipidemia, it costs approximately $80 billion in 2005 U.S. dollars, independent of the cost for cardiovascular diseases. Of this 80 billion in medical expenditure, $28 billion were used for prescription drugs. The average out-of-pocket cost per patient was $1668, of which $830 was used for prescription drugs (Sullivan, Ghushchyan, Wyatt, & Hill, 2007). Thus, weight loss needs to become a public health priority in the U.S.

1.2.2 Behavioral weight loss program

Behavioral interventions have been used for the treatment of overweight and obesity for over three decades and have resulted in successful weight loss (Wadden, Crerand, & Brock, 2005). The theory guiding these behavioral approaches to obesity treatment is Social Learning Theory, which posits that eating and exercise influence body weight, and by changing eating and exercise behaviors, body weight can be altered. This theory further assumes that eating and exercise are learned behaviors, which can be modified, and long term maintenance of these changes requires environmental change (Wing, 2002). The earliest application of behavioral intervention on weight loss was in the late 1960s (Stuart, 1996). These early programs (early 1970s) focused on modifying eating habits and monitoring cues that affect eating, and on average, achieved an average weight loss of 3.8 kg during an 8.4-week program (Wing, 2002). Gradually, behavioral weight loss programs increased the length of the intervention, and began to prescribe calorie and fat gram goals for diet, and physical activity goals. Having incorporated these changes into behavioral weight loss programs, weight loss success doubled by 1990 (Wadden, 1993).

Currently, standard behavioral treatment for weight loss involves a comprehensive protocol to address lifestyle change, and typically includes goals for daily energy (calorie) and fat gram consumption and weekly physical activity goals, as well as self-monitoring eating and physical activity behaviors, which permits individuals to develop an awareness of their behaviors and the circumstances that precipitate or surround the behaviors they are attempting to modify (Wadden, Crerand, et al., 2005). Standard behavioral treatment (SBT) usually includes group sessions that cover an array of topics related to behavior, physical activity and nutrition. Key strategies traditionally used in SBT include self-monitoring, goal setting, nutrition and exercise counseling, stimulus control, problem solving, cognitive restructuring, and relapse prevention (Wing, 2004). Wing (2002) analyzed 12 studies of behavioral weight loss from 1990 to 2000 and found that weight loss for the initial treatment was usually 10.4 kg over 5.6 months, and 8.1 kg over 17.6 months at follow-up. Weight regain usually occurred during the 12- to18-month window.

We conducted a literature search on four databases: Ovid MEDLINE and PsycINFO, PUBMED, and CINAHL. We used key words “obesity”, “weight loss”, “overweight” and “behavior therapy” and/or “behavior modification”. Additionally, we did a hand search of other relevant articles. The inclusion criteria of the studies for review were (1) English language, (2) adults, (3) used standardized behavioral treatment for obesity, (4) reported weight loss as primary outcome, and (5) randomized clinical trials. We included articles from 2000 and through January 2010. The literature review process, including keywords, limitations, and the number of initial reviewed abstracts and full articles, was summarized in Table 7, Appendix A. In addition, the screening and inclusion procedures, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, Altman, & The

PRISMA Group, 2009) was reported in Figure 8, Appendix A. Table 8 in Appendix A describes the 12 selected studies that were included in the review. Age, gender, ethnicity, and BMI were reported. Attrition rates were reported, if available. Moreover, a summary of the weight loss at different time points for each intervention group from these studies was reported in Table 9 in Appendix A.

Among these recent studies, researchers have been trying to optimize the effect of SBT by adding elements, such as motivational interviewing, or by examining and comparing the effectiveness of SBT delivered via different methods, such as different doses of exercise, or Internet and email delivery. For example, Tate and colleagues found that delivering structured behavioral weight loss interventions via the Internet and emails was promising (Tate, Wing, & Winett, 2001). Another group of investigators conducted a 6-month clinical trial (N=376) that had a 70% retention rate and examined different delivery methods of lifestyle modification: high-frequency face-to-face lifestyle modification counseling, low-frequency face-to-face counseling, high-frequency telephone counseling, high-frequency e-mail counseling, or no dietitian contact. Face to face and telephone interventions with high frequency were found to be more effective in achieving weight loss compared to the other groups (Digenio, et al., 2009). Researchers have also examined the effect of lifestyle intervention using similar behavioral strategies but delivered through one-on-one intervention sessions, and they have achieved significant success in weight loss and reduction in the risk of developing diabetes. This multi-center randomized trial, the Diabetes Prevention Program (DPP), demonstrated the superior efficacy of lifestyle modification compared to pharmacotherapy in preventing the development of type 2 diabetes and in improving the cardiovascular risk profile (Frost, et al., 2002; Ratner, et al., 2005; Wadden, et al., 2004). Indeed, the DPP trial demonstrated that the incidence of

diabetes was significantly lower among participants who were advised to limit their calorie and fat intake, increase their physical activity, and reduce their weight by 7%, with weight loss being the strongest factor (Hamman, et al., 2006; Knowler, et al., 2002). In summary, empirical evidence has demonstrated the efficacy of behavioral interventions for weight reduction; however, the effect of introducing technology in delivering the intervention is less well established.

Furthermore, without measuring each behavior and examining the mediation effect of that behavior in the intervention, it is difficult to evaluate whether a specific behavioral strategy contributes to the mechanism that is found to be effective for the overweight and obese population. Our parent study is the first study that randomized overweight and obese adults to use a personal digital assistant (PDA) or paper record (PR) as part of the intervention when delivering an SBT for weight loss in group sessions (Burke, et al., 2009). We have examined the role of dietary self-monitoring adherence in this trial, and found that it mediated the effect of the feedback group on weight loss at the 6-month point of the behavioral intervention (Turk, et al., Under Review). To the best of our knowledge, no study has examined the mediation effect of specific behavioral strategies (e.g., adherence to self-monitoring of both diet and exercise or problem-solving skills) on the group effect using three different self-monitoring approaches (PR vs. PDA vs. PDA + feedback) on changes in weight and cardiometabolic outcomes at 12 months.

1.2.3 Social problem solving

Social problem solving is defined as the self-directed cognitive-behavioral process whereby individuals try to find effective solutions to problems that they encounter in their daily lives

(D'Zurilla & Goldfried, 1971). More specifically, this cognitive-behavioral process (1) makes available a variety of potentially effective solutions for a particular problem, and (2) increases the probability of selecting the most effective solution from among the various alternatives. The adjective *social* in the term social problem solving is not meant to limit the problem to a specific type of problem; rather, it is used to address the fact that the emphasis on problem solving occurs in the natural social environment (D'Zurilla, 2007). Social problem solving comprises two partially independent components: problem-solving orientation and problem-solving styles. Problem-solving orientation reflected individuals' understanding of the problem and their own abilities to solve the problem. Problem-solving style refers to a person's activity to try to find effective solutions to the problems. Social problem solving specifically includes five components: positive problem orientation, negative problem orientation, rational problem-solving style, impulsivity/carelessness style, and avoidance style. The schematic representation of these five dimensions of social problem solving is depicted in Figure 1.

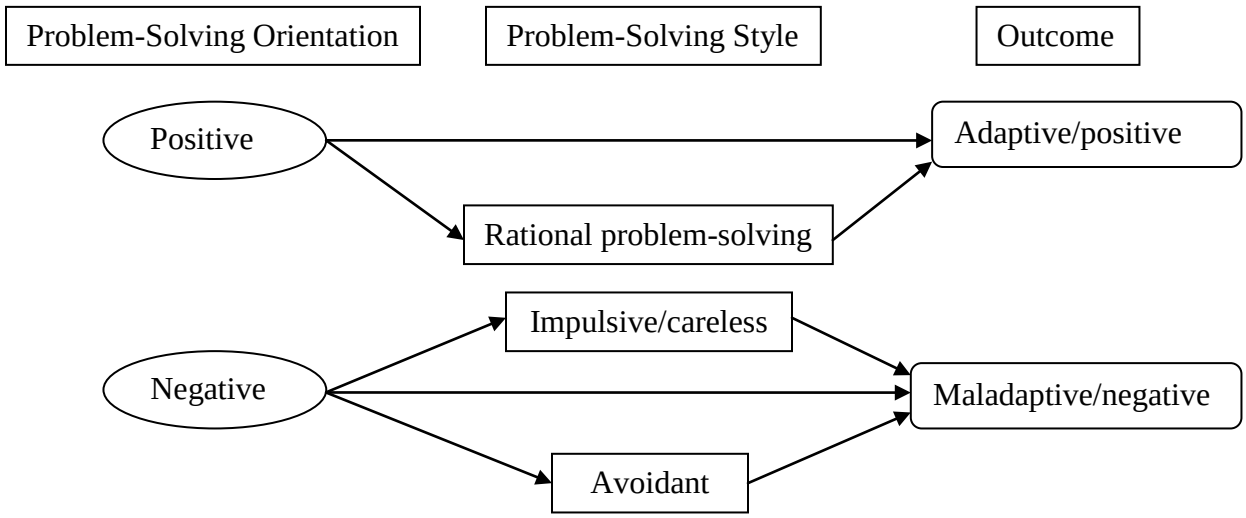


Figure 1. Five-Dimensional Model of Social Problem Solving

D'Zurilla et al. (1998) have found that middle-aged adults have better social problem-solving skills than young adults and older adults, and that there were gender differences on some components of social problem solving. Specifically, men had better positive problem orientation and poorer negative problem orientation than women. Further examination of gender differences among different age groups (young: 17-20 years, middle age: 40-55 years, elderly: 60-80 years) revealed that the gender difference on two problem orientation components only existed in the young adult group, and negative problem orientation in the elderly group. Additionally, young women had lower scores on impulsivity/carelessness style than young men. The drawback of this study is that they used three different age samples, instead of examining the effect of age on social problem-solving ability using age as a continuous variable. To the best of our knowledge, the investigation of predictors of social problem solving has been quite limited, and no study has yet to examine predictors in the overweight and obese population. In order to fill the gap in this area, we identified a comprehensive list of potential predictors of social problem solving by gathering opinions from experts in the area of behavioral weight loss interventions. Possible predictors of social problem solving that were identified included age, gender, race, education, marital status, employment status, income, history of psychiatric disorders, mental health quality of life, sleep duration, history of weight cycling, perceived stress, eating habits, life events, barriers to healthy eating, and cholesterol-lowering diet self-efficacy.

D'Zurilla et al. (2007) also developed Problem-Solving Therapy (PST), which was defined as a grouping of clinical intervention strategies that are implemented in order to reach a particular goal. Thus, PST could be very different for achieving different goals in different populations. Hence, PST training emphasizes a focus on the behavioral principles.

Only one study was located that used PST in an overweight population and found that the effect of PST in weight loss maintenance is superior to standard behavioral treatment (SBT) only (Perri, et al., 2001). A standard behavioral weight loss intervention typically includes problem solving as a component of the intervention; however, no literature was found that reported the mediational effect of problem solving between lifestyle intervention and weight loss. Murawski et al. found that problem-solving skills were associated with weight loss in a sample of women from a rural environment. They also demonstrated that social problem solving partially mediated self-monitoring adherence and weight loss (Murawski, 2009). D'Zurilla pointed out that most studies demonstrated problem solving as part of the intervention; however, since data were not collected on problem solving, it is difficult to evaluate the effect of problem solving during the intervention (D'Zurilla, 2007). The parent study used a standard behavioral treatment and the session materials that included problem solving components in the parent study are included in Appendix B.

1.2.4 Adherence to self-monitoring

There is a large body of evidence supporting the role of self-monitoring in achieving successful outcomes in behavioral weight loss programs (Baker & Kirschenbaum, 1993; Boutelle & Kirschenbaum, 1998). Acharya et al. (2009) found that adherence to self-monitoring was associated with weight loss and cardiovascular biomarkers. However, when comparing self-reported data and electronically recorded data from the instrumented paper diaries, researchers found little concordance between self-reported and electronically documented data pertaining to the timing of the recording (Burke, et al., 2008; Stone, Shiffman, Schwartz, Broderick, & Hufford, 2002). Furthermore, most studies on self-monitoring focused on dietary self-monitoring

only. Only two studies examined both dietary and exercise self-monitoring. Helsel and her colleagues compared the method of self-monitoring using 1) traditional paper diary, and 2) transitioning to use an abbreviated checklist (Helsel, Jakicic, & Otto, 2007). They focused only on the number of diaries returned as a measure of self-monitoring adherence, without having detailed information on the content of self-monitoring. Shay and colleagues compared the use of paper diary, web-based diary, and PDA diary, no significant difference in weight loss was found among three groups (Shay, Seibert, Watts, Sbrocco, & Pagliara, 2009). Moreover, these two randomized clinical trials had similar methodological limitations (e.g., small sample (N<45), short study duration (12 weeks or 14weeks) and approximately a 50% attrition rate) that make it difficult to generalize the study's findings. Few studies on dietary self-monitoring have examined the use of technology in monitoring diet. Yon et al. found that the use of a PDA was comparable to paper diaries across two behavioral weight loss programs. The absence of concurrent groups mades the findings from this study limited (Yon, et al., 2007). While these studies have provided us with valuable information, better-designed studies are warranted to further investigate this topic. Burke and colleagues have suggested that using technology may reduce the burden of self-monitoring, resulting in greater vigilance in tracking energy intake and physical activity, possibly leading to improved short- and long-term weight loss (Burke, et al., 2005). The parent study is the first study comparing three different methods of self-monitoring in relation to weight loss (Burke, et al., 2009). However, no single study has yet examined the relationship between social problem solving and adherence to self-monitoring using different self-monitoring approaches in relation to weight loss and change in cardiometabolic risk factors.

1.2.5 Mediational model

Baron & Kenny.(1986) maintained that processes (mediating variables) intervened between the stimulus (independent variable) and the response (dependent variable). D'Zurilla et al. suggested that mediational analysis could be used to investigate the effect of social problem solving when it is hard to differentiate its effect from other behavioral strategies used in the same intervention. Glasgow et al. used mediational analysis in a lifestyle intervention with a component of problem solving and found that problem solving was partially mediating the intervention on diabetes self-management (Glasgow, Toobert, Barrera, & Strycker, 2004). Murawski et al. also demonstrated that social problem solving partially mediated weight loss and self-monitoring adherence measured by the number of entries in their diaries in a study using problem-solving guided therapy (Murawski, 2009).

1.2.6 Theoretical framework

Self-regulation theory (SRT) has provided the foundation for the self-monitoring intervention in the parent study. This conceptual model suggests that there are three steps for individuals to change their behaviors: self-monitoring, self-evaluation, and self-reinforcement. Self-monitoring is critical in ensuring the success in this self-regulation process (Kanfer, 1970). Guided by Baron and Kenny's mediation model, SRT, and the literature review on social problem solving, adherence to self-monitoring of diet and exercise in relation to weight loss and risk of developing diabetes and cardiovascular disease, we constructed a theory-guided framework, as depicted in Figure 2. In this study, we conducted an investigation of multiple mediation models that 1) examined adherence to self-monitoring of diet and exercise or social problem solving (processes)

that mediated the relationship between different self-monitoring approaches (stimuli) and weight loss and cardiometabolic risk factors (responses); 2) examined weight loss (process) that mediated the relationship between adherence to self-monitoring or social problem solving (stimuli) and cardiometabolic risk factors (responses).

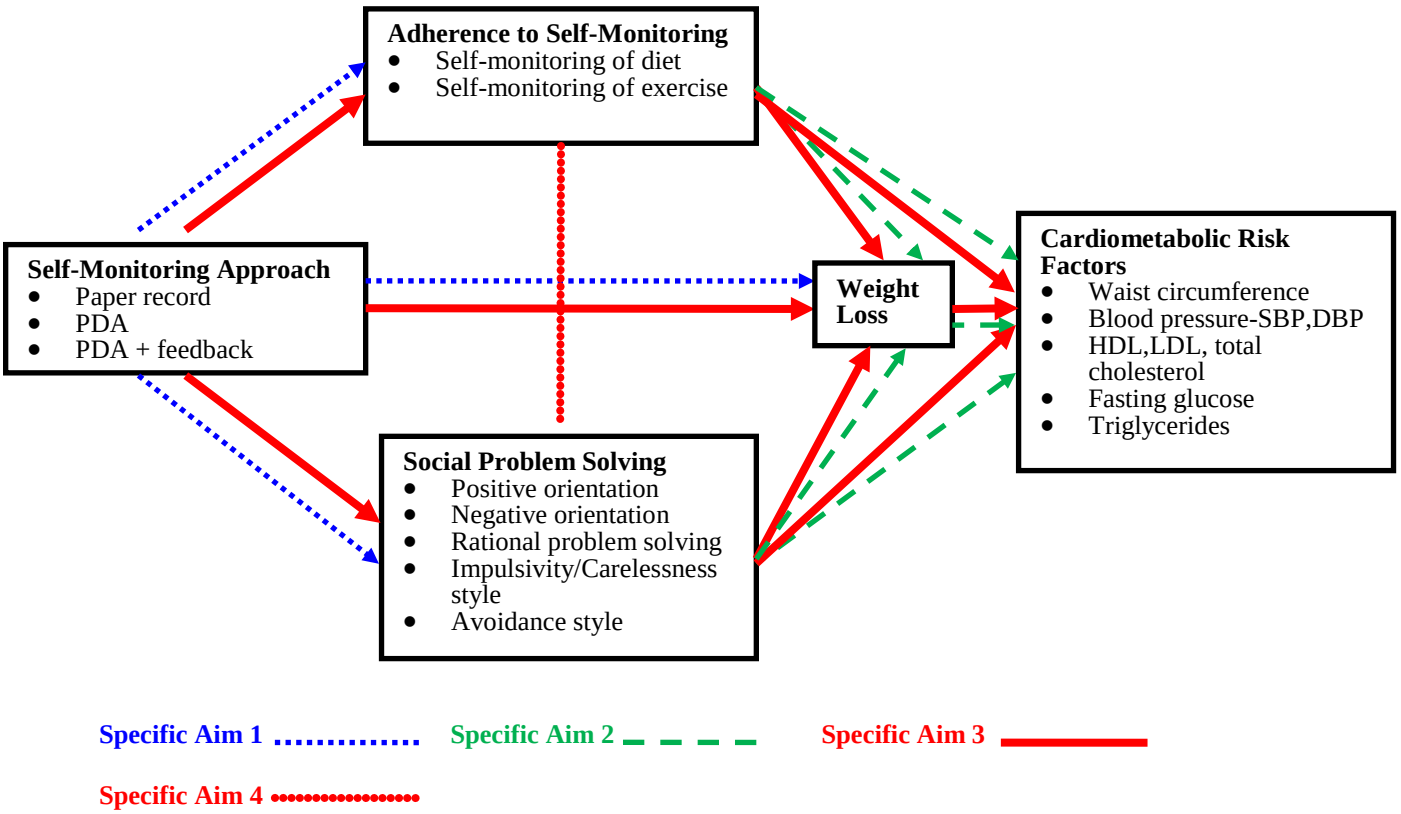


Figure 2. Theoretical Model Based on Self-Regulation Theory and Mediation Model

2.0 METHODS

The dissertation study was a secondary data analysis of a randomized clinical trial examining the efficacy of three self-monitoring methods (paper record, PDA, and PDA with feedback) in achieving short- and long-term weight loss.

2.1 PARENT STUDY

The SMART (Self-Monitoring And Recording using Technology) Weight Loss Trial, a three-group randomized clinical trial with a standard behavioral weight loss treatment, was designed to test the efficacy of three approaches to self-monitoring on weight loss: (1) paper record, (2) personal digital assistants (PDA) with dietary and exercise software, and (3) PDA with the same software plus a tailored feedback message. Participants received nutritional and behavioral counseling, practical hands-on experiences to develop skills to implement a healthy lifestyle, and homework assignments during a total of 20 group sessions, each lasting approximately 45-60 minutes. Groups met weekly for the first 4 months, then bi-weekly for months 5-12, monthly for months12-18, and one last meeting in month 21. Participants in all groups received a calorie goal based on their body weight (for women: 1200 kilocalories for < 200 lbs or 1500 kilocalories for $\geq$ 200 lbs; for men: 1500 kilocalories for < 200 lbs or 1800 kilocalories for $\geq$ 200 lbs). This formula was used successfully in Burke's previous study, as well as in other studies (Wing &

Jeffery, 1999). Fat gram goals approximated 25% of calorie goal, e.g., 27 or 33 grams per day for females. All participants were told to increase their exercise gradually, primarily through walking, until they reached a minimum goal that increased over the course of the study. The starting goal, to be reached by 12 weeks, was 150 minutes per week, equal to a caloric expenditure of 1000 calories per week, assuming a pace of 1 mile in approximately 15-20 minutes, which is equivalent to 100 calories expended (Pronk & Wing, 1994). Using the self-monitoring approach to which participants had been randomly assigned, they were asked to document their diet and exercise behaviors in a timely manner throughout the day. At each session, participants in the paper diary group turned in their diaries, received the diaries submitted at the previous session that had been reviewed by and contained feedback from the interventionists, and received new diaries to use until the next session. During the session the self-monitoring data from participants' PDAs were uploaded and converted to a format that was downloaded to an Access database. The interventionists then received printed reports that looked similar to the standard paper diaries for their review and comments.

2.2 SAMPLE

At the time of study enrollment, participants in the parent (SMART) study were 21 to 59 years of age and had a BMI > 27 and $\leq$ 43 kg/m^2. For the secondary analysis, the data of the full sample, 210 participants, was used regardless of adherence and retention.

2.3 MEASURES

We used the socio-demographic and health history data collected at baseline by the parent study to describe our sample. These variables included age, gender, race, education, marital status, employment status, annual income, BMI, history of hypertension, history of hyperlipidemia, use of antihypertensive medication and lipid-lowering medication, and family history of diabetes.

2.3.1 Social problem solving

Social problem solving was measured by the Social Problem Solving Inventory-Revised (SPSI-R). This instrument has 52 items with five response options ranging from 0 to 4 representing from “not at all true of me” to “extremely true of me”. It asks respondents how they think, feel, and act when faced with problems in everyday living, and it has five subscales including two constructive problem-solving dimensions: positive problem orientation, and rational problem solving; and three dysfunctional dimensions: negative problem orientation, impulsivity/carelessness style, and avoidance style.

Psychometric work on this instrument tested in various samples including college students, middle-aged adults, and elderly adults, demonstrated that both the total score and the five subscale scores had good internal consistency with Cronbach’s alphas ranging from .69 to .95 for subscales, .95 for the total score, as well as good test-retest reliability at 3 weeks, with correlation coefficients ranged from .69 to .91 for the subscales, and .89 to .93 for the total score. Additionally, the five subscales, except for the rational problem solving subscale, had moderate to strong significant correlations with anxiety measured by the Trait Anxiety scale of the State-Trait Anxiety Inventory, depression measured by the Beck Depression Inventory, and

psychological distress measured by the Perceived Stress Scale in a college student sample (D'Zurilla & Nezu, 1990). Both the total score and the five subscale scores were used in this study.

2.3.2 Adherence to self-monitoring of diet

Adherence to self-monitoring of diet was measured by the proportion of weeks when participants adhered to dietary self-monitoring. There were 32 weeks in total from baseline to 12 months, when participants were asked to submit their diaries. We allowed participants to bank calories during the week, which means they could eat fewer calories for one day, if they knew they would eat more calories on another day. Thus, even though participants were given daily calorie goals, adherence to self-monitoring of diet for each week was computed as a binary variable based on whether participants recorded at least 50% of the daily calorie goal. Each diary submitted represented their dietary intake of the preceding week. For biweekly sessions, we took only the preceding week of the intervention session into account. This method was used and evaluated in a previous study (Acharya, et al., 2009). For example, a person on a 1200 calorie/day allowance needed to record food intake of at least 600 calories/day. In this example, recording less than 600 calories/day was considered non-adherent to self-monitoring of diet. A missing diary was defined as non-adherent to self-monitoring of diet for that week.

2.3.3 Adherence to self-monitoring of exercise

Adherence to self-monitoring of exercise was measured by the proportion of sessions when participants adhered to self-monitoring of exercise. Adherence to self-monitoring of exercise for

each session was computed as a binary variable based on whether participants recorded any exercise minutes in their diaries. They were given a weekly exercise goal, for example, if a person recorded 5 minutes of exercise/day, the individual would be considered as adherent to self-monitoring of exercise. Even if the person was not meeting the exercise goal; the participant was self-monitoring actual exercise behavior. A missing diary is defined as non-adherent to self-monitoring of exercise for that week, which included diaries not submitted to the interventionist and those submitted but without any recordings of exercise minutes in the diary.

2.4 DATA ANALYSIS

Mplus (version 5.21), SPSS (version 17.0, SPSS, Inc., Chicago, IL, USA), and SAS (version 9.2, SAS Institute, Inc., Cary NC) were used for data analysis. Assessment of data accuracy was performed prior to the main analyses. Exploratory data analysis methods were used first to identify data anomalies (i.e., outliers, amount and patterns of missing data, violations of assumptions). Specifically, descriptive statistics with graphical representations of all the variables were used for range checking, and contingency checking. Univariate outliers were assessed based on the variables' level of measurement. For categorical variables, frequency of the variables was examined to screen very uneven splits (e.g., 90%, 10% for binary variables) among the categories. For continuous variables, histograms, box plots, normality probability plots, detrended normal probability plots were used to identify points far removed from the rest of the distribution of the data. Multivariate outliers were screened using both bivariate scatterplots between each pair of variables and Mahalanobis distance computed for the set of variables of interest. Once outliers were identified, procedures were taken to see whether the

outliers were influential or not. Sensitivity analyses, with and without outliers, were performed. Then the results were compared to see whether the outliers influenced the results or not. Also, a dummy grouping variable was created to distinguish the outliers from the remaining observations, and then treated as the dependent variable in logistic regression, in order to see what characteristics distinguished subjects with outlying values. Underlying assumptions (linearity of variables, independence of observations, homoscedasticity of error variance, normality of the residuals, no multicollinearity, and no outliers) for multiple linear regression were assessed. First, bivariate scatter plots were used to examine the independence of cases by plotting the key variables of interest versus the subject's identifying number; assuming subject identifiers were sequentially assigned. Second, the shape of distribution and the magnitudes of skewness and kurtosis were used to examine the shape of the data distribution for continuous variables. Kolmogorov-Smirnov test was also computed to assess for normality. Transformation was considered as appropriate. Third, bivariate scatter plots were used to examine linearity between any pair of the variables. Lastly, the Levene test and bivariate scatter plots were examined for homoscedasticity for continuous dependent variables with categorical independent variables and continuous dependent variables with continuous independent variables, respectively.

We also examined the demographic differences between the total sample (N=210) at baseline and the sample (N=179) of those who completed both baseline and 12-month assessments. Amount and patterns of missing data for all the variables were used to examine the missingness of data. We employed an intention to treat approach using participants' data at baseline and 12 months, regardless of their adherence and retention. We assumed no change for those who had missing values on cardiometabolic risk factors by imputing baseline values for 12

months, wherever they were missing. We used three imputational strategies for missing weight measures and compared the results with the results using complete data only. The first approach assumed no change in weight, and baseline weight was imputed for the missing weight at 12 months. The second strategy used the last observation carried forward (LOCF) approach, a widely used method for dealing with missing data. The third technique used was more conservative and assumed a weight regain of 0.3kg per month after leaving the study, which has been used in previous weight loss studies (Wadden, Berkowitz, Sarwer, Prus-Wisniewski, & Steinberg, 2001; Wing, 1998).

Variables were described using frequency counts and percentages and, as appropriate, measures of central tendency and dispersion (e.g., means and standard deviations for normally distributed interval- and ratio-scaled variables; medians and ranges [semi-quartile, interquartile] for ordinally scaled or non-normally distributed variables). The significance level was set at .05 and 95% confidence intervals were estimated.

Primary aim 1: Examine the impact of the self-monitoring approach (paper record vs. PDA vs. PDA with feedback) on adherence to self-monitoring of diet and exercise and changes from baseline to 12 months in social problem solving, weight, and cardiometabolic risk factors (SBP, DBP, waist circumference, HDL, LDL, total cholesterol, triglycerides, fasting glucose).

Data analysis 1: Simple linear regression was used to examine the effect of three self-monitoring approaches on the two self-monitoring adherence variables (measured by the proportion of sessions participants were adherent to self-monitoring of diet/exercise from baseline to 12 months), and the change scores (from baseline to 12 months) of five social problem solving subscales and the total score of the SPSI-R, weight, and the cardiometabolic risk

factors. The predictor variable was the randomly assigned self-monitoring approaches. Using the paper record group (PR) as the reference group, two predictors were created: 1) PDA group compared to PR group, and 2) PDA with feedback group compared to PR group. Residual analyses were performed as a part of model assessment. Covariates (e.g., medication use) were considered as indicated. Given the fixed sample size of 179, we had 80% power to detect an effect size (f) as small as 0.23 [medium effect size from a behavioral science perspective (Cohen, 1988)] for differences among three groups when using an F-test at a significance level of 0.05. Regression coefficient estimates and R-squared statistics with confidence intervals, standard errors of the estimate, F-statistic and its significance testing of the regression model, t statistic and its significance testing for each predictor variable were computed from these analyses. Residual analysis were performed through examination of deviating data points in residual plots, studentized deleted residuals, Cook's distances, standardized beta coefficients, and fit statistics, covariance ratios, and leverage statistics. Sensitivity analyses with and without outliers were conducted to determine whether the identified outliers were overly influential or not.

Primary aim 2: Examine the bivariate associations among adherence to self-monitoring of diet and exercise, change in individuals' social problem solving, weight, and cardiometabolic risk factors from baseline to 12 months.

Data analysis 2: Correlational and linear regression analysis was performed for each self-monitoring adherence variable (measured by the proportion of sessions participants were adherent to self-monitoring of diet/exercise), and each social problem solving subscale score and its total score with the outcome variables of cardiometabolic risk factors. Residual analysis, influence diagnostics, and nonlinearity were examined in each regression analysis. For each regression model fitted, point estimates and 95% confidence intervals were computed for

regression coefficients and R-squared values. F- and t-statistics were used for significance testing for the overall regression model and each regression coefficient, respectively. Covariates were considered in the model as necessary. Possible covariates were considered in the regression analysis when examining cardiometabolic outcomes, e.g., use of antihypertensive medication was controlled when evaluating blood pressure as the dependent variable. With a sample size of 179, we had 80% power to detect effect sizes (R^2) as small as 0.04 (small effect size from a behavioral science perspective (Cohen, 1988)) for each predictor when using an F-test at a significance level of 0.05.

Primary aim 3a: Explore the extent to which change on individuals' social problem solving from baseline to 12 months mediated the relationship between the self-monitoring approaches and change in weight and cardiometabolic risk factors from baseline to 12 months.

Data analysis 3a: Observed variable path analysis was used to fit the proposed mediational model described in Figure 2 for specific aim 3a using Mplus. Path coefficients with standard errors and R-square values for the proximal (social problem solving) and distal (weight and metabolic risk factors) endogenous variables were estimated. Indirect, direct and total effects were also estimated. Path analysis via 5000 bootstrapping was used to test for mediation effects. Goodness-of-fit was assessed using the recommended indices including root mean square error of approximation (RMSEA) and comparative fit index (CFI). Residual analysis was performed for each path analysis model fitted to identify sources of model misspecification, outliers and influential observations. For the mediational model based on 10 covariances and 4 variances, 5 parameters were estimated. Bentler and Chou (Bentler & Chou, 1987) recommended at least a 10 to 15:1 ratio of cases to parameters when using structure equation modeling (SEM) when data

are possibly non-normal or incomplete. Boomsma (Boomsma, 1983) has recommended a sample size of about 200 when fitting small to medium sized structural equation models.

Primary aim 3b: Explore the extent to which individuals' adherence to self-monitoring of diet and exercise during the 12-month intervention mediated the relationship between the self-monitoring approaches and change in weight and cardiometabolic risk factors from baseline to 12 months.

Data analysis 3b: An analysis strategy similar to that used for primary aim 3a was employed to examine the structural equation model for adherence to self-monitoring of diet, adherence to self-monitoring of exercise (proximal endogenous variables) and weight and cardiometabolic risk factors (distal endogenous variables). As described in Aim 1, the self-monitoring approach, represented as two indicator variables, served as the main independent (exogenous) variables of interest.

Primary aim 3c: Explore the extent to which weight loss at 12 months mediated the relationship between change in individuals' social problem solving from baseline to 12 months and changes in weight and cardiometabolic risk factors from baseline to 12 months.

Data analysis 3c: An analysis similar to that used for primary aim 3a was conducted to examine the structural model for weight loss (proximal cardiometabolic risk factors) and cardiometabolic risk factors (distal endogenous variables). Change score of SPSI-R served as the main independent (exogenous) variables of interest.

Primary aim 3d: Explore the extent to which weight loss at 12 months mediated the relationship between adherence to self-monitoring of diet and exercise during the 12 months intervention and change in cardiometabolic risk factors from baseline to 12 months.

Data analysis 3d: An analysis similar to that used for primary aim 3a was conducted to examine the structural model for proximal (weight loss) and distal (cardiometabolic risk factors) endogenous variables. Adherence to self-monitoring measures served as the main independent (exogenous) variables of interest.

Primary aim 4: Explore the relationship between problem solving and adherence to self-monitoring of diet and exercise in their role of predicting change in weight and cardiometabolic risk factors from baseline to 12 months across the three treatment groups.

Data analysis 4: An analysis similar to that used for primary aim 3a was conducted to examine the structural model for proximal (adherence to self-monitoring of diet, adherence to self-monitoring of exercise, and social problem solving) and distal (weight and cardiometabolic risk factors) endogenous variables. Observed variable path analysis was employed to fit the dual mediation models simultaneously, by considering different mediators of interest jointly, not in isolation.

Secondary aim 1: Evaluate selected psychometric properties (internal consistency, construct validity, convergent validity, and concurrent validity) of the Social Problem-Solving Inventory-Revised (SPSI-R).

Data analysis 5: We used Cronbach's alpha to estimate the internal consistency of the SPSI-R, and correlation and simple linear regression to examine the convergent validity with barriers to healthy eating, cholesterol-lowering self-efficacy, and binge eating. Similarly, we used correlation and regression to examine concurrent validity of social problem solving in relation to stress, psychological well being, diet and exercise behaviors at baseline and 12 months. Residual analysis was performed through examination of deviating data points in residual plots, studentized deleted residuals, Cook's distance, standardized change in beta and fit

statistics, covariance ratio, and leverage statistics. Sensitivity analyses with and without outliers were conducted to determine whether the identified outliers were overly influential or not. Regression coefficient estimates and R-squared change with confidence intervals, standard errors of the estimate, F statistic and its significance testing of the regression model, t statistic and its significance testing for each predictor variable were computed from these analyses for purposes of hypothesis testing and parameter estimation when examining validity aspects. Confirmatory factor analysis (CFA) was conducted in Mplus to examine the construct validity and factor structure of the SPSI-R in this patient sample. Maximum likelihood estimation was considered if data were normally distributed. However, since the data were skewed, a more robust method, weighted-least-squares with means and variances adjusted (WLSMV), was ultimately used. Factor loadings, standard error of factor loadings, and correlations between factors were estimated and examined. Goodness-of-fit of the five-factor structure was assessed using the recommended chi-square goodness-of-fit, the root-mean-square error of approximation (RMSEA), and comparative fit index (CFI). Residual analysis and modification indices (MIs) were used to examine and explore lack of fit. We assumed correlations among factors due to the nature of the instrument. MIs were used for hypothesis generation.

Secondary aim 2: Explore potential predictors (age, gender, ethnicity, education, marital status, employment status, income, history of psychiatric disorders, mental health quality of life, sleep duration, history of weight cycling, perceived stress, eating habits, life events, barriers to healthy eating, cholesterol-lowering self-efficacy) of social problem solving.

Data analysis 6: Six predictive models were developed for the total score and five subscale scores of the SPSI-R. A predictor selection process was initially applied to examine bivariate correlation between each predictor and outcome variable. Pearson's product moment

correlation, Spearman's rank-order correlation, or point-biserial correlation was used to examine the association of SPSI-R total score and five subscale scores with all predictors, depending on the level of measurement for each variable. Any variable having a significant correlation with p-value less than 0.10 was selected as a candidate for the multivariate analysis. More traditional levels such as 0.05 can fail in identifying variables known to be important. All possible subsets regression method was utilized to identify parsimonious sets of predictors to develop a predictive model of social problem solving. The choice of the best subset of predictors was accomplished using selection criteria: 1) Mallow's Cp, 2) mean square error (MSE), 3) R square, and 4) adjusted R square. Multicollinearity was examined using the criteria listed below: 1) Correlation coefficients for any of the two variables needed to be <.90, all tolerance values needed to be >.10, and all VIF values needed to be <10. Residual analysis strategies mentioned in data analysis plan for aim 1 were used. Regression coefficient estimates and R-squared change with confidence intervals, standard errors of the estimate, F statistic and its significance testing of the regression model, t statistic and its significance testing for each predictor variable were computed from these analyses.

3.0 SUMMARY OF DISSERTATION FINDINGS

The dissertation project examined the role of social problem solving and adherence to self-monitoring of diet and exercise in a randomized controlled clinical trial testing the efficacy of three different modes of self-monitoring (paper record [PR], personal digital assistant [PDA], PDA with daily tailored feedback messages [PDA+FB]).

The first manuscript, addressed the following specific aims:

Primary aim 1. Examine the impact of the self-monitoring approach (PR vs. PDA vs. PDA+ FB) on adherence to self-monitoring of diet and exercise and changes from baseline to 12 months in social problem solving, weight, and cardiometabolic risk factors (systolic blood pressure [SBP], diastolic blood pressure [DBP], waist circumference, high-density lipoprotein [HDL], low-density lipoprotein [LDL], total cholesterol, triglycerides, and fasting glucose).

Primary aim 2. Examine the bivariate associations among adherence to self-monitoring of diet and exercise, changes in individuals' social problem solving, weight, and cardiometabolic risk factors from baseline to 12 months.

Primary aim 3: Explore the extent to which: a. change on individuals' social problem solving from baseline to 12 months mediate the relationship between the self-monitoring approaches and change in weight, and cardiometabolic risk factors from baseline to 12 months; b. individuals' adherence to self-monitoring of diet and exercise during the 12 months intervention mediate the relationship between the self-monitoring approaches and changes in weight, and cardiometabolic

risk factors from baseline to 12 months; c. weight loss at 12 months mediates the relationship between change in individuals' social problem solving from baseline to 12 months and change in cardiometabolic risk factors from baseline to 12 months; d. weight loss at 12 months mediates the relationship between adherence to self-monitoring of diet and exercise during the 12-month intervention and change in cardiometabolic risk factors from baseline to 12 months.

Primary aim 4. Explore the relationship between problem solving and adherence to self-monitoring of diet and exercise in their role of predicting change in weight and cardiometabolic risk factors from baseline to 12 months across the three treatment groups.

Group effect in this analysis was evaluated using two group variables: 1) PDAs (PDA group and PDA+FB group) vs. PR, and 2) daily feedback [DFB] vs. none (PR group and PDA group). In brief, the impact of three self-monitoring approaches was only significant on adherence to self-monitoring of diet and exercise. Social problem solving did not mediate any group effect on weight loss and changes in cardiometbolic risk factors. Adherence to self-monitoring of diet and exercise both partially mediated the group effect (PDAs vs. PR) on weight loss and decrease in waist circumference. In addition, these two adherence variables fully mediated the group effect (DTF vs. none) on changes in weight and waist circumference. Weight loss at 12 months mediated the effect of both social problem solving and self-monitoring adherence on changes in cardiometabolic risk profile.

The findings for the secondary aim 1 are described in the second manuscript, Psychometric Properties of Social Problem-Solving Inventory-Revised in Weight Loss Study Participants.

Secondary aim 1. Evaluate selected psychometric properties (internal consistency, construct validity, convergent validity with barriers to healthy eating, cholesterol-lowering self-efficacy,

and binge eating, as well as concurrent validity with stress, psychological well being, diet and exercise behaviors at baseline and 12 months) of the Social Problem-Solving Inventory-Revised (SPSI-R).

This psychometric analysis had a mean body mass index of 34. Cronbach's alpha was .95 for the total score and ranged from .67 (RPO) to .92 (RPS) for subscales. The confirmatory factor analysis showed that the hypothesized five factor structure did not fit the data well (χ^2=1750, p<.01; RMSEA=.09; CFI=.89). The SPSI-R total score was negatively associated with barriers to healthy eating and binge eating and positively associated with self-efficacy in following a cholesterol-lowering diet. The SPSI-R significantly predicted health behaviors and outcomes where weight loss participants indicated better problem-solving skills: consumed fewer calories and fat grams, exercised more frequently, reported lower psychological distress, and higher mental quality of life. The SPSI-R appears to be a promising tool to predict health behaviors and outcomes in weight loss studies, however, further work in a larger sample is needed to confirm the five-factor structure of the SPSI-R.

The third manuscript, Factors Associated with Social Problem Solving in Weight Loss Study Participants, addressed the second secondary aim:

Secondary aim 2. Explore potential predictors (age, gender, ethnicity, education, marital status, employment status, income, history of psychiatric disorders, mental health quality of life, sleep duration, history of weight cycling, perceived stress, eating habits, barriers to healthy eating, cholesterol-lowering self-efficacy) of social problem solving at baseline.

We developed predictive models for the total score and five scale scores of the SPSI-R. Individuals who were younger, had a higher weight at baseline, had better mental health, perceived less stress and fewer barriers to healthy eating together, tended to have better problem-

solving skills. Being older, having a lower weight at baseline, poor mental health, perceived more barriers and stresses, and being single together built a significant predictive model of a negative problem orientation, while a higher income, perceived fewer barriers and less stress predicted positive problem orientation. Higher levels of income and education, fewer perceived stresses, and a history of weight cycling predicted a rational problem-solving style, while less education and perceived more eating barriers and stress predicted an impulsive or careless style. Being older, having poor mental health and perceived more eating barriers and stresses together predicted an avoidance style of social problem solving.

Implications for future studies are also discussed in the manuscripts. Future research examining the mechanism of social problem solving, self-monitoring adherence, and other traditional behavioral factors used in a standard behavioral treatment for obesity with longer follow-up in a larger sample is warranted to provide scientific evidence for the optimization of SBT for the long-term.

4.0 RESULTS MANUSCRIPT #1: EFFECT OF SOCIAL PROBLEM SOLVING AND ADHERENCE TO SELF-MONITORING IN A BEHAVIORAL WEIGHT LOSS TRIAL

4.1 ABSTRACT

Objective: To examine the role of social problem solving and adherence to self-monitoring of diet and exercise on weight loss and changes in cardiometabolic risk factors in a behavioral weight loss trial. **Methods:** We conducted a series of mediation analyses using data from a behavioral weight loss trial testing the effect of three different modes of self-monitoring (paper record [PR], personal digital assistant [PDA], and PDA with daily automated and tailored feedback [PDA+FB]). Adherence to self-monitoring was measured by the proportion of weeks when participants adhered to dietary/exercise self-monitoring. The total score and five scale scores of the Social Problem Solving Inventory-Revised were used to measure social problem solving. Group effect was evaluated using two treatment variables: 1) PDAs vs. PR, and 2) daily feedback [DFB] vs. none. **Results:** The sample was predominantly white (78%) and female (85%). Adherence to self-monitoring of diet and exercise were found to partially mediate the treatment effect (PDAs vs. PR) on weight loss and decrease in waist circumference. Also, two adherence variables fully mediated the treatment effect (DTF vs. none) on changes in weight and cardiometabolic outcomes. Social problem solving did not mediate any treatment effect. Weight loss was found to be a mediator between social problem solving/self-monitoring adherence and

changes in cardiometabolic risk factors. **Conclusions:** Adherence to self-monitoring partially explained the effect of receiving a PDA resulting in greater weight loss and fully explained the effect of receiving daily tailored feedback messages on weight loss, while social problem solving did not. Weight loss explained the mechanism by which social problem solving and self-monitoring adherence affected cardiometabolic risk factors.

4.2 INTRODUCTION

Although much research effort is devoted to weight loss, prevalence rates for overweight and obesity continue to be 66% for U.S adults (Flegal, et al., 2010). Standardized behavioral treatment (SBT) for obesity has been shown to be efficacious in achieving weight loss (Wadden, Crerand, et al., 2005; Wing, 2004); however, optimizing SBT might lead to improved outcomes, especially for the long-term. Therefore, evaluation of the effectiveness of each behavioral strategy used in SBT could help with the optimization process.

Social problem solving has traditionally been included in behavioral weight loss programs (Wing, 2004). However, only one study has examined the role of problem solving in a behavioral weight loss trial with a sample of overweight women living in rural areas, revealing that social problem solving partially mediated the relationship between self-monitoring adherence and weight loss (Murawski, 2009).

There is a large body of evidence supporting the role of self-monitoring in achieving successful outcomes in behavioral weight loss programs (Baker & Kirschenbaum, 1993; Boutelle & Kirschenbaum, 1998; Burke, Wang, & Sevick, 2010). However, when comparing self-reported data and electronically recorded data from instrumented paper diaries, researchers found

little concordance between self-reported and electronically documented data pertaining to the timing of the recording (Burke, et al., 2008; Stone, et al., 2002). Thus, it is essential to evaluate adherence to self-monitoring and its role in SBT.

Acharya et al. (2009) found that adherence to self-monitoring was associated with weight loss and changes in cardiovascular biomarkers. A multi-center randomized trial, the Diabetes Prevention Program (DPP), demonstrated the superior efficacy of lifestyle modification compared to pharmacotherapy in preventing the development of type 2 diabetes and improving cardiovascular risk profile (Frost, et al., 2002; Ratner, et al., 2005; Wadden, et al., 2004). Investigators found weight loss to be the strongest factor contributing to the lower incidence of diabetes in the behavioral intervention group (Hamman, et al., 2006; Knowler, et al., 2002). However, no study has yet examined the role of weight loss on the relationship between behavioral strategies and cardiometabolic risk profile in the context of a behavioral weight loss program.

Researchers have been using mediation analysis, guided by Baron and Kenny's work, to explore the underlying mechanism of the interventions involving multiple intervention strategies. Thus, we conducted an investigation of multiple mediation models that 1) examined processes (adherence to self-monitoring of diet and exercise and social problem solving) that potentially mediate the relationship between a stimulus (different self-monitoring approaches) and a response (weight loss and cardiometabolic risk factors); and 2) examined processes (weight loss) that mediate the relationship between a stimulus (adherence to self-monitoring of diet and exercise and social problem solving) and a response (cardiometabolic risk factors). The full study model is depicted in Figure 1.

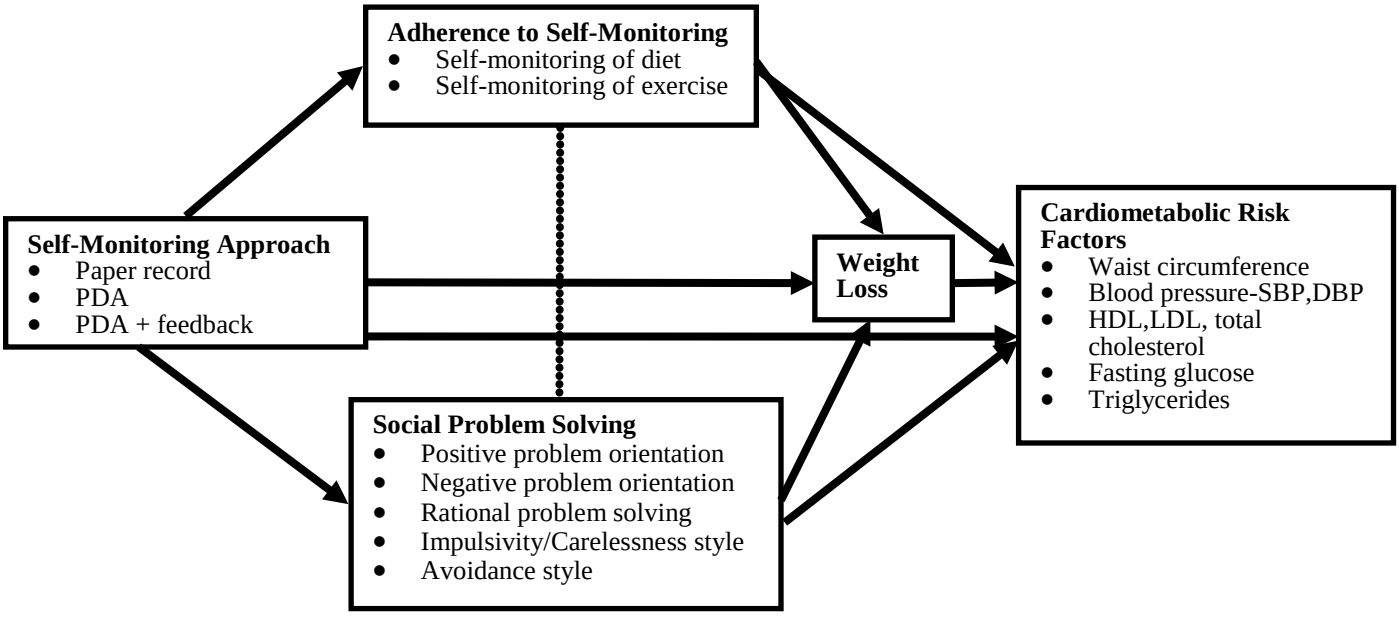


Figure 3. Theoretical Model with Multiple Mediation Models

4.3 METHODS

To examine the role of social problem solving and adherence to self-monitoring of diet and exercise on weight loss and cardiometabolic risk factors in a behavioral weight loss trial, we used data from a randomized clinical trial, the SMART (Self-Monitoring And Recording using Technology) Weight Loss Trial. It is a three-group randomized clinical trial with a standard behavioral weight loss treatment designed to test the efficacy of three modes of self-monitoring on weight loss: (1) paper record, (2) personal digital assistants (PDA) with dietary and exercise software, and (3) PDA with the same software plus a tailored feedback message. Group effect in

this analysis was evaluated using two group variables: 1) PDAs (PDA group and PDA+FB group) vs. PR, and 2) daily feedback [DFB] vs. none (PR group and PDA group). Participants received nutritional and behavioral counseling, practical hands-on experiences to develop skills to implement a healthy lifestyle, and homework assignments during a total of 20 group sessions, each lasting approximately 45-60 minutes. Groups met weekly for the first 4 months, then bi-weekly for months 5-12, monthly for months12-18, and once for a final meeting in month 21. Participants in all groups received a calorie goal based on their baseline body weight (for women: 1200 kilocalories for < 200 lbs or 1500 kilocalories for $\geq$ 200 lbs; for men: 1500 kilocalories for < 200 lbs or 1800 kilocalories for $\geq$ 200 lbs).

There were 210 participants at baseline and 179 of them completed the 12-month assessment. All of the participants were 21 to 59 years of age and had a BMI > 27 and $\leq$ 43 kg/m^2.

Adherence to self-monitoring of diet was measured by the proportion of weeks when participants adhered to dietary self-monitoring. There were 32 weeks in total from baseline to 12 months, when participants were asked to submit their diaries. Participants were permitted to bank calories during the week, which means they could eat fewer calories for one day, if they knew they would eat more on another day. Thus, even though they were given daily calorie goals, adherence to self-monitoring of diet for each week was computed as a binary variable based on whether participants recorded at least 50% of the daily calorie goal using the mean calorie intake of the total weekly calorie goal. For example, a person on a 1200 calories/day allowance would need to record food intake of at least 600 calories/day. In this example, recording less than 600 calories/day is considered non-adherent to self-monitoring of diet. Each diary submitted represented a participant's dietary intake for the preceding week. For biweekly sessions, only the

diaries from the immediate preceding intervention session were taken into account. This method of measuring dietary self-monitoring adherence was used and evaluated in a previous study (Acharya, et al., 2009). A missing diary was defined as non-adherent to self-monitoring of diet for that week.

Adherence to self-monitoring of exercise was measured by the proportion of sessions that participants adhered to self-monitoring of exercise. Adherence to self-monitoring of exercise for each session was computed as a binary variable based on whether participants recorded any exercise minutes in their diaries. They were given weekly exercise goals, for example, if a person recorded 5 minutes of exercise/day, the individual would be considered as adherent to self-monitoring of exercise. Even if the person was not meeting the prescribed exercise goal, the participant was self-monitoring actual exercise behavior. A participant with a missing diary was defined as non-adherent to self-monitoring of exercise for that week, and included diaries that were not submitted to the interventionist and those submitted without any recorded minutes of exercise.

Social problem solving was measured by the Social Problem Solving Inventory-Revised (D'Zurilla & Nezu, 1990). This instrument has 52 items with five response options ranging from 0 to 4 representing from “not at all true of me” to “extremely true of me”. Respondents were asked how they think, feel, and act when faced with problems in everyday living, and it is comprised of five scales including two constructive problem-solving dimensions: positive problem orientation and rational problem solving style; and three dysfunctional dimensions: negative problem orientation, impulsivity/carelessness style, and avoidance style. Psychometric work on this instrument has demonstrated that both the total score and the five subscale scores had good internal consistency with Cronbach’s alphas ranging from .69 to .95 for subscales, .95

for the total score. The scale has also demonstrated good test-retest reliability at 3 weeks with correlation coefficients ranging from .69 to .91 for the subscales and .89 to .93 for the total score in various samples, including college students, middle-aged adults, and elderly adults.

Mplus (version 5.21), SPSS (version 17.0, SPSS, Inc., Chicago, IL, USA), and SAS (version 9.2, SAS Institute, Inc., Cary NC) were used for the data analyses. Observed variable path analysis was used to fit the proposed mediational models. Path coefficients with standard errors and R-square values for the proximal (social problem solving) and distal (weight and metabolic risk factors) endogenous variables were estimated. Indirect, direct and total effects were also estimated. The observed variable path analysis via 5000 bootstrapping was used to test for mediation effect. Goodness-of-fit was assessed using the recommended indices including root mean square error of approximation (RMSEA) and comparative fit index (CFI). Residual analyses were performed for each path analysis model fitted to identify sources of model misspecification, outliers and influential observations. The study was approved by the University of Pittsburgh Institutional Review Board.

4.4 FINDINGS

There were 179 participants who had complete data on weight and cardiovascular risk factors at 12 months. Demographic differences at baseline between completers and non-completers at 12 month are described in Table 1. The only significant differences between completers and non-completers were age and BMI at baseline. Participants who completed the 12-month assessment were older and had a lower BMI than those who did not.

Baseline and 12-month percent changes on social problem-solving, adherence to the self-monitoring of diet and exercise, weight, and cardiovascular risk factors are presented in Table 2. Regression analyses revealed that the effect of the self-monitoring approach (PR vs PDA vs PDA+FB) on adherence to self-monitoring of diet and exercise differed significantly (Ps < .001), while its effect on percent change in social problem solving total score, five subscale scores, and weight and cardiometabolic risk factors was not significant, Ps >.05.

Bivariate correlations between independent variables (adherence to self-monitoring of diet and exercise and baseline to 12-month changes in social problem solving total score and five subscale scores) and dependent variables (baseline to 12-month changes in weight and cardiometabolic risk factors) are presented in Table 3. Negative problem orientation score was associated with weight loss and waist circumference decrease at 12 months. Social problem solving in general was associated with weight loss at 12 months. Self-monitoring of diet and exercise was associated with weight loss and decrease in waist circumference and fasting glucose. After controlling for the effect of antihypertensive or lipid-lowering medication use on blood pressure and lipid profile, the results did not change.

Mediation analyses revealed that social problem solving did not mediate any group effect (PDAs vs. PR or DTF vs. none) on changes in weight and cardiometabolic risk factors at 12 months, while adherence to self-monitoring of diet and exercise both partially mediated the effect of using PDAs (vs. PR), and fully mediated the effect of receiving daily tailored feedback (vs. no DTF), on weight loss and changes in waist circumference at 12 months. The mediation models explaining the mechanism of each mediation effect are individually presented in Figure 2. Adherence to self-monitoring of diet and exercise did not mediate the group effect on changes

in systolic and diastolic blood pressure, total cholesterol, HDL, LDL, triglycerides, and fasting glucose at 12 months.

Weight loss at 12 months fully mediated the effect of social problem solving measured by the SPSI-R total score, and adherence to self-monitoring of diet and exercise on changes in all of the cardiovascular risk factors at 12 months, except for fasting glucose. The mediation mechanisms of these models are individually described in Figures 3, 4 and 5. However, 12-month weight loss only mediated the effect of social problem solving measured by the SPSI-R total score; there was no mediated effect of weight loss on positive problem orientation, negative problem orientation, rational problem- solving style, impulsivity/carelessness style and avoidance style, as measured by the five SPSI-R scale scores. Further mediation analyses revealed that there was no significant association between social problem solving and adherence to self-monitoring of diet or exercise in their role of predicting change in weight loss and cardiometabolic risk factors.

4.5 DISCUSSION

As standard behavior treatment involves many behavioral strategies, it is very difficult to tease out which strategy is playing a real role or the most important role contributing to the outcomes of interest. Our findings using mediation analysis explained the underlying mechanism of social problem solving and adherence to self-monitoring of diet and exercise in standard behavioral treatment. The effect of receiving a PDA, rather than a paper record, had a direct effect on weight loss, as well as an indirect effect on weight loss through adherence to self-monitoring of diet or exercise. The effect of receiving daily tailored feedback messages, versus no messages,

on weight loss and waist circumference was fully explained by participants' adherence to self-monitoring of diet and exercise. After controlling for adherence to self-monitoring of diet, the effect of receiving daily tailored feedback messages became nonsignificant. Additionally, the effect of social problem solving and adherence to self-monitoring of diet and exercise on cardiometabolic risk factor changes was entirely mediated through weight loss at 12 months.

Other researchers have explored other factors as possible mediators of weight loss. In a family-based Internet weight loss program for African American adolescents, parents' life and family satisfaction were found to mediate the adolescents' weight loss, while for their parents, dietary practice during the intervention werefound to be the strongest mediator of parental weight loss (N=57) (White, et al., 2004). Researchers in Australia explored the mediators of weight loss in the SHED-IT study, an Internet-based weight loss program for overweight men (N=65). They explored the role of dietary behavior and physical activity as mediators of the intervention, but found no significant results (Lubans, Morgan, Collins, Warren, & Callister, 2009). Using the 6-month data of the SMART study, Turk et al. (under review) found that adherence to self-monitoring of diet fully mediated the effect of receiving daily tailored feedback versus no message, on weight loss. Our 12-month findings were consistent with the 6-month findings. In addition, we have demonstrated that adherence to self-monitoring of diet mediate the effect of having a PDA or paper diary for self-monitoring. Similar mediated effects were also found on adherence to self-monitoring of exercise.

D'Zurilla (2007) suggested the use of mediation analysis to examine the effect of social problem solving in interventions involving many behavioral strategies. Since everyone in this study received SBT, we did not hypothesize that there would be a significant difference in social problem solving among the three treatment groups. Instead, we explored the role of social

problem solving in this trial testing different self-monitoring approaches, and found that social problem solving did not mediate any treatment effect. Murawski et al. (2009), in contrast, found that social problem solving partially mediated the effect of self-monitoring adherence on weight loss, while our exploration of the relationship between social problem solving and self-monitoring adherence in diet and exercise revealed non-significant results.

Although Yon et al. (2007) reported that using a PDA is comparable to using a paper diary in achieving weight loss; our results suggest that using a PDA for self-monitoring led to a greater weight loss only when participants adhered to the self-monitoring of diet or exercise. Studies have shown the superiority of getting automated feedback through digital devices (Blanson Henkemans, et al., 2009; Tate, Jackvony, & Wing, 2006). Our findings further explained that the mechanism for achieving differences in weight loss when receiving feedback from a PDA was due entirely to their self-monitoring adherence.

Weight loss at 12 months fully mediated the effect of social problem solving and adherence to self-monitoring of diet and exercise on changes in cardiometabolic risk factors. That said, the changes in cardiometabolic risk factors related to implementing these behavioral strategies were entirely due to weight loss. Our findings were similar to that of the DPP study, which reported weight loss as the strongest predictor of lower incidence of diabetes.

There were several limitations to this study. First, our sample was comprised predominantly of Caucasian Americans and fairly well-educated females. Therefore, the results may not be generalizable to ethnic minority populations, males, and, the less educated. Second, since this is a secondary analysis of existing data, the sample size was fixed. In order to achieve enough statistical power, we examined only two behavioral factors in this study, self-monitoring adherence and social problem solving; however, there are many other behavioral factors

including self-efficacy enhancement, stimulus control, and goal setting worthy of further investigation. Third, we did not examine the effect of three treatment groups simultaneously due to a lack of degrees of freedom in the path analysis. Our decision to examine the three-group treatment effect by creating two treatment variables gave us a better picture of the two underlying treatment factors in this three-group design (having PDA or not, and receiving daily tailored feedback or none).

In conclusion, self-monitoring adherence had an indirect effect on reducing cardiovascular risks through weight loss, as did social problem solving as measured by the SPSI-R total score. Receiving a PDA for self-monitoring of diet and exercise had a direct effect on weight loss and an indirect effect on weight loss through self-monitoring adherence, whereas receiving daily tailored feedback messages from a PDA had only an indirect effect on weight loss through self-monitoring adherence. Further investigation of social problem solving and self-monitoring adherence in a larger sample with a longer follow-up is a reasonable endeavor to provide scientific evidence for the optimization of the SBT for the long-term. Future research examining the mechanism of other behavioral strategies traditionally used in a standard behavioral treatment for obesity is also warranted.

Table 1. Baseline Characteristics of the Sample (Completers vs. Non-Completers)

Characteristics	Total sample (N=210)	Completers (n=179)	Non-Completers (n=31)	P
Age (years)	46.80 ± 9.02	47.73±8.46	41.45±10.36	<.001
Gender				.695
Female	84.8 (178)	84.3(151)	87.0(27)	
Male	15.2 (32)	15.7(28)	13.0(4)	
Ethnicity				.400
White	78.1 (164)	77.0(138)	83.9(26)	
Black	21.9 (46)	23.0(41)	16.1(5)	
Education (years)	15.65 ± 3.00	15.80±3.03	14.77±2.68	.079
BMI(kg/m^2)	34.01 ± 4.49	33.69±4.42	35.88±4.46	.012
Marital status				.389
Currently married	68.6 (144)	67.0(120)	77.4(24)	
Never married	13.8 (29)	15.0(27)	6.5(2)	
Divorced or separated	17.6 (37)	18.0(32)	16.1(5)	
Employment status				.166
Employed full time/	82.9 (174)	84.3(151)	74.2(23)	
Not full time	17.1(36)	15.7(28)	25.8(8)	
Gross household income				.565
>$50,000	60.0 (123)	60.9(106)	54.8(17)	
$30,000-$50,000	23.9 (49)	24.1(42)	22.6(7)	
$10,000-$30,000	16.1 (33)	14.9(26)	22.6(7)	

Table 2. Percent Changes from Baseline to 12 Months in Key Variables by Treatment Group

Characteristics	PR	PDA	PDA+FB
Social Problem Solving			
Total score	2.97 (-6.29, 12.44)[a]	3.96 (-3.96, 11.47)	4.15 (-7.37, 12.81)
Positive problem orientation	6.67 (-12.16, 25.89)	7.69 (-6.67, 25.00)	7.14 (-8.33, 27.27)
Negative problem orientation	-12.50 (-48.08, 15.74)	-8.33 (-37.50, 16.67)	-11.11 (-40.00, 32.14)
Rational problem solving	5.90 (-4.51, 30.31)	1.92 (-13.33, 22.10)	-2.22 (-15.00, 20.93)
Impulsiveness/Carelessness	0.00 (-33.33, 40.63)	0.00 (-49.04, 44.62)	-5.88 (-56.70, 25.00)
Avoidance style	-2.50 (-50.00, 10.39)	-14.29 (-44.44, 33.33)	-20.00 (-33.33, 34.85)
Adherence to SM of diet[§]	34.38 (16.41, 75.00)	57.81 (34.38, 87.50)	71.88 (36.72, 88.28)
Adherence to SM of exercise[§]	29.69 (13.28, 59.38)	59.38 (28.13, 92.97)	68.75 (42.19, 90.63)
Weight (lb)	-5.19 (-9.99, -0.23)	-3.92 (-9.40, -1.27)	-5.30 (-11.75, -0.99)
Cardiometabolic risk factors			
Waist circumference	-3.96 (-8.55, -0.95)	-4.57 (-7.92, -1.51)	-5.42 (-10.30, -2.05)
Systolic blood pressure	-1.87 ± 12.50	-0.15 ± 13.58	-0.74 ± 11.87
Diastolic blood pressure	-3.52 ± 10.27	-3.58 ± 11.09	-2.92 ± 11.71
High density lipoprotein	-7.69 (-14.52, 5.66)	0.00 (-10.92, 8.04)	-2.79 (-10.45, 3.51)
Low density lipoprotein	2.85 (-5.45, 16.41)	4.55 (-6.86, 17.44)	-3.52 (-9.78, 11.40)
Total cholesterol	0.47 (-7.34, 8.45)	-0.05 (-7.77, 9.05)	-2.99 (-8.88, 4.40)
Triglycerides	-12.09 (-28.81, 13.99)	-12.55 (-38.63, 9.21)	-13.71 (-28.18, 7.22)
Fasting glucose	5.32 (-1.90, 13.19)	1.97 (-6.23, 9.99)	0.58 (-7.53, 11.63)

Note. SM = self-monitoring; PR = Paper record group; PDA = Personal digital assistant group; PDA+FB = PDA with feedback group.
[a] mean ± standard deviation are reported for normally distributed variables, median and inter-quartile range are reported for those non-normally distributed.
[§]Group difference found only in adherence to self-monitoring of diet and exercise.

Table 3. Bivariate Correlations between Independent and Dependent Variables

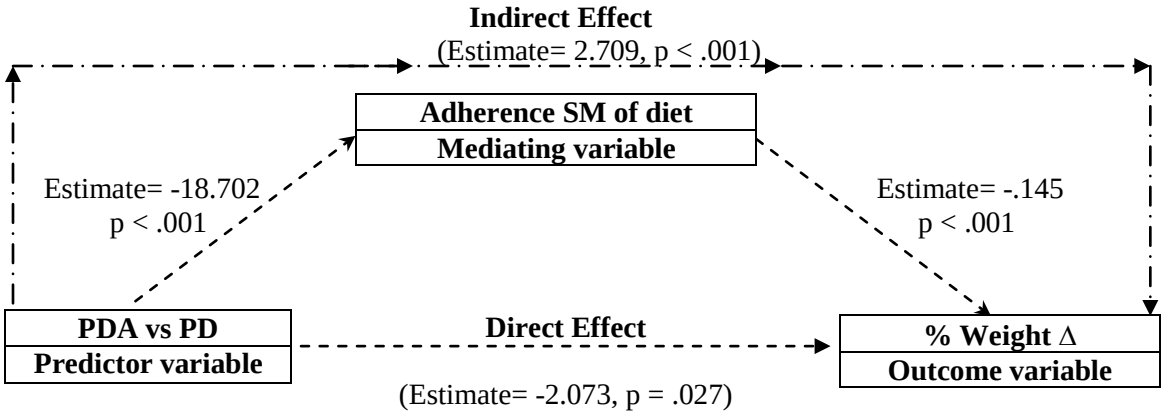
	Weight	Waist	SBP	DBP	HDL	LDL	TC	Trig	Glucose
SPS[a]	-.175[*b]	-.104	.014	-.012	.124	-.073	-.003	.052	-.094
PPO	-.092	-.031	.014	-.010	.138	-.125	-.052	.070	-.051
NPO	.239[**]	.215[**]	0.061	.046	-.081	.062	.022	.000	.044
RPS	-.041	-.043	.065	.117	.140	-.001	.094	.146	-.037
ICS	.083	.044	-.035	.096	-.026	-.009	-.014	-.012	.133
AS	.134	.119	-.031	.024	.027	-.048	-.048	.002	-.030
SMDiet	-.511[**]	-.450[**]	-.043	-.003	.136	-.151[*]	-.134	-.135	-.212[**]
SMExer	-.500[**]	-.464[**]	-.006	.006	.126	-.117	-.101	-.107	-.249[**]

Note. Waist = waist circumference; SBP = systolic blood pressure, DBP = diastolic blood pressure; HDL = high-density lipoprotein; LDL = low-density lipoprotein; TC = total cholesterol; Trig = triglycerides; Glucose = fasting blood glucose; SPS = social problem-solving total score; PPO = positive problem orientation; NPO = negative problem orientation; RPS = rational problem-solving style; ICS = impulsiveness/carelessness style; AS = Avoidance style; SMDiet = Adherence to self-monitoring of diet; SMExer = Adherence to self-monitoring of exercise.

[a]Percent change scores for social problem solving, weight, and cardiometabolic risk factors are reported.

[b]Spearman correlation coefficient in all cells

* P<.05, ** P<.01.



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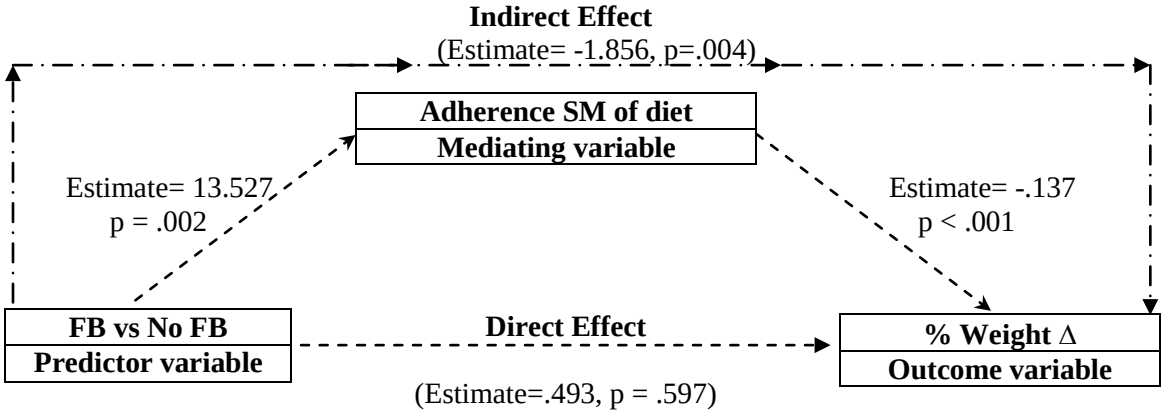

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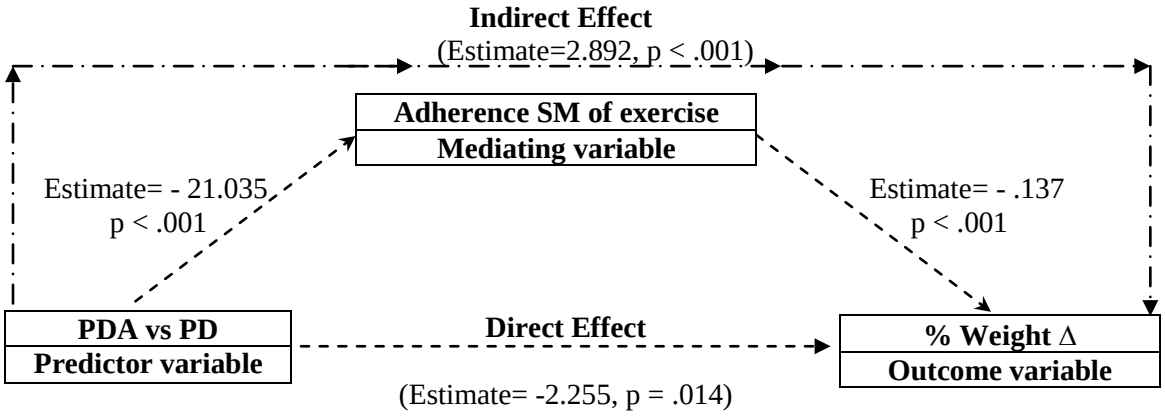
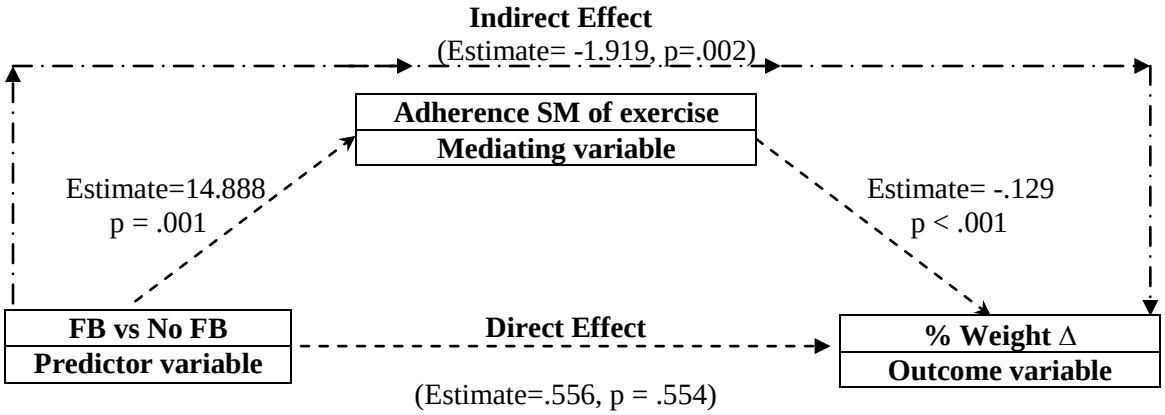


C.

Figure 4. Adherence to Self-Monitoring Mediating the Group Effect on Changes in Weight and Cardiometabolic Risk Factors at 12 Months

Note. SM=self-monitoring; Δ=change.



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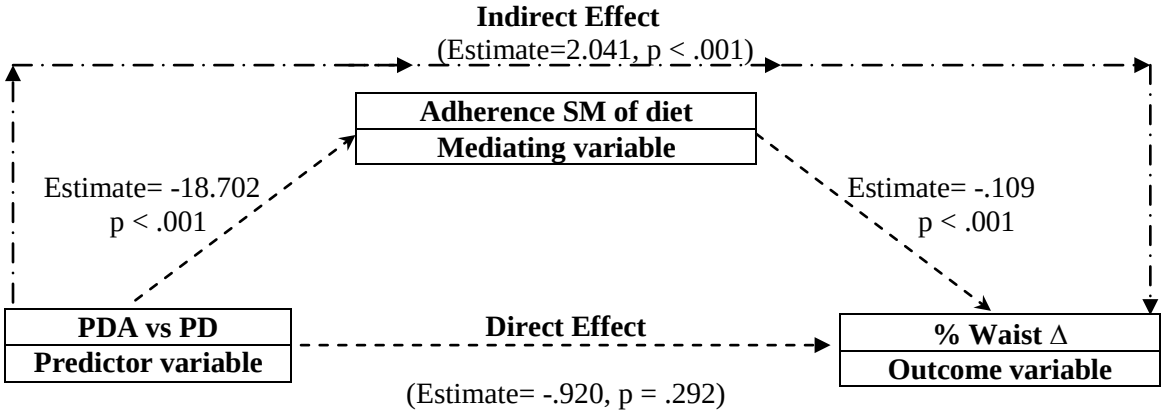

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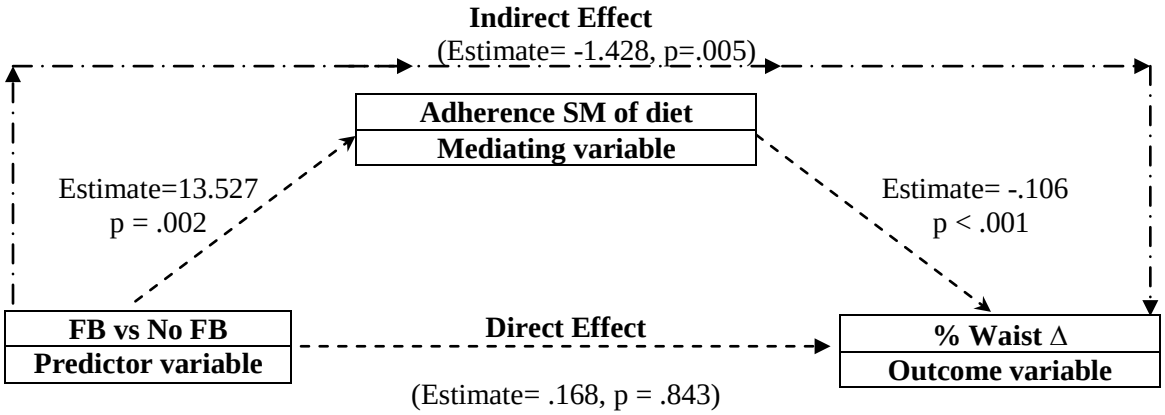
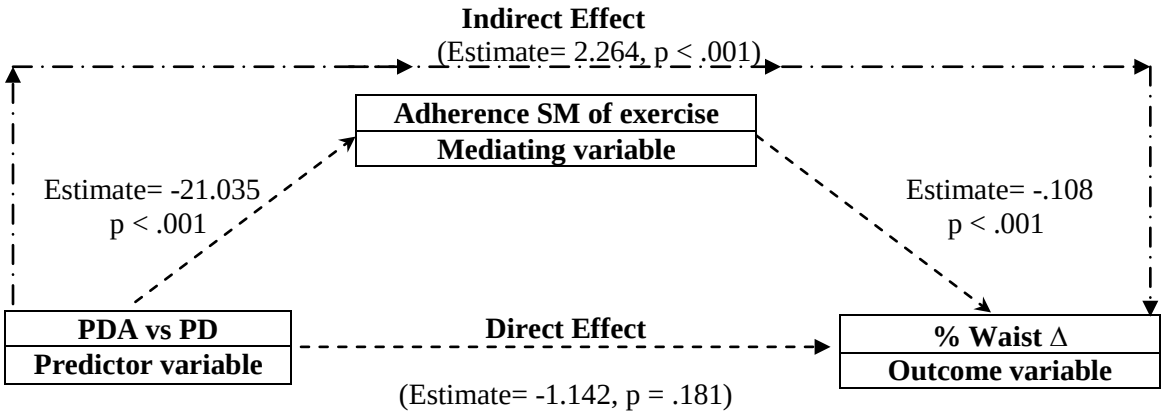


F.

Figure 4. Adherence to Self-Monitoring Mediating the Group Effect on Changes in Weight and Cardiometabolic Risk Factors at 12 Months (continued)
Note. SM=self-monitoring; Δ=change.



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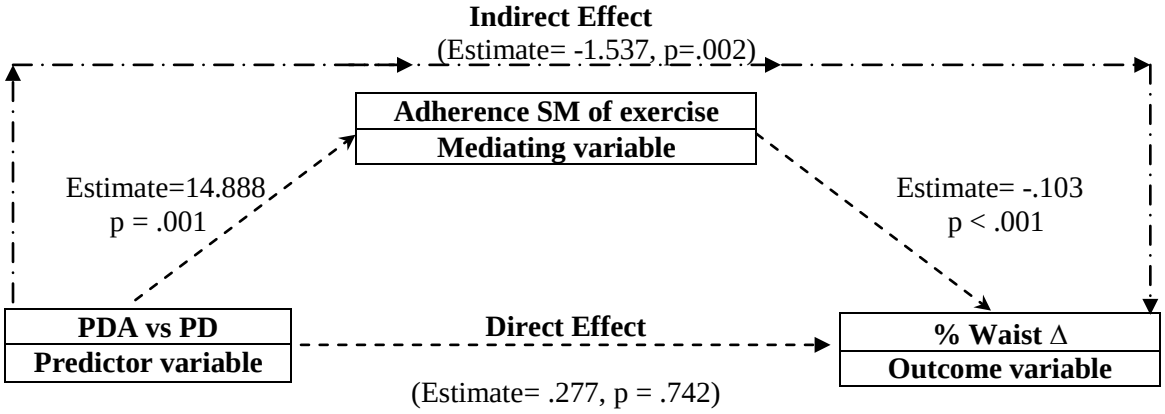


H.

Figure 4. Adherence to Self-Monitoring Mediating the Group Effect on Changes in Weight and Cardiometabolic Risk Factors at 12 Months (continued)

Note. SM=self-monitoring; Δ=change.

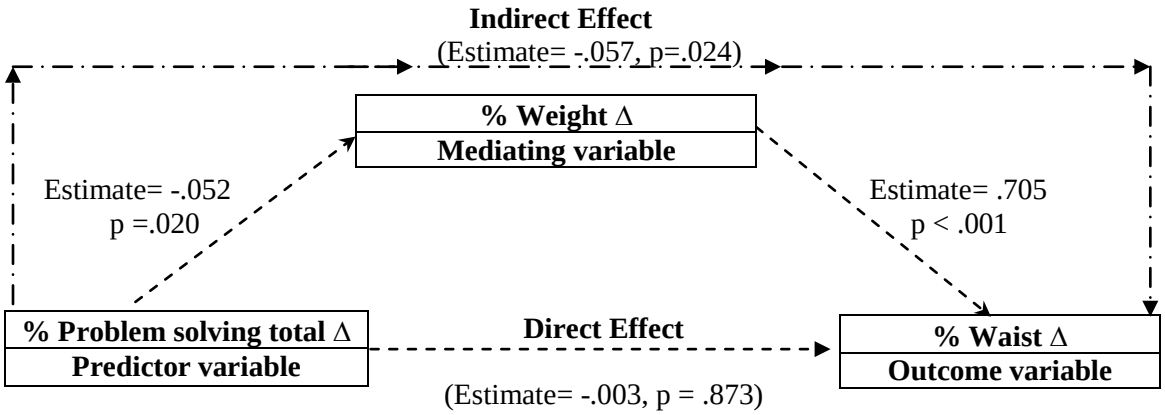
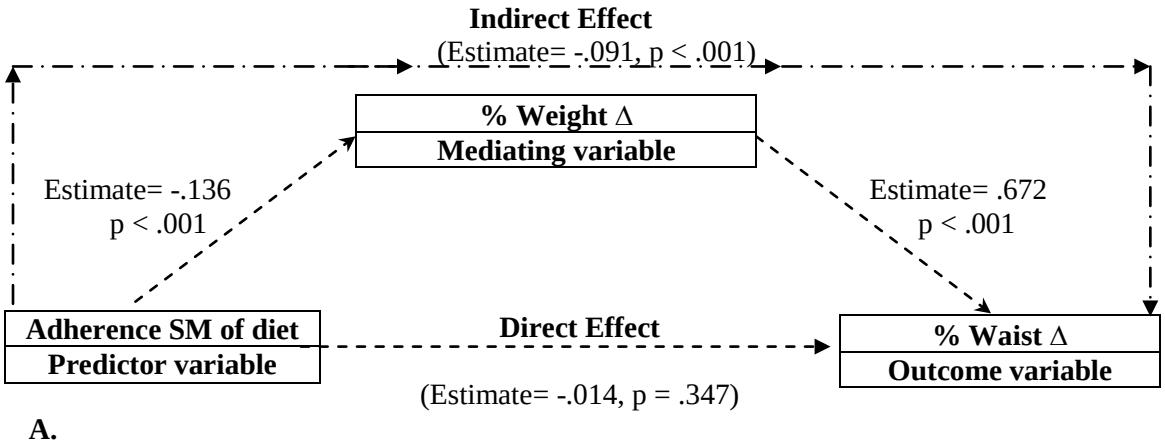


Figure 5. Weight Loss Mediating the Effect of Social Problem Solving on Changes in Cardiometabolic Risk Factors at 12 Months

Note. Δ=change.



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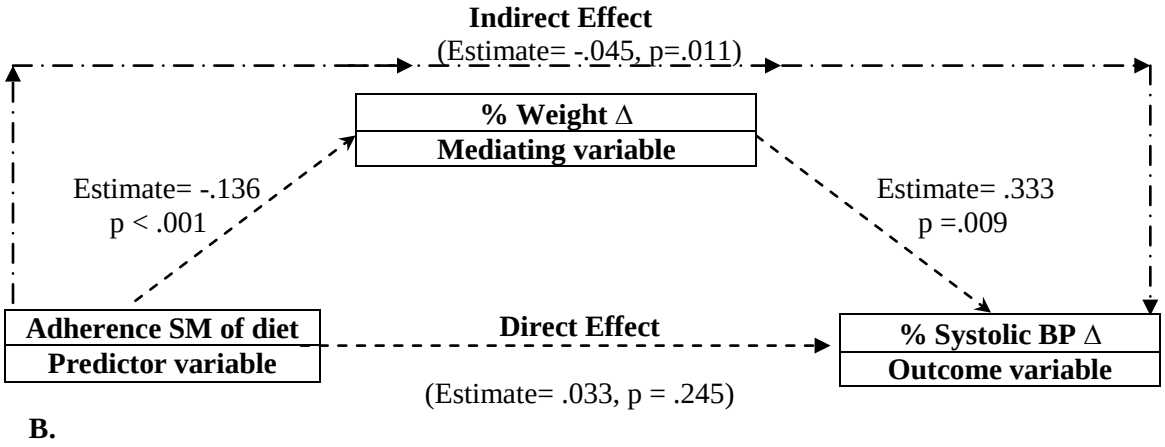

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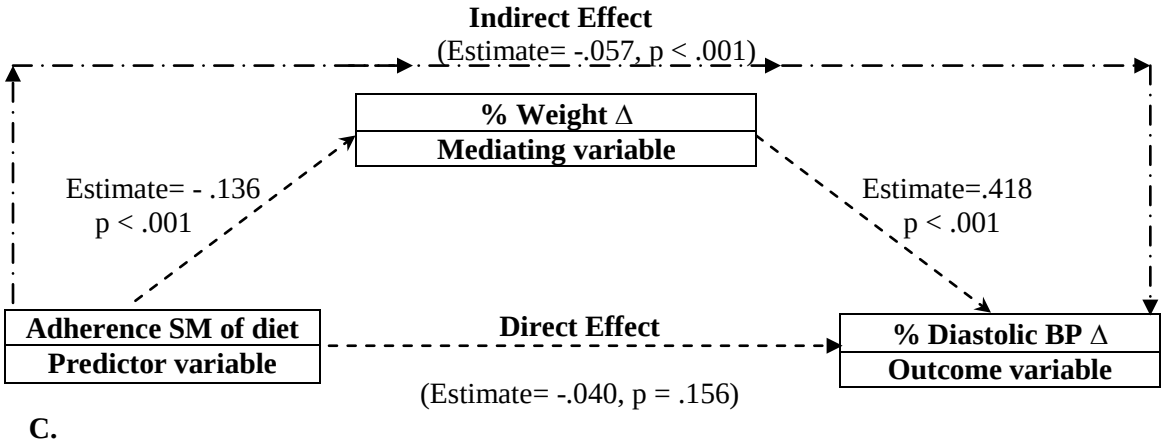

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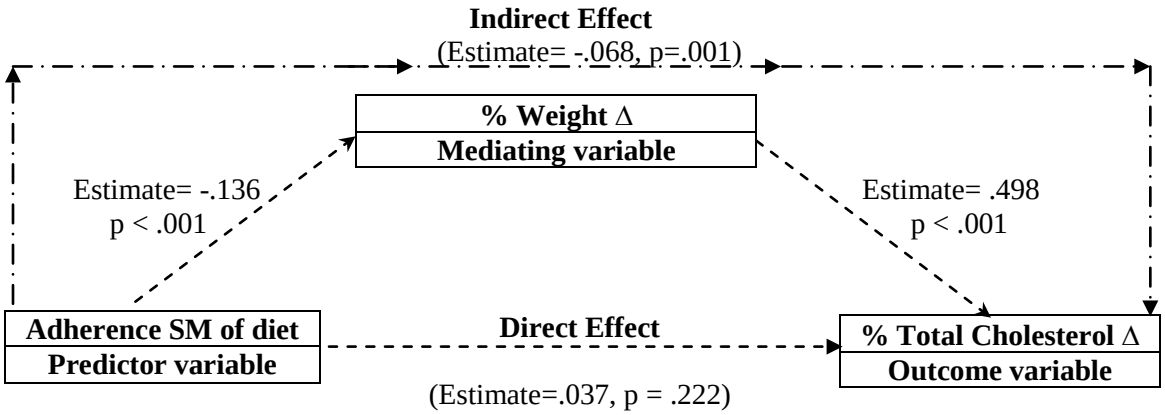
Figure 6. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Diet on Changes in Cardiometabolic Risk Factors

Note. SM=self-monitoring; Δ=change.



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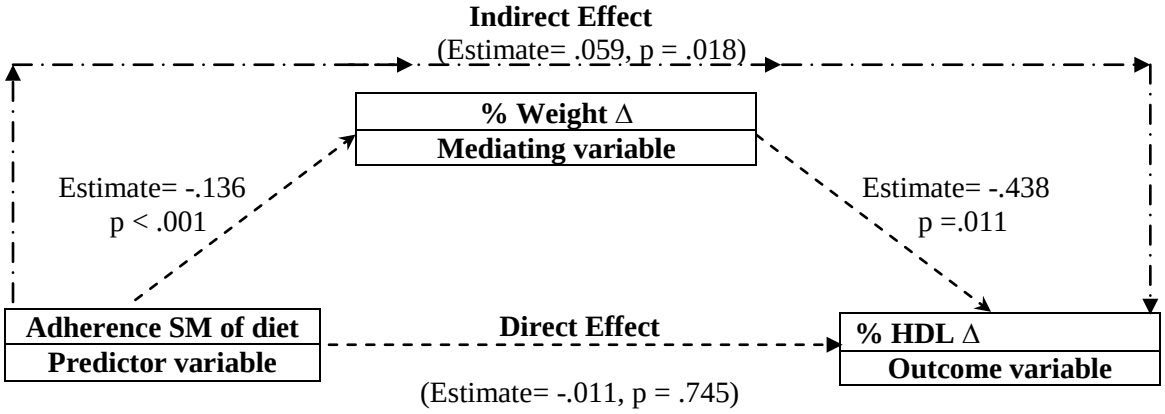

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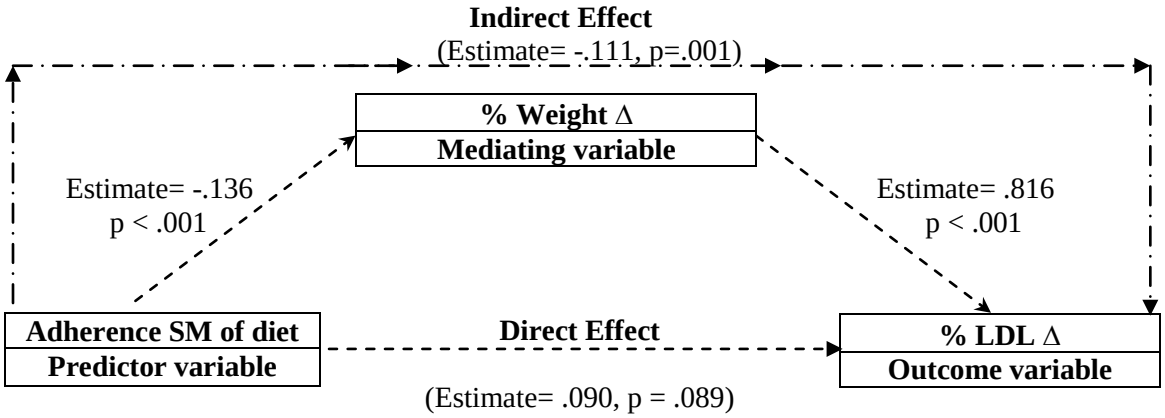
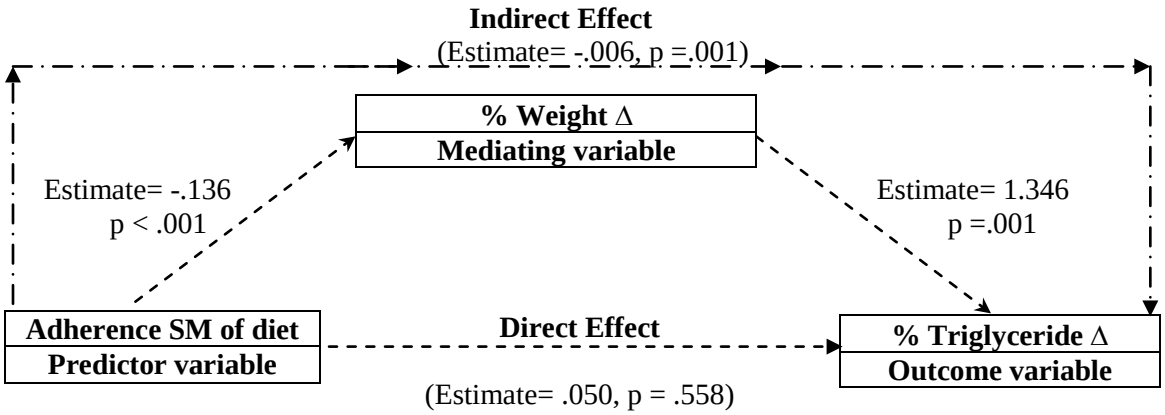


F.

Figure 6. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Diet on Changes in Cardiometabolic Risk Factors (Continued)

Note. SM=self-monitoring; Δ=change.



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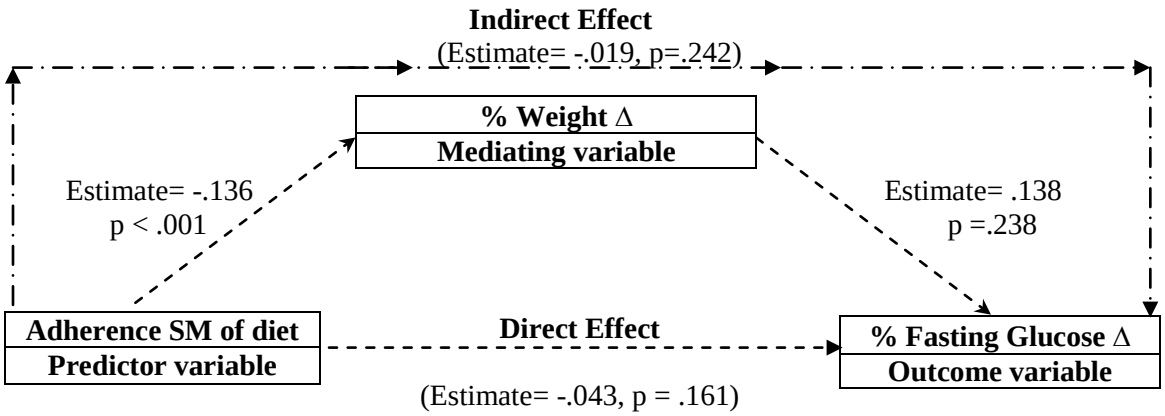

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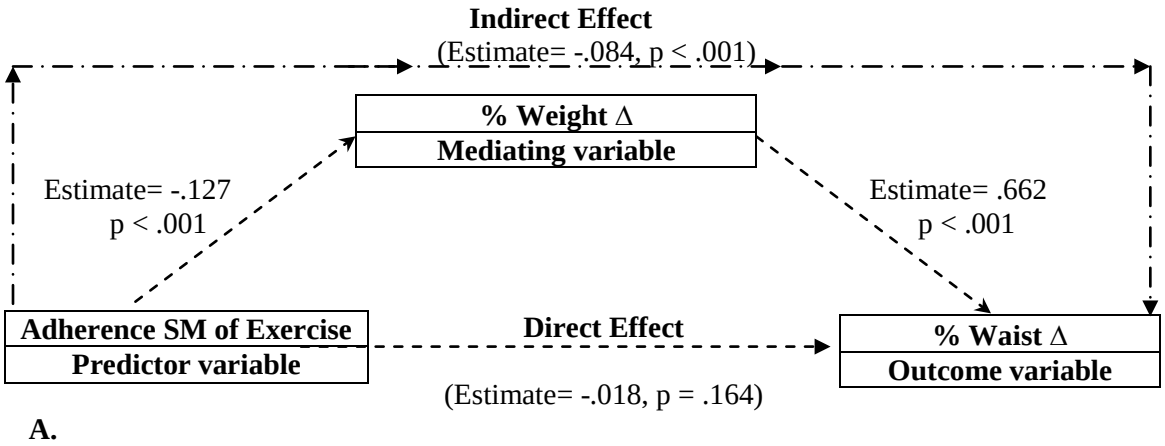
Figure 6. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Diet on Changes in Cardiometabolic Risk Factors (Continued)

Note. SM=self-monitoring; Δ=change.



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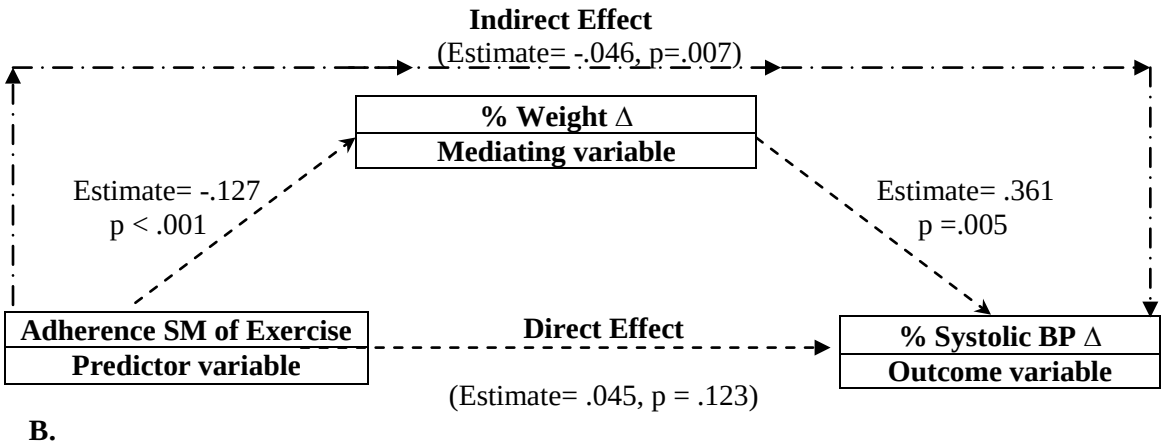

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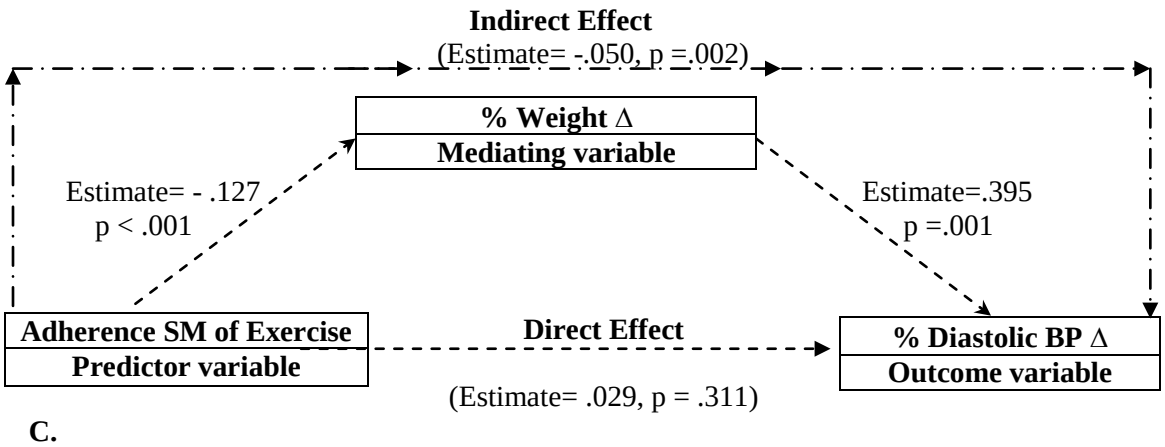

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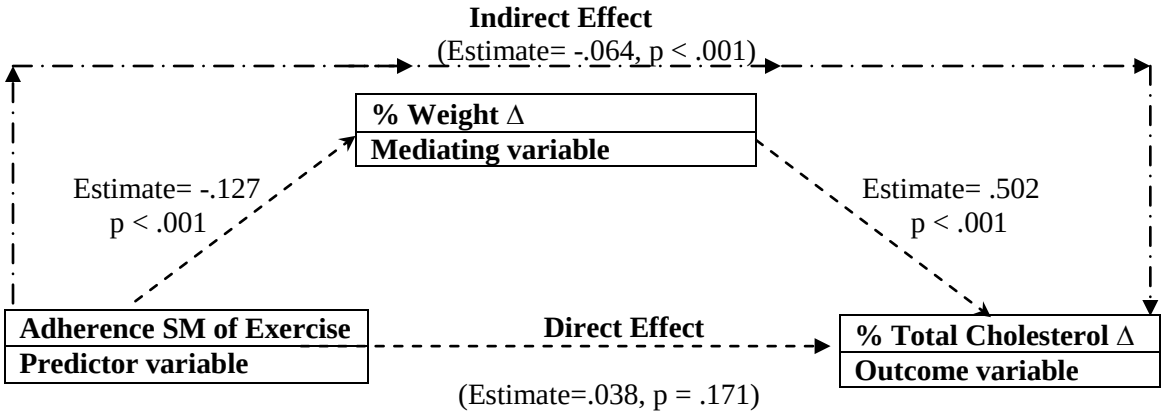
Figure 7. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Exercise on Changes in Cardiometabolic Risk Factors

Note. SM=self-monitoring; Δ=change.



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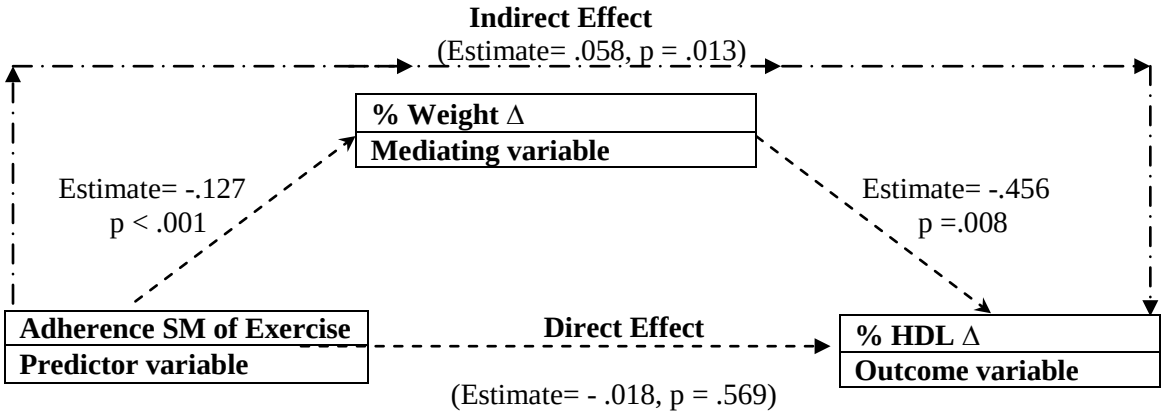

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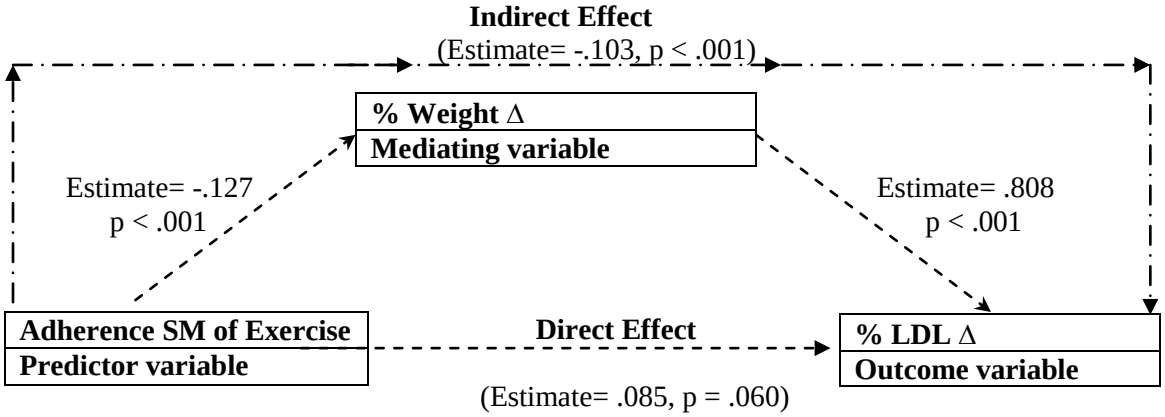
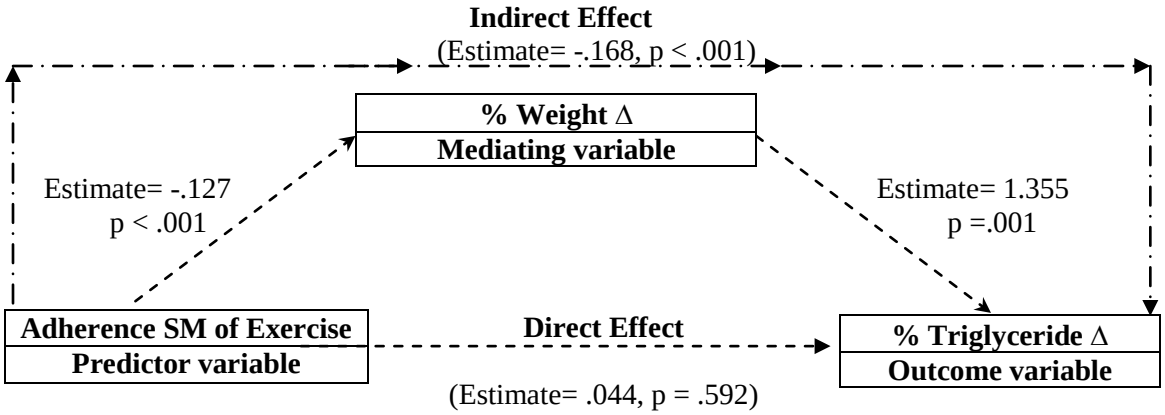


F.

Figure 7. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Exercise on Changes in Cardiometabolic Risk Factors (Continued)

Note. SM=self-monitoring; Δ=change.



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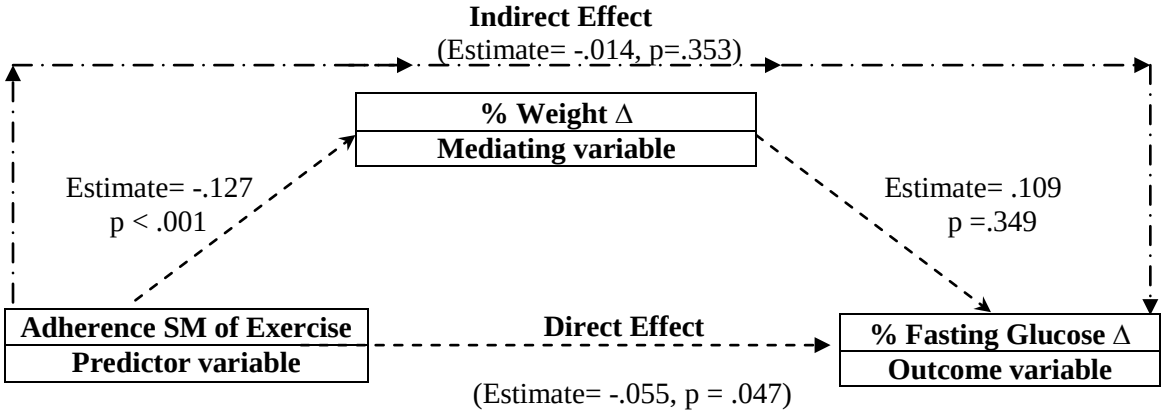

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Figure 7. Weight Loss Mediating the Effect of Adherence to Self-Monitoring of Exercise on Changes in Cardiometabolic Risk Factors (Continued)

Note. SM=self-monitoring; Δ=change.

5.0 RESULTS MANUSCRIPT #2: EXAMINATION OF THE PSYCHOMETRIC PROPERTIES OF SOCIAL PROBLEM-SOLVING INVENTORY-REVISED IN WEIGHT LOSS STUDY PARTICIPANTS

5.1 ABSTRACT

Introduction: Few studies have measured the effect of problem solving on weight loss success even though it has been traditionally included in behavioral weight loss interventions. We evaluated the psychometric properties of the Social Problem Solving Inventory-Revised (SPSI-R), which has a total scale and five subscales: rational problem orientation (RPO), negative problem orientation, rational problem solving (RPS), impulsive/careless style, and avoidance style. **Methods:** This is a secondary data analysis of baseline data from the SMART trial, a behavioral weight loss study (N=210). We used Cronbach's alpha value to evaluate internal consistency and confirmatory factor analysis to examine construct validity. We used correlational analyses to examine the convergent validity of the SPSI-R with instruments measuring barriers to healthy eating, cholesterol-lowering self-efficacy, and binge eating, as well as its concurrent validity with stress, mental health, diet, and exercise behaviors. **Results:** The sample was white (78%), female (85%), on average 47 years old, and had a mean body mass index of 34. Cronbach's alpha was .95 for the total score and ranged from .67 (RPO) to .92 (RPS) for subscales. The hypothesized five factor structure did not fit the data well (χ^2=1750,

p<.01; RMSEA=.09; CFI=.89). The SPSI-R was negatively associated with barriers to healthy eating (r=-.31, p<.01) and binge eating (r=-.24, p<.01) and positively associated with self-efficacy in following a cholesterol-lowering diet (r=.22, p<.01). The SPSI-R significantly (p<.05) predicted health behaviors and outcomes where weight loss participants indicated better problem-solving skills: consumed fewer calories (r=-.19) and fat grams (r=-.17), exercised more frequently (r=.19), reported lower psychological distress (r=-.48), and higher mental quality of life (r=.40). **Conclusions**: The SPSI-R appears to be a promising tool to predict health behaviors and outcomes in weight loss studies, however, further work in a larger sample is needed to confirm the five-factor structure of the SPSI-R.

5.2 INTRODUCTION

Significant effort has been devoted to weight loss treatment, however, the prevalence of overweight and obesity among U.S adults continues to be 66% (Flegal, et al., 2010). The efficacy of standardized behavior therapy (SBT) in achieving weight loss has been demonstrated in several trials (Wadden, Crerand, et al., 2005; Wing, 2004). However, improving SBT could result in better outcomes for the short- and long-term. Therefore, an evaluation of the components of the behavioral strategies, e.g. problem solving, used in SBT could lead to a stronger intervention.

As an important behavioral strategy, problem solving, has been traditionally included in behavioral weight loss programs (Wing, 2004). Most of the research on problem solving has been based on the social problem solving model developed and refined by D'Zurilla and colleagues. Problem solving has been defined as a self-directed cognitive-behavioral process

used when an individual attempts to find an effective solution to problems they encounter in their daily lives. The term *social problem solving* has been widely used in clinical and health psychology to emphasize that the problem solving occurs in a natural social environment (D'Zurilla, 2007). However, compared to other strategies (such as self-monitoring, and goal setting), the role of social problem solving in behavioral weight loss programs is still unclear. Few studies have measured the effect of problem solving on weight loss success even though it has been traditionally included in behavioral weight loss interventions. Only one study used problem-solving therapy (PST) and found that PST after receiving SBT is better than SBT alone in weight loss maintenance (Perri, et al., 2001). The same group of researchers found that problem solving partially mediated self-monitoring adherence and weight loss in adult obese participants (Murawski, 2009).

It is difficult to evaluate the role of any behavioral factors without an accurate measurement of that specific variable. D'Zurilla et al. developed the Social Problem Solving Inventory (D'Zurilla & Nezu, 1990), which was further modified to be the Social Problem Solving Inventory -Revised (SPSI-R). The SPSI-R is consistent with the five dimension model of social problem solving, and it has demonstrated good reliability and validity in large college student samples (D'Zurilla, 2007). Thus it has been tested but in limited groups.

No study has yet examined the psychometric properties of the SPSI-R among weight loss study participants. To address this gap, our study aims to explore the internal consistency, construct validity, convergent and concurrent validity of the SPSI-R in this population.

5.3 METHODS

A cross-sectional design was used in this analysis using data from an ongoing clinical trial of behavioral weight loss treatment, SMART, the *S*elf-*M*onitoring *a*nd *R*ecording using *T*echnology (SMART) weight loss trial. It was a single-center, three-group, randomized clinical trial testing the efficacy of three different self-monitoring approaches on short- and long-term weight loss and on adherence to dietary and physical activity self-monitoring during a 24-month standard behavioral weight loss intervention. The 210 participants who completed the baseline assessment in SMART were included in this secondary data analysis.

Eligible individuals included those who were 21 to 59 years of age with a body mass index (BMI) range of 27 to 43 inclusively, and who successfully completed a 5-day paper diary recording of food intake during the screening process. Exclusion criteria included a condition requiring diet and exercise supervision or any severe psychiatric illnesses.

Socioeconomic and demographic characteristics were measured by the Socio-Demographic Questionnaire. The continuous-type variables considered in this paper were age, years of formal education, and the numbers of adults and children living in the household. Categorical factors included gender, ethnicity, marital status, employment status, and gross annual income.

Social problem solving was measured by the Social Problem Solving Inventory-Revised scale. This instrument has 52 items with five response choices ranging from 0 to 4, representing “not at all true of me” to “extremely true of me”. It asks respondents how they think, feel, and act when faced with problems in everyday living. It has five subscales including two constructive

problem-solving dimensions: positive problem orientation (PPO) and rational problem-solving style (RPS); and three dysfunctional dimensions: negative problem orientation (NPO), impulsivity/carelessness style (ICS), and avoidance style (AS). The developers of the tool demonstrated that both the total score and the five subscale scores had high internal consistency (Cronbach's alpha ranged from .69 to .95 for subscales, .95 for the total score) and good test-retest reliability over 3 weeks (correlations ranged from .69 to .91 for subscale scores and .89 to .93 for the total score). Additionally, the five subscales, except for the rational problem solving subscale, had moderate to strong significant correlations with anxiety, which was measured by the Trait Anxiety scale of the State-Trait Anxiety Inventory, depression measured by the Beck Depression Inventory, and psychological distress measured by the Perceived Stress Scale.

Barriers to healthy eating were measured by the Barriers to Healthy Eating Scale (BHE), a 22-item Likert-scaled questionnaire. The items ranged from 1 (no problem) to 5 (very important problem). The scale asks individuals to rate various feelings or situations related to following the diet, e.g., feelings of deprivation and cost of the regimen. The scale was found to have good test-retest reliability (r=.89); internal consistency with a Cronbach's alpha =.86 and predictive validity with weight loss at 6 months (r=0.28) in an earlier study (Burke, Kim, & Music, 2004). The internal consistency reliability in the parent study was .87.

Cholesterol-lowering diet self-efficacy was measured by the Cholesterol-Lowering Diet Self-Efficacy-Short Form scale. It has 8 subscales and 22 statements involving 40 items, which was shortened from the original 56-item scale (Burke, Dunbar-Jacob, Sereika, & Ewart, 2003) The response to each item ranges from 0 to 100% representing the probability that the person will engage in the requested behavior, or the confidence the person feels carrying out the

activities in the next three months. The total score of the scale was used in this study to evaluate individuals' self-efficacy for following a cholesterol-lowering diet. The Cronbach's alpha estimate of internal consistency was .95, and the concurrent validity of the short form with the Connor Diet Habit Cholesterol Saturated Fat Subscale was .61 ($p<.01$) (Burke, et al., 2006). The internal consistency based on Cronbach's alpha was .94 in this study.

Disordered binge eating was measured by the Eating Habits Checklist. This scale has 16 items and was used to screen potential participants for a binge eating disorder. Participants were asked to choose 1 out of 3 or 4 statements for each item. Each statement had an assigned weight ranging from 0 to 3, with 0 indicating no binge eating behaviors and 3 reflecting severe binge eating behaviors. A total score was derived from totaling the individual weights for the selected 16 statements, with higher scores indicating more severe binge-eating behaviors (Gormally, Black, Daston, & Rardin, 1982). The scale has been used in our previous studies; a score over 37 indicates the person has significant disordered eating behaviors and is excluded from participating in the study.

Dietary behaviors were measured by mean energy intake and mean fat grams consumed per day assessed through two 24-hour, unannounced dietary recalls, which were conducted on one weekday and one weekend or leisure day, during the baseline assessment using the Nutrition Data System for Research (NDSR). NDSR is a comprehensive nutrient calculation software developed by the Nutrition Coordinating Center at the University of Minnesota, and guides the 24-hour food recall interview for collecting very detailed information on foods and beverages consumed (Buzzard, Schakel, & Ditter-Johnson, 1995).

Exercise behaviors were assessed by the Modified Activity Questionnaire, which reports (Kriska & Caspersen, 1997) the average MET-hours spent on total physical activity in the past week. Studies have shown that it is a reliable and valid questionnaire compared with field testing and doubly labeled water techniques in adults (Kriska, et al., 1990; Schulz, Harper, Smith, Kriska, & Ravussin, 1994).

Perceived stress was measured by the Perceived Stress Scale (PSS), which has 14 items with five response choices: 0-4 representing "never" to "very often". It asks the respondent to report frequency of feeling stress during the last month. Cronbach's alpha was .84 and .86, and the test-retest was .85 over 2 days and .55 in 6 weeks in previous studies conducted in college students. The concurrent predictive validity was .65 and .76 with depression, and .52 and .70 with physical symptoms (Cohen, Kamarck, & Mermelstein, 1983). The Cronbach's alpha was .89 in the parent study.

Mental component of the health-related quality of life was measured by the SF-36 Version 2 (SF36v2). It has 36 items and yields eight domain scores: 1) physical functioning, 2) role limitations due to physical problems, 3) bodily pain, 4) general health perceptions, 5) vitality, 6) social functioning, 7) role limitations due to emotional problems, and 8) emotional well-being, as well as two component scores: physical and mental component scores, derived from the domain scores. The SF-36v2 has good internal consistency reliability with Cronbach's alphas of .95 and .93 for the physical and mental component scores, respectively, and ranged from .84 (general health perceptions) to .95 (physical functioning) for the eight domain scores in the 1998 general U.S. population (Ware, 2000). The mental component score of this scale is used in this study.

We used Cronbach's alpha to describe the internal consistency of the SPSI-R, and correlation and simple linear regression to examine the convergent validity with barriers to healthy eating, cholesterol-lowering self-efficacy, and binge eating, as well as the concurrent validity of social problem solving in relation to stress, psychological well being, diet and exercise behaviors. Confirmatory factor analysis (CFA) was conducted in Mplus to examine the construct validity of the SPSI-R in the study. Since the data were heavily skewed, the robust method- weighted-least-square with means and variances adjusted (WLSMV) was used. Goodness-of-fit of the five-factor structure was assessed using the recommended chi-square, root-mean-square error of approximation (RMSEA), and comparative fit index (CFI) fit indices.

5.4 FINDINGS

Sociodemographic characteristics of the sample are described in Table 1. Participants were predominantly white (78%), female (85%), on average 47 years old, and had a mean BMI of 34 kg/m^2.

Internal consistency

The internal consistency of the SPSI-R was evaluated with the use of Cronbach's alpha coefficient. The Cronbach's alpha was .95 for the total score of the SPSI-R, .67 for rational problem orientation, .92 for negative problem orientation, .92 for rational problem solving style, .87 for impulsiveness/careless style, and .86 for avoidance style subscale.

Convergent validity

The convergent validity of SPSI-R was demonstrated by its negative association with barriers to healthy eating ($r=-.31$, $p<.01$) and binge eating ($r=-.24$, $p<.01$), as well as its positive association with self-efficacy for following a cholesterol-lowering diet ($r=.22$, $p<.01$).

Concurrent validity

The SPSI-R total score was significantly correlated with baseline health behaviors and outcomes among weight loss participants, which included consumption of fewer calories ($r=-.19$) and fat grams ($r=-.17$), more frequent exercise ($r=.19$), lower perceived psychological distress ($r=-.48$), and higher mental quality of life ($r=.40$, $ps<.05$).

Construct validity

We performed confirmatory factor analysis using the maximum likelihood approach to confirm the hypothesized five-factor structure of the 52-item questionnaire. The Root Mean Square Error of Approximation of .09, had shown inadequate goodness of fit, where the results should be close to .05 or less. Moreover, we did not find adequate goodness-of-fit using the chi-square statistics ($\chi^2=1750$, $p<.01$), and with the Comparative Fit Index =.89, which was not large enough as $\geq .95$ is needed to demonstrate an adequate structural validity. Further examination of the modification indices suggests that more paths should be considered.

5.5 DISCUSSION

Researchers consistently reported problem solving as a component of the standard behavior treatment delivered for overweight and obese adults. However, only two studies reported the use of the SPSI-R in behavioral weight loss treatment and no psychometric evaluation of this tool in this population has been located (Murawski, 2009; Perri, et al., 2001). To the best of our knowledge, this is the first study to report evaluating the psychometric properties of the SPSI-R in a sample of overweight and obese adults seeking behavioral weight loss treatment. We found high internal consistencies for both the total score and six subscales of the SPSI-R. The SPSI-R shows high internal consistency reliability in assessing social problem solving in weight loss participants, which was consistent with the reports by the developers of this tool indicating that the tool is good for males and females aged 13 years or older (D'Zurilla & Nezu, 1990). We were not able to perform test-retest reliability of the SPSI-R since the parent study was a randomized controlled trial with all three randomization groups receiving SBT for obesity.

The SPSI-R appears to be a promising tool to "predict" health behaviors and outcomes. However, we used only baseline information to examine the concurrent validity instead of predictive validity. Again, with all groups in this study receiving SBT that included a problem-solving component, we were not able to perform predictive analysis examining the correlations between changes in SPSI-R with changes in health behaviors and outcomes at follow up. Developers of the SPSI-R had evaluated the predictive validity with various measures of distress (D'Zurilla, 2007). We used validated measures of perceived stress, mental component of health-related quality of life, dietary intake and exercise, behaviors that are associated with high problem-solving skills to evaluate its concurrent validity. We found significant associations

between the SPSI-R with all of these validated measures, which demonstrated good concurrent validity.

Locus of control, optimism and outcome expectancy, and traits were considered as constructs that overlapped with problem-solving processes (D'Zurilla, 2007). We evaluated convergent validity of the SPSI-R with similar measures of perceived barriers to healthy eating, binge eating, and self-efficacy in following a cholesterol-lowering diet, and found significant correlations among these measures.

Confirmatory factor analysis has shown a poor goodness of fit through the examination of the five-factor structure using chi-square statistics, RMSEA, and CFI results, while the RMSEA results from the confirmatory factor analysis results performed by the developers in two independent samples of college students indicated good to adequate fit. In addition, we have a sample of only 210 and with 52 items in the factor analysis, responses to each items were heavily skewed so that some categories among the responses were clearly under populated. Thus, further work in a larger sample is needed to confirm the five-factor structure of the SPSI-R, in order to achieve sufficient power when assessing model fit, point and interval estimates of path coefficient, and eliminate underpopulated categories for individual items.

This study evaluated selected psychometric properties (internal consistency reliability, concurrent and convergent validity and construct validity) of the SPSI-R in an adult overweight and obese population, and found the SPSI-R to be a promising tool for this population. However, test-retest reliability and predictive validity should be explored in a controlled condition, and confirmatory factor analysis should be performed in a larger sample to demonstrate the construct validity of the SPSI-R. However, the results may not be generalizable to adolescent or young adults who are seeking weight loss treatment.

Table 4. Descriptive Statistics for Candidate Predictor and Outcome Variables (N=210)

Characteristics		% (n) or M±SD
Age (years)		46.80 ± 9.02
Gender	Female	84.8 (178)
Ethnicity	White	78.1 (164)
Education (years)		15.65 ± 3.00
BMI(kg/m^2)		34.01 ± 4.49
Marital status	Currently married	68.6 (144)
	Never married	13.8 (29)
	Formerly married (divorced or separated)	17.6 (37)
Employment status	Employed full time/ Not full time	82.9 (174)
Gross household income	>$50,000	60.0 (123)
	$30,000-$50,000	23.9 (49)
	$10,000-$30,000	16.1 (33)

6.0 RESULTS MANUSCRIPT #3: FACTORS ASSOCIATED WITH SOCIAL PROBLEM SOLVING IN WEIGHT LOSS STUDY PARTICIPANTS

6.1 ABSTRACT

Objective: To examine factors associated with social problem solving (SPS) in weight loss study participants. **Methods:** We conducted a secondary analysis using baseline data from a behavioral weight loss trial. The total score and five subscale scores (positive problem orientation [PPO], negative problem orientation [NPO], rational problem-solving style [RPS], impulsivity/carelessness style [ICS] and avoidance style [AS]) of the Social Problem-Solving Inventory- Revised (SPSI-R) were used to assess SPS. **Results:** After screening, we examined the following factors: age, gender, education, marital status, employment status, income, mental health, perceived stress, and barriers to healthy eating (BHE). Predictive models were developed using all possible subsets regression in SAS. The sample was predominantly white (84.8%), female (78.1%), and middle-aged (average 46.80 years). Age, baseline weight, mental health, BHE, and perceived stress were jointly identified as predictors of the total score of SPSI-R (R^2=.40, F=26.4, p<.0001). This same group of factors, with the addition of being single, formed a significant predictive model of NPO score (R^2=.19, F=24.7, p<.0001). Higher levels of income and education, fewer perceived stresses, and history of weight cycling were associated with RPS score (R^2=.34, F=24.7, p<.0001), while a higher income, fewer barriers and perceived stresses

were associated with RPO (R^2=.22, F=23.8, p<.0001). Less education, more eating barriers and perceived stress were associated with impulsivity/carelessness style (R^2=.18, F=24.7, p<.0001), while being older, having poor mental health and perceiving more eating barriers and stress together were associated with an avoidant style of problem-solving (R^2=.34, F=24.7, p<.0001). **Conclusions:** Age, income, education, mental health, perceived stress, and barriers to healthy eating need to be considered when developing or conducting interventions to address problem-solving ability related to managing lifestyle changes and weight reduction.

6.2 INTRODUCTION

The most recent statistics showed that two in three adults in the U.S. are overweight or obese, with the overweight and obesity prevalence rates remaining at 66% (Flegal, et al., 2010). Even though standard behavior treatment (SBT) has demonstrated that individuals can achieve an average weight loss of 10.4 kg at 6 months and maintain a weight loss of 8.1 kg at 18 months (Wing, 2004), a revaluation of our efforts to tackle obesity is essential to improve the long-term effort of the treatment approach.

Behavioral weight loss programs have included problem solving as one of the key intervention strategies (Wing, 2004), which was developed by D'Zurilla and colleagues. In the problem solving approach, participants are asked to identify problems, brainstorm solutions, select one solution, carry out the selected solution, and evaluate the attempt (D'Zurilla, 2007). However, no evidence exists to support the effect of using this strategy in behavioral weight loss treatment. Only one study used problem-solving therapy exclusively in weight loss treatment of adult obese patients (Perri, et al., 2001). This study compared 2 extended therapy programs for

weight management with standard behavioral treatment (SBT) without additional interventionist contacts. The sample included 80 obese women who completed 20 weekly group sessions of BT and achieved a mean initial weight loss of 8.74 kg. Participants were randomly assigned to a no-further-contact condition (SBT only) or to one of two extended interventions consisting of relapse prevention training (RPT) or problem-solving therapy (PST). No significant overall weight-change differences were observed. However, participants who completed the PST intervention had significantly greater long-term weight reductions than BT participants, and a significantly larger percentage of PST participants achieved clinically significant losses of 10% or more in body weight than did SBT participants (35% vs. 6%). This study demonstrated that the effect of PST in weight loss maintenance is superior to SBT only. However, another group of researchers reported that problem solving did not add to the treatment efficacy of a 6-month family-based behavioral weight loss intervention, due to the fact that child problem-solving increased equally in their SBT group, SBT + parent and child problem-solving group, and SBT+ child only problem-solving group (Epstein, Paluch, Gordy, Saelens, & Ernst, 2000). Thus, the effectiveness of teaching problem-solving strategies in achieving weight loss and weight loss maintenance in adult obese patients remains unclear.

D’Zurilla et al. reported in one of their earlier studies that social problem-solving ability, measured by the Social Problem-Solving Inventory-Revised, increased from young adulthood (ages 17-20) to middle-age (ages 40-55) and then decreased in older age (ages 60-80) (D'Zurilla, et al., 1998). Compared to younger adults, middle-aged individuals scored higher on positive problem orientation and rational problem solving, and lower on negative problem orientation, impulsivity/carelessness style, and avoidance style. Middle-aged individuals scored higher on positive problem orientation and rational problem solving than older adults. Compared to

women, men had higher scores on positive problem orientation and lower scores on negative problem orientation. Except for age and gender, no other factors were examined in association with social problem solving in this population.

To optimize the effect of teaching problem-solving strategies in standard behavior treatment for overweight and obesity, it is essential to identify factors that are associated with problem solving among overweight and obese adults seeking behavioral weight loss treatment; thus, individualized strategies could be developed to improve individuals' problem-solving skills. The purpose of our study was to identify factors that could influence overweight and obese adult patients' problem-solving abilities and skills by examining associations between selected patient characteristics (demographic and psychosocial factors) and their problem-solving skills.

6.3 METHODS

To examine factors associated with social problem solving in this group, we used a cross sectional design and conducted a secondary analysis using baseline data from a behavioral weight loss trial – the SMART trial. The design and methods of the parent study have been described in detail elsewhere (Burke, et al., 2009).

Social problem solving was measured by the Social Problem-Solving Inventory- Revised (SPSI-R). The total score and five subscale scores (positive and negative problem orientation [PPO, NPO], rational problem solving [RPS], impulsive/careless style [ICS], and avoidance style [AS]) were dependent variables in this study. Both the total score and the five subscale scores had high internal consistency (Cronbach's alpha ranged from .69 to .95 for five subscale scores,

.95 for the total score) and good test-retest reliability over 3 weeks (correlations ranged from .69 to .91 for subscale scores and .89 to .93 for the total score) (D'Zurilla, 2007).

Predictive models were developed for the total score and five subscale scores of the SPSI-R using all possible subsets regression in SAS (version 9.2, SAS Institute, Inc., Cary NC). All of the other analyses were conducted in SPSS (version 17.0, SPSS, Inc., Chicago, IL, USA).

We conducted a preliminary analysis to begin the predictor selection process by examining bivariate correlations between each predictor and dependent variable. Depending on the level of measurement for each variable Pearson's product moment correlation, Spearman's rank-order correlation, or Point-Biserial Correlation was used to examine the associations of SPSI-R total score and five subscale scores with all of the following potential predictors for screening purposes: age, gender, ethnicity, education, marital status, employment status, income, history of psychiatric disorders, mental health quality of life, sleep duration, history of weight cycling, perceived stress, eating habits, barriers to healthy eating, and self-efficacy for following a cholesterol-lowering diet. Age, gender, education, marital status, employment status, income, history of weight cycling, mental health quality of life, perceived stress, and barriers to healthy eating had a significant correlation with at least one of the dependent variables, ps< 0.10. They were then selected as candidates for the multivariate analysis. We then conducted all possible subsets method in SAS to identify parsimonious sets of predictors to develop a predictive model of social problem solving. We chose the best subset of predictors using selection criteria: 1) Mallow's Cp, 2) mean square error (MSE), 3) R square, 4) adjusted R square.

Age, gender, education, marital status, employment status, and income level were measured by the Socio-Demographic Questionnaire. Age and years of formal education were continuous variables. Gender, marital status, employment status, and gross annual income were

categorical variables. History of weight cycling was assessed using a summary variable based on the intensity and frequency of weight cycling, which was derived for analysis by summing the five intensities of weight cycling, each weighted by the self-reported frequency of occurrence. Intensity of weight cycling was coded 0 to 4 representing the maximum amount of weight lost at any point and ranged from "10-19 pounds" to "more than 100 pounds". Frequency of weight cycling was coded 0-4 representing maximum number of times of weight cycling ranging from "never" to "more than 10 times". This weighted summary variable was highly ordinal and approximated an interval scaled variable.

Mental health quality of life was assessed using the mental component score (MCS) of the SF-36 Version 2. The Cronbach's alpha for the MCS was .93 for the 1998 general U.S. population (Ware, 2000). Perceived stress was measured by the Perceived Stress Scale. It has good reliability (Cronbach's alpha = .86, test-retest = .85 over 2 days and .55 in 6 weeks), as well as good concurrent predictive validity with depressive symptoms, r= .76 and physical symptoms, r=.70 (Cohen, et al., 1983). Barriers to healthy eating was measured by the Barriers to Healthy Eating Scale, a 22-item questionnaire asking individuals to rate various feelings or situations related to following the diet, e.g., feelings of deprivation and cost of the regimen. It has good reliability (test-retest reliability, r=.89; internal consistency, Cronbach's alpha =.86) and predictive validity with weight loss at 6 months (r=.28) in an earlier study (Burke, et al., 2004).

6.4 FINDINGS

The sample (N=210) was mainly comprised of Caucasian Americans (84.8%), female (78.1%), and middle-aged adults (average 46.80 years). Demographic characteristics of the sample were described in detail in Table 1.

In the predictive model for the total score of SPSI-R, the following factors were jointly identified as predictors of a higher score of the SPSI-R: being younger, had a higher weight at baseline, had better mental health, perceived less stress and fewer barriers to healthy eating together, were associated with better problem-solving skills (R^2=.40, F=26.40, p<.0001).

Being older, having a lower weight at baseline, poor mental health, perceived more barriers and stresses, and being single together built a significant predictive model of a negative problem orientation (R^2=.19, F=24.7, p<.0001), while a higher income, perceived fewer barriers and less stress predicted positive problem orientation (R^2=.22, F=23.8, p<.0001).

Higher levels of income and education, fewer perceived stresses, and a history of weight cycling predicted a rational problem-solving style (R^2=.34, F=24.7, p<.0001), while less education and perceiving more eating barriers and stress predicted an impulsive or careless style (R^2=.18, F=24.7, p<.0001). Being older, having poor mental health and perceiving more eating barriers and stresses together predicted an avoidant style (R^2=.34, F=24.7, p<.0001) of social problem solving.

In Table 2, standardized estimate and significance testing of t statistic for each predictor, as well as parameter statistics on selection criteria: Mallow's Cp, MSE, R square, and adjusted R square for each predictive model are reported.

6.5 DISCUSSION

This study was the first attempt to build predictive models for social problem-solving in an overweight/obese population seeking treatment. We found that older adults were more likely to view problems from a negative perspective and an avoidance style when they encountered problems. This result is consistent with the findings of D'Zurilla et al. (1998), even though age did not appear to be a predictor of the other three subscales of the social problem-solving measure. However, one thing worth noting is that they used three different age samples, instead of examining the effect of age on social problem-solving ability using age as a continuous variable. In the same study, they reported gender difference on positive problem orientation and negative problem orientation; however, gender did not appear to be a factor that was associated with social problem-solving skills in our sample of overweight/obese adults.

To the best of our knowledge, we are the first to find that individuals who are married or had previously married, were less likely to have a negative view on problems, while those who had a higher level of education and income or who had more frequent or more severe weight cycling, tended to have a rational problem-solving style. Similarly, people who had a higher baseline weight but had better social problem-solving skills in general were less likely to have a negative view on problems encountered.

Perceived stress has been associated with all aspects of social problem solving, indicating that overweight and obese adults who perceived high level of stress were more likely to have a negative view of problems, and to have an impulsive/careless or avoidance style, while those who had lower levels of stress were more likely to view problems positively and had a rational problem-solving style. Even though no study reported an association between social problem solving and perceived stress, similar constructs had been reported to be associated with social

problem solving in school children. D'Zurilla and his colleagues found social problem solving associated with psychological distress in their validation studies of the SPSI-R measure (D'Zurilla, 2007). Depression was found to be a predictor of social problem solving in school-aged children (Levendosky, Okun, & Parker, 1995). Similarly, we found our participants who had higher scores on the mental component of the health-related quality of life measured by the SF-36 tended to have a less negative problem orientation and avoidance style. However, individuals who perceived more barriers were more likely to have a negative view of problems, and an impulsive/careless or avoidance style when solving problems.

There may be other factors that could possibly be associated with social problem solving in this population, but due to the nature of the secondary data analysis, we were not able to generate a comprehensive list of predictors for screening. However, this study has provided initial evidence that age, income, education, mental health, perceived stress, and barriers to healthy eating were associated with participants' social problem-solving abilities. These factors need to be considered when developing interventions to address problem-solving skills related to managing lifestyle changes and weight reduction. Identifying the factors that influence individuals' social problem solving skills is important in improving the problem-solving skills of those seeking weight loss treatments.

Table 5. Demographic Characteristics of the Sample (N=210)

Characteristics	% (n) or M±SD
Age (years)	46.80 ± 9.02
Gender	
Female	84.8 (178)
Male	15.2 (32)
Ethnicity	
White	78.1 (164)
Black	21.9 (46)
Education (years)	15.65 ± 3.00
BMI(kg/m^2)	34.01 ± 4.49
Marital status	
Currently married	68.6 (144)
Never married	13.8 (29)
Divorced or separated	17.6 (37)
Employment status	
Employed full time/	82.9 (174)
Not full time	
Gross household income	
>$50,000	60.0 (123)
$30,000-$50,000	23.9 (49)
$10,000-$30,000	16.1 (33)

Table 6. Best Predictive Models of the Total Score and Five Subscale Scores of the Social Problem-Solving Inventory-Revised Based on All Possible Subsets Regression

	SPSI-R total score	PPO	NPO	RPS	ICS	AS
Age						.17**
Baseline weight (lbs)			-.15**			
Mental health	.21** [a]		-.24**			-.25*
Barriers to healthy eating	-.20**	-.13	.19***		.18**	.22***
Perceived stress	-.31***	-.37***	.37***	-.25***	.32***	.22**
Medium income level				.20*		
High income level				.23*		
Education (years)				.15*		
Model summary statistics						
MSE	5.42	9.83	37.66	152.49	33.91	20.78
Cp	2.88	-1.92	1.49	-1.11	-1.65	1.40
R^2	.39	.23	.48	.12	.22	.34
Adj R^2	.38	.22	.46	.11	.21	.32

Note. Only the predictors identified as the best possible subset based on the model selection criteria are presented. PPO = positive problem orientation; NPO = negative problem orientation; RPS = rational problem-solving style; ICS = impulsivity/carelessness style, AS = avoidance style; SPSI-R = Social Problem-Solving Inventory-Revised.

a: standardized regression estimate is reported in each cell of the table unless otherwise specified

*p<.05. ** p<.01. *** p< .001.

APPENDIX A. Literature Review on Standard Behavioral Treatment for Obesity

Table 7. Process of Literature Search

	OVID MEDLINE	OVID PsycInfo	PUBMED	CINAHL
Limits	OVID English language, human, adults (19yrs and plus), 2000-2010Jan, Clinical Trial, Conducted in the U.S.	English language, human, adulthood(18yrs and plus), 2000-2010,TreatmentOutcome/Randomized Clinical Trials	Published in the last 10 years, Clinical Trial, English, Humans, All Adult, 19+years	Published 2000-2010, English, Clinical Trials, All Adult 19+
Keywords for searching	Obesity Overweight Behavior therapy Weight Loss	Obesity Overweight Weight loss Behavior therapy Behavior modification	Obesity Overweight Weight loss Weight reduction Behavior therapy Behavior modification	Obesity Weight Loss Weight Reduction programs Behavior therapy Behavior modification(5 articles found, did not fit inclusion criteria)
# Initial abstracts identified	115	12	423	27
# Reviewed abstracts	41	3	33	5
# Reviewed full articles	8	2	14	3

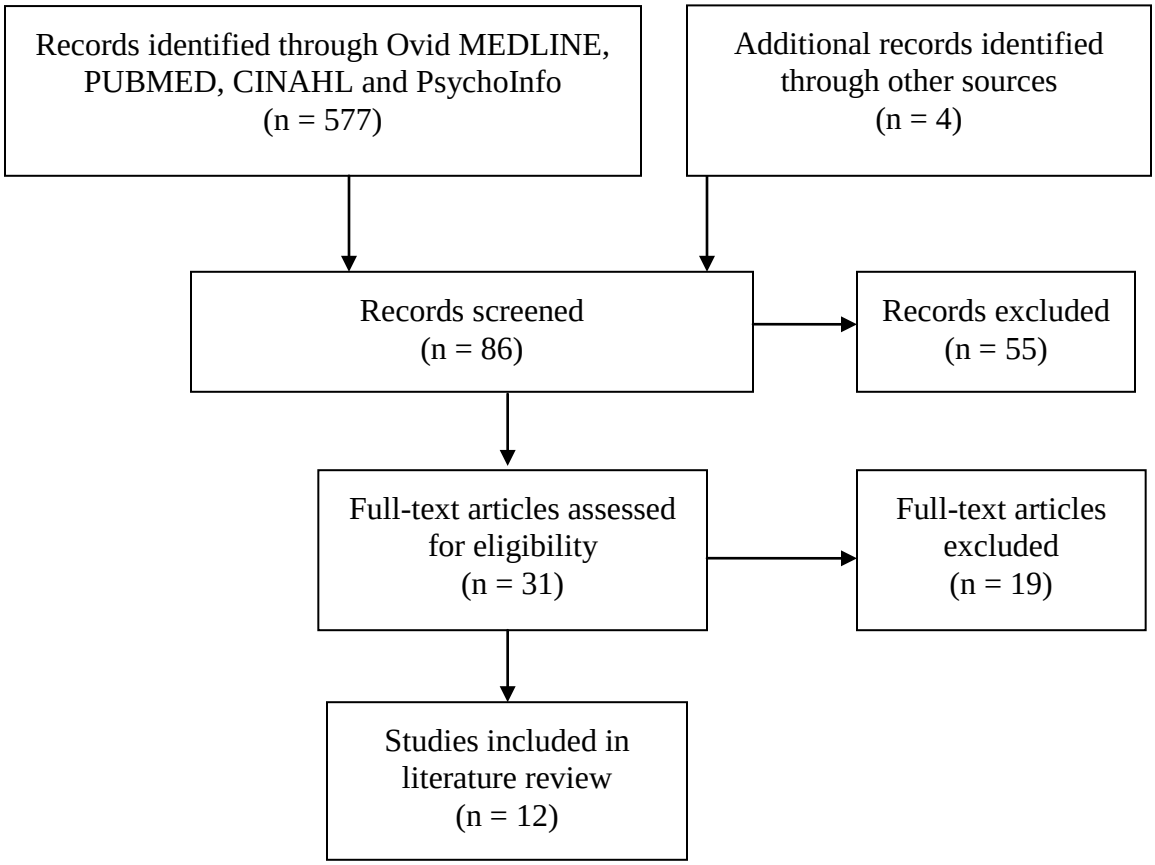

Figure 8. Flow Diagram of Study Selection in the Systematic Review

Table 8. Weight Loss Trials between 2000 and 2010 in the United States

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
(Tate, et al., 2001)	6 months	6 months	Internet education	N=91 Internet education (n=45) 89% Women 78% White Age: 40.6 ± 9.7 years BMI: 28.9 ± 3.1 kg/m^2 Attrition=22.2%	Internet behavior therapy group (4.1 ± 4.5kg) lost significantly more weight than the Internet education group at 6 months (1.6 ± 3.3kg).
			Internet behavior therapy	Internet behavior (n=46) 89% Women 89% White Age: 41.1 ± 11.6 years BMI: 29.1 ± 3.0 kg/m^2 Attrition=21.7%	
(Tate, Jackvony, & Wing, 2003)	12 months	12 months	Basic Internet group	N=92 Basic Internet (n=46) 89% Women 89% White Age: 47.3 ± 9.5 years BMI: 33.7 ± 3.7 kg/m^2 Attrition=15.2%	Behavioral e-counseling group (4.4 ± 6.2 kg) lost more weight at 12 months than the basic Internet group (2.0 ± 5.7 kg).
			Basic Internet + behavioral e-couseling group	E-counseling (n=46) 91% Women 89% White Age: 49.8 ± 9.3 years	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				BMI: 32.5 ±3.8 kg/m^2 Attrition=17.4%	
(Jakicic, Marcus, Gallagher, Napolitano, & Lang, 2003)	12 months	12 months	Four groups with different exercise duration and intensity: Vigorous Intensity/High Duration (VI/HD)	N=201 VI/HD (n=50) 100% Women 88% White Age: 38.3 ± 5.4 years BMI: 32.8 ± 3.9 kg/m^2 Attrition=4%	No group difference was found among four groups, with significant weight loss at 12 months for all of the four groups: Vigorous Intensity/High Duration grop lost 8.9 ± 7.3 kg, Moderate Intensity/High Duration lost 8.2 ± 7.6 kg; Vigorous Intensity/Moderate Duration lost 6.3 ± 5.6 kg; while Moderate Intensity/ Moderate Duration lost 7.0 ± 6.4 kg.
			Moderate Intensity/High Duration (MI/HD)	MI/HD (n=50) 100% Women 90% White Age: 36.8 ± 5.3 years BMI: 32.2 ± 3.9 kg/m^2 Attrition=12%	
			Vigorous Intensity/Moderate Duration (VI/MD)	VI/MD (n=50) 100% Women 70% White Age: 36.8 ± 6.0 years BMI: 32.8 ± 4.3 kg/m^2 Attrition=12%	
			Moderate Intensity/ Moderate Duration (MI/MD)	MI/MD (n=51) 100% Women 76% White Age: 35.9 ± 5.7 years	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				BMI: 32.8 ± 4.6 kg/m^2 Attrition=5.9%	
(Heshka, et al., 2003)	24 months	24 months	Weight Watchers: weekly group session with successful weight losers, food plan, and physical activity plan	N=423 Weight Watchers (n=211) 82% Women Ethnicity N/A Age: 45 ± 10 years BMI: 33.8 ± 3.4 kg/m^2 Attrition=28.9%	Weight Watchers' group lost significantly more weight than self-help group at 12 months (4.3 ± 6.1kg vs. 1.3 ± 6.1kg) and 24 months (2.9 ± 6.5kg vs. 0.2 ± 6.5kg).
			Self-help: Consultation with dietitian at baseline and 12 weeks, given printed education materials	Self-help (n=212) 87% Women Ethnicity N/A Age: 44 ± 10 years BMI: 33.6 ± 3.7 kg/m^2 Attrition=25%	
(Poston, et al., 2003)	12 months	12 months	Orlistat, 120mg three times per day and lifestyle modification intervention (OLM)	N=108 Orlistat + OLM (n=56) 100% Women 100% Mexican American Age: 42.4 ± 9.2 years BMI: 37.8 ± 6.2 kg/m^2 Attrition=42.9%	The OLM group (8.8% ± 1.5) lost significantly more weight than the wait-list group at 12 months (0.2% ± 1.0).
			Wait-list Control	Wait-list Control (n=52) 100% Women 100% Mexican American	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				Age: 43.7 ± 9.2 years BMI: 36.0 ± 5.2 kg/m^2 Attrition=34.6%	
(Harvey-Berino, Pintauro, Buzzell, & Gold, 2004)	6 month	12 months	Everyone received a 6-month behavioral weight loss program conducted over interactive television, followed by a 12-month weight maintenance program with: Frequent in-person support (F-IPS)	N=232 F-IPS (n=77) 84% Women Ethnicity N/A Age: 45.2 ± 8.9 years BMI: 28.9 ± 3.8 kg/m^2 Attrition=20.8%	No significant different was found among three groups (5.1 ± 6.5kg for F-IPS vs. 5.5 ± 8.9kg for M-IPS vs. 7.6 ± 7.3kg).
			Minimal in-person support (M-IPS)	M-IPS (n=77) 86% Women Ethnicity N/A Age: 46.5 ± 7.7 years BMI: 29.0 ± 4.3 kg/m^2 Attrition=32.5%	
			Internet support (IS)	IS (n=78) 81% Women Ethnicity N/A Age: 46.5 ± 9.8 years BMI: 29.3 ± 5.2 kg/m^2 Attrition=19.2%	
(Wadden, Berkowitz, et al., 2005)	12 months	12 months	Sibutramine Alone (SA)	N=224 SA (n=55) 80% Women	The combined therapy group (12.1 ± 9.8 kg) lost

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				56% White Age: 42.1 ± 10.2 years BMI: 38.2 ± 3.9 kg/m^2 Attrition=18.2%	significantly more weight than the other three groups at 12 months (5.0 ± 7.4 kg for SA, 6.7 ± 7.9 kg for LMA, and 7.5 ± 8.0 kg for S+BT group).
			Lifestyle Modification Alone (LMA)	LMA (n=55) 76% Women 64% White Age: 43.3 ± 9.7 years BMI: 37.8 ± 4.2 kg/m^2 Attrition=14.5%	
			Combined Therapy (CT)	CT (n=60) 82% Women 70% White Age: 44.2 ± 10.8 years BMI: 37.9 ± 4.2 kg/m^2 Attrition=18.3%	
			Sibutramine plus Brief Therapy (S+BT)	S+BT (n=54) 83% Women 72% White Age: 44.9 ± 10.1 years BMI: 37.6 ± 4.7 kg/m^2 Attrition=18.5%	
(Carels, Darby, Douglass, Cacciapaglia, &	6 months	12 months		N=53 Attrition=24.5% at 6 months post treatment,	No group different was found between two intervention

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
Rydin, 2005)				2.5% at 1 year follow up after post-treatment	groups at 6 months post intervention, and at 12 months follow-up post treatment.
			Behavioral Weight Loss Program (BWLP)	BWLP (n=26) 89% Women Ethnicity N/A Age: 43.5 ± 9.8 years BMI: 37.2 ± 5.1 kg/m^2	
			BWLP + Glycemic index education (BWLP + GI)	BWLP+ GI (n=27) 78% Women Ethnicity N/A Age: 43.4 ± 9.0 years BMI: 38.0 ± 13.4 kg/m^2	
(Burke, et al., 2006)	12 months	6 months	First, participants were randomized to two preference groups (PREFER vs. PREFER No). Within each preference group, they were randomized into two dietary groups: Standard Behavioral Treatment (SBT) Standard Behavioral Treatment + Lacto-ovo-vegetarian (SBT+LOV)	PREFER- SBT (n=48) 88% Women 71% White Age: 43.2 ± 9.4 years BMI: 34.5 ± 3.9 kg/m^2 Attrition = 25% PREFER- SBT+LOV (n=36) 80% Women 71% White Age: 44.3 ± 8.4 years BMI: 34.1 ± 3.5 kg/m^2 Attrition = 20%	The two groups that were assigned a diet (PREFER NO-SBT 8.0 ± 7.8 kg, PREFER NO- SBT 7.9 ± 8.1 kg) lost significantly more weight that the groups that were given a choice for their diets (PREFER- SBT 3.9 ± 6.1 kg PREFER- SBT+LOV 5.3 ± 6.2 kg).

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				PREFER NO- SBT (n=50) 88% Women 71% White Age: 43.2 ± 8.4 years BMI: 32.9 ± 4.1 kg/m^2 Attrition = 30% PREFER NO- SBT+LOV (n=48) 91% Women 69% White Age: 43.2 ± 8.6 years BMI: 33.7 ± 4.3 kg/m^2 Attrition = 24%	
(Tate, et al., 2006)	6 months	6months	Weight loss website and no counseling (NC)	N=192 NC (n=67) 82% Women 91% White Age: 49.9 ± 8.3 years BMI: 32.3 ± 3.7 kg/m^2 Attrition=11.9%	There was a significant greater weight loss in the human e-mail counseling group at 6 months (7.3 ± 6.2kg) than in the computer-automated feedback (4.9 ± 5.9kg) or no counseling (2.6± 5.7kg) groups.
			Website and computer-automated feedback (AC)	AC (n=61) 87% Women 90% White Age: 49.7 ± 11.4 years BMI: 32.7 ± 3.5 kg/m^2 Attrition=27.9%	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
			Website and human email counseling (HC)	HC (n=64) 84% Women 87% White Age: 47.9 ± 9.8 years BMI: 32.8 ± 3.4 kg/m^2 Attrition=18.8%	
(Sherwood, et al., 2006)	24 months	24 months	Mail intervention with 10 behavioral lessons	N=1801 Mail (n=600) 69% Women 90% White Age: 50.6 ± 0.5 years BMI: 34.1 ± 0.2 kg/m^2 Attrition=36.5%	Weight losses at 24 months did (0.73±0.22kg mail, 0.93±0.22kg phone, 0.59±0.22kg usual care, P=0.55)
			Phone intervention with 10 interactive lesions	Phone (n=601) 73.5% Women 92.2% White Age: 50.7 ± 0.5 years BMI: 33.5 ± 0.2 kg/m^2 Attrition=32.6%	
			Usual care-access to weight management services	Usual care (n=600) 72.8% Women 91% White Age: 50.8 ± 0.5 years BMI: 34.0 ± 0.2 kg/m^2	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				Attrition=31.7%	
(Gold, Burke, Pintauro, Buzzell, & Harvey-Berino, 2007)	12 months	12 months	VTrim	N=124 VTrim (n=62) 77% Women 98% White Age: 46.5 ± 10.7 years BMI: 32.3 ± 3.9 kg/m^2 Attrition=22.5%	The VTrim group (8.3 ± 7.9kg) lost significantly more weight than the eDiets.com group (4.1 ± 6.2kg) at 6 months and maintained a greater loss at 12 months (7.8 ± 7.5kg vs. 3.4 ± 5.8kg).
			eDiets.com	eDiets.com (n=62) 86% Women 98% White Age: 48.9 ± 9.9 years BMI: 32.5 ± 4.2 kg/m^2 Attrition=35.5%	
(Helsel, et al., 2007)	16 weeks	16 weeks	Detailed self-monitoring (SM): weekly recording of diet and exercise for 16 weeks	N=42 Detailed SM (n=21) Gender N/A Ethnicity N/A Age: 38.0 ± 5.9 years BMI: 32.0 ± 1.6 kg/m^2 Attrition=52.4%	No significant difference was found between detailed self-monitoring group (3.9 ± 5.3 kg) and transitional self-monitoring group (4.3 ± 5.8 kg).
			Transitional SM: detailed SM for week 1-8, then abbreviated checklist for week 9-16	Transitional SM (n=21) Gender N/A Ethnicity N/A Age: 35.0 ± 6.6 years	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
				BMI: 32.5 ± 1.5 kg/m^2 Attrition=42.9%	
(Carels, et al., 2007)	16 + 6 weeks	6 months	Behavioral weight loss program (BWLP) + no contact for 6 weeks	N=51 BWLP (=20) 80% Women 88.2% White Age: 53.2 ± 9.5 years Weight: 112.0 ± 29.6 kg Attrition=11.5% post BWLP, 23.1% follow up	The weight maintenance group had significantly greater weight loss post the 6-week MI intervention (BWLP: 4.9 ± 3.3% weight loss, BWLP + MI: 4.9 ± 3.3%), and at 6-month follow up (BWLP: 9.1 ± 6.0%, BWLP + MI: 10.1 ± 7.6%).
			BWLP+ 6-week weight maintenance intervention (MI)	BWLP + MI (n=18) 89% Women 89% White Age: 47.3 ± 9.4 years Weight: 108.5 ± 17.1 kg Attrition=20% post BWLP, 28% follow up	
(Polzien, et al., 2007)	12 weeks	12 weeks		N=57 98.3 Women	There was a significant difference in weight loss at 12weeks among three groups (4.1 ± 2.8 kg for SBT, 3.4 ± 3.4 kg for INT-TECH, 6.2 ± 4.0 kg for CON-TECH).
			In-person SBT	SBT (n=19) Gender N/A 63.2% White Age: 41.3 ± 8.7 years BMI: 33.6 ± 2.7 kg/m^2 Attrition=15.8%	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
			Intermittent technology-based program (INT-TECH)	INT-TEC (n=19) Gender N/A 85% White Age: 41.1 ± 8.3 years BMI: 33.4 ± 2.8 kg/m^2 Attrition=15.8%	
			Continuous technology-based program (CON-TECH)	CON-TECH (n=19) Gender N/A 85% White Age: 42.6 ± 10.0 years BMI: 32.6 ± 2.7 kg/m^2 Attrition=5.3%	
(Micco, et al., 2007)	12 months	12months		N=123 Attrition=21%	There was no significant group difference in weight loss at 6 months (6.8±7.8kg for Internet-only group, 5.1 ± 4.8kg for I+IPS group) or 12 months (5.1 ± 7.1kg for Internet-only group, 3.5 ± 5.1kg for I+IPS group).
			Internet-Only (VTrim website)	Internet-Only(n=62) 77% Women 98% White Age: 46.5 ± 10.7 years BMI: 32.3 ± 3.9 kg/m^2	
			Internet+in-person treatment (I+IPS)	I+IPS (n=61) 89% Women 100% White Age: 47.1 ± 11.1 years BMI: 31.0 ± 4.1 kg/m^2	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
(Carels, et al., 2007)	6 months	6 months	Behavioral weight loss program (BWLP)	N=55 BWLP (n=27) 88.5% Women 92.3% White Age: 48. ± 9.0 years Weight: 96.6 ± 22.1kg Attrition=18.5%	No group difference in weight loss was found between BWLP +SC group (5.8 ± 5.5 kg) and BWLP group (3.8 ± 4.9 kg).
			BWLP + Stepped Care (SC)	BWLP + SC (n=28) 85.2% Women 92.9% White Age: 48.3 ± 11.0 years BMI: 101.6 ± 2.5kg Attrition=14.3%	
(Jakicic, Marcus, Lang, & Janney, 2008)	18 months	6 months	Vigorous Intensity/ High Duration(VI/HD)	N=201 VI/HD (n=50) 100% Women 84% White Age: 38.8 ± 5.5 years BMI: 32.8 ± 3.9 kg/m^2 Attrition=10	There was no significant difference among three groups at 24 months (VI/HD: 4.7kg, MI/HD: 3.5kg, MI/MD: 3.5kg, VI/MD: 2.9kg).
			Moderate Intensity/ High Duration(MI/HD)	MI/HD (n=50) 100% Women 88% White Age: 37.4 ± 5.4 years BMI: 32.2 ± 3.9 kg/m^2 Attrition=18	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
			Moderate Intensity/ Moderate Duration(MI/MD)	MI/MD (n=50) 100% Women 66% White Age: 37.2 ± 6.1years BMI: 32.8 ± 4.3 kg/m^2 Attrition=22	
			Vigorous Intensity/ Moderate Duration(VI/MD)	VI/MD (n=51) 100% Women 74.5% White Age: 36.4 ± 5.7 years BMI: 32.8 ± 4.6 kg/m^2 Attrition=12	
(Turner-McGrievy, et al., 2009)	12 weeks	12 weeks	Currently available weight-loss podcast (Control Podcast-CP)	N=78 CP Group (n=37) 81% Women 78% White Age: 39.6 ± 12.2 years BMI: 31.4 ± 4.1 kg/m^2 Attrition=24.3%	The enhanced podcast group lost significantly more weight than the control group (2.9 ± 3.5kg for EP group vs. 0.3 ± 2.1kg for CP group).
			Theory-based weight-loss podcast designed by researchers (Enhanced Podcast-EP)	EP Group (n=41) 68% Women 85% White Age: 37.7 ±11.8 years BMI: 31.8 ± 3.2 kg/m^2 Attrition=17%	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
(Digenio, et al., 2009)	6 months	6 months	High-frequency face-to-face counseling (HF-F2F)	N=376 HF-F2F Group (n=74) 88% Women 84% White Age 45 ± 9 years BMI 34.6 ± 3.0 kg/m^2 Attrition =25.7%	The two high frequency groups (HF-F2F: 8.9% [95%CI: 8.0% - 9.8%)], HF-TEL: 6.4% [95%CI: 5.4% - 7.3%]) had similar weight loss, and had significantly greater weight loss that the other three groups (LF-F2F: 7.7% [95%CI: 6.8% - 8.7%], HF-EMAIL: 5.9% [95%CI: 5.0% - 6.8%], SELF: 5.2% [95%CI: 4.3% - 6.1%]).
			Low-frequency face-to-face counseling (LF-F2F)	LF-F2F Group (n=76) 88% Women 82% White Age 43 ± 10 years BMI 34.2 ± 2.7 kg/m^2 Attrition =25.7%	
			High-frequency telephone counseling (HF-TEL)	HF-TEL Group (n=76) 91% Women 71% White Age 43 ± 10 years BMI 34.0 ± 3.2 kg/m^2 Attrition =25.7%	
			High-frequency e-mail counseling (HF-EMAIL)	HF-EMAIL Group (n=74) 84% Women 86% White Age 44 ± 9 years BMI 34.0 ± 2.8 kg/m^2 Attrition =25.7%	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
			Self-help (SELF)	SELF Group (n=74) 83% Women 74% White Age 44 ± 10 years BMI 35.0 ± 2.6 kg/m^2 Attrition =25.7%	
(Jeffery, et al., 2009)	18 months	18 months	Standard Behavior Therapy (SBT)	N=213 SBT (n=106) 51.9% Women 69.8% White Age: 49.1 ± 1.0 years BMI: 35.2 ± 0.3 kg/m^2 Attrition=26.4%	No group difference was found at 18 months. However, the weight loss pattern differed. The SBT group (7.4 ± 0.5kg) had significant greater weight loss that MTT group (5.7 ± 0.5kg), both groups had similar weight loss from 6 months to 12 months (SBT: 3.3 ± 0.7kg, MTT: -2.4 ± 0.7kg). The SBT had significant weight gain (1.4 ± 0.3kg), while the MTT group (0.1 ± 0.6kg) had stable weight from 12 months to 18 months.
			Maintenance-tailored therapy (MTT)	MTT (n=107) 54.2% Women 64.5% White Age: 45.8 ± 1.0 years BMI: 34.6 ± 0.3 kg/m^2 Attrition=25.5%	
(DiMarco, Klein, Clark, & Wilson, 2009)	11 weeks	11 weeks		N=39 82% Women 71.8% White Age: 39.9 ± 8.84 years	There was no significant difference in weight loss between GSH group (BMI: 31.58 ± 3.1) and GSH+MI group (BMI: 30.9 ± 3.1).

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
			GSH/MI	GSH/MI (n=20) N/A % Women N/A % White Age: N/A BMI: 33.1 ± 3.2 kg/m^2 Attrition=25%	
			GSH	GSH (n=19) N/A % Women N/A % White Age: N/A BMI: 31.6 ± 2.8 kg/m^2 Attrition=42.1%	
(Samuel-Hodge, et al., 2009)	4 months	5 months	Weight Wise Program (WWP)	N=143 WWP (n=72) 100% Women 61% White Age: 51.9 ± 0.8 years BMI: 34.5 ± 0.6 kg/m^2 Attrition=11.1%	The Weight Wise Program (3.7 ± 0.4kg) lost significantly greater weight than the control group (0.7 ± 0.4kg).
			Control	CG (n=71) 100% Women 59% White Age: 53.7 ± 0.9 years BMI: 34.3 ± 0.6 kg/m^2 Attrition=12.7%	

Study	Treatment			Sample	Outcome/Results
	Length of treatment	Length of follow up	Randomization Group		
(Patrick, et al., 2009)	4 months	4 months	Text-message intervention with typically one morning and one afternoon messages, with a choice of one to three additional messages as reminders + weekly varied topics + monthly brief phone calls	N=78 Intervention (n=39) 76% Women 76% White Age: 47.4 ± 7.1 years BMI: 32.8 ± 4.3 kg/m^2 Attrition=15.4%	The text-message group (2.1 ± 0.5kg) lost significantly greater weight than the control group (0.5 ± 0.4kg).
			Control	Control (n=39) 84% Women 75% White Age: 42.4 ± 7.5 years BMI: 33.5 ± 4.5 kg/m^2 Attrition=17.9%	

Table 9. Summary of Weight Loss Trials in the U.S. between 2000 and 2010

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
(Tate, et al., 2001)	Internet education	45	Website access for 6 months	78.8 28.9	1.6			
	Internet behavior therapy	46	Weekly email session	77.4 29.1	4.5			
(Tate, et al., 2003)	Basic Internet	46	Website access for 12 months, weekly reminder for weight submission	89.4 33.7	2.5	2.0		
	Internet + behavioral e-counseling	46	Daily (for month 1) or weekly (for month 2-12) diary submission and email counseling	86.2 32.5	5.2	4.4		
(Jakicic, et al., 2003)	Vigorous intensity/ high duration exercise	50	Weekly for 6 months, biweekly mo 7-12	87.3 32.8	9.4	8.8		
	Moderate intensity/high duration exercise	50	Same as above	86.8 32.2	8.0	7.8		
	Moderate intensity/moderate duration	50	Same as above	87.2 32.8	7.1	6.4		

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
	exercise							
	Vigorous intensity/Moderate duration exercise	51	Same as above	88.1 32.8	7.5	6.9		
(Heshka, et al., 2003)	Weight Watchers-cognitive restructuring	211	Weekly for 2 yrs	94.2 33.8		5.0	3.0	
	Self-help	212	Printed education materials and two-time consultation with dietitian	93.1 33.6		1.4	0.1	
(Poston, et al., 2003)	Orlistat and lifestyle modification	56	Weekly for 6 months, bimonthly for 3 months, and monthly for 3 months	96.4 37.8	5.2	5.6		
	Wait-list control	52	N/A	92.2 32.0	1.0	0.3		
(Harvey-Berino, et al., 2004)	SBT + frequent in-person support (IPS)	77	Weekly for 6mos over interactive television (ITV) + bi-weekly for mo 7-18	81.2 28.9	7.6		5.1	
	SBT + minimal	78	Weekly for 6mos over	80.5	7.6		7.6	

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
	IPS		ITV + monthly ITV for mo 7-12 + no contact for mo 13-18	29.0				
	SBT +Internet support	77	Weekly for 6mos over interactive television + bi-weekly internet chat session and email contact for mo 7-18	82.7 29.3	8.4		5.5	
(Wadden, Berkowitz, et al., 2005)	Lifestyle modification alone	55	Weekly for wk 1-18, biweekly for wk 20-40, Follow up at wk 52	105.1 37.8		6.7		
	Sibutramine alone	55	8 visits on wk 1,3,6,10,18,26, 40, 52	107.9 14.7		5.0		
	Combined therapy	60	8 visits + group sessions (same as lifestyle alone)	108.5 37.9		12.1		
	Sibutramine plus brief therapy	54	8 visits on wk 1,3,6,10,18,26, 40, 52	106.0 37.6		7.5		
(Carels, Darby, Douglass, et al.,	BWLP-LEARN	26	Weekly for 20wks 60-75 mins/session	104.8 37.2	8.2	N/A		
	BWLP+GI	27	Weekly for 20wks	101.2	7.1	N/A		

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
2005)	(Glycemic index education)		90-120 mins/session	38.0				
(Burke, et al., 2007; Burke, et al., 2006)	PREFER-YES SBT	48	Weekly for 6 mos, biweekly for mo 7-9, monthly for mo10-12	97.9	6.4	5.3	3.3	
	PREFER-YES SBT+LOV (lacto-ovo-vegetarian)	35	Same as above	97.7	7.8	7.0	4.0	
	PREFER-NO SBT	48	Same as above	93.7	7.3	7.6	6.1	
	PREFER-NO SBT+LOV	45	Same as above	93.0	7.3	7.9	5.9	
(Tate, et al., 2006)	Weight loss website and no counseling	67	Website-weekly weight report and email prompts	88.3 32.3	2.7			
	Website and computer-automated feedback	61	Above + weekly feedback from computer	89.0 32.7	4.9			
	Website and human email	64	Above + weekly feedback from a	89.0 32.8	7.0			

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
	counseling		human counselor					
(Sherwood, et al., 2006)	Mail	600	10 sessions + feedback between sessions	34.1			2.3	0.7
	Phone	601	Same as above, delivered by phone	33.5			2.4	0.9
	Usual care	600	None	34.0			1.9	0.6
(Gold, et al., 2007)	VTrim	62	Weekly for 6 mos, biweekly for 6 mos	92.0 32.3	6.8	5.1		
	eDiets.com	62	Online resource access throughout the study	90.2 32.5	3.3	2.6		
(Helsel, et al., 2007)	SBT with Detailed SM	21	Weekly mailed lessons for 16 weeks	87.0 32.0	3.9 (4 mos)			
	SBT with Transitional SM	21	Same as above	90.0 32.5	4.3 (4 mos)			
(Carels, et al., 2007)	SBT	20	Weekly for 16 wks, then no contact till 6-mo follow up	112.0	3.7	4.3		
	SBT+ maintenance	18	Weekly for 16 wks, weekly maintenance session for 6 wks, and follow up at 6 mos	108.5	9.3	10.6		

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
(Polzien, et al., 2007)	SBT	19	Weekly for mo 1, biweekly for mo 2, monthly for mo 3	89.1 33.6	4.1 (3mos)			
	Intermittent technology-based SBT	19	Above + wearing a body monitor for week 1, 5, and 9	91.0 33.4	3.4 (3mos)			
	Continuous technology-based SBT	19	Above + wearing a body monitor with Internet monitoring throughout	86.6 32.6	6.2 (3mos)			
(Micco, et al., 2007)	Internet only	62	Weekly for 6 months, and biweekly for 6-12 months	92.0 32.3	6.8	5.1		
	Internet + in-person treatment	61	Same above, but substitue a in-person meeting every month	86.1 31	5.1	3.5		
(Carels, et al., 2007)	SBT	27	20 sessions over 24 weeks	96.6	3.6			
	SBT+ stepped care	28	Same as above	101.6	5.8			
(Jakicic, et al., 2008)	Vigorous intensity/high	50	Weekly for mo 1-6, biweekly for mo 7-12,	87.3 32.8	9.5	9.1	7.3	4.7

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
	duration		monthly for mo 13-18					
	Moderate intensity/high duration	50	Same as above	86.8 32.2	8.2	8.3	6.4	3.5
	Moderate intensity/ moderate duration	50	Same as above	87.2 32.8	7.3	6.5	4.7	3.5
	Vigorous intensity/ moderate duration	51	Same as above	88.1 32.8	7.5	6.9	5.3	2.9
(Turner-McGrievy, et al., 2009)	Enhanced podcast	48	Two theory-based weight-loss podcasts per week for 12 weeks	91.9 31.8	2.9 (3mos)			
	Control podcast	46	Same as above, but with currently available weight-loss podcast	89.0 31.4	0.3 (3mos)			
(Digenio, et al., 2009)	Face-to-face high frequency (HF)	74	Weekly for 3 mos, biweekly for mo 3-6	95.3 34.6	8.7			
	Face-to-face							

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
	low frequency	76	Monthly for 6 mos	94.4 34.2	6.3			
	HF telephone	76	Weekly for 3 mos, biweekly for mo 3-6	93.9 34.0	7.3			
	HF email	74	Weekly for 3 mos, biweekly for mo 3-6	93.4 34.0	5.5			
	Self-help	76	No dietitian contact	97.1 35.0	4.9			
(Jeffery, et al., 2009)	SBT	106	Weekly for 6 mos, bi-weekly for mo 6-12, monthly for mo 12-18	--- 35.2	5.7	8.2	8.3	
	Maintenance tailored therapy	107	Same as above	--- 34.6	7.4	10.7	9.3	
(DiMarco, et al., 2009)	Guided self-help (GSH)	19	Weekly for 5 wks, biweekly for 6wks	--- 31.6	0.5 kg/m^2 (11wks)			
	GSH + motivational interviewing (MI)	20	Same above, but with 2 MI sessions in the end	--- 33.1	1.6 kg/m^2 (11wks)			

Study	Group	Sample size	Treatment format	Initial weight (kg) and/or BMI (kg/m^2)	Weight loss (kg) 6 month	12 month	18 month	24 month
(Samuel-Hodge, et al., 2009)	Weight Wise Program	72	16 weekly sessions	92.0 34.5	3.7 (5mos)			
	Control	71	2 newsletters by mail	90.8 34.3	0.7 (5mos)			
(Patrick, et al., 2009)	Text-message behavioral intervention	39	Monthly brief phone calls + at least two daily text messages as participants choose	89.8 32.8	4.6 (4mos)			
	Control	39	Monthly mailed newsletter for 4mos	88.2 33.5	0.4 (4mos)			

Note. SBT = standard behavioral treatment; SM = self-monitoring; mo = month; wk = week; yr = year.

APPENDIX B. Problem Solving Component in the Parent Study

Session 21: Problem Solving

In a previous session, we used the example below to create a behavior chain.

> "Sarah" is a participant in our program. After doing well for several weeks she "had a really bad day" and ate a lot of cookies that were not part of her eating plan.

Problem solving can help Sarah manage such situations in the future.

The five Steps of Problem Solving:

1. Describe the problem in detail – create a behavior chain.

As described above, list each link in the behavior chain that lead to a problem you have had in the past…

2.Sarah's Behavior Chain 

- Didn't eat lunch
- Boss was critical
- Felt stressed and anxious
- Came home tired, upset, and angry
- Saw cookies on the kitchen counter
- Ate the cookies

2. Brainstorm your options.

Here are some things Sarah thinks may break links in her behavior chain.

Links 	***3.Some of Sarah's Options***
Didn't eat lunch	• Pack a quick bag lunch • Call a restaurant for a healthy, quick lunch
Boss was critical Sarah felt stressed and anxious	• Quit her job (Just kidding) • Talk with her boss about solving the problems at work • Take a break • Get support from a co-worker
Came home tired, upset, and hungry	• Go for a walk after work to unwind
Went right to the kitchen	• Enter house through different door • Avoid going to the kitchen when upset • Plan something to do the minute she gets home (like getting out in the yard, straightening a closet or room in the house)
Saw cookies on counter	• Don't buy cookies • Keep cookies out of sight • Keep fruit in sight

3. Pick options you will try.

First, weigh the **pros** and **cons** of each option. 

Here is Sarah's list of the pros and cons of some options:

Option	Pros	Cons
Pack a quick bag lunch.	Lunch is right there whenever I can get to it.	I have to be organized and shop for lunch food. I might forget to pack it.
Call a restaurant for a healthy lunch.	This saves me time and effort. It will help me stay on my eating plan.	I might be tempted by unhealthy menu items. It costs more money.
Keep cookies out of sight.	This makes it less tempting to eat them.	None that I can think of.

Second, choose several options that you will try.

Choose:

- Options that are likely to work and that you feel you can do
- Options that are early in the behavior chain
- More than one option

4. Make a positive action plan. *Example for Sarah:*

I will…	pack a quick bag lunch
When?…	Tuesday and Thursday next week
First, I will…	shop for the foods pack a lunch the night before
Roadblocks that might come up, and how I'll handle them…	might forget find a healthy sandwich place with quick service or order a turkey sandwich by phone
To make my success more likely, I will…	ask a friend who also brings bag lunches to work to join me for lunch on Tuesday

5. Try it. See how it goes.

Did it work? If yes, great!

If not, try to understand why. Make a behavior chain that shows what happened when you tried an option.

Then, think of some new options you can try the next time you are in that high risk situation. Create another action plan for those options.

You may need to create two or three action plans before you succeed.

Now, It's Your Turn

Think of a time or a typical situation in which it is hard to stick to your eating plan.

Find the behavior chain Links	Brainstorm your options Options

Pick one option. Is it very likely to work? Can you do it? Will you do it?

Make a positive action plan.

I will: _____

When? _____

I will do this first: _____

Roadblocks that might come up: I will handle them by:

_____ _____

_____ _____

_____ _____

I will do this to make my success more likely:

_____

How can others help you?

_____

In Summary

Planning for high risk situations involves looking in detail at the chain of events that may lead to overeating or not exercising. Being able to break links in that chain is key to having a sense of control and making healthy lifestyle changes.

Problem solving is a *process*. **Don't give up!**

Continue to:

- Your exercise goal this week is **150 minutes of cardio and 75 of strength**.
- Keep track of your exercise minutes in your diary.
- Stay at or under you calorie and fat gram goals.
- Record the amount of calories and fat grams eaten each day.

APPENDIX C. IRB Approval

University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)
http://www.irb.pitt.edu

Memorandum

To: Jing Wang

From: Sue Beers, PhD, Vice Chair

Date: 11/12/2009

IRB#: PRO09040513

Subject: Social Problem Solving and Adherence to Self-Monitoring in Association with Changes in Weight and Cardiovascular Risk Factors in a Behavioral Weight Loss Trial

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The above-referenced project has been reviewed by the Institutional Review Board. Based on the information provided, this project meets all the necessary criteria for an exemption, and is hereby designated as "exempt" under section
45 CFR 46.101(b)(4).

Please note the following information:

- If any modifications are made to this project, use the "**Send Comments to IRB Staff**" process from the project workspace to request a review to ensure it continues to meet the exempt category.
- Upon completion of your project, be sure to finalize the project by submitting a "**Study Completed**" report from the project workspace.

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

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